UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LEXMARK INTERNATIONAL, INC.,

Petitioner,

v.

FLEXIWORLD TECHNOLOGIES, INC.,

Patent Owner.

PTAB Case No. IPR2023-00845

Patent No. 7,609,402

DECLARATION OF MAJID RABBANI IN SUPPORT OF PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 7,609,402

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

TABLE OF CONTENTS

LIST OF APPENDICES iii

EXHIBIT LIST v

I. INTRODUCTION 1

II. QUALIFICATIONS AND EXPERIENCE 2

A. Qualifications 2

B. Materials Reviewed 13

III. UNDERSTANDING OF LEGAL PRINCIPLES AND PERSPECTIVES 14

A. Types of Claims 15

B. Anticipation and Obviousness 15

C. Claim Construction 18

D. Person of Ordinary Skill in the Art 19

IV. STATE OF THE ART / OVERVIEW OF THE TECHNOLOGY 21

V. DISCUSSION OF KEY PRIOR ART 39

A. Yamaguchi 39

B. Kammer 43

C. Moore 43

D. Davis 45

E. Kemp 46

F. Behlok 47

VI. THE ’402 PATENT 48

A. Overview of the ’402 Patent 48

B. Prosecution History 52

C. Priority Date of the ’402 Patent Claims 52

VII. INVALIDITY GROUNDS OF THE CHALLENGED CLAIMS 58

A. Ground 1: Claims 13-21, 33-37 Are Obvious Over Yamaguchi, Kammer, and Moore 58

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

1. Claim 13 58
2. Claims 14-21 82
3. Claim 33 89
4. Claims 34-37 91
B. Ground 2: Claim 21 is Obvious Over Yamaguchi, Kammer, Moore, and Davis 92
1. Claim 21 92
C. Ground 3: Claims 1-7, 9-21, 23-37 Are Obvious Over Yamaguchi, Kammer, and Kemp 96
1. Claim 1 96
2. Claims 2-7 110
3. Claim 9 116
4. Claims 10-12 120
5. Claim 13 120
6. Claims 14-21 123
7. Claim 23 125
8. Claims 24-27 128
9. Claim 28 129
10. Claims 29-32 131
11. Claim 33 132
12. Claims 34-37 134
D. Ground 4: Claim 8 is Obvious Over Yamaguchi, Kammer, Kemp, and Behlok 135
1. Claim 8 135
VIII. CONCLUSION 138

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

LIST OF APPENDICES

Appendix [Ref]	Description of the Appended Document
Appendix A	*Curriculum Vitae* of Majid Rabbani
Appendix B	Spencer, J., "History Of The Cell Phone (1973 to 2023)," Practically Networked, available at https://www.practicallynetworked.com/history-of-the-cell-phone/
Appendix C	"Motorola Has a Pocket-Size Cellular Phone," L.A. Times Archives, April 26, 1989, available at https://www.latimes.com/archives/la-xpm-1989-04-26-fi-1843-story.html
Appendix D	"1999: World First Camera Phone the Kyocera VP-210 was released," Physical, Electrical, Digital, available at https://kimon.hosting.nyu.edu/physical-electrical-digital/items/show/1518
Appendix E	Hildebrand, J. et al., "A history of all the major Bluetooth releases and updates," Android Central, November 21, 2019, available at https://www.androidcentral.com/history-major-bluetooth-releases-and-updates
Appendix F	"Ericsson T39 - Full phone specifications," GSMarena, available at https://www.gsmarena.com/ericsson_t39-252.php
Appendix G	"New Nokia style engine makes debut," Nokia Press Releases, March 21, 2001, available at https://web.archive.org/web/20020606093157/http://press.nokia.com/PR/200103/813134_5.html
Appendix H	"The story behind how Bluetooth® technology got its name," Bluetooth: Origin of the Bluetooth Name, available at https://www.bluetooth.com/about-us/bluetooth-origin/#:~:text=In%201996%2C%20three%20industry%20leaders,as%20a%20temporary%20code%20name
Appendix I	M. T. Camp, "Development of the Bluetooth version 1.0 specification," 2000 IEEE Emerging Technologies

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

	Symposium on Broadband, Wireless Internet Access. Digest of Papers (Cat. No.00EX414), Richardson, TX, USA, 2000, pp. 7 pp.-, doi: 10.1109/ETS.2000.916530
Appendix J	"What is Infrared Data Association (IrDA)?" March 25, 2018, available at https://www.electronicsforu.com/technology-trends/learn-electronics/infrared-data-association-irda
Appendix K	"Infrared Data Association," Wikipedia, available at https://en.wikipedia.org/wiki/Infrared_Data_Association
Appendix L	Millar, I. et al., "The IrDA Standards for High-Speed Infrared Communications," Hewlett-Packard Company, The Hewlett-Packard Journal, February 1998, available at https://www.hpl.hp.com/hpjournal/98feb/feb98a2.pdf
Appendix M	"A Brief History of the Internet," Online Library Learning Center, available at https://www.usg.edu/galileo/skills/unit07/internet07_02.phtml#:~:text=January%201%2C%201983%20is%20considered,Protocol%20(TCP%2FIP
Appendix N	"Internet Growth Statistics: Today's road to e-Commerce and Global Trade Internet Technology Reports," Miniwatts Marketing Group, updated January 21, 2023, available at https://www.internetworldstats.com/emarketing.htm
Appendix O	ISO/IEC 16485:2000 Information technology — Mixed Raster Content (MRC), available at https://www.iso.org/standard/32228.html
Appendix P	Bátiz-Lazo, B., "A Brief History of the ATM," The Atlantic, March 26, 2015, available at https://www.theatlantic.com/technology/archive/2015/03/a-brief-history-of-the-atm/388547/
Appendix Q	"X.509 certificate: What is It and How It Works?" eMudhra Blog, March 5, 2023, available at https://emudhra.com/blog/x509-certificate

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

EXHIBIT LIST

EX[No.]	Description of the Exhibit Document
EX1001	U.S. Patent No. 7,609,402 ("'402 Patent")
EX1002	Prosecution File History of the '402 Patent
EX1003	Declaration of Majid Rabbani
EX1004	U.S. Patent Publication No. 2002/0083121 A1 ("Chang-121")
EX1005	U.S. Patent No. 7,941,541 B2 ("Chang-541 Patent")
EX1006	U.S. Patent No. 7,355,732 B2 ("Yamaguchi")
EX1007	U.S. Patent No. 6,950,645 B1 ("Kammer")
EX1008	U.S. Patent No. 6,952,831 B1 ("Moore")
EX1009	U.S. Patent Publication No. 2002/0078160 A1 ("Kemp")
EX1010	Reserved
EX1011	U.S. Provisional Patent Application No. 60/262,764 ("'764 Provisional")
EX1012	U.S. Patent Application No. 10/053,651 ("'651 Application")
EX1013	Comparison of '651 Application and '764 Provisional
EX1014	Reserved
EX1015	U.S. Patent No. 6,469,805 B1 ("Behlok")
EX1016	PCT Publication No. WO 97/39553 ("Davis")

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

I. INTRODUCTION

1. I, Dr. Majid Rabbani, have been retained as an expert consultant by Perkins Coie LLP on behalf of Lexmark International, Inc. ("Petitioner") in this proceeding before the United States Patent and Trademark Office ("PTO") against Flexiworld Technologies, Inc. ("Patent Owner") regarding U.S. Patent No. 7,609,402 ("the '402 Patent") (Ex 1001). The Petition requests that the Patent Trial and Appeal Board ("PTAB" or "Board") review and cancel claims 1-21, 23-37 of the '402 Patent.

2. I have been asked to consider whether certain references teach or suggest the features recited in claims 1-21, 23-37 ("the challenged claims") of the '402 Patent. My opinions are set forth below.

3. I am being financially compensated for my time. I am not receiving any other form of compensation. I have no interest in the outcome ofthis proceeding, and my compensation is not dependent on the content of my opinions or the outcome of this proceeding.

4. I understand that the '402 Patent has been assigned to Flexiworld Technologies, Inc.

5. This declaration is based on the information currently available to me. To the extent that additional information becomes available, I reserve the right to continue my investigation and study, which may include a review of documents and

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

information that may be produced, as well as testimony from depositions that have not yet been taken.

II. QUALIFICATIONS AND EXPERIENCE

6. I am an independent consultant. All opinions stated in this Declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my knowledge and experience relating to the technology referenced in this Declaration.

7. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. A copy of my current *Curriculum Vitae*, which includes a more detailed summary of my education and professional and academic experience, is provided as **Appendix A** to this Declaration. The following provides an overview of some of my experience that is relevant to the matters set forth in this Declaration.

A. Qualifications

8. I possess the knowledge, expertise, skills, experience, training and education to form an expert opinion and expert testimony in this matter. I have 43 years of experience in the field of digital information, signal, image, and video processing and encoding and communications. I received my Ph.D. in Electrical Engineering from the University of Wisconsin-Madison in 1983, with a specialty in digital signal and image processing and communications. My thesis was entitled

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

"Restoration of Nonlinearly Distorted Images" and was concerned with deblurring digital images that were captured by partially or completely coherent light.

9. Since fall of 2016, I have been employed first as a visiting full professor of Electrical and Micro-Electronic Engineering at Rochester Institute of Technology (RIT), and currently as a Professor of Practice where I perform research, teach graduate courses in digital signal and image processing and compression and supervise and advise PhD student research in the area of information processing using deep learning. Graduate level courses that I have taught in the past 4 years include Digital Signal Processing, Digital Image Processing, Pattern Recognition, Digital Image and Video Compression, Information Theory, and Random Signals and Noise. In addition to my teaching responsibilities, I am currently the co-PI (principle investigator) on a $750,000 grant from the Army Research Labs to conduct research in the area of image and video processing with deep learning.

10. Prior to joining RIT, I was employed by the research labs of Eastman Kodak Company for 33 years, from 1983 (upon graduation with my Ph.D.), until April of 2016, when I retired from Kodak. Throughout my career at Kodak Research Laboratories I held positions as Research Scientist, Senior Research Scientist, Research Associate, Senior Research Associate, Department Head, and, finally, as a Kodak Fellow, the title with which I retired from Kodak. The title of Kodak Fellow

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

in the digital sector of Kodak has been held by only one other individual in the history of the Kodak Research Labs.

11. The focus of my work over my career has been digital information, signal, image and video processing, signal encoding and compression, and image and video analysis. During my years at Kodak, I have undertaken research and development related to imaging and printing technologies and have developed technologies implemented in printers and digital proofing systems. For example, I invented a method for encoding color image data of the type having multiple color planes for a printer that prints the color planes in a given sequence, which was patented as U.S. Patent No. 5,956,467, titled "Encoding Color Image Data for Multipass Color Printers."

12. Upon joining Kodak in 1983, I initiated research in analyzing the transfer of signal and noise in medical screen-film systems. The result of my research, which was published both internal and external to Kodak, received the Kodak C. E. K. Mees Award in 1988 among a pool of 150 submitted technical reports. The Mees Award was regarded as Kodak's highest honor in conducting and reporting research. I was awarded the Mees Award for a second time almost two decades later in 2005 for my research on digital watermarking of images and video.

13. In 1985, I formed a research group and initiated research in the area of image and video compression, which was a novel topic at Kodak. The result of my

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

research, which led to several patents and several internal and external publications, was implemented in the Kodak SV9600 Transceiver system in 1988. This product was used by CBS in 1989 to transmit still images from China during the unrest in Tiananmen Square. The Chinese government had shut down satellite links to stop the transmission of electronic images and the only means available to the journalists for transmitting electronic images was dial-up telephone lines. This product, which predated the JPEG standard, used a proprietary still image compression and encoding algorithm developed and patented by me and one of my colleagues. This algorithm was capable of compressing digital color images by an average factor of 20:1, which enabled the transmission of such images over dial-up telephone lines in less than one minute given the modem technology of that era and the typical size of a digital image. Because of the extraordinary engineering achievement of this product and its utility in communicating images, the National Academy of Television Arts and Sciences granted Kodak an Engineering Emmy Award in 1990 for outstanding achievement in the technical field of image compression. I received the award on behalf of Kodak during a ceremony in New York City.

14. In 1987, I started participating in the JPEG committee that was responsible for the development of the JPEG image compression standard as the Kodak representative. The JPEG Committee had just been formed in 1986, with the objective of developing methods for the lossy compression of continuous-tone

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

digital still images, particularly, images produced by digital photography. I remained a participant in JPEG for the next 25 years and until 2012, during which I assumed many leadership positions to advance the objectives of the committee. For example, in 1990, when the JPEG committee had reached an impasse due to technical differences between IBM and AT&T, and the approval of the standard had been seriously jeopardized, I was appointed by ISO (International Organization for Standardization) as the technical mediator between the two companies to resolve the selection of the arithmetic coder technology. As another example of my leadership role, I was the Chairman of the Coding Efficiency Group (50+ scientists) of the JPEG-2000 committee from 1997-2000. I was interviewed in 2003 by the El Pais Spanish newspaper regarding my leadership role in the JPEG2000 compression standard after delivering a seminar on JPEG2000 in Madrid ("Majid Rabbani: Es major desarrollar estandares abiertos que propietarious," Madrid, Spain, October 2, 2003).

15. In 1992, I started participating at the MPEG Committee as the Kodak representative, a role that I continued for the next 20 years until 2012. In recognition of my dedication and contributions to the JPEG and MPEG committees, I was awarded in 1997 an Engineering Emmy Award for the second time by the National Academy of Television Arts and Sciences for my co-editorship role in the JPEG and MPEG standardization committees.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

16. In 1991, I was the principal author of a book on the technical subject of image compression entitled "Digital Image Compression Techniques" that was published by the SPIE Press. This book achieved the highest sales record of any SPIE technical publication and sold more than 6,000 copies in a period of just a few years. In 1992, I edited another book entitled "Image Coding and Compression" as part of the SPIE Milestone Series. Additionally, I have authored several prominent book chapters on the topic of image and video compression and coding including ("JPEG2000 Core Coding system - Part 1" The JPEG2000 Suite, John Wiley and Sons, "JPEG Compression in Medical Imaging," in Handbook of Medical Imaging, SPIE Press, and "Digital Image Compression," in Digital Image Processing: Fundamentals and Applications, Marcel Dekker).

17. My group was responsible for the development of the compression algorithm and the hierarchical file format used in the Kodak Photo-CD product that was launched in 1992. Photo-CD used a high-quality proprietary compression algorithm for encoding a still image in multiple resolutions (referred to as the Image Pac), the lowest of which was intended for thumbnail representation of the image. I was interviewed by the Photo Electronic Imaging Magazine regarding the Photo-CD product ("A Lossless Explanation of Photo-CD," Vol. 37, No 2, 1994).

18. Because of my contributions to the science and technology of image and video compression, I was elected as a Fellow of SPIE (International Society for

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Optics and Photonics) in 1993. This rank is achieved by less than 7% of all SPIE's 19,000 worldwide members. In 1997, I was elected as a Fellow of IEEE (professional association of Institute of Electrical and Electronics Engineers) for the same technical recognition, a rank granted to less than 3% of IEEE's 420,000 members worldwide. Currently, I am a Life Fellow of both the SPIE and the IEEE technical societies. In 2008, I was awarded the high honor of IEEE Region 1 Technical Award for my pioneering work in image compression. In 2015, I was awarded the Electronic Imaging Scientist of the Year Award by IS&T (Society for Imaging Science and Technology) and SPIE for fundamental contributions to image compression. From 2013-2017, I served as the Chairman of the SPIE Fellows Committee. In 2018, I was awarded the SPIE Directors' Award, which is presented to an individual who, in the opinion of the SPIE Board of Directors, has rendered a significant service of outstanding benefit to the Society.

19. In 1992, I was asked by the Department of Justice to direct the efforts of Los Alamos scientists in the digital enhancement of George Holliday's video of the beating of Rodney King. I subsequently testified as the prosecution's expert witness in the Federal Court in Los Angeles. I was interviewed by the local CBS news in Rochester, NY and appeared in an article in the Rochester's local newspaper, Democrat and Chronicle, for my expert witness testimony. Because of my recognition in this event, I have been frequently hired by the law enforcement

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

community in both US and Canada to train their video analysts in the methods of image and video processing, coding and compression.

20. Throughout my career at Kodak, I was constantly involved in educating the technical community on the subject matters of digital image and video processing and compression. I have held positions as adjunct faculty at both the Rochester Institute of Technology (my current employer) and the University of Rochester. I provided training in digital imaging to Kodak senior VP's and other Kodak internal training programs and taught numerous courses at technical societies such as IEEE, SPIE, IS&T, SMPTE, SID and SIRA, and educational institutions such as VIGC in Europe, MIT, Berkeley, and Portland State University. My educational activities are expected to have trained over 5,000 scientists and engineers in the area of digital image and video processing and have been honored by various awards, the most recent of which is the "Electronic Imaging Distinguished Educator Award," awarded by IS&T and SPIE in January of 2012 for 25 years of educational service to the electronic imaging community.

21. I have taught a short course on the various areas of digital image and video processing and compression for 35 consecutive years (1988-2022) at the Electronic Imaging (EI) Symposium held in Northern California Bay Area and regarded as the premier venue for promoting the electronic imaging science and technology. I was asked by the USPTO to spend two weeks in summers of 2007

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

and 2008 as the Chief Technical Expert to assist in planning and execution of a comprehensive training and mentoring program of patent examiners in the field of digital image and video processing.

22. Because of my expertise in the field of image and video compression, I was elected by the Digital Cinema Initiatives (DCI) Consortium as the sole industry expert to the Digital Cinema Compression Experts Panel during 2003-2004, which evaluated the suitability of compression standards for the motion picture industry.

23. During my career at Kodak, I was responsible for the research and deployment of many technologies and products related to image and video coding and compression. Examples in addition to those cited above are the Kodak Hyper Compression product for storing a color facial image in the 57-byte record provided on the back of a standard credit card, space-qualified compression ASIC's used onboard the Space Imaging Ikonos satellite and Digital Globe QuickBird satellite, the Flashpix file format, various compression algorithms used in Kodak digital copiers, the first commercial Internet application of JPEG2000 by empowering the visualization of aerial imagery on Map Quest servers, and the proprietary compression technology used in the Kodak QT-100 and QT-150 first generation digital cameras that were marketed by Apple.

24. In 1996 I developed an encryption algorithm based on stream cipher technology for the secure transmission of digital visual content (such as high-quality

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

images) over the network of Kodak Kiosks. I presented the technical details of my encryption algorithm to the National Security Agency and obtained the agency's approval for international exportation.

25. In the time span of early 2000, my research team was also in charge of evaluating the various video compression and encoding technologies and codecs for adoption in the Kodak digital camera models. My team, under my supervision and guidance, designed and conducted rigorous tests to evaluate the impact of various encoder implementations of a wide range of video compression standards, such as Motion JPEG, MPEG2, and H.264, on the quality and bit rate of the compressed video data.

26. I am an inventor or co-inventor on 44 issued patents, almost all of which pertain to the field of signal, image and video processing. I was awarded the rank of Kodak Distinguished Inventor by my previous employer, Eastman Kodak Company, in recognition of the magnitude and impact of my inventions.

27. I was the General Chair of the Electronic Imaging Symposium in 2012 and a co-chair of that Symposium in 2011 and in 1996. The Electronic Imaging Symposium, which has been held once a year for the past 36 years, consists of 20-24 conferences covering a broad range of technical areas pertaining to the field of electronic imaging and is considered as the premier venue for reporting research and

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

technology in this field. Until 2015, this Symposium was co-sponsored by the SPIE and IS&T professional societies and it is currently sponsored by IS&T.

28. In June of 1995, I was asked by the National Research Council to organize and chair a 2-day technical event in Washington D.C., entitled "Maintaining and Certifying Image and Instrument Integrity." The Proceedings of this event, which was co-authored by me, was used by the Computer Science and Telecommunications Board (CSTB) to identify research topics and allocate government funding.

29. I have been a plenary or a keynote speaker on more than 50 different occasions throughout my career, all of which pertain to the field of signal, image and video processing.

30. I have been involved in professional service in numerous technical venues concerned with the promotion of digital image and video processing technology. For example, I was the Chair of the SPIE Commercial + Scientific Sensing and Imaging Symposium, Anaheim, CA, in April 2017, which hosted several thousand technical participants. A detailed list of my professional involvements appears in my attached Curriculum Vitae (**Appendix A**).

31. As an example, from 2014 to 2018 I was the Associate Editor for the technical area of image and video compression standards for IEEE Transaction on Circuits and Systems for Video technology (TCSVT). This transaction, which

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

covers the circuits and systems aspects of all video technologies, is a premier venue for publishing state-of-the-art research. Among areas covered are encoding and compression, transmission, communication and networking; and/or hardware and software design and implementation. As another example, for the past 25 years (since 1997) I have been an active member of the Program Committee of the IEEE Data Compression Conference (DCC), which is an international forum for current theoretical and experimental research on data compression and related applications.

B. Materials Reviewed

32. The opinions contained in this Declaration are based on the documents I have reviewed, my professional judgment, and my education, experience, and knowledge relating to digital information, signal, image, and video processing and encoding and communications, and related fields. In forming my opinions, I have reviewed all materials listed in the Exhibit List provided above (as well as any other materials and information I reference in this Declaration).

33. My opinions contained in this Declaration are based on the documents I have reviewed and considered, as well as my knowledge and professional judgment. My opinions have been guided by my appreciation of how a person of ordinary skill in the art ("POSITA") would have understood the state of the art, the prior art, and the claims and the specification of the '402 Patent at the time of the alleged invention.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

34. The time of the alleged invention of the '402 Patent encompasses the time frames near and including January 19, 2001. I understand the application for the '402 Patent claims priority to a provisional application filed on January 19, 2001. See '402 Patent cover page, (60). My opinions reflect how a POSITA (which I describe below) would have understood the '402 Patent, the prior art to the '402 Patent, and the state of the art at the time of the alleged invention.

35. Based on my experience and expertise, it is my opinion that the prior art teaches or suggests all the limitations recited in challenged claims 1-21, 23-37 of the '402 Patent, as I discuss in detail below.

III. UNDERSTANDING OF LEGAL PRINCIPLES AND PERSPECTIVES

36. I am not a lawyer and I will not provide legal opinions. Although I am not a lawyer, I have been advised that certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims.

37. I understand that a patent claim is invalid if it is anticipated or obvious in view of the prior art and that a claim can be unpatentable even if all requirements of the claim cannot be found in a single prior art reference. I further understand that invalidating a claim requires that the claim be anticipated or obvious from the perspective of a POSITA at the time the invention was made.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

38. In forming my analysis, opinions, and conclusions expressed in this Declaration, I have applied the legal principles set forth below, which were provided to me by counsel for Petitioner.

A. Types of Claims

39. I understand that there are two types of U.S. patent claims: 1) independent claims and 2) dependent claims. I understand that independent claims only include the aspects stated in the independent claim. I further understand that dependent claims include the aspects stated in that dependent claim, and any other aspects stated in any claim from which that dependent claim depends.

B. Anticipation and Obviousness

40. I understand that a claim is not patentable if it is anticipated or obvious. I understand that anticipation of a claim requires that every element of a claim is disclosed expressly or inherently in a single prior art reference.

41. I further understand that obviousness of a claim requires that the claim be obvious from the perspective of a person of ordinary skill in the relevant art at the time the invention was made. I understand that the earliest patent application claimed by Patent Owner leading to the '402 Patent was U.S. Provisional Patent Application No. 60/262,764 filed on January 19, 2001. I have therefore analyzed the unpatentability of the challenged claims as of that day. I may refer to the relevant time as the "2001 timeframe" in this Declaration, with the understanding that this

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

does not include the time period on or after the filing date of the first application (i.e., the provisional patent application filed January 19, 2001).

42. I understand that to prove that prior art or a combination of prior art renders a patent obvious, it is necessary to:

a) identify the particular references that, singly or in combination, make the patent obvious;

b) specifically identify which elements of the patent claim appear in each of the asserted references; and

c) explain why a POSITA would have combined the references, and how they would have done so, to create the inventions claimed in the patent.

43. I further understand that exemplary rationales that may support a conclusion of obviousness include:

a) combining prior art elements according to known methods to yield predictable results;

b) simple substitution of one known element for another to obtain predictable results;

c) use of known technique(s) to improve similar devices (methods or products) in the same way;

d) applying a known technique to a known device (method or product) ready for improvement to yield predictable results;

e) "obvious to try" - choosing from a finite number of identified, predictable solutions with a reasonable expectation of success;

f) known work in one field of endeavor may prompt variations of the work for use in either the same field or a different field based on design incentives or other market forces if the variations are predictable to a POSITA; and

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

g) some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

44. In analyzing obviousness, I understand that it is important to understand the scope of the claims, the level of skill in the relevant art, the scope and content of the prior art, the differences between the prior art and the claims, and any "secondary considerations" (described below). I also understand that if a technique has been used to improve one device, and a POSITA would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. Although I understand that it is not required, there may also be a specific "teaching, suggestion or motivation" to combine any first prior art reference with a second prior art reference. Such a "teaching, suggestion, or motivation" to combine the first prior art reference with the second prior art reference can be explicit or implicit and may provide further evidence of obviousness.

45. I understand that secondary (or objective) considerations are relevant to the determination of whether a claim is obvious. Such secondary (or objective) considerations can include evidence of commercial success caused by an invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention, or evidence that an invention achieved a surprising or unexpected result. I understand that such evidence must have a nexus, or causal

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

relationship to the elements of a claim, to be relevant to the obviousness or non-obviousness of the claim. I am not currently aware of any such evidence for the claims of the '402 Patent and reserve my right to review and respond to such evidence if presented.

C. Claim Construction

46. I understand that, for purposes of my analysis, the terms appearing in the patent claims should be interpreted according to their "ordinary and customary meaning" at the time the alleged invention was made. In determining the ordinary and customary meaning, the words of a claim are first given their plain meaning that those words would have had to a POSITA. I understand that the structure of the claims, the specification, and the file history also may be used to in the construction of a claim term. Additionally, treatises and dictionaries may be used, in limited circumstances, to determine the meaning attributed by a POSITA to a claim term at the time of filing.

47. For all claim terms considered in this Declaration, I have applied the ordinary and customary meaning of those terms as they would have been understood by a POSITA at the time the alleged invention was made. To the extent the Patent Owner proposes any constructions or the Board construes any claims, I reserve the right to address such proposals or constructions. Regardless, under any reasonable

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

construction of the claims, the prior art discloses, teaches and/or suggests all the limitations recited in the challenged claims 1-21, 23-37 of the '402 Patent.

D. Person of Ordinary Skill in the Art

48. I understand that my assessment and determination of invalidity must be undertaken from the perspective of what would have been known or understood by a POSITA at the time of the earliest patent application supporting the '402 Patent.

49. I have been informed and understand that the POSITA is not a real person, but rather a legal construct—a hypothetical person. This hypothetical person is presumed to have known the relevant art at the time of the invention. I have been informed by counsel that relevant factors in determining the level of ordinary skill include (1) the educational level of the inventor, (2) the type of problems encountered in the art, (3) prior art solutions to those problems, (4) the rapidity with which innovations are made, (5) sophistication of the technology, and (6) the educational level of active workers in the field. I further understand that the person of "ordinary skill" is not a person of extraordinary skill in the art. In other words, this person of ordinary skill is not necessarily an expert in the field.

50. As discussed above, I understand that when interpreting the claims of the '402 Patent, I should do so based on the perspective of a POSITA as of the relevant priority date.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

51. On its face, the ’402 Patent claims priority to U.S. Provisional Application No. 60/262,764 filed on January 19, 2001. This date is in dispute, as I discuss later in my declaration. See Section VI.C of this Declaration. Nevertheless, I understand that all of the asserted prior art is prior art to the ’402 Patent, because the prior art priority dates precede the January 19, 2001 date.

52. For purposes of this proceeding, a POSITA as of January 2001 would have had a bachelor’s degree in computer science, computer engineering, or electrical engineering, or a similar field and two years of practical work experience with printer technologies. The POSITA would be familiar with well-known networking and wireless communication technologies. I believe that additional graduate education could substitute for work experience, just as significant work experience could substitute for formal education. My opinion about the level of ordinary skill would not change if the claims were only entitled to the January 18, 2002 actual filing date of the ’402 Patent.

53. At the time of the alleged invention, I was a person of at least ordinary skill in the art, and I have applied the perspective of the POSITA in forming and expressing my opinions below.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

IV. STATE OF THE ART / OVERVIEW OF THE TECHNOLOGY

54. In the late 1990s technological advancements in hardware and solid state memory had made portable personal computing devices such as laptops, personal digital assistants (PDAs) and cell phones ubiquitous. Although cell phones had been around for a long time, the following milestones are noteworthy.[1] The year 1989 marked the start of the flip phone era with the Motorola MicroTac;[2] 1992 marked the first mass produced GSM (2G) phone by Nokia and the year of the first text message.



Motorola MicroTAC Flip Phone - Circa 1989

55. 1994 marked the arrival of the first smartphone (as it was the first gadget to include apps and a touchscreen) called the IBM Simon; 1997 marked the first phone

[1] https://www.practicallynetworked.com/history-of-the-cell-phone/
[2] https://www.latimes.com/archives/la-xpm-1989-04-26-fi-1843-story.html

with no external antenna, and in1998 the 3G network was launched which accelerated ubiquitous wireless connectivity and the use of cellular technology. *Id*.

56. In 1999 Kyocera, a Japanese electronics company, released its VP-210 VisualPhone, which arguably was the first mobile phone sold with a front-facing camera to send two photos per second and a storage capacity of 20 JPEG photographs.[3] The same year, in 1999, Nokia introduced its Nokia 7110 phone, the first cell phone with a wireless application protocol (WAP) browser that allowed users to browse the internet.



VP-210 VisualPhone - Circa 1999

[3] https://kimon.hosting.nyu.edu/physical-electrical-digital/items/show/1518

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Bluetooth and Infrared Connections:

57. In 2000, Ericsson unveiled the first mobile phone with Bluetooth connectivity (Ericsson T39), which became available for purchase in 2001,[4] the same year Nokia released its mobile phone with infrared communications capability (Nokia 8310).[5]

58. It goes without saying that commercial release of these products was the result of years of research and development, as well as standardization of wireless and imaging technologies that preceded the commercial launch of those products. For example, Bluetooth technology was originally conceived in 1994 by using short-range radio waves between 2.4 and 2.485 GHz, and was temporarily named "Bluetooth" in 1996 (a name that has persisted ever since) in a meeting between the then-industry leaders, Intel, Nokia and Ericsson.[6] The first Bluetooth Specification (version 1.0) was published in 1999 with the goal of providing short range and direct communications between devices.[7]

---

[4] https://www.androidcentral.com/history-major-bluetooth-releases-and-updates ; *see also* https://www.gsmarena.com/ericsson_t39-252.php

[5] https://web.archive.org/web/20020606093157/http://press.nokia.com/PR/200103/813134_5.html

[6] https://www.bluetooth.com/about-us/bluetooth-origin/#:~:text=In%201996%2C%20three%20industry%20leaders,as%20a%20temporary%20code%20name .

[7] M. T. Camp, "Development of the Bluetooth version 1.0 specification," 2000 IEEE Emerging Technologies Symposium on Broadband, Wireless Internet

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

59. Similarly, infrared (IR) signals for short range connectivity between PDAs, laptops and other electronic devices were another topic of interest from the early 1990s—many years prior to the launch of Nokia 8310 mobile phone in 2001. In particular, the Infrared Data Association (IrDA) was founded in 1994 by a group of about 50 companies and provided specifications for wireless infrared communications protocols.[8] The IrDA protocol provides a short range (maximum of 2 meters), high speed (from 2.4 kb/s to 4 Mb/s), line-of-sight, very low error rate, and secure means of wireless communications. A comprehensive review of the IrDA standard as of 1998 can be found in the publication entitled "The IrDA standards for high-speed Infrared Communication."[9]

60. Using Bluetooth and infrared protocols to establish wireless connectivity between a mobile device and a printer was a natural use-case for the Bluetooth and IrDA that allowed printing documents and images directly from the mobile device.

61. For example, Kodak's Patent No. 7,024,051 to Miller *et al*. (2000) described using IrDA and Bluetooth to transfer images from a camera to a computer

---

Access. Digest of Papers (Cat. No.00EX414), Richardson, TX, USA, 2000, pp. 7 pp.-, doi: 10.1109/ETS.2000.916530.

[8] https://www.electronicsforu.com/technology-trends/learn-electronics/infrared-data-association-irda ; *see also* https://en.wikipedia.org/wiki/Infrared_Data_Association .

[9] https://www.hpl.hp.com/hpjournal/98feb/feb98a2.pdf

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

(4:59-5:7), and Kodak's Patent Nos. 6,940,541 to Jeffrey Small (1997), and 7,212,229 to Parulski *et al*. (2001) described using IrDA and Bluetooth connections to print an image directly from a camera to a printer, an excerpt from the latter (7:18-22, 27-30) is reproduced below:

> To print images without using a host computer, an interface cable 342 can be used to connect between printer interface 24 in digital camera 10 and the corresponding camera interface in digital printer 30. … Alternatively, the ***interface may utilize a wireless interface such as the well-known IrDA (Infrared Data Association) interface or an RF (radio frequency) interface such as the well-known Bluetooth RF interface***.

62. As another example, Figure 1 (below) of U.S. Patent No. 6,285,889 to Nykänen *et al*. (1997) showed infrared transceivers (11, 34) in a mobile device (10) and a printer (30) that allowed mobile device (10) to directly use the printer (9:67-10:3).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

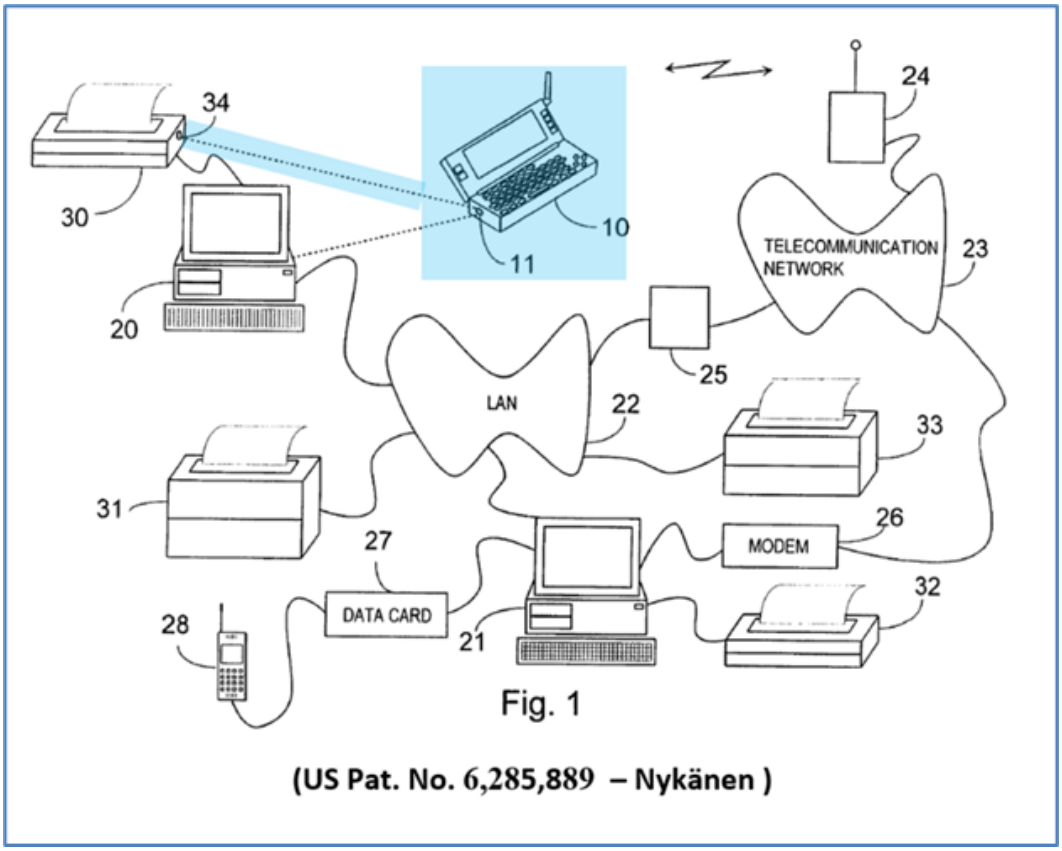


Fig. 1

(US Pat. No. 6,285,889 – Nykänen)

63. Yamaguchi's U.S. Patent No. 7,355,732 (used in the Petition) is yet another example of how a phone could directly communicate with a printer via Bluetooth (3:65-4:9), as shown in its Figure 1 (below).

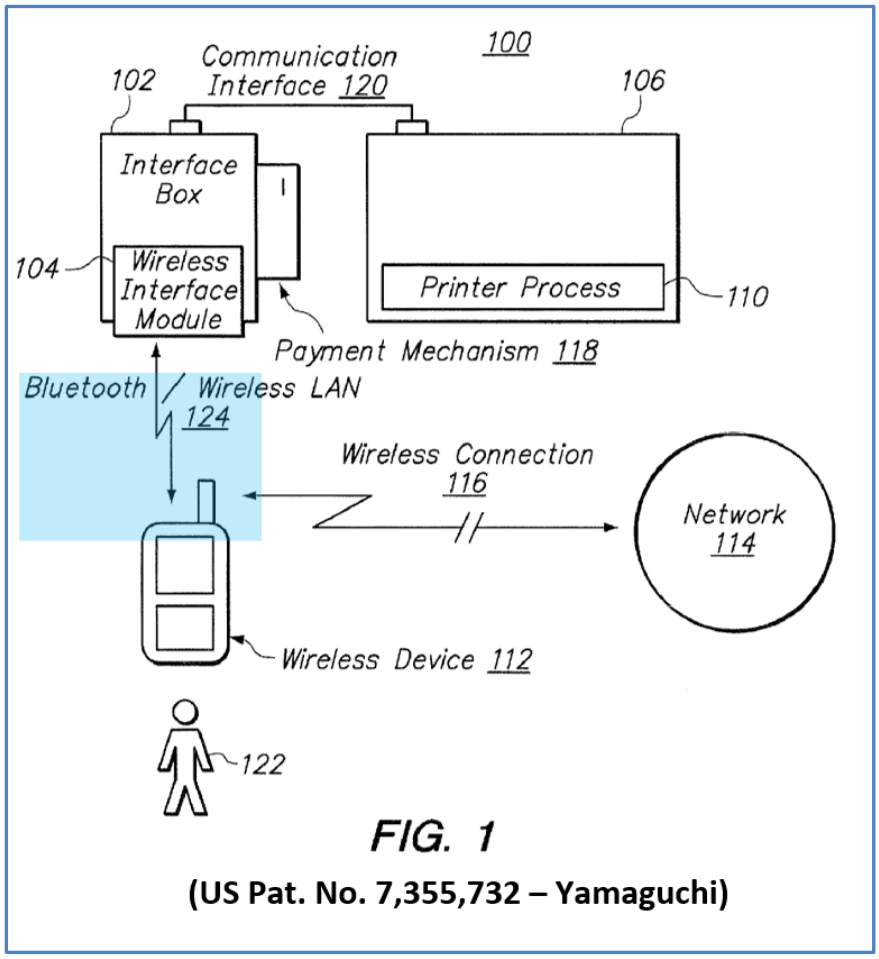


FIG. 1

(US Pat. No. 7,355,732 – Yamaguchi)

64. These and many other publications and patents illustrate that direct communications from a mobile device to a printer was well understood by around 2000 or 2001, and person of ordinary skill in the art at that time frame would have been familiar with Bluetooth and IrDA standard protocols, including how to connect the two and the type of information that were exchanged between the devices to establish a connection.

Other Enabling Technologies

65. Alongside the above advancements, the use of the Internet had reached a critical mass prior to year 2000. The official birth of the internet is marked as 1983,

which led to new communications protocols to be established. In particular, Transmission Control Protocol/Internet Protocol (TCP/IP) allowed different kinds of computers on different networks to "talk" to each other.[10] By December of 2000, the number of worldwide Internet users had reached 361 million.[11]

66. The explosive growth of internet was partly fueled by advancements in storage, compression, transmission, data security, as well as computational capabilities of electronic devices, which had reached a certain level of maturity to allow proliferation of Internet-based applications. Some of these technologies are briefly described below.

67. **Compression and Coding**: Efficient compression of digital multimedia content (binary images, photographic grayscale or color images, video and associated audio) to facilitate its efficient transmission or storage has historically been the most critical factor in enabling various applications that involve the storage and transmission of such content. By the year 2000, the technology for the compression of all types of digital media was at a very mature stage and a suite of compression algorithms had been developed by international organizations such as ISO and ITU to compress text, audio, images, and video content.

---

[10] https://www.usg.edu/galileo/skills/unit07/internet07_02.phtml#:~:text=January%201%2C%201983%20is%20considered,Protocol%20(TCP%2FIP
[11] https://www.internetworldstats.com/emarketing.htm

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

68. A prominent example of an international image compression standard is JPEG ("Joint Photographic Experts Group"), which was developed under the joint auspices of the three major international standards organizations, ISO, ITU, and IEC, and was approved in September 1992 as ITU-T Recommendation T.81. It was intended as a standard for the encoding of continuous tone grayscale and color images. By the year 2000 owing to the economies of scale, inexpensive hardware and software implementations of JPEG were prevalent and the JPEG standard was almost exclusively used to encode still images in any aspect of digital image acquisition which employed compression.

69. Another example is the CCITT Group 4 compression that is a lossless method for compression of binary (black and white) images intended for facsimile transmission. Another related example is the ISO standard called Mixed Raster Content (MRC) coding (ISO/IEC 16485:2000),[12] which defines algorithms to efficiently represent raster-oriented pages that contain a mixture of multi-level and bi-level images. These are examples of compression technologies for storage and transmission of data that were well known and mature by the year 2000.

70. **Encryption and Authentication**: Encryption protects the stored digital data (e.g., on nodes of a network or various digital devices such as computers and

[12] https://www.iso.org/standard/32228.html

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

cellphones), for providing secure transmission, and for providing user authentication and access control. Authentication refers to verifying credentials of a person (or a device) before allowing the use of digital resources or communication links by that person or device.

71. The '402 Patent, and its claims 13 and 21-22, describe verifying a user's identity against an authorized list of users as a form of authentication or access control. This is one of earliest forms of access control that involves entry of, for example, a Personal Identification Number (PIN), or an alpha-numeric passcode, for authenticating a user accessing a system. This technique originated with the introduction of Automatic Teller Machines (ATMs) in the 1960s.[13]

72. Over the years, many proprietary variations of this technique have been suggested for specific applications. For example, Patent No. 5,280,527 to Gullman *et al*. (1992) described a security apparatus receives a biometric input from a user, which then is compared to a template to determine whether the person entering the sample is a person whose templates are stored (5:55-65). Gullman's technique includes additional nuances in using a correlation factor, a fixed code and either a time-varying code or a challenge code that are combined to generate a token that is used to provide access (6:8-45). But, at its core, Gullman illustrates that comparing

[13] https://www.theatlantic.com/technology/archive/2015/03/a-brief-history-of-the-atm/388547/

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

a user's identity to a list, template, or some other parameter was well known for many years prior to 2000.

73. In 1988, to improve and standardize identity-based authentication, the ITU issued the X.509 international standard, which acted like a "digital identity card" to enable secure communication and transaction between two parties. The use of X.509 certificates ensures that the communication is encrypted and authenticated, thereby providing a high level of security for online transactions.[14]

74. Other protocols that provided standardized connectivity and authentications were IPSec developed by IETF (1995), and Wireless Transport Layer Security (WTLS) Specification (1997), developed by the Wireless Application Forum (WAP). The WTLS release in February 2000 provided data integrity, privacy, authentication, and denial of service protection among other features. The Nokia 7110 mobile phone, unveiled in February of 1999, is primarily recognized as being the first WAP phone.

75. One example of using a PIN-code in the context of printing documents (and WAP) was described in U.S. Patent 7,028,102 to Larsson *et al*. (2000), where a user typed a PIN-code into the telephone and the telephone passed the PIN-code and a SIM-code of the phone to an information service provider as an authentication

[14] https://emudhra.com/blog/x509-certificate

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

message; and once the information service provider had accepted the user, it sent an initial WAP-page to the telephone (12:12-26).

76. By the year 2000, security, authentication and access control protocols had reached a very mature state and were being employed routinely as part of either international standards or industry standards to provide privacy, security and authentication for the storage and transmission of digital data over various networks and communication channels.

77. **Printing Workflow**: Printing usually contains two basic sets of operations. One is the generation of a Page Description Language (PDL) file where the content to be printed is converted to a format that defines the page elements independently of the printer technology so that a page's appearance would stay consistent regardless of the specific printer used. Another element is the Raster Image Processing (RIP) set of operations that convert a PDL file to a printer-specific bitmap image ready to be printed.

78. Most printers treat printed pages as a rectangular array of pixels (e.g., a bitmap image) with a certain width and height and bit depth, which could be very large depending on the device type. However, this may not be a convenient representation for storing, editing, and transferring such files over the distributed network. PDLs describe the appearance of a page at a higher level than an array of pixels and serve as a link between computer applications, such as graphics tools and

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

text editors, and output devices, such as printers and displays. PDLs are text (human-readable) or binary data streams, usually intermixed with text or graphics to be printed.

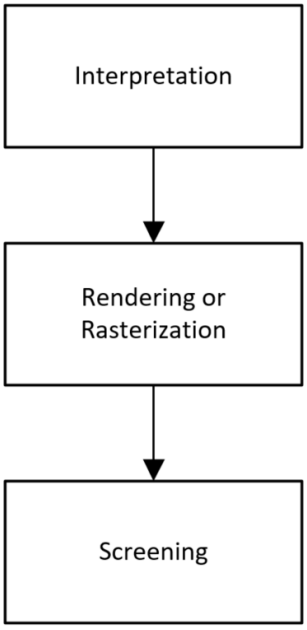
79. Some PDLs were invented by printer manufacturing companies. For example, PCL (HP printer language) was invented by Hewlett-Packard and AFP (IBM and Ricoh printers' language) was devised by IBM. Others were developed by software companies, such as Adobe's PostScript (PS) and PDF (Portable Document Format) languages. Every company that invented its own PDL also developed a corresponding device specific interpreter, often referred to as a "driver," which translates high-level PDL to an array of pixels to be transferred to the native low-level software of a specific printer.

80. A RIP operation manages the translation of a high-level PDL such as Adobe PostScript, PDF, or HP PCL to printer language, e.g., a bitmap image with the proper spatial resolution, bit depth and color, ready to be printed by a specific printer. In simple terms, it translates graphics files to an image that a printer can understand and print. The RIP set of operations can be performed either in hardware or in software, but they are typically performed in software.

81. The RIP set of operations vary depending on the specific printer but generally include the following. (i) Interpretation: During this stage, the PDL file is decoded into a printer specific internal database of graphical elements that must be

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

placed on the output. (ii) Rendering or "rasterization": During this stage, the image is converted into a rectangular array of dots (pixels) that has a printer specific supported spatial resolution, and color and tonal information are assigned to each dot. In many practical applications, rendering is performed simultaneously with the interpretation stage. (iii) Screening: At this stage, the image is converted into a halftone pattern that can be printed using limited ink colors. For example, since the ink of an inkjet printer cannot be diluted during printing to create a lighter shade, halftones are used to control grayscale and color by printing various sizes of tiny dots, spaced closely together to create the appearance of continuous tones. An example of a popular half-toning algorithm is error diffusion. Finally, the RIP software sends the processed image to the printer for printing.



Typical Printing Process Flow

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

82. The RIP stage can also have in its input images in their native formats such as JPEG or TIFF and it might also include other operations such as encryption/decryption, compression/decompression, encoding/decoding, scaling, segmentation, color space conversion and correction, and contrast and brightness adjustment. In general, the RIP operations are computation intensive.

83. Figure 6 of the Parulski patent (US 7,212,229) mentioned earlier—the same patent that described IR/Bluetooth connection between a camera and a printer—also described a typical set of image processing operations to prepare an image for sending to an inkjet printer, as illustrated in Figure 6 of the Parulski patent below (3:37-43, 7:31-10:2). These operations were well understood at the time the '402 Patent was filed, and, as explained below, they could be done by different components of a printing system.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

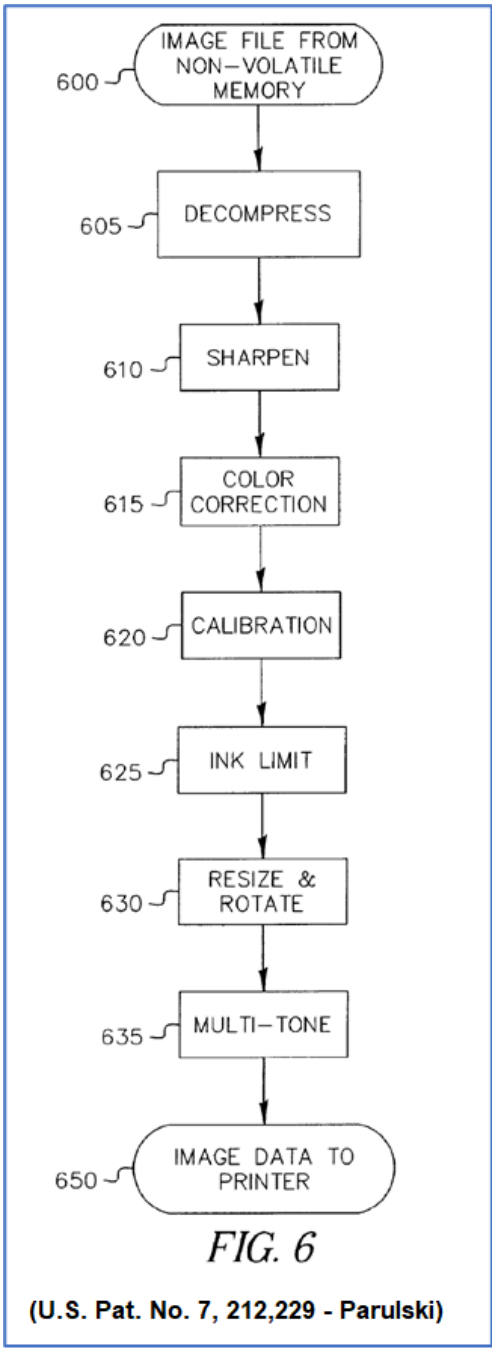


FIG. 6

(U.S. Pat. No. 7, 212,229 - Parulski)

84. **Division of Labor and Universal Printing**: Well before the year 2000, the printing technology was quite mature, and different printing technologies, such as electrophotographic, dye sublimation, inkjet, and others were part of the printer landscape. With the proliferation of networks and associated technologies, many

remote printing options, both wired and wireless, became available. And, as a natural consequence, different options were available for how to divide the print processing operations between the computer (or mobile device), the printer, or some other processing node that could perform the processing operations. Some factors besides the computational complexity of the RIP operations that could impact the distribution of the tasks included the communications range, data transfer rate, error rates, and bandwidth costs of the various connections in the printing network.

85. Another consideration in remote printing related to knowing which printer, or printer type, was available, and processing the digital information and delivering it to the printer in a format that the printer understood. This was typically done by using a device driver specific to a printer, which allowed ripping the data in a format acceptable to that printer. So, it was also important to have ready access to the proper print driver and/or to be able to obtain the print driver or its functionality.

86. Prior to 2000, both of the above issues had been addressed, some examples of which are described below.

87. For example, U.S. Patent Publication 2002/0078160 to Kemp *et al*. (2000) described a remote printing environment (see Figure 3), where a rendering engine (14) performed certain rendering operations in the host computer (10) to produce a "generic" rendering of the data. This data was sent to print server (20), which performed additional processing operations at the print site (2) so the data

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

could be printed at a particular printer (21 to 26). I will provide more detailed explanations of the relevance of this publication to the claims of the '402 Patent later.

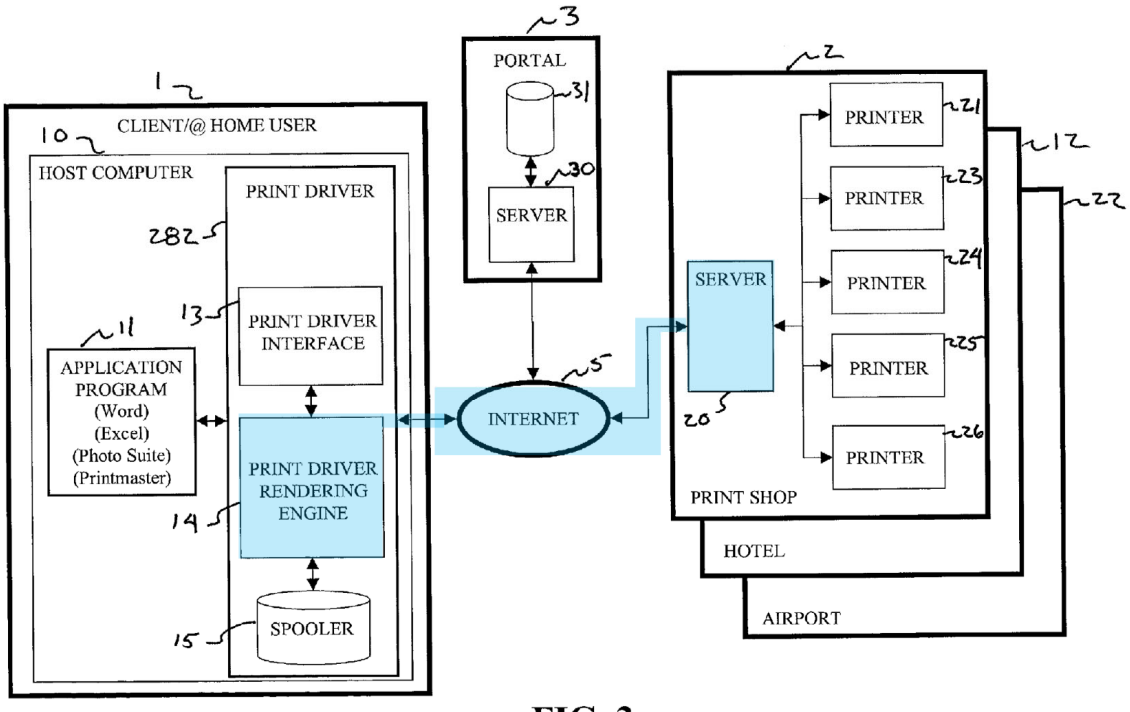


FIG. 3
(U.S. 2002/0078160A1 to Kemp)

88. As another example, Nykänen's Patent mentioned earlier, described a system (see Nykänen's Figure 1 below), where data to be printed was converted at mobile device (10) into a data transfer format that was independent of the application, and was wirelessly sent to another terminal (20), which converted the data into a form suitable for an output device (30) that could be a printer or a monitor (Abstract, 8:20-35).

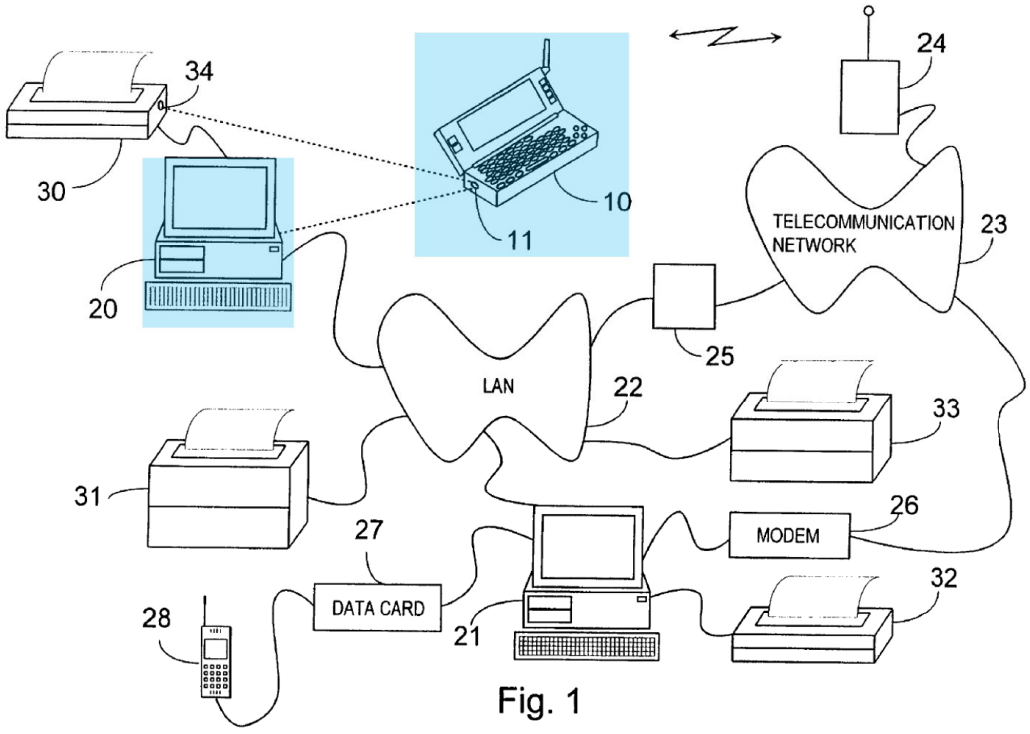


Fig. 1

(US Pat. No. 6,285,889 – Nykänen)

89. Given the prevailing distributed network paradigms that were known by the year 2000, the need to distribute the computational load of the printing process among the various nodes of the network based on their capabilities would have been known to a POSITA.

V. DISCUSSION OF KEY PRIOR ART

A. Yamaguchi

90. Yamaguchi invented a wireless printing method from a laptop or hand-held device to a printer for users to remotely print "hard copies of electronic documents," as described in the U.S. Patent titled "Printing Mechanism for Wireless

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Devices. EX1006, Abstract, 1:56-2:3, 1:27-35, 3:19-22. Yamaguchi disclosed a printer "interface box" (**blue**) connected to the printing apparatus (**red**) that wirelessly communicates with the user's "wireless device" (**green**) to receive the electronic document over a wireless connection (using Bluetooth) and cause the printer to generate the hard copy of the document. EX1006, FIG. 1 (*annotated below*), 3:55-4:10.

Yamaguchi FIG. 1

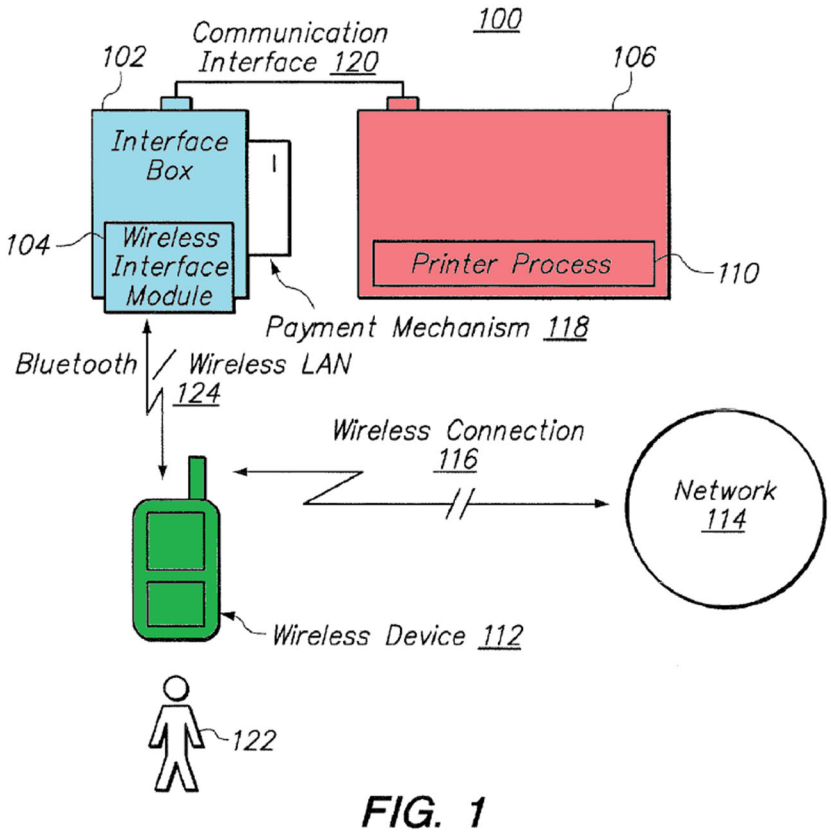


FIG. 1

91. Yamaguchi described processing the electronic document print requests at the wireless device and printer, which included conforming the electronic

document into "a print ready file [as] a file that is in a format that can be read and processed by a printing device." EX1006, 7:5-19, FIG. 3A. Yamaguchi taught that the wireless device could include a printer driver configured to receive print requests from an application software like "Microsoft Word®, Lotus Notes, Adobe Acrobat, etc." and generate a "print ready file" for wireless delivery to the printer via the interface box. The print ready file could be in a device-neutral format, like a PostScript file, or a device-dependent format, like "Printer Control Language ("PCL") defined by Hewlett-Packard Company." EX1006, 7:22-33.

92. To conduct the wireless printing method, Yamaguchi taught a device authentication scheme using a secure ID number communicated between the wireless device and interface box of the printer to authenticate the user for establishing the wireless connection between the devices. EX1006, 7:5-49, FIG. 5. Yamaguchi's authentication technique compared the secure ID number to a control value generated at the interface box and, upon a successful comparison (equal values), the user was authorized for printing the hard copy of the electronic document. EX1006, 7:45-49.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Yamaguchi FIG. 5

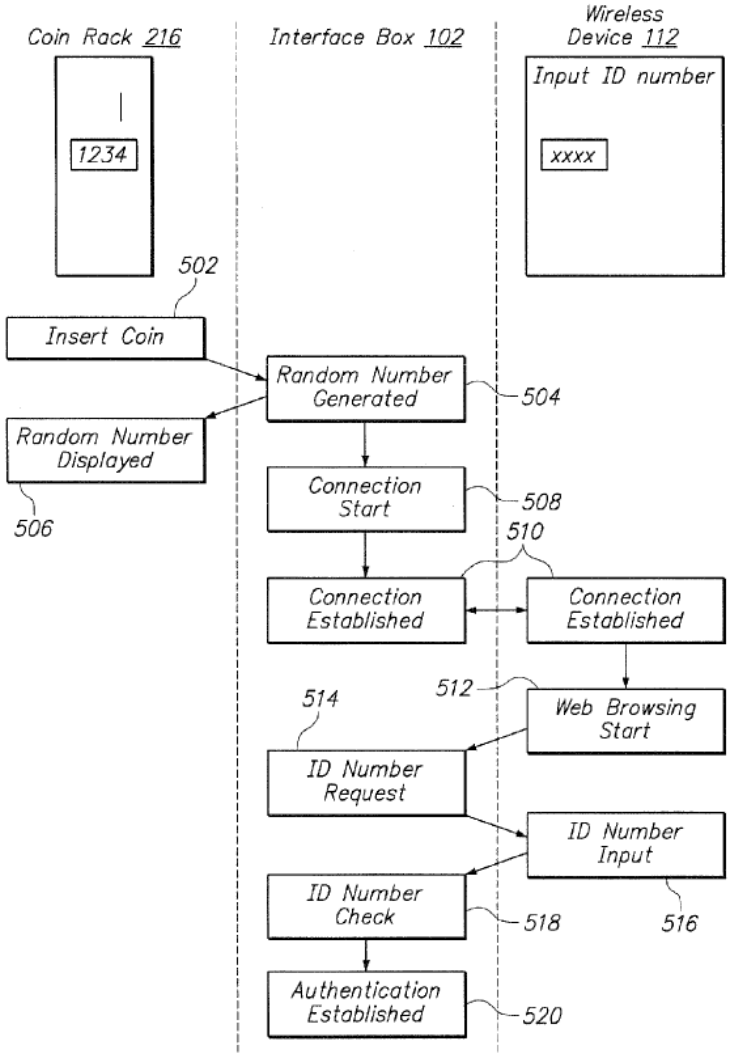


FIG. 5

93. Also, Yamaguchi described a technique for the user to provide a monetary payment prior to the hard copy document being printed. EX1006, Abstract, 2:67-3:2, 4:10-29. Yamaguchi's payment system was configured to accept a variety of different types of payment and payment information, including physical currency (cash, coins) and non-physical currency (credit card, ATM, Cyber-Cash). EX1006, 4:14-23.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

94. I understand that Yamaguchi is prior art with respect to the '402 Patent because Yamaguchi was filed before the earliest claimed priority date of the '402 Patent.

B. Kammer

95. Kammer disclosed a method for managing a wireless device (having a transceiver for wireless communication) when operating in discovery mode in a wireless network of devices, such as a Bluetooth network. EX1007, Abstract, 1:7-11. Kammer discussed, in detail, conventional Bluetooth protocol for a Bluetooth-enabled device to discover and connect with another Bluetooth-enabled device (EX1007, 1:15-2:58) that was used at the time of Yamaguchi and the '402 Patent, as well as a power optimization approach for the discovery process (EX1007, 4:15-22).

96. I understand that Kammer is prior art with respect to the '402 Patent because Kammer was filed before the earliest claimed priority date of the '402 Patent.

C. Moore

97. Moore disclosed a "driverless printing" method that created a peripheral driver that is universal to any peripheral device (such as a printer) by learning the peripheral options and the commands for those options from the peripheral itself. EX1008, Abstract. Moore's method used a GPD file resident on the printer to convey information about the printer (e.g., type, name, supported functions) to a universal printer driver ("unidriver") resident on a computer to

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

implement the common printer driver functions to the particular printer." EX1008, 1:5-7, 2:59-3:14, 6:3-12.

98. Moore's configuration of a unidriver-GPD file sought to "to simplify the process for users" beyond what conventional "pre-installed printer drivers" (EX1008, 1:56-61), or a system of "smaller drivers, called minidrivers, [and] one unidriver" (EX1008, 2:5-16), or even the existing "unidriver-GPD system" at the time of Moore's patent (EX1008, 2:25-36), were able to achieve. Moore's approach was to facilitate communication between the printer and user device to obtain "information such as the type and name of the [printer] device, together with functions the [printer] device supports, attributes of those functions, and the commands necessary to use those functions" (EX1008, 2:64-67); and thus Moore's approach was able to create a scheme for customizing printer drivers so that the user would not be required to know which GPD file was appropriate for the printer the user sought to attach to the user's device (EX1008, 2:37-40). *See* also 6:3-18, Figure 3 (reproduced below).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Moore Figure 3

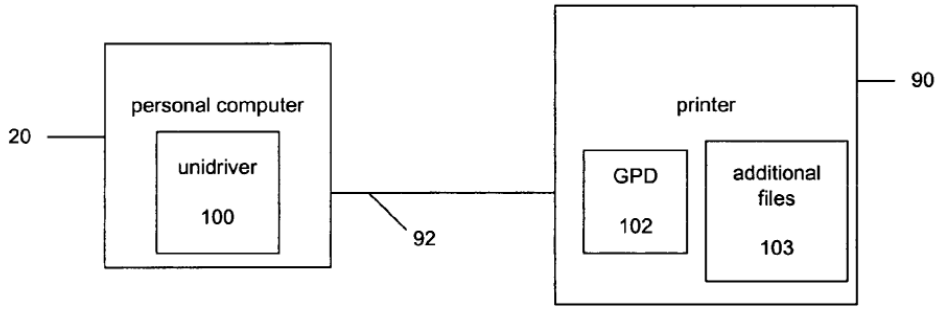


Figure 3

99. I understand that Moore is prior art with respect to the '402 Patent because Moore was filed before the earliest claimed priority date of the '402 Patent.

D. Davis

100. Davis disclosed a wireless authentication method for controlling an operating state of a computer using a challenge/response protocol for a user possessing an authentication token within proximity of the computer. EX1016, Abstract. The computer generates/transmits a challenge message to the user's token (device), which generates/transmits a response message to the computer for authenticating the user. EX1016, 4:1-12. Davis disclosed using the wireless authentication method with another authentication system, such as a password-based system. EX1016, 7:27-30, 11:8-20.

101. I understand that Davis is prior art with respect to the '402 Patent because Davis's publication date is more than one year older than the '402 Patent's earliest claimed priority date.

E. Kemp

102. Kemp disclosed a printing method over a network, such as the Internet, using a print driver "generic to all printer types" to print from a user device remotely to a printer. EX1009, Abstract, ¶[0012]. Kemp's print driver renders print data "into a generic printer definition language not related to any specific printer type" to be packaged with protocol for transmission over the network. EX1009, ¶¶[0013]-[0015].

103. Kemp's printing method presented an option for a user to select a service provider where the user wished to print content, and upon such selection, Kemp's print driver was "activated to render the print job into a neutral printer definition language (NPDL) and spool the print job data." EX1009, ¶[0068], step S111 of FIG. 5 (reproduced below). The spooled NPDL print data was then packed for transport to the service provider server (EX1009, ¶[0068], [0083], step S116 of FIG. 5), which converted the print data rendered in NPDL into the appropriate printer definition language of the printer for rendering. EX1009, ¶[0087], steps S125, S126 of FIG. 10 (reproduced below).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Kemp FIG. 5

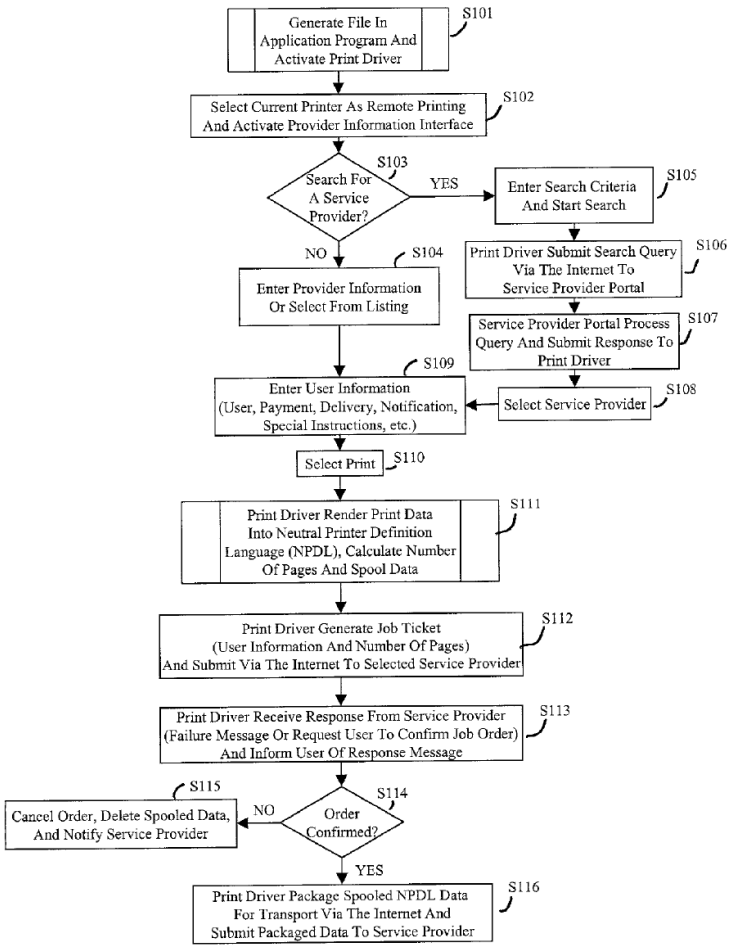


FIG. 5

Kemp FIG. 10

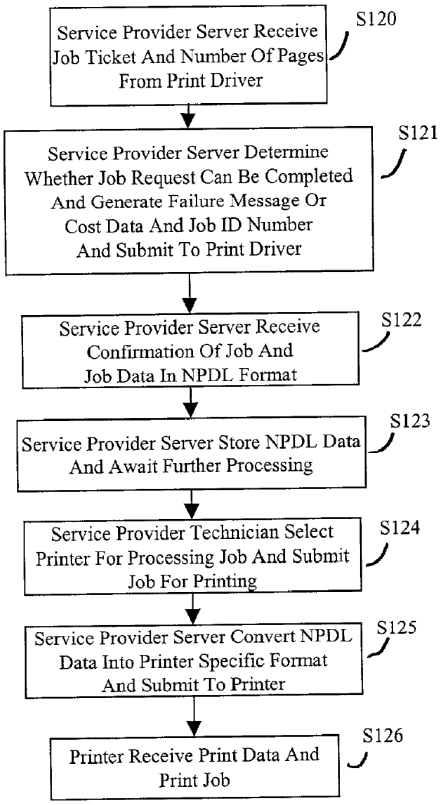


FIG. 10

104. I understand that Kemp is prior art with respect to the '402 Patent because Kemp was filed before the earliest claimed priority date of the '402 Patent.

F. Behlok

105. Behlok disclosed a digital color image printing apparatus and method to adjust image characteristics of a printed image such as lightness/darkness, midtone contrast, highlight emphasis, shadow emphasis, and color cast. EX1015, Abstract.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

106. I understand that Behlok is prior art with respect to the '402 Patent because Behlok was filed before the earliest claimed priority date of the '402 Patent.

VI. THE '402 PATENT

A. Overview of the '402 Patent

107. The '402 Patent (EX1001) is based on Application No. 10/053,651 filed on January 18, 2002 with two listed inventors, William Ho Chang and Christina Ying Liu. The '402 Patent's Abstract explains that the patent is directed to:

> A data output method for rendering at an output device content accessible with an information apparatus, includes obtaining at the information apparatus one or more rasterization parameters corresponding to the output device and conforming at the information apparatus at least part of the data content into one or more output images with said one or more rasterization parameters. An intermediate output data is transmitted from the information apparatus to an output controller that is distinct from the information apparatus and associated with the selected output device, the intermediate output data including one or more output image. The intermediate output data is converted at the output controller into an output data acceptable for rendering at the output device.

108. I have read the '402 Patent in its entirety, including the specification and the claims. From my reading, I believe the challenged claims are directed to variations of previously-known schemes for (1) generating "intermediate" print data

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

at a user's device (which the '402 Patent refers to as the "information apparatus") to be further processed at an "output device," such as a printer, (2) establishing wireless communications (using well known technologies like Bluetooth) between the information apparatus and output device for data transmission, and/or (3) performing authentication of the information apparatus. *See* the '402 Patent at the Abstract and Claims 1, 9, 13, as well as 7:15-17. All of these techniques described and claimed in the '402 Patent were known prior to its priority date, as discussed in detail in the Invalidity Grounds sections below.

109. Per my review, I understand that the written description of the '402 Patent describes the term "*intermediate output data*"—which appears in only some of the claims—as "***the output data of the present invention***," further noting that "it includes the broader definition of an output file or data generated by an information apparatus, or a client application or device driver included in the information apparatus[,]" and offering an incredibly broad array of examples thereof. *See* EX1001, 10:66-11:11. FIGS. 12A-12B exemplify the processing steps performed on the information apparatus to produce the intermediate data subsequently sent to the output device (printer) (EX1001, 31:52-37:17); and FIGS. 13A-13B exemplify the processing steps after the intermediate data is transmitted, notably, processing and conversion into a form suitable for sending to a printer engine (EX1001, 37:18-41:32).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

'402 Patent, FIGS. 12A-12B

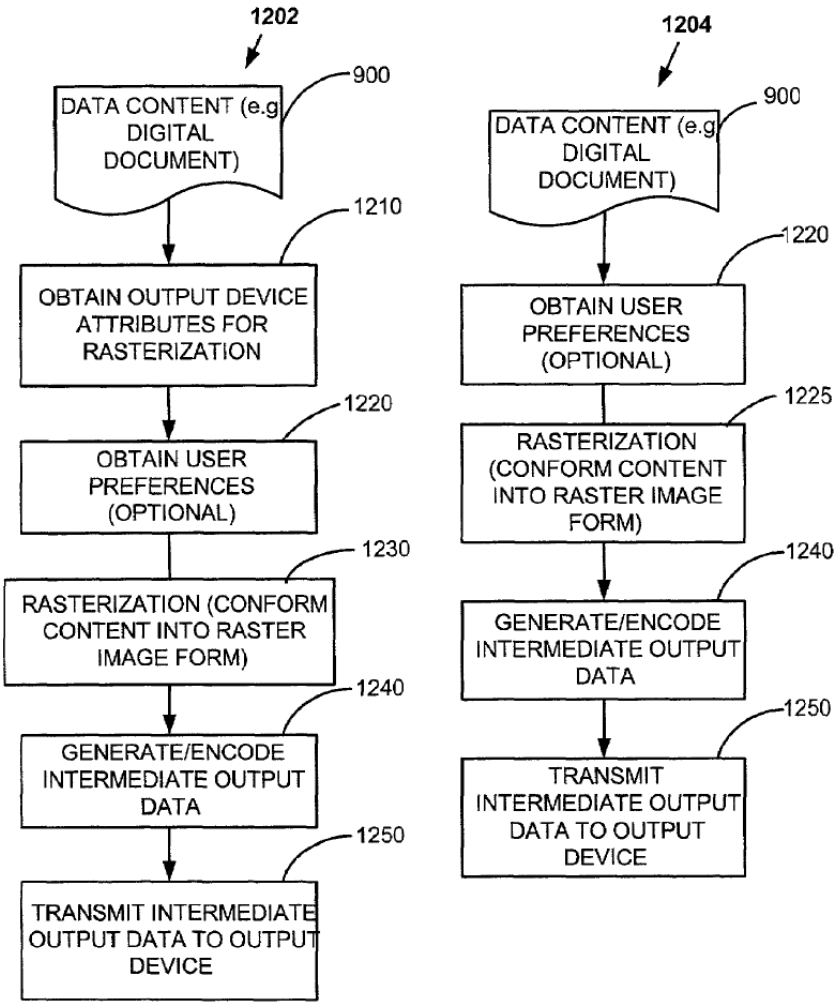


FIG 12 A FIG 12 B

'402 Patent, FIGS. 13A-13B

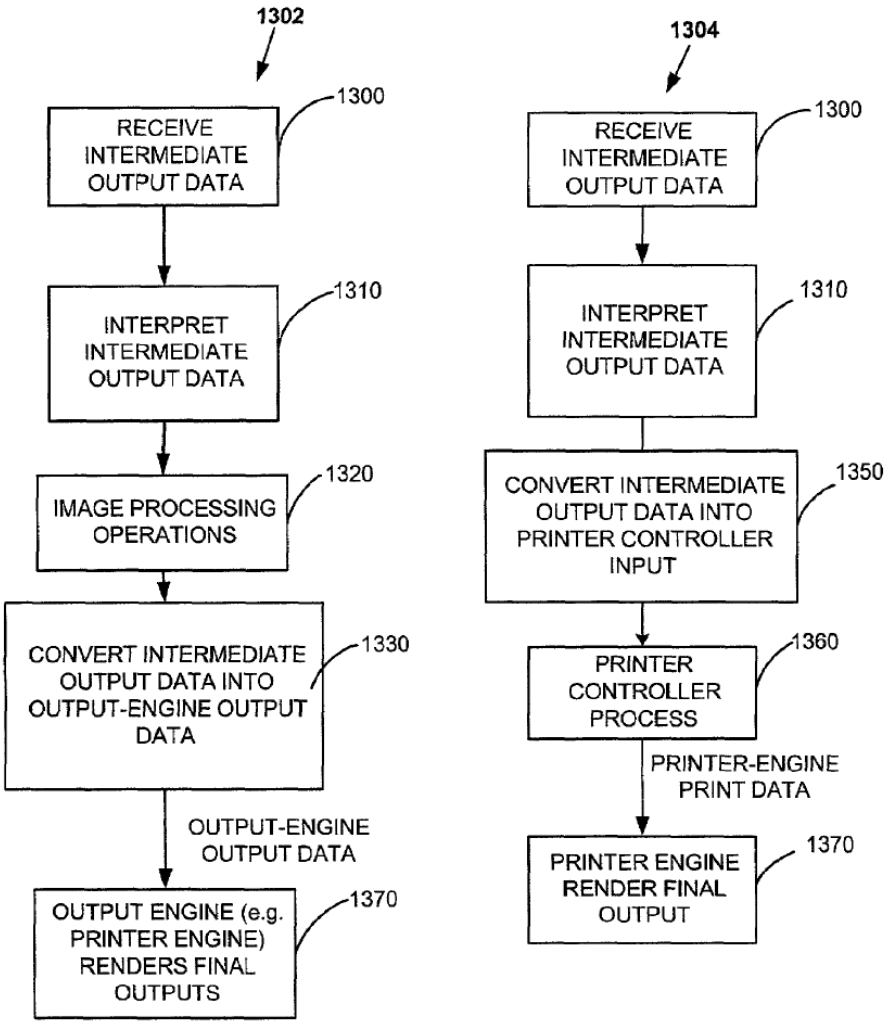


FIG 13 A FIG 13 B

110. Overall, the '402 Patent is simply directed to a method to "provide[] a more balanced distribution of the raster image processing computational load between the information apparatus and the output device" (EX1001, 6:40-42, 5:29-32) that also attempts to "eliminate[] the need to install a plurality of device-dependent dedicated drivers or applications in the information apparatus in order to output to a plurality of output devices." EX1001, 5:32-35.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

111. As demonstrated in the Invalidity Grounds sections below, all of these ideas were already described in the prior art.

B. Prosecution History

112. I have reviewed the prosecution history of the ’402 Patent.

113. I understand that the file history does not include any remarkable events other than addition of new claims, some relatively minor claim amendments, and submission of prior art references to the Patent Office.

114. I understand that the patent examiner issued a notice of allowance and in its “Reasons For Allowance” it stated that the prior art Yoshida (U.S. Patent No. 7,366,468) did not teach some of the limitations in the independent claims of the ’402 Patent.

115. The ’402 Patent issued on October 27, 2009.

C. Priority Date of the ’402 Patent Claims

116. I have been informed that a U.S. patent application may claim the benefit of the filing date of an earlier patent application if the earlier patent application disclosed each limitation of the invention claimed in the later-filed U.S. patent application. I have also been informed that priority is determined on a claim-by-claim basis so that certain claims of a patent may be entitled to the priority date of an earlier-filed patent application even if other claims of the same patent are not entitled to that priority date.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

117. I have also been informed that a patented claim is invalid if the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention, or the claimed invention was described in an issued patent or a published patent application that was effectively filed before the effective filing date of the claimed invention.

118. I have reviewed the claims of the ’402 Patent and the disclosure of its earliest claimed priority document: U.S. Provisional Application No. 60/262,764 (“’764 Provisional”), filed January 19, 2001. From my review, I have determined that the ’764 Provisional fails to provide sufficient explanation about many of the terms and steps that are in the claims of the ’402 Patent. Therefore, my conclusion is that the ’402 Patent claims are not entitled to the filing date of the ’764 Provisional.

119. The reasons I have formed this opinion are based on the following facts.

120. U.S. Patent Application No. 10/053,651 (“’651 Application,” EX1012) was filed on January 18, 2002, which ultimately issued as the ’402 Patent. The ’651 Application included fourteen new figures (FIGS. 1A-1B, 2B, 3A-3B, 4A-4B, 5A-5B, 6A-6C, 7A, 7B, 7F) and included extensive new additions and descriptions of previously undescribed concepts and terminology that were not part of the ’764 Provisional. EX1013 shows the differences between the text of the two documents.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The new description describes features and concepts that are recited in, if not central to, the'402 Patent claims that were not supported by the '764 Provisional.

121. I understand that when a patent or patent application includes a claim reciting a new concept not adequately disclosed in the priority application—in this case, the '764 Provisional—the priority date of that claim with the new concept corresponds to the filing date when that new concept was introduced. In this case, the table below shows which new concepts and new terminology were introduced in certain claims of the '402 Patent.

'402 Patent Claims	**Lack of '112 Support Explanation**
Claims 13, 33 and all their dependents claims	Claims 13 and 33 both introduce the term "***security key***," and claim 13 also recites a "***security code***." Both claims include an authentication procedure that involves transmitting and receiving the security key or the security code in elements 13[e]-[h] and 33[e]-[h]. In my opinion, the '764 Provisional does not discuss a security key or a security code, and does not explain the authentication procedure of claims 13 and 33. There is some discussion of an authentication procedure in the provisional application about the information apparatus gaining access after confirming with the control list - and some even more generalized description that the system can deploy an authentication scheme. See Ex1011, 9:24, 19:17-21, which is repeated

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

	again at 20:33-21:2, and 36:33-37:2. But there are no details about how this authentication takes place and/or the security key or security code, or the specific authentication steps that are in claims 13 and 33. And because I understand that dependent Claims 14-22 and 34-37 include the same limitations of their base claims, these claims are thus not entitled to the early priority date for the above reasons.
Claims 9, 13, 28, 33, and all their dependents; Dependent claims 3, 25	Independent Claims 9, 13, 28, 33 recite an "***output device profile.***" Dependent claims 3 and 25 recite a "***device profile***." I have compared the section of the '402 Patent (EX1001, 9:7-10:36) that provides a listing of different parameters and attributes that can make up an output device profile with a similar section in the '764 Provisional. EX1011, 9:7-10:6. This comparison shows that the '402 Patent has expanded the definition of an "output device profile, which includes three additional components: • "***communication protocols***," • "***rendering intents***" and • "***Another profile which contain parameters and information about the output device and its service (e.g. color profiles, halftoning profiles, communication profiles, rasterization profiles, quality of service etc.)***,"

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

	In my opinion additional items expand the meaning of an output device profile, and were not explained in the '764 Provisional. For example, a POSITA reading the provisional application would not have known that the device profile could include "communications protocols," which is something newly introduced in the '651 Application.
Claims 1-37	All independent claims recite "***conforming***" operations (1) at the information device (e.g., Element 1[f], 9[e], 13[j]), and (2) at the output device (Element 1[k]). The '764 Provisional does not include the word "conforming" or any of its variations, but the '651 Application uses this term, and as noted above, for different operations at the information apparatus (user device), or at the output device. The '764 Provisional describes performing a ***rasterization*** operation at the information apparatus to produce "intermediate print data." EX1011, 10:8-11:24, 25:5-28. The '651 Application appears to expand the operations that occur at the information device beyond rasterization, and called "***conforming***." For example, claim 5 states that the new "***conforming***" operation "includes one or more of a rasterization operation, a scaling operation, an interpolation operation, ***a decoding operation, an***

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

	encoding operation, a filtering operation and a ***compression operation***." The '764 Provisional does not explain ***a filtering operation***, neither as part of rasterization, or otherwise. In addition, scaling and interpolation are described in the '764 Application as part of rasterization operations, so a POSITA would have understood that they are separate from rasterization as they appear in the claim 5. EX1011, 25:7-13. Plus, ***encoding, decoding and compression*** are only described as part of "creating metafile" in the provisional (*id*., 25:31-26:8), which again reinforces my opinion that a POSITA would not have been able to understand what the "conforming" operation meant just by reading the '764 Provisional.
Claims 2, 10, 19, 24, 29, 37	I determined that providing a ***password or security code, address, signatures, a physical or digital security key, biometrics, a fingerprints, and a voice***, as part of authentication (or otherwise), is neither recited nor explained in the '764 Provisional.
Claims 3, 11, 25, 30	I determined that receiving a ***security code*** as an attribute at the information apparatus is not recited or explained in the '764 Provisional. *See* explanation for Claim 13.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Claims 5, 26	I determined that a ***filtering operation*** as part of the "***conforming***" step (or otherwise) is not recited or explained in the '764 Provisional.

VII. INVALIDITY GROUNDS OF THE CHALLENGED CLAIMS

122. As discussed in detail below, the alleged invention of the '402 Patent was disclosed in the prior art before the '402 Patent's alleged January 2001 priority date.

A. Ground 1: Claims 13-21, 33-37 Are Obvious Over Yamaguchi, Kammer, and Moore

1. Claim 13

13[pre]: A method of mobile wireless data output from an information apparatus with access to at least part of a content to a wireless output device by short range wireless communication, wherein the information apparatus includes at least one wireless communication unit and is a distinct device from the output device, the method comprising:

123. Yamaguchi taught a method of mobile wireless data output for printing, at a printing device ("output device"); electronic document information ("content") wirelessly was sent from a wireless device ("information apparatus") to a wireless/printer interface component "locally connected [to the] printing device" of the wireless device. EX1006, 1:6-9, 1:63-2:3, 2:55-67. Yamaguchi disclosed the "printing device … generate[d] a hard copy document based on the electronic

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

document information" wirelessly communicated from the wireless device to the wireless/printer interface component. EX1006, 2:56-67.

124. Referring to Yamaguchi's FIG. 1 (annotated below), Yamaguchi's wireless device 112 corresponds to the claimed "information apparatus," which is distinct from the printing device 106 and its "locally connected" interface box 102 that together form the "wireless output device." This configuration is analogous to how the '402 Patent depicts the location of the "output controller" in FIGS. 7A, 7D and 7F, as well as 7B and 7E, where the output controller is placed external to the printer, or is a separate component at the printer. *See*, EX1001, FIG. 7A-F. In Yamaguchi, the interface box was attached to the printer via a standard connection, such as "a USB, parallel or serial port connection (EX1006, 3:40-46), which together formed the "wireless output device."

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Yamaguchi FIG. 1 (annotated)

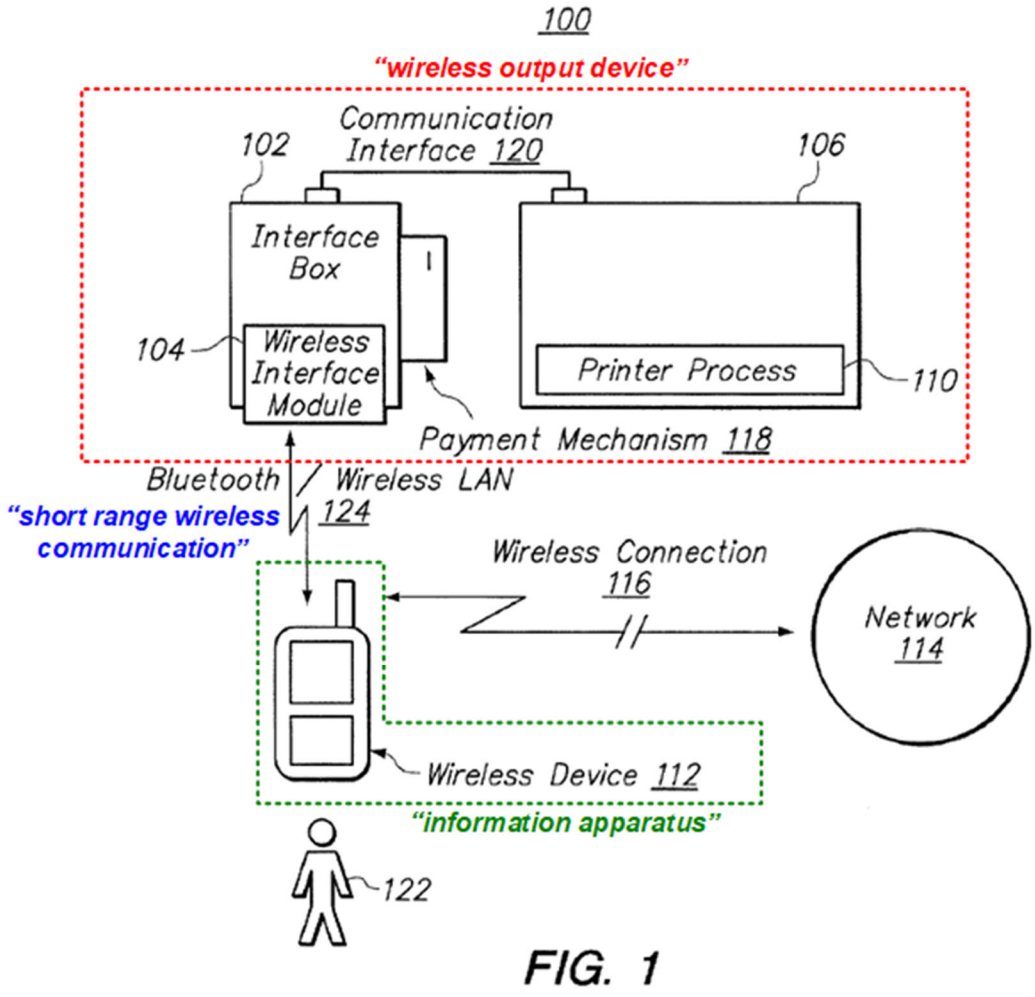


FIG. 1

125. Yamaguchi further taught wireless connection 124 was a short range wireless communication: "wireless interface module 104 is configured to use a set of one or more communication frequencies that require ***the wireless device 112 to be within a relatively short distance from interface box 102*** … configured to use the ***Bluetooth***, 802.11 or other similar protocols that operate over frequencies … ***typically used for communicating over a short distance***." EX1006, 3:65-4:6.

Yamaguchi's wireless device could be "a lap-top, cellular phone, Palm Pilot, or other wireless device." EX1006, 3:19-20, 3:62-65.

126. Thus, in my opinion, it would have been both inherent and obvious that such wireless devices disclosed in Yamaguchi had a wireless communication unit to communicate through wireless connection 124. This is because a wireless receiver and/or transmitter unit was a required component in a wireless communication device in order to conduct wireless communications.

13[a]: opening a wireless communication channel;

127. Yamaguchi taught opening a wireless communication channel in FIG. 5's method "to establish a wireless connection between the interface box 102 and a wireless device 112." EX1006, FIG. 5, 7:5-10. One way Yamaguchi established the wireless connection is through Bluetooth communication (EX1006, 4:3-6), which Kammer described with more detail. For instance, Kammer disclosed broadcasting "a general inquiry message" from a Bluetooth-enabled device (over nominal range (e.g., 10 meters)) for discovering another Bluetooth device. EX1007, 1:61-67.

128. While Kammer is used to illustrate the knowledge of a POSITA about the then-standardized Bluetooth communications, it would have also been obvious to a POSITA to combine Yamaguchi with Kammer because Kammer provided additional details about opening a wireless communication channel with another

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Bluetooth device, which were not explicit in Yamaguchi. This is because Yamaguchi described that the wireless device 112 could communicate via the Bluetooth protocol, while Kammer explicitly outlined some of the basic steps in the Bluetooth discovery protocol. Communicating via the Bluetooth protocol as recommended by Yamaguchi would have been within the knowledge of the POSITA, and by reading Kammer, that knowledge of the Bluetooth discovery process would have been reinforced.

13[b]: discovering wirelessly one or more wireless devices that are available for wireless connection;

129. Kammer taught discovering available wireless devices in a Bluetooth environment. EX1007, Title, 1:42-60. Specifically, Kammer disclosed "Bluetooth technology allows Bluetooth devices to "discover" other Bluetooth devices that are within range and then connect with those devices," including for devices having a Bluetooth transceiver (like Kammer's transceiver 308) "integrated into [a] Bluetooth-enabled device." EX1007, 1:42-60, 7:39-41. *See also* EX1007, FIG. 1, 1:61-2:11 (initiator device 20 discovering another Bluetooth device, responder device 30).

130. A POSITA would have recognized implementing Kammer's standard Bluetooth discovery protocol can be part of Yamaguchi's procedure establishing a

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

wireless connection between the interface box 102 and the wireless device 112 using Bluetooth for the same reasons as in 13[b]. EX1006, 7:5-10, 3:19-22, 4:3-6.

13[c]: receiving over the wireless communication channel an attribute corresponding to each discovered wireless device, the attribute including one or more of a name, a device type, a device address, and an indication of a supported output device profile;

131. As part of Bluetooth wireless device discovery, Kammer disclosed "[t]he device discovery process has two primary steps: an inquiry step … and a name discovery[,]" where the wireless devices "exchange attributes (e.g., [device] addresses)" in the inquiry step and exchange "user-friendly names" in the name discovery step. EX1007, 1:42-60; FIG. 1 (reproduced below).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Kammer Figure 1

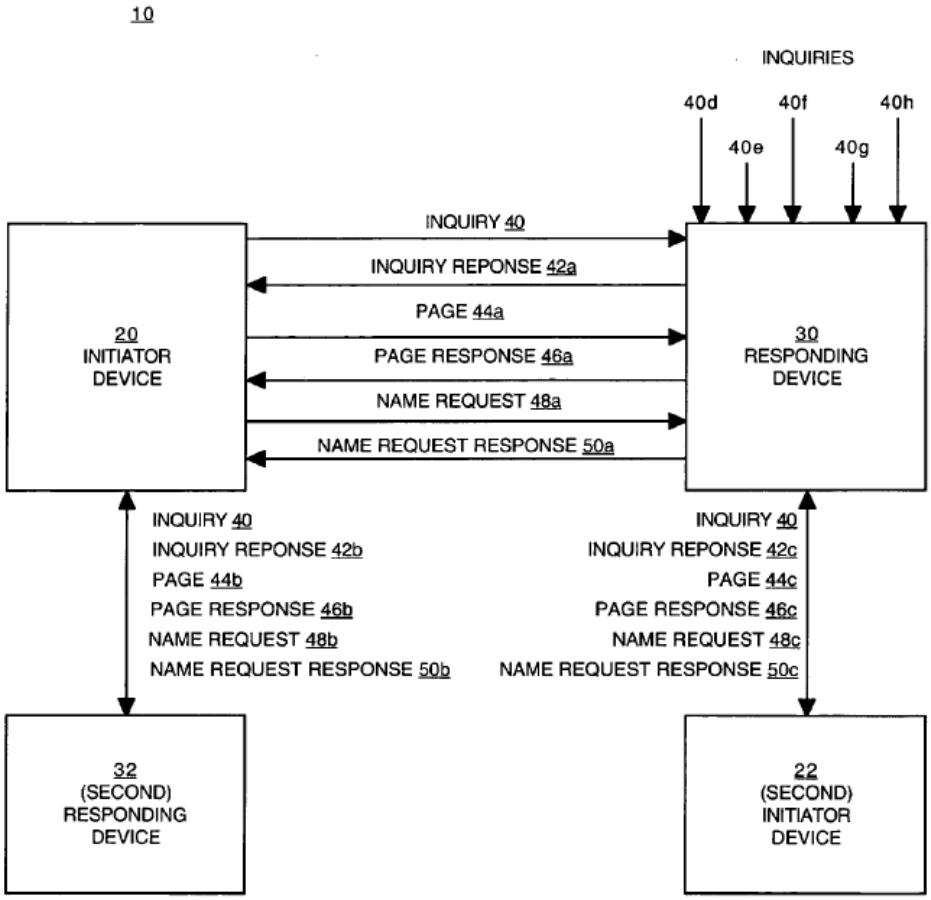


Figure 1
(Prior Art)

132. Particularly, inquiry responses to initiator device 20 "provide[d] the Bluetooth ***device addresses (a numerical address or a device access code***) for responder devices 30 and 32" during the inquiry step (EX1007, 1:61-2:3, 2:11-18, 2:23-26). Additionally, during the name discovery stage, the responder devices 30 and 32 "provide[d] the ***user-friendly name***" (EX1007, 2:32-58), which "c[ould] be used to identify each printer's location and features, allowing the user to make a selection of one over the other." EX1007, 3:29-34. Hence, Kammer taught

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

receiving attributes (device address, user-friendly name) of each discovered device (printer) over the wireless Bluetooth communication channel in the Yamaguchi-Kammer combination. EX1006, 7:5-10, 3:19-22, 4:3-6. This combination, which entailed using the standardized Bluetooth discovery procedure, was obvious for the same reasons as in 13[b] and 13[c].

133. While not needed to establish obviousness of Element 13[c], Moore, which described wireless printing techniques, also taught receiving printer attributes during establishing communications between a printer and a computer, where the computer requested and received a "Generic Printer Description (GPD) … file …contain[ing] information such as the ***type and name of the device***" to convey capabilities of the printer. EX1008, 2:59-3:4. Moore provided an illustrative example depicting a printer device profile that included parameters such as "Print Quality: 600 dpi [resolution]." EX1008, FIG. 4 (below).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Moore Figure 4

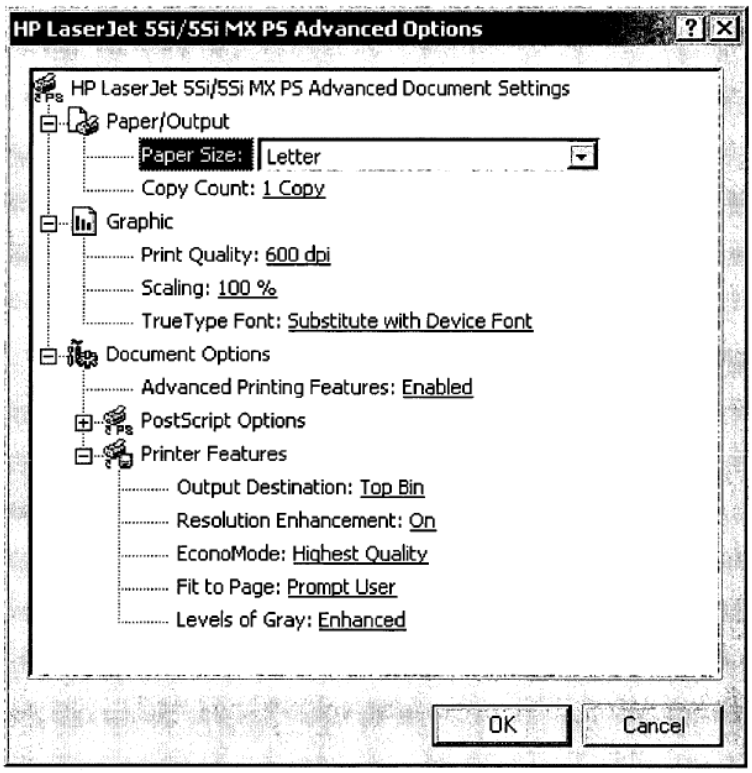


Figure 4

13[d]: selecting a wireless output device from among the one or more discovered wireless devices based at least in part on the received attribute;

134. Kammer taught that the user of the wireless output device could "***select*** the appropriate device with which to connect" based on the received "user-friendly name for each of the devices that responded" to the initiator device in the name discovery step. EX1007, 2:34-38. *See also* EX1007, FIG. 1, 2:39-58, describing the name discovery step. As Kammer discussed, multiple discoverable wireless devices could respond to the initiator wireless device's broadcast inquiry. EX1007, FIG. 1, 1:61-2:11. In the Yamaguchi-Kammer combination, a user of Yamaguchi's wireless

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

device wanting to print a document (EX1006, 2:55-66, 3:55-4:6) would have selected the desired printer based on the received attribute, such as the user-friendly name, as described in Kammer. This combination, which entailed using the standardized Bluetooth discovery procedure to allow selection of another Bluetooth-enabled device, was obvious for the same reasons as in 13[b], [c] and [d].

13[e]: obtaining a security key at the information apparatus, the security key enabling wireless data transfer to the selected output device;

135. Yamaguchi disclosed obtaining a security key at the wireless device ("information apparatus") to enable wireless data transfer to the selected printer ("wireless output device") as part of the security steps that establish authentication of the user. Yamaguchi's authentication procedure included the following operations:

- Interface box 102 generated a random number (box 504) that was used to authenticate the user for establishing the wireless connection;
- The random number was displayed to the user (box 506);
- The user entered the random number, as ID number, on the wireless device 112 (box 516).

EX1006, FIG. 5, 7:16-41.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Yamaguchi FIG. 5 (annotated)

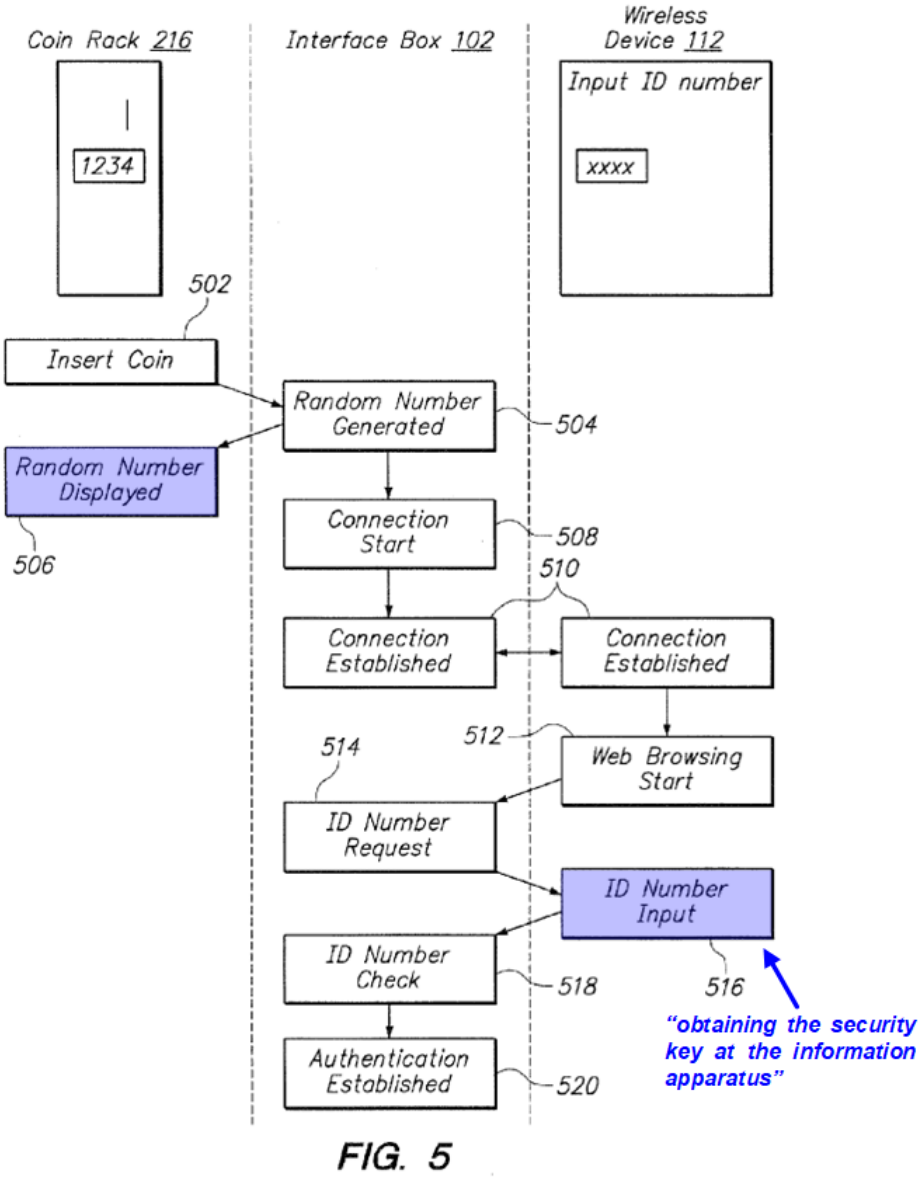


FIG. 5

136. Notably, Yamaguchi disclosed obtaining a security key at the information device by explaining that the user entered the ID number in box 516, which is consistent with the '402 Patent's description that the security key can be obtained when a user manually enters the identification information. EX1001, 35:38-39; 45:5-6.

13[f]: sending a security code related at least partly to the security key over the wireless communication channel and requesting the selected wireless output device to open a wireless connection channel for data transfer;

137. Yamaguchi taught sending a security code that related to the security key to the selected output device as part of operations 516 and 518. Particularly, Yamaguchi disclosed "the user enter[d] the random number that was previously generated by interface box 102" at the wireless device 112; *see* block 516 of FIG. 5. "At block 518, the interface box compare[d] the value of the number that was entered by the user with the value of the previously generated random number. EX1006, FIG. 5, 7:41-44. It would have been both inherent and obvious that, between blocks 516 and 518, the user-inputted number was collected and processed by the wireless device 112 in order to convert the user-inputted information into the proper format (e.g., digitize or encode) so that it could be wirelessly sent to the interface box 102. In doing so, the processed version of the security key ("security code") was sent over the wireless channel.

138. When a security code is inputted by a user, such as a PIN code, it needs to be converted into a digital representation prior to transmission. For example, a PIN code might be converted into an ASCII representation, which is the most common character encoding format for text data in computers and on the Internet. In standard ASCII-encoded data, there are unique values for 128 alphabetic, numeric or special additional characters and control codes. Moreover, the digital

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

representation of the security code might be further encrypted for security purposes. As such, a POSITA would know that all of these operations produce an entity (a security code) that is related at least partly to the security key obtained at the information apparatus.

139. Yamaguchi taught requesting the selected wireless printer to open a "wireless connection channel" for data transfer between the wireless device 112 and interface box 102 of the selected printer by disclosing the user inputting, and the user wireless device sending the ID number, as part of the "steps … performed by a user to establish a wireless connection between an interface box and a wireless device." EX1006, 2:35-37, 7:6-10, FIG. 5. Per Yamaguchi's description, a POSITA would have understood that, having already provided the payment information (EX1006, 7:13-15), the provision of the ID number (assuming it was correctly entered), would have "allowed [the user] to proceed to generate a printed copy an electronic document that is of interest to them" ***through a wireless connection***. EX1006, 7:45-49, FIG. 5. Therefore, a POSITA would have understood, and found it obvious, that sending the ID number to the output device also served as a request for opening a "wireless connection."

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Yamaguchi FIG. 5 (annotated)

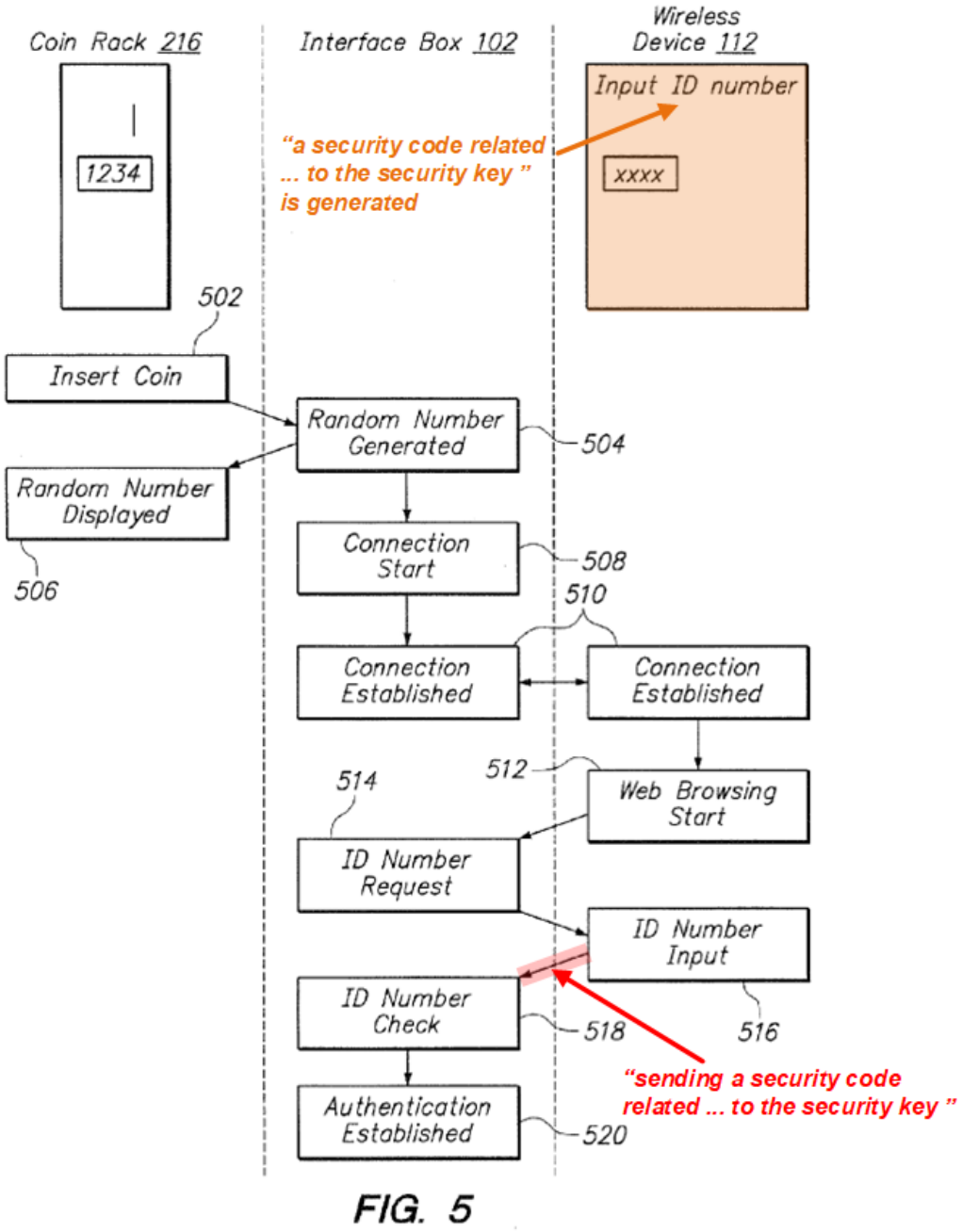


FIG. 5

140. For instance, sending a security code could have been one way to also request for opening a wireless channel. Per Yamaguchi's disclosure, a wireless connection channel must be established in order to carry out the wireless printing

process. EX1006, FIG. 5, 7:45-49. This was done after the user provided the security code (ID number inputted based on the random number generated at the interface box). And although Yamaguchi does not explicitly describe a separate step for sending a request to open the wireless connection channel, this would have been accomplished by entering and sending a security code to the interface box (as shown by the arrow between blocks 516-518 in FIG. 5), or by another obvious alternative, such as sending a request as another field within the same communication that sends the security code, or even as a separate message before or after sending the security code. None of these request operation examples would have been new or innovative on their own or as part of this method of Claim 13; rather, they are simply obvious ways for a wireless device to request another wireless device to make a wireless connection with it. Thus, a POSITA would have certainly understood that sending the security code related to the security key could accomplish this request.

13[g]: receiving over the wireless communication channel a response related to an authentication; and

13[h]: if the received response is positive,

141. Yamaguchi taught or suggested 13[g] and 13[h] by disclosing "the user is authorized and thus allowed to proceed to generate a printed copy" at block 520. EX1006, 7:45-49, FIG. 5. Yamaguchi's statement that "***the user is authorized and***

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

thus allowed to proceed" can be construed to mean the user is informed of his/her authorization.

142. A POSITA would have found it obvious to provide such a response (i.e., a positive response if the ID number is correctly verified) based on the above description of Yamaguchi. Notably, such a response would have informed the user that he/she can initiate the printing process, and any potential interruptions to the printing operations were not the result of incorrect authentication. In addition, providing a confirmation of successful or unsuccessful verification would have been a routine and well-known operation.

143. Thus, providing a positive response that the authentication process was successful is both an obvious, routine operation and is implied in Yamaguchi's disclosure by the establishment of the wireless connection. EX1006, 7:45-49. To a POSITA, sending a positive response in addition to establishing connection when the authorization was successful would have been an obvious step that would have informed the wireless device user that the print data would be transmitted to the printer for printing.

13[i]: establishing a wireless connection channel between the information apparatus and the selected wireless output device,

144. Yamaguchi taught establishing a wireless connection channel between the wireless device 112 and interface box 102 of the selected printer as a result of

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

establishing authentication (block 520) upon completion of the method of FIG. 5. EX1006, 7:5-10 ("Establishing a Wireless Connection"), 2:35-37, 7:45-49, FIG. 5.

13[j]: conforming, at the information apparatus, at least part of the content into an output data encoded with at least one format, the conforming relating at least in part to the attribute received over the wireless communication channel, and

145. Yamaguchi and Moore taught this claim limitation.

146. Yamaguchi discloses "a [wireless] printing mechanism for printing electronic document information" such as emails, web pages, pictures, etc. in a variety of different content formats like HTML, Microsoft Word® doc, JPEG, GIF, etc. EX1006, 1:8-9, 1:15-26. Yamaguchi described that a "variety of techniques may be used … to process requests for generating hard copy documents based on the electronic document information [content] that is received." EX1006, 5:9-12. Yamaguchi further explained that its "wireless device 302 include[d] software for generating a print ready file [to be] ***read and processed*** by a printing device." EX1006, 5:14-17.

147. Particularly, Yamaguchi disclosed conforming, at wireless device 302 ("information apparatus"), the electronic document information ("content") into output data encoded with a format by disclosing "printer driver 310 … generate[s] a print ready file for delivery to interface box 304[, for example] formatted in a page description language ("PDL"), such as a PostScript file or a file formatted in the

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Printer Control Language ("PCL") defined by Hewlett-Packard Company." EX1006, 5:24-31. Yamaguchi expressly described "a print ready file [as] a file that is in a format that can be read and processed by a printing device[, e.g.,], a Postscript file that has been generated based on an electronic document." EX1006, 5:15-19.

148. Yet, while Yamaguchi may not have expressly disclosed conforming the content into output data encoded with a format ***related to an attribute of the printer***, the Yamaguchi-Moore-Kammer taught this conforming operation using Moore's "universal printer driver (unidriver)" concept.

149. Specifically, Moore described "a method for characterizing and customizing printer drivers" using a GPD file 102 resident on the printer and a universal printer driver ("unidriver") 100 that "tailor[s] the common printer driver functions to the particular printer." EX1008, 1:5-7, 6:3-12, FIG. 3 (*below*). By receiving the GPD file at the user device (computer/information apparatus), Moore's invention allowed for any computer (information apparatus) to "obtain the necessary information to utilize a particular peripheral [printer] from the [printer] itself[,]" thereby making the computer's printer driver "universal" to effectively create "driverless printing," the title of Moore's patent. EX1008, Title, 1:48-54, 7:50-54, FIG. 3 (below).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Moore Figure 3

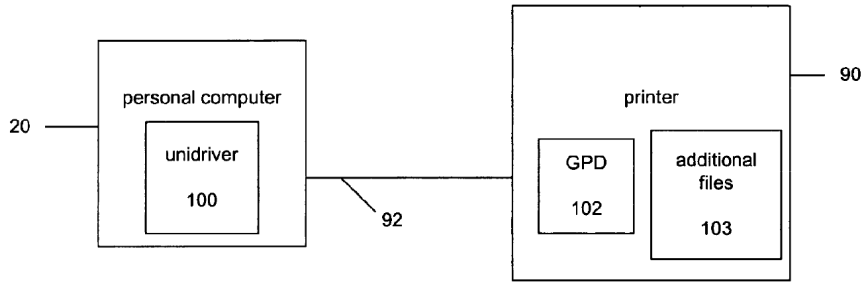


Figure 3

150. In the combination, Yamaguchi's wireless device 112 (information apparatus) would have received a GDP file (attributes or printer profile) from the printer/interface box (output device) informing the information device of the capabilities of the printer, and allowing the user to select the desired printing option(s).

151. Moore taught how the unidriver 100 "tailor[s] common printer driver functions to the particular printer" based on the printer's attribute(s) contained in the GPD file 102. EX1008, 6:3-18. Specifically, Moore described an example illustrating this feature:

> [A] specific printer 70 may be able to support duplex printing, or printing on both sides of a sheet of paper simultaneously. However, the unidriver 100 does not initially know how to instruct the printer to perform this task. ***The GPD file 102 can contain the appropriate option name and value or code so that the unidriver 100 can instruct the printer 70 to perform duplex printing. The unidriver 100 learns these codes by reading the GPD file 102.*** The user

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

> interface, also obtained from the GPD file 102, can then present the option of duplex printing to the user. If the user selects duplex printing through this user interface, the unidriver 100 sends the command to the printer 90, and the printer performs duplex printing.

EX1008, 6:43-56. Other printer-specific parameters, such as print quality, truetype font, etc., which Moore's unidriver can use to tailor Yamaguchi's printer drivers conformation of the content, are illustrated in FIG. 4 of Moore, below.

Moore FIG. 4

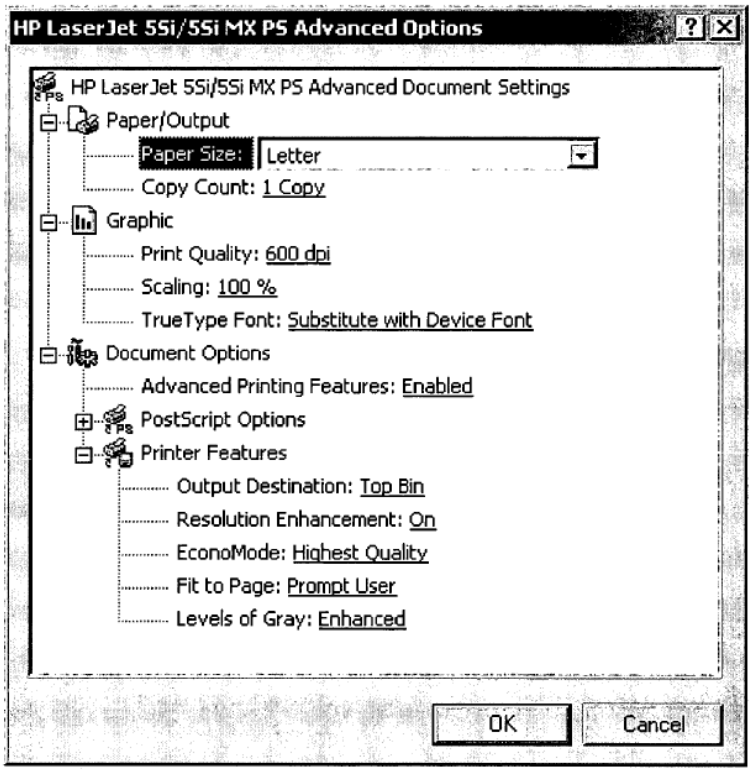


Figure 4

152. In my opinion, a POSITA would have found it obvious with a reasonable expectation of success to combine Yamaguchi's printer driver with

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Moore's unidriver to "conform" the electronic document information ("content") into the print ready file ("output data") that is encoded with a format ***related to an attribute of the printer*** for several reasons. First, inclusion of Moore in the combination would have improved the user experience and the printing process because the user would not have needed to "download the correct printer driver for [a particular printer] MFP 306" "if wireless device 302 [lacked] the appropriate printer driver." Second, and relatedly, Moore's technique would have circumvented installing "a setup file" to print at the printing device, MFP 306. See EX1006, 5:34-40.

153. Moreover, my opinion is that the POSITA would have found it relatively easy to augment Yamaguchi's wireless printing devices with Moore's unidriver-GPD method because Yamaguchi's wireless device 112 already had wireless communication capabilities, and already included software that performed image- and print-processing operations "for generating a print ready file." EX1006, 5:14-17. And, Moore's unidriver-GPD configuration and associated operations would have been additional software- features that could have been readily added to the existing capabilities of Yamaguchi's device.

154. Notably, the combination of these known features from Yamaguchi, Kammer and Moore to arrive at Element 13[j] would not have changed these known features' respective functions because Moore's unidriver-GPD features are software

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

based, which would have been easy to incorporate with the software based printer driver on Yamaguchi's wireless device, particularly since Yamaguchi broadly described the printer driver "configured to receive print requests from application 308 and to generate a print ready file for delivery to interface box 304." EX1006, 5:14-17. In addition to have been well within the skill level of a POSITA to combine these known features, the POSITA would have also been able to predict that doing so would have successfully resulted in conforming a print ready file formatted for any type of printer selected and determined by an attribute of the printer.

155. Importantly, the proposed combination is consistent with the respective principle of operations and purposes of Yamaguchi, Kammer and Moore. *See also* EX1006 1:59-42 and EX1008 2:37-54.

13[k]: transferring the output data from the information apparatus to the selected output device over said wireless connection channel for rendering,

156. Yamaguchi taught transferring the print ready file ("output data") from wireless device 302/112 ("information apparatus") to interface box 102/304 connected to MFP 306/106 ("selected output device") over the wireless connection channel for printing the hard copy document ("rendering") by disclosing "[o]nce generated, the print ready file is transmitted from wireless device 302 to interface box 304 via wireless interface 312." EX1006, 5:9-12, 5:31-33.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

13[l]: receiving at the selected output device the output data,

157. Yamaguchi taught receiving the print ready file ("output data") at the interface box 304/012 connected to MFP 306/106 ("selected output device") by disclosing:

> Upon ***receiving the print ready file at wireless interface 314***, the file is forwarded to spooler 316 for transmitting the file to a multifunctional peripheral (MFP) device 306. Thereafter, the file is forwarded to the MFP 306 via Ethernet interface 318.

EX1006, 5:41-45.

13[m]: performing at the selected output device at least one decoding operations on said output data, and

158. Yamaguchi did not expressly disclose a decoding operation on the print ready file ("output data") at the interface box 304/102 connected to MFP 306/106 ("selected output device"), but this is an obvious operation in view of Kammer's disclosure. Kammer taught wireless communications, per Bluetooth protocol, require encoding on the transmit side and decoding on the receive side, such as "baseband processing" that a POSITA would recognize involves encoding/decoding of the data suitable for transmission, as well as "Quality-of-Service, asynchronous transfers, synchronous transfers, audio coding, and encryption." EX1007, 7:25-8:19.

159. Bluetooth communications, regardless of the type of content being transmitted (e.g., voice or text or image data), used a modulation encoding

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

technology to encode digital information on the transmitter side, transmit the encoded information to the receiver, and decode the received encoded information on the receiver side. The specific modulation technique used can be different for different wireless communications (e.g., modulation techniques for Bluetooth are different than those for infrared (IR)), but necessarily involves encoding and decoding. For example, for Bluetooth, the modulation encoding technology, which is part of the specification, is Gaussian Frequency Shift Keying (GFSK).

160. Thus, in my opinion, a POSITA would have found it obvious that Yamaguchi's wireless interface 314, which was capable of Bluetooth communications, performed a decoding operation, as part of standard Bluetooth communication protocol, on the print ready file.

13[n]: converting the output data into an output engine data acceptable for rendering by an output engine included in the selected output device.

161. Yamaguchi disclosed that once generated, the "print ready" file was wirelessly transmitted from the wireless device to the interface box (EX1006, 5:31-33), and "a hard copy document [was]… generated ***based on*** the print ready file ***information***." EX1006 5:45-46. Yamaguchi further explained that "***a print ready file is a file that is in a format that can be read and processed by a printing device***" EX1006, 5:15-17; *see also id*., 5:17-19, 5:27-31 explaining Postscript and PCL-formatted files as examples of print ready files.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

162. Based on the above disclosures of Yamaguchi, it would have been obvious to a POSITA that a so-called print ready file that was Postcript or PCL format would be converted (processed) by the printer device into the proper format to drive the print engine for producing the printouts. Notably, a POSITA would have been informed by the teachings of Moore that "a print engine [can be]… ink jet printing, laser printing, dot matrix printing, daisy-wheel printing, thermal transfer printing, or dye sublimation printing" (EX1008, 5:49-52) and would have readily recognized that certain conversion and processing steps at the printer would have been necessary to produce the printouts for such potentially diverse types of printing technologies.

163. Thus, in my opinion the POSITA would have found it obvious for the printer to perform some processing (converting), for example at the print engine, so that the proper signals or data would be produced and sent to the marking engine to physically create the hard copy rendition of the content to be printed.

2. Claims 14-21

14: The method according to claim 13 in which the information apparatus is one of a mobile phone, a digital camera, a laptop, and a PDA.

164. Yamaguchi taught the information apparatus (wireless device) includes "wireless lap-tops and a variety of different hand-held devices[:] cellular phones, Palm Pilots, PDAs, etc." EX1006, 1:29-35; 3:19-20.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

15: The method according to claim 13 in which the output device is one of a printer, a projection, a copier, a speaker, an audio output device, a display screen, and a TV.

165. Yamaguchi taught the output device includes "a standard printer device or … a multifunctional peripheral (MFP) device." EX1006, 3:40-54.

16: The method of claim 13 in which discovering one or more output devices includes one or more output devices posting their availability as discoverable and the information apparatus finding one or more output devices.

166. Kammer taught "[i]n the inquiry step [of the Bluetooth discovery process] Bluetooth devices make their presence known to each other[,]" where after initiator device 20 broadcasts inquiry message 40, responder device 30 "send[s] inquiry response[] 42a … to initiator device 20 in response to inquiry 40" providing its address, access code, and/or optional information, which initiator device 20 "receive[s,]" thereby finding the responder device 30. EX1007, 1:53-56, 2:12-18, 2:23-26.

167. A POSITA would have found it obvious that Yamaguchi's wireless interface module 104 (part of interface box 102 connected to printing device 106) could post its availability as discoverable by an inquiry response to the wireless device 112's broadcasted inquiry message because this operation in Kammer's description was part of the well-known and ***standardized Bluetooth communication***

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

protocol and Yamaguchi's system used Bluetooth as a means for wireless communication.

168. This is because Bluetooth was fully standardized before the 2001 timeframe of the '402 Patent and the Generic Access Profile (GAP) of the Bluetooth specification (version 1.0B, December 1999) described the processes whereby Bluetooth devices can discover each other available devices, and thus a POSITA would have been familiar with the standard protocol.

17: The method of claim 13 further comprising:
obtaining a payment information at the information apparatus, the payment information enabling data rendering service by the selected output device;
sending the payment information over the wireless communication channel and requesting the selected wireless output device to open a wireless connection channel for enabling data rendering service.

169. Yamaguchi taught a payment component of the printing mechanism for wireless devices for "control[ing] the printing of documents by requiring the user to provide monetary payment prior to the hard copy documents being generated." EX1006, Abstract, 2:3-6. Yamaguchi described interface box 102 (which is part of the selected printing device 106) included payment mechanism 118, "a combination of one or more hardware and/or software components or processes," which accepted "monetary payment information" (such as "Smartcard, credit card or bank card (ATM) information, Cyber-Cash") provided by a user. EX1006, FIG. 1, 2:67-3:2; 3:60-62; 4:10-23. Yamaguchi disclosed the payment mechanism could receive such

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

monetary payment information ("Cyber-Cash information") over the wireless communication channel ("wireless connection") from the user's wireless device. EX1006, 10:6-9, 9:24-29, 8:17-22.

170. Yamaguchi's reception of such electronic payment information (e.g., ATM or Cyber-Cash information) over a wireless channel would also have been obvious to a POSITA because Yamaguchi's wireless device already (and perhaps exclusively) communicated with the interface box via a wireless connection. Therefore, a POSITA would have found it obvious that the user could enter the electronic payment information on his/her wireless device ("information apparatus") to be transmitted over the wireless communication channel to the interface box ("selected wireless output device").

171. This is also obvious because Yamaguchi explained using electronic means for making the payment. Similar to the prior explanation, a POSITA would have understood that providing that payment could also serve as making a request, or a separate request could be sent prior to, along with, or after sending the payment. There is nothing novel or technically/conceptually challenging about sending a separate request and/or sending payment information submission that could also serve as request for services.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

172. Further, it would have been obvious that such a transmission and/or an accompanying request would have provided a request to begin (enable) a printing process (rendering service).

18: The method of claim 13 in which the conforming, at the information apparatus, related at least in part to the supported output device profile of the selected output device and included in said attribute received over the wireless communication channel.

173. See 13[j], demonstrating the combination of Yamaguchi and Moore taught conforming the content into output data encoded with a format ***related to an attribute of the printer*** from the GPD file, such as "type and name of the device," to convey capabilities of the printer. EX1008, 2:59-3:4, 6:28-31. Moore taught such conforming can be in accordance with a printer device profile based on "options of the printer," such as "Print Quality: 600 dpi." EX1008, 6:57-7:8, FIG. 4.

174. See also 13[c], discussing reception of "said attribute."

175. Notably, the '402 Patent explains the attribute "may identify and describe, for example, the capabilities and functionalities of a particular output device such as a printer." EX1001, 9:31-34. This is consistent with Moore's characterization.

176. A POSITA would have found this combination obvious for the same reasons as in 13[j].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

19: The method of claim 13 in which said security key comprises at least one of a user name, password, ID number, signatures, physical or digital security key, biometrics, fingerprints, and a voice.

177. See 13[e] and 13[f], demonstrating Yamaguchi taught the security key is a generated random number viewed as "ID number" and inputted on the wireless device 112. EX1006, FIG. 5, 7:40-44.

20: The method of claim 13 in which the step of obtaining said security key comprises inputting by a user or retrieving a key that was previously stored in the information apparatus.

178. See 13[e], demonstrating Yamaguchi taught ID number inputted by the user on wireless device 112. EX1006, FIG. 5, 7:40-41.

21: The method of claim 13 further comprising:
receiving at the output device and over the wireless communication channel established a security key for authentication;
comparing the received security key with an access control list stored in the output device or input by a user; and
if the step of comparing the received security key with an access control list is successful, granting the information apparatus a secured wireless connection channel access to the output device.

179. Claim 21 recites "receiving … ***a security key*** for authentication." First, it is unclear to me whether "a security key" received in Claim 21 is the same "security key" obtained in Claim 13 (*see* 13[e]) or a new "security key," particularly since Claim 21 recites the method is "further comprising" of this feature.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

180. Nevertheless, a POSITA would have understood both interpretations are obvious based on Yamaguchi's teaching (EX1006, 7:5-49, FIG. 5). Yamaguchi described an authentication technique where (1) an "ID number" (security key) is received at interface box 102 (block 518) having been sent by wireless device 112 (block 516), (2) the ID number is "compare[d to] the previously generated random number" (block 518), and (3) the wireless device 112 is "authorized" to complete the method establishing the wireless connection. See discussion above for 13[e]-13[i].

181. While Yamaguchi did not expressly disclose comparing a security key to "an access control list," the ID number previously generated and stored at the interface box can be construed as a list or a record of authorized users. A POSITA would have deemed it as obvious that some type of 'list' could have been maintained at Yamaguchi's interface box (e.g., in its digital memory) to authorize users by checking the stored authorization record for controlling access against the ID number sent over by the user's device. For instance, a POSITA would have recognized a need for the interface box to keep track of multiple generated ID numbers (i.e., an access control list with multiple entries) in scenarios where multiple print jobs, whether by the same user or by different users, were requested on the printing device (via the interface box), which would have resulted in the

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

generation of different ID numbers for different print jobs and thereby multiple numbers to store on an access list of some form to compare with such security keys.

182. Notably, the '402 Patent describes "an access control list … specifies what device or user may obtain service from its host (or connected) output device 220." EX1001, 21:7-9. This broad explanation in the '402 Patent of what an access control list does—not what it is—is consistent with what the POSITA in the 2001 timeframe would have understood.

3. Claim 33

33[pre]: A method of mobile wireless data output from an information apparatus with access to at least part of a content to a wireless output device by short range wireless communication, wherein the information apparatus includes at least one wireless communication unit and is a distinct device from the output device, the method comprising:

183. See 13[pre].

33[a]: opening a wireless communication channel at the information apparatus;

184. See 13[a].

33[b]: discovering wirelessly one or more wireless devices that are available for wireless connection;

185. See 13[b].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

33[c]: receiving over the wireless communication channel an attribute corresponding to each discovered wireless device, the attribute including one or more of a name, a device type, a device address, and an indication of a supported output device profile;

186. See 13[c].

33[d]: selecting a wireless output device from among the one or more discovered wireless devices based at least in part on the received attribute;

187. See 13[d].

33[e]: obtaining a security key at the information apparatus, the security key enabling wireless data transfer to the selected output device;

188. See 13[e].

33[f]: sending at least part of the security key over the wireless communication channel and requesting the selected wireless output device to open a wireless connection channel for data transfer;

189. See 13[f], demonstrating Yamaguchi disclosed sending "ID number" based on the generated random number (security key) over the wireless communication channel and requesting a wireless connection channel for data exchange with the output device.

33[g]: receiving over the wireless communication channel a response related to an authentication; and

190. See 13[g].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

33[h]: if the received response is positive,

191. See 13[h].

33[i]: establishing a wireless connection channel between the information apparatus and the selected wireless output device, and

192. See 13[i].

33[j]: conforming, at the information apparatus, at least part of the content into an output data encoded with at least one format, the conforming relating at least in part to the attribute received over the wireless communication channel, and

193. See 13[j].

33[k]: transferring the output data from the information apparatus to the selected output device over said wireless connection channel for rendering.

194. See 13[k].

4. Claims 34-37

34: The method according to claim 33 in which the information apparatus is one of a personal computer, a mobile phone, a smart phone, a digital camera, a laptop, and a PDA.

195. See [14].

35: The method according to claim 33 in which the output device is one of a printer, a projection, a copier, a speaker, an audio output device, a display screen, and a TV.

196. See [15].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

36: The method of claim 33 in which the conforming, at the information apparatus, related at least in part to the supported output device profile of the selected output device and included in said attribute received over the wireless communication channel.

197. See [18].

37: The method of claim 33 in which said security key comprises at least one of a user name, password, ID number, signature, physical or digital security key, biometric, fingerprint, and a voice.

198. See [19].

B. Ground 2: Claim 21 is Obvious Over Yamaguchi, Kammer, Moore, and Davis

1. Claim 21

21: The method of claim 13 further comprising:
receiving at the output device and over the wireless communication channel established a security key for authentication;
comparing the received security key with an access control list stored in the output device or input by a user; and
if the step of comparing the received security key with an access control list is successful, granting the information apparatus a secured wireless connection channel access to the output device.

199. Davis taught a wireless authentication method for authorizing use of a "node," such as a computer or printer (EX1016, 7:13-19), involving a two-step process using (1) a password (see annotated FIG. 5), followed by (2) challenge/response message protocol. EX1016, FIG. 5, 11:8-12:9.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Davis FIG. 5 (annotated)

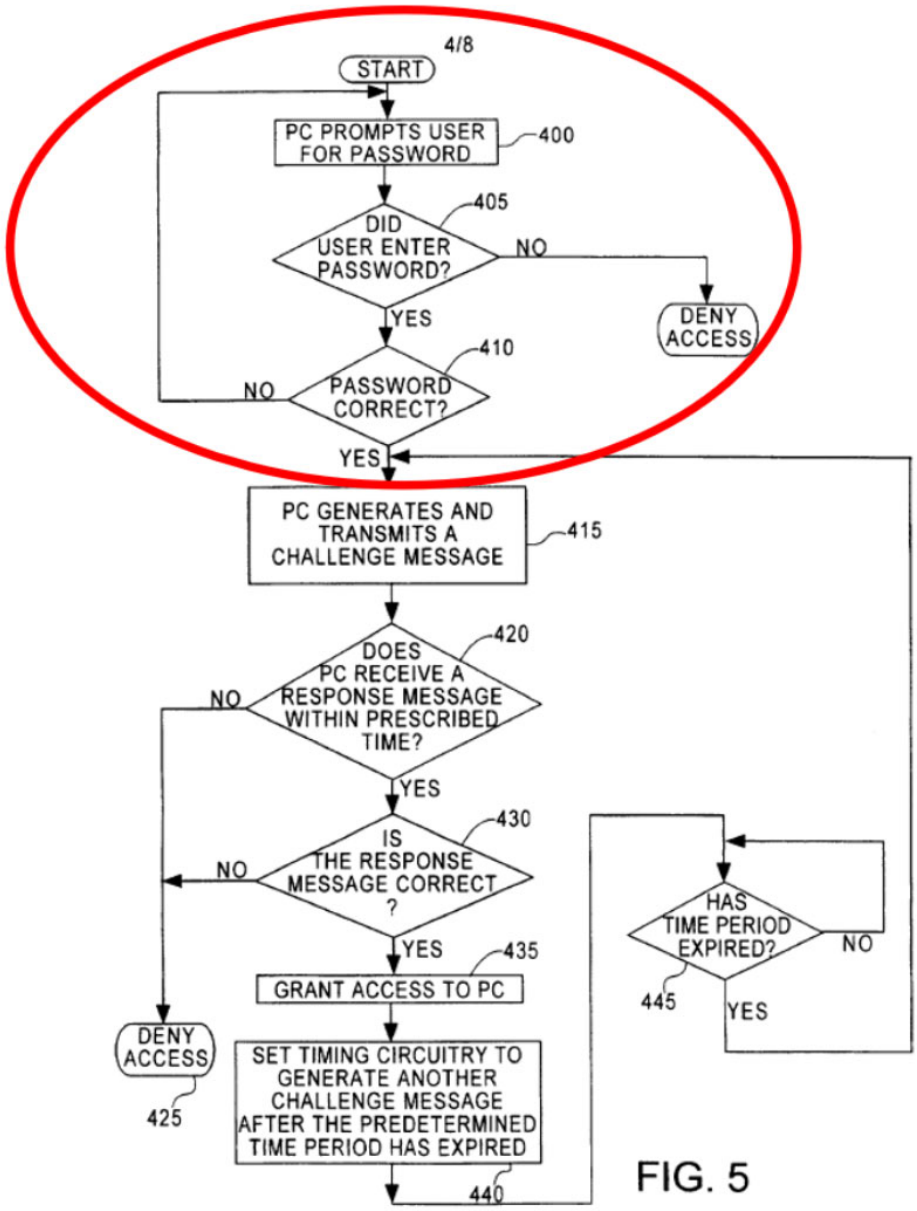


FIG. 5

200. In the Yamaguchi-Kammer-Moore-Davis combination, a POSITA would have incorporated Davis' password-checking operations into Yamaguchi's authentication protocol by first asking a user to enter a password to confirm the

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

user's identity before proceeding with Yamaguchi's authentication protocol that involved generating a random number.

201. Yamaguchi taught the user can utilize the printing device by paying with non-physical currency payments, such as "Smartcard, credit card or bank card (ATM) information, Cyber-Cash" (EX1006, 4:18-19), which are payment means linked to a particular user. Also, Yamaguchi expressed concern to avoid ""hacking" by unwanted unauthorized network users" (EX1006, 6:50-52) and disclosed a physical shielding technique as one way to minimize such risks. EX1006, 6:32-61.

202. A POSITA would have found this combination obvious because Yamaguchi described making electronic payments via "Smartcard, credit card or bank card (ATM) information, Cyber-Cash" (EX1006, 4:18-19), and having an added password check would have prevented fraudulent transactions. This would have been consistent with Yamaguchi's concern to avoid "hacking" by adding physical shielding (EX1006, 6:32-61) and would have additionally thwarted the use of stolen credit cards or bank account information for purchasing printing services.

203. In my opinion, the Yamaguchi-Kammer-Moore-Davis combination makes claim 21's "receiving" step obvious because of Davis' teaching that a user entered his/her password on Yamaguchi's wireless device that would be sent to Yamaguchi's wireless interface box to determine whether the password was correct.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

EX1016, 11:8-20, FIG. 5. Notably, the '402 Patent describes a password as a security key. EX1001, Claim 19.

204. A POSITA would have found the "comparing" of the password to an access control list obvious because of Davis' disclosure that "the node determine[d] whether the password [wa]s correct (Step 410)." EX1016, 11:14-15. Comparing a password to some record or form of an authorized list of passwords would have been a common way of confirming that the password was still valid, had not expired or been revoked. A common method of storing passwords in the 2001 timeframe was to hash each one of them into a fixed length (e.g., into a 128-bit record) using a secure hashing function such as MD5. Hashing, which is a form of encryption, was known at that time to create a more secure environment for storing the passwords because even if a hacker was able to break into the system, they still would not be able to steal the passwords. In such a system, the user's password would first get hashed and the hashed value would then be compared to a record of stored hashed passwords. This is just one form of a 'list' that the POSITA would have found as an obvious way to compare with the security key to authorize the user's device for printing.

205. The POSITA would have found the "granting" step obvious over Yamaguchi-Davis combined teaching because upon successful password check, the user would have needed to submit credit card or bank account numbers, which would

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

have been advantageously conducted over a secure wireless connection with Yamaguchi's interface box.

C. Ground 3: Claims 1-7, 9-21, 23-37 Are Obvious Over Yamaguchi, Kammer, and Kemp

1. Claim 1

1[pre]: A pervasive mobile data output method for rendering at an output device content at least partly accessible with an information apparatus, the information apparatus including at least one wireless communication unit, the pervasive mobile output method comprising:

206. See 13[pre] (Ground-1), demonstrating Yamaguchi taught all features in 1[pre].

1[a]: accessing at the information apparatus at least part of said content;

207. Yamaguchi taught this limitation because it disclosed that wireless device included software applications, such as Microsoft Word®, Excel, etc. to generate and store electronic documents that were retrieved and accessed to be printed. EX1006, 3:27-39, 2:55-67].

1[b]: opening at the information apparatus a wireless communication channel;

208. See 13[a] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

1[c]: searching wirelessly at the information apparatus for wireless output devices available for wireless communication;

209. See 13[b] (Ground-1). A POSITA would have recognized Yamaguchi's wireless device broadcast of the Bluetooth inquiry message would be to search for wireless printing device(s) that could respond to such request.

1[d]: receiving at the information apparatus and over the wireless communication channel at least one attribute corresponding to each wireless output device found in the search;

210. See 13[c] (Ground-1).

1[e]: selecting at the information apparatus a wireless output device found in the search based at least in part on a received attribute;

211. See 13[d] (Ground-1).

1[f]: conforming at the information apparatus at least part of the content into one or more output images;

1[g]: generating at the information apparatus an intermediate output data that includes said one or more output images, the intermediate output data conforming at least partly based on said received attribute of the selected output device;

212. Yamaguchi did not expressly disclose these limitations, but Kemp did.

213. Kemp taught a remote printing method from a computing device to a printer over a data communication network, such as the Internet or any similar network EX1009, ¶¶[0015], [0044], [0072]. Kemp's computing device 10 allowed

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

a user to print documents to remote printers at, e.g., a print shop, hotel or a kiosk at an airport, mall, etc. EX1009, ¶¶[0036], [0038]; FIG. 3 (annotated below). The computing device 10 included a print driver 282 (including a rendering engine 14), which was invoked to "***prepare image data for printing***" on a local printer or remote printer operated by a service provider 2. EX1009, ¶¶[0036], [0048], [0051], [0068].

Kemp FIG. 3

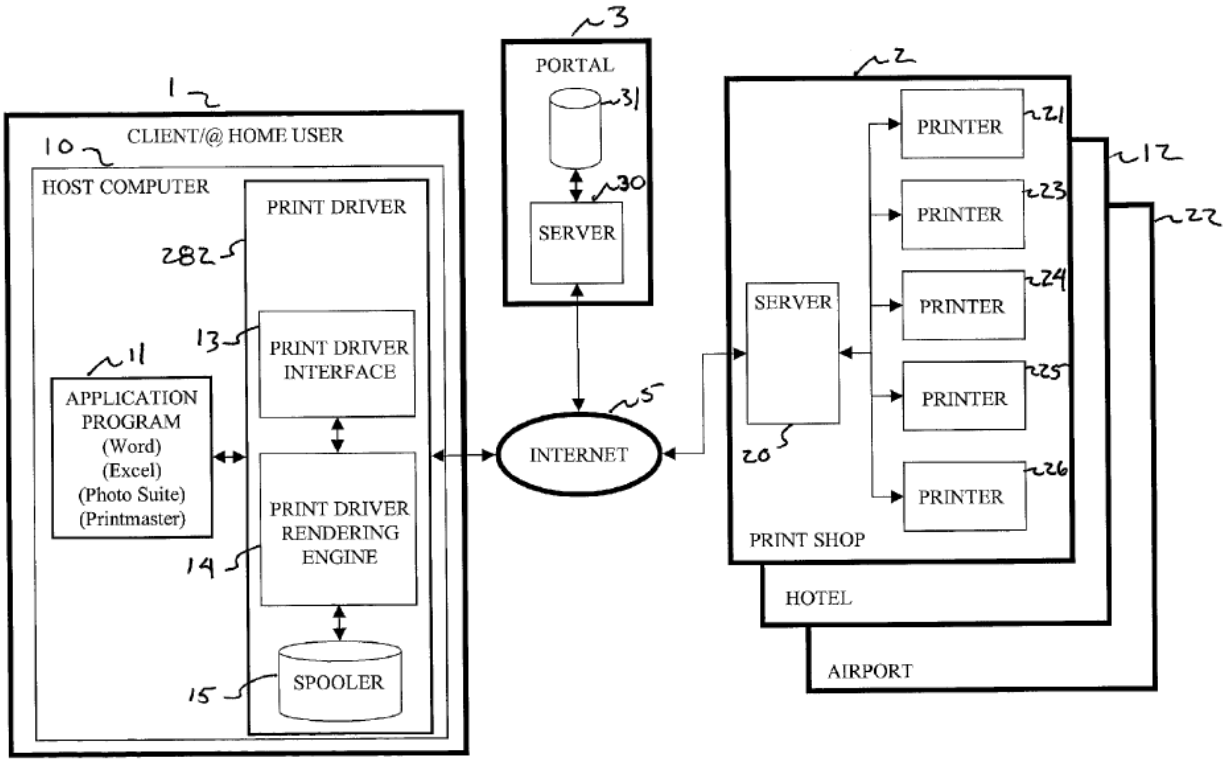


FIG. 3

214. Kemp disclosed the "conforming" step 1[f] by describing that "[w]hen the user select[ed] print button 65, print driver rendering engine 14 … ***render[ed] the print job into a neutral printer definition language (NPDL)***[,]… a language that is not specific to any type of printer." EX1009, ¶[0068]. Kemp also described

the "generating" step because it explained that, subsequently, the "rendered NPDL data ***[wa]s packaged in a transport protocol for transport*** … and [wa]s transmitted from print driver 282 to service provider server 20." EX1009, ¶[0072]; see also *id*., ¶[0012] (encapsulate the print data for transport), ¶[0013] (package the rendered print data with a protocol for transmission), and ¶[0053] (a format suitable for transport across the Internet).

215. Notably, the packaged NPDL data was intermediate output data because the NPDL rendering produced generic print data, which needed to be "convert[ed] … into the appropriate printer definition language of the printer selected by the operator" at the print shop. EX1009, ¶[0068]. Additionally, Kemp's NPDL data included output images because Kemp described the user may select to print an image (EX1009, ¶¶[0036]-[0037], [0075]), and the "print driver 282 … prepare[d] ***image data*** for printing." EX1009, ¶[0048]. A POSITA would have understood that rendering an input image by Kemp's print driver would produce an NPDL-rendered ***image***. Kemp's technique does not alter the content of the data but changes the representation of the data, such as its spatial resolution, bit depth, etc., to be suitable for the printing device to render it.

216. Furthermore, in the combination, the wireless device of Yamaguchi would be augmented to include the NPDL rendering capability of Kemp. The wireless device would communicate with printer(s) via Bluetooth, as was described

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

by Yamaguchi and Kammer, allowing the wireless device to receive attributes and information from the printer(s), and to encapsulate and send the NPDL-rendered data via Bluetooth protocol.

217. Also, in this combination, generating the NPDL data for transport would have been "conforming at least partly based on the received attribute of the selected output device," as recited in 1[g]. Specifically, as noted in Ground-1's explanation of 13[c], a device address (attribute) of the printer was communicated to the wireless device of Yamaguchi as part of Bluetooth discovery. This is consistent with the '402 Patent's explanation that an "IP address" is an example of an "attribute" (or an "output device profile") (EX1001, 9:47-53)[15], as well as Kemp's teachings that an Internet address of the print service device was needed for communications with the print service. EX1009, ¶[0039], Claim 39. Accordingly, a POSITA would have understood that, in the Yamaguchi-Kammer-Kemp combination, preparation of NPDL-rendered data for transport to a printer would have included preparing for porting to a specific device address (attribute). This is so that the user device knows where to send the rendered file, and one obvious way would have been to use the printer address, i.e., the Bluetooth address specific to the

[15] The '402 Patent describes "communication protocols" as another example attribute. EX1001, 9:60-61.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Bluetooth-enabled printer that had been received during the wireless discovery process (taught by Kammer).

218. A POSITA would have found it obvious to make the combination by including the NPDL-rendering capability of Kemp in the Yamaguchi-Kammer system because it would have expanded printing capabilities of Yamaguchi by producing print data that "[wa]s not limited to a specific printer, but c[ould] be processed and printed by virtually any printer." EX1009, ¶[0016].

219. Moreover, it would have been easy for the POSITA to combine Kemp's NPDL-rendering technique with Yamaguchi's wireless device/interface box wireless printing environment (using Bluetooth communication according to Kammer) because these Kemp's print driver features were implemented in software that was designed to reside on any host computer and/or server (EX1009, FIGS. 1-3, ¶¶[0046]-[0047]), which would have been easy to incorporate with software-based printer driver on Yamaguchi's wireless device (EX1006, FIG. 3A, 5:20-27), particularly since Yamaguchi broadly described the print driver "configured to receive print requests from application 308 and to generate a print ready file for delivery to interface box 304." EX1006, 5:14-17; EX1009, FIG. 4, ¶¶[0057], [0068].

220. Not only was it within the skill level of the POSITA to combine these known features, the POSITA also would have been able to predict that doing so would have successfully resulted in generating a packaged intermediate print file on

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

the user's wireless device able to be transmitted and printed at the selected printer based on the address (attribute) of the printer. Such expected success would be because Yamaguchi's wireless device already included software and computational abilities to perform image- and print-processing operations "for generating a print ready file" (EX1006, 5:14-17), which could have readily been augmented to include an additional software module to implement Kemp's NPDL rendering.

221. Yamaguchi explained that its device could produce print-ready documents, so it had the capability (e.g., both hardware horsepower and software execution capability) to process data per Kemp's NPDL-rendering technique, which would have consumed even less resources. The NPDL rendering engine was part of a device driver, and it was well known to a POSITA at the 2001 timeframe how to incorporate a device driver in software/firmware.

222. Furthermore, while Kemp used the Internet as an example transmission channel for sending the NPDL-rendered data, it reiterated that other networks or transport protocols could be used. EX1009, ¶¶[0044], [0072]. Therefore, a POSITA would have understood that using Bluetooth networks and protocols would have been consistent with the teachings of Kemp.

223. Kemp's use of Internet expanded the ability of Kemp's neutral or generic printing technique to reach out to a multitude of different print shops, if needed or desired. Yet, Kemp's disclosure of using the Internet to print a document

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

from computer 10 via a printer connected to server 20 would not have been necessary for the way Kemp is combined with Yamaguchi here. Instead, the application of Kemp's neutral or generic printing technique would be similar to Kemp's described scenario of a printing kiosk at an airport, convention center, or mall (EX1009, ¶[0038]), where the user could walk up directly to the kiosk, establish a Bluetooth wireless connection with the printer/output controller (as described by Kammer), and print the documents according to the combined print processing technique taught by Yamaguchi and Kemp. This would have been obvious to a POSITA, as discussed above.

1[h]: establishing a wireless connection between the information apparatus and the selected wireless output device;

224. See 13[i] (Ground-1).

1[i]: transmitting the intermediate output data from the information apparatus to an output controller that is distinct from the information apparatus and associated with the selected output device, the output controller including at least one wireless communication unit;

225. In the combination, Yamaguchi's wireless device transmitted the NPDL-rendered data via Bluetooth to the print site, as explained in 1[h]. See also, Ground-1, 13[k].

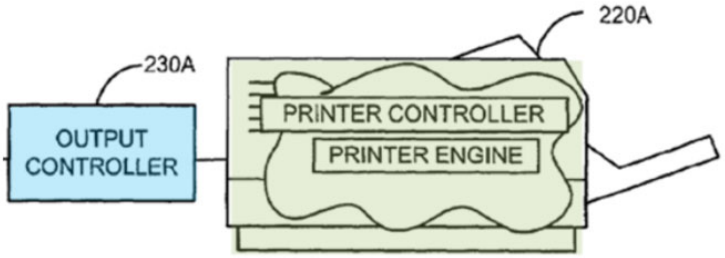
226. While Yamaguchi did not expressly disclose an intermediate output data was transmitted to "*an output controller*," Kemp described transmission of the

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

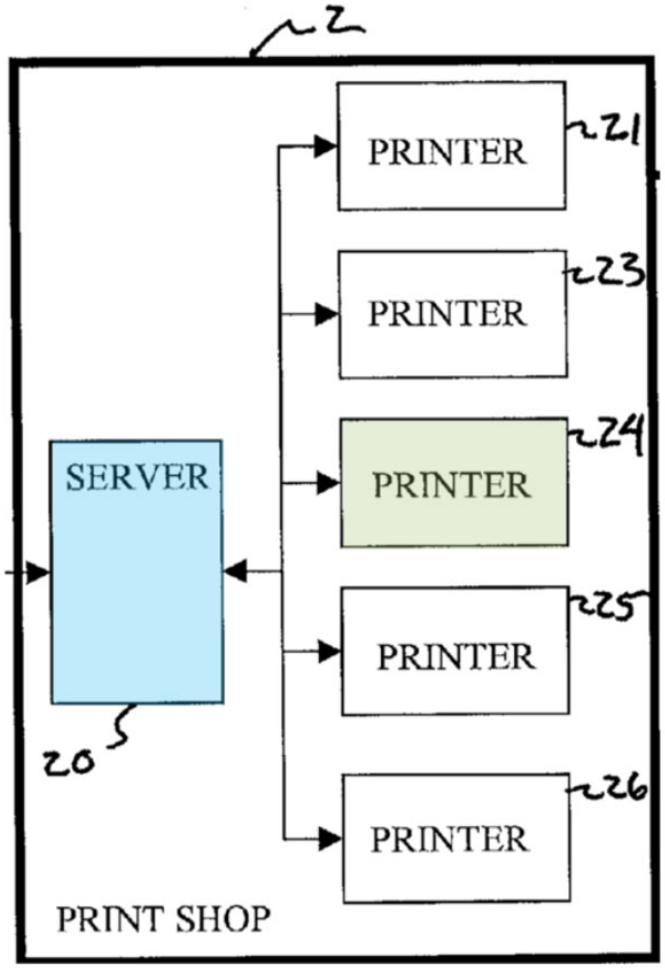
NPDL-rendered data to a "service provider server 20," which constituted the claimed "output controller. Notably, Kemp's service provider server 20 received and processed the NPDL data, before providing it to the printer(s) within the service provider 2. EX1009, ¶¶[0053], [0056], [0068]. This interpretation is consistent with the ''402 Patent, which described the "***output controller 230 is sometimes referred to as a print server or output server***" (EX1001, 17:50-51), and with FIGS. 7A, 7D and 7F, each depicting an output controller that is external to the printer. See the annotated figure below, showing the (highlighted) output controller 230A and printer 220A from FIG. 7A of the '402 Patent juxtaposed to (highlighted) server 20 and printer 24 from FIG. 3 of Kemp.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Annotated Drawings from '402 Patent (FIG. 7A) and Kemp (FIG. 3)



(FIG. 7A – '402 Patent)



(FIG. 3 - Kemp)

227. Based on the teachings of Kemp, a POSITA would have understood to include an output controller that communicated with at least one printer (e.g., at a kiosk EX1009, ¶¶[0038], [0056]); the output controller would have communicated wirelessly (via Bluetooth protocol) with the wireless device to receive the NPDL data. A POSITA would have found the inclusion of NPDL processing at the output controller obvious because it provided the expanded printing capabilities that were described in 1[f]-1[g].

228. A POSITA would have reasonably expected Kemp's service provider server to provide operations of an output controller for NPDL data processing because Kemp noted service provider server "need not be a server per se" but rather needs to be able to process data and communicate with the computer(s) and printer(s) in order to receive and respond to print requests. EX1009, ¶[0039]. Therefore, a POSITA would have understood that the output server need not be an expensive or a bulky device. A POSITA would have further understood that the output controller need not have full-Internet capability and a Bluetooth transceiver would have sufficed to allow wireless connections with Bluetooth-enabled information devices described in Yamaguchi and Kammer. Therefore, providing the service provider server with the output controller would not have been an expensive or difficult task.

229. During the 2001 timeframe, it was well known to include Bluetooth-enabled transceivers in electronic equipment. Kemp did not require a sophisticated

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

server at the print site; rather, Kemp explained that a device that could be communicated with over a network would have sufficed. The output controller would have provided the additional benefit of allowing the user to perform the generic NPDL rendering and save a portion of the resources of the user device (e.g., Yamaguchi's wireless device) for other tasks. It would have also expanded the breadth of the available printers. For example, only the output controller needed to be updated to accommodate the different printers at different locations (e.g., convention center might utilize a black and white highspeed printer whereas a mall might use a photo printer.

1[j]: converting at the output controller the intermediate output data into an output data acceptable for rendering at the output device, and delivering the output data to the output device for rendering;

230. Kemp disclosed this limitation because it described "the ***service provider server*** [output controller] ***convert[ed]*** the NPDL print data into a printer specific format based on the printer selected by the operator and ***submit[ted] the print data to the printer for printing***." EX1009, ¶[0087], FIG. 10, S125; *see also* ¶¶[0056], [0068].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Kemp FIG. 10

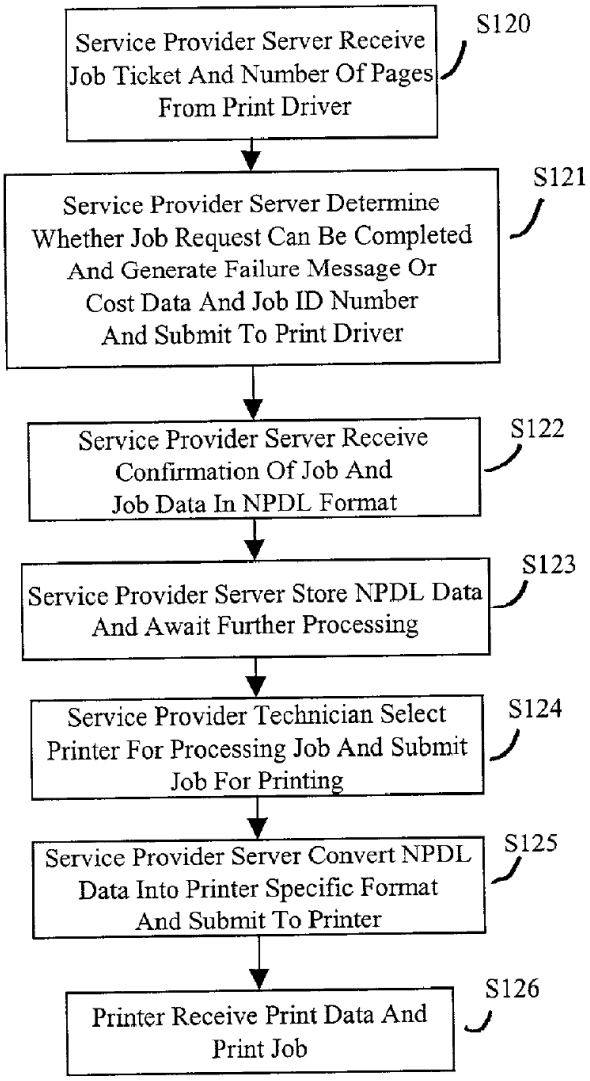


FIG. 10

1[k]: conforming at the output device the output data into a data format that is acceptable for rendering by a rendering engine in the output device, and delivering the data format to the rendering engine for output,

231. Kemp disclosed this limitation in connection with Figure 10 by explaining that once the NPDL data is converted to a format for a specific printer

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

and delivered to the printer, "***the printer processe[d]*** and print[ed] the print job" (step S126)." EX1009, ¶[0087], FIG. 10.

232. It would have been obvious to a POSITA that Kemp's description of ***processing*** the data at the printer amounted to conforming the output data so it can be sent to a marking engine to produce the physical printout. Notably, Kemp explained that service provider may accommodate different types of printers and printing technologies (e.g., a combined printer/copier, color printer, black and white printer, color plotter and black and white plotter) (EX1009, ¶[0040]), which would have informed a POSITA that certain processing steps at the printer would have been necessary to produce the printouts for such potentially diverse types of printing technologies.

233. Furthermore, the conformed or processed data was sent to the rendering engine because Kemp described that printer printed the print job. EX1009, ¶[0087].

1[l]: whereby, the information apparatus is able to output, in a mobile pervasive manner, one or more images representative of said content to an output device without the need to install an output device driver specific to that output device.

234. The combination of Yamaguchi-Kammer-Kemp taught this limitation because in the combination, the wireless device (information apparatus) would be able to wirelessly transmit intermediate output data using Kemp's generic/neutral NPDL rendering, which was "a language that is not specific to any type of printer."

**Lexmark, Exhibit 1003
Lexmark v. Flexiworld**

EX1009, ¶[0068]. The NPDL-rendered data could include images (*see* 1[f]), and allowed a "single print driver … to submit print data … without having to install separate print drivers for each printer type that a print job is to be submitted to." EX1009, ¶[0017].

2. Claims 2-7

2: The method of claim 1 in which establishing a wireless connection with the selected wireless output device comprises authenticating wireless access to the output device by sending over the wireless communication channel one or more of a name, a password or security code, an ID number or address, a signatures, a physical or digital security key biometrics, a fingerprints, and a voice.

235. See 13[e]-13[i] (Ground-1).

3: The method of claim 1 in which the receiving at least one attribute over the wireless communication channel comprises receiving one or more of a device name, a device type, an address or ID number, an indication of a supported device profile, a device profile, and a security code.

236. See 1[d], referring to 13[c] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

4: The method of claim 1 further comprising obtaining at the information apparatus one or more rasterization parameters corresponding to the output device and related at least in part to the received attribute from the output device or from user input.

237. Kemp taught obtaining "rasterization parameters" as print options corresponding to printer(s). Kemp described "print driver interface 13 provided a graphical user interface [displayed on] computer 10 when print driver 282 is activated [for] selecting a print option[,]" presenting a menu (shown in FIGS. 6A-6B). EX1009, FIGS. 6A-6B, ¶[0052]. The user rendered the document based on the selected printer, which had a "user-friendly name" (an "attribute") such as HP C Laserjet 4500-HP; and upon selection of "Properties" button 62 a Page Setup tab 71 provided rendering parameters. EX1009, FIGS. 6B-7, ¶[0058].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Kemp FIG. 7 (annotated)

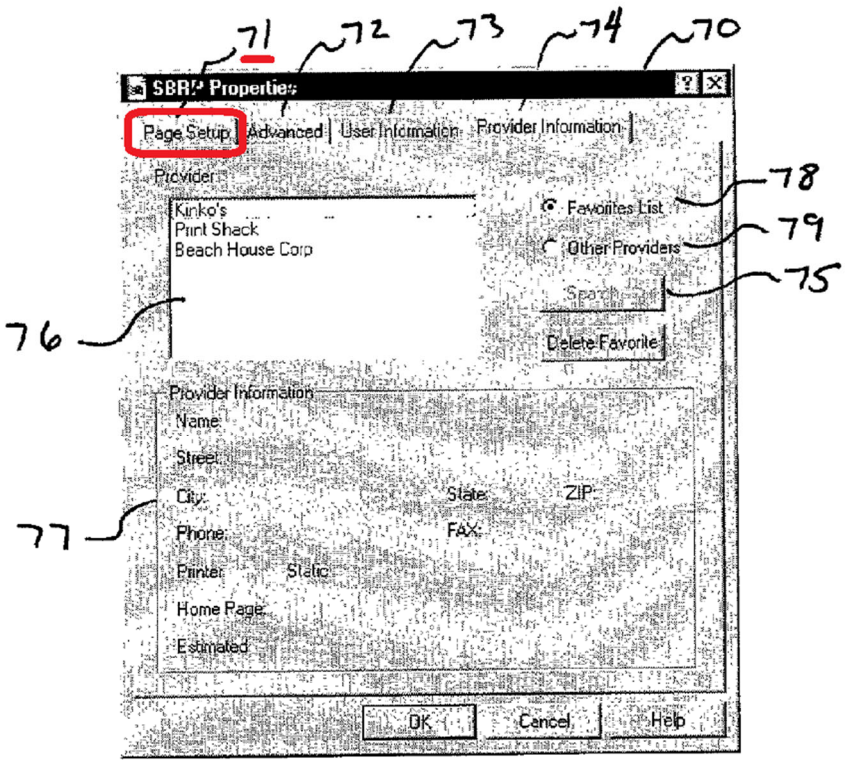


FIG. 7

238. A POSITA would have found it obvious that Page Setup included parameters/options related to how the printouts appeared, such as their resolution, (and thus quality), page size, color vs. black-and-white, single-sided vs. duplex and other properties, because these were commonly known and understood options for setting up and printing a page at the time of the alleged invention.[16]

[16] The '402 Patent's examples of "rasterization parameters" include "resolution, scale factor, bit depth, output size, and or color space." EX1001, 11:23-25, 12:24-47, 15:8-9.

239. Furthermore, typical page setup options on pop-up printer windows routinely included such parameter choices for selection by the layman user.

5: The method of claim 1 in which the conforming at the information apparatus at least part of the content into one or more output images includes one or more of a rasterization operation, a scaling operation, an interpolation operation, a decoding operation, an encoding operation, a filtering operation and a compression operation.

240. Kemp taught print driver 282 "***prepare[d] image data for printing***" on a local printer or remote printer (EX1009, ¶[0048]), as well as explained that NPDL data was generated and encapsulated so it could be transmitted for printing. *See* discussion above for 1[f], 1[g]. Importantly, NPDL data encapsulation for transportation over a network constituted an "encoding operation." For instance, Kemp expressly disclosed "the NPDL data is packaged in HTTP [or] ***any other suitable transport protocol***[,]" which a POSITA would have recognized as employing an encoding operation. EX1009, ¶[0072]. As such, it would have been obvious that the conforming data content into image data for printing would have necessarily included an encoding operation since the printing would be performed at a printer in wireless communication (Bluetooth) with the information device that initiated the printing of the data content. In the Yamaguchi-Kammer-Kemp combination, a POSITA would recognize the NPDL data would be encoded for transport via Bluetooth.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

241. Also, as I previously discussed above (in Ground-1 13[m]), Bluetooth communications, regardless of the type of content being transmitted (e.g., voice or text or image data), used a modulation technology to encode digital information on the transmitter side, transmit the encoded information to the receiver, and decode the received encoded information on the receiver side. Here, the POSITA would have recognized that the packaging of the NPDL data would use a specific modulation technique for encoding the data to be transmitted from the user's wireless device—such as by Bluetooth—and subsequently decoded at the output device, such as Yamaguchi's interface box.

6: The method of claim 1 in which the content includes one or more of a text, a graphics element data, a video data, an audio data, and an image data.

242. Yamaguchi taught the electronic document ("content") included "a variety of different content formats" that includes text, graphic elements, and images, such as "HTML, XML, WML, Microsoft Word®, WordPerfect®, JPEG, GIF." EX1006, 1:22-25.

7: The method of claim 1 in which the output controller is included in the output device.

243. Kemp did not expressly disclose that its service provider server (output controller) was included in the output device, but this would have been obvious in view of Kemp's disclosure. As explained in [1f], the output controller in the

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Yamaguchi-Kammer-Kemp combination could be a small device with only basic communication capabilities over Bluetooth. See 1[f] *supra*. Therefore, a POSITA would have found it obvious to include the output controller as part of the printer, especially in a space-confined environment, such as "a kiosk in an airport or a mall." EX1009, ¶¶[0038], [0056].

244. Kemp stated that the service provider server 20 "need not be a server per se" (EX1009, ¶[0039]), and only needed basic communications capabilities. *Id*. As a result, it did not need to be bulky or have expansive capabilities, especially in the scenarios where it was implemented in a booth or at a kiosk. During the 2001 timeframe, Bluetooth-enabled devices were well known and Bluetooth communications had been implemented in printers and other devices. Therefore, it would have been obvious to a POSITA that one option of implementing the Kemp's generic printing approach was to include the print management software capability for the example server 20 in a controller device in the printer.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

3. Claim 9

9[pre]: A pervasive mobile data output method for rendering content to an output device from a mobile wireless information apparatus, the content being at least partly accessible with the information apparatus, the output device being a distinct device from the information apparatus and including a wireless communication unit, the method comprising:

245. See 1[pre] and 1[i]. 9[pre] differs from 1[pre] by reciting the "information apparatus" is "a mobile wireless information apparatus" and "the output device being a distinct device from the information apparatus and including a wireless communication unit." These features are explained in 1[pre] and 1[i], respectively.

9[a]: opening a wireless communication channel at the information apparatus;

246. See 1[b].

9[b]: searching wirelessly at the information apparatus for wireless output devices available for wireless communication;

247. See 1[c].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

9[c]: receiving over the wireless communication channel at least one device attribute associated with at least one available wireless output device, the device attribute including at least an indication of a supported output device profile;

248. See 1[d], referring to 13[c] (Ground-1). Furthermore, as explained in 1[g], the '402 Patent states that any single attribute can form the "output device profile." *See* EX1001, 9:47-53 ("an output device profile ***may contain one*** or more of the following fields and or attribute descriptions"). Accordingly, either or both of the "user friendly name" or the "IP address" discussed in 1[d] and 1[g] constitutes the claimed indication of a supported output device profile.

249. See also [4], demonstrating Kemp described "print driver interface 13 provides a graphical user interface [displayed on] computer 10 when print driver 282 is activated [for] selecting a print option[,]" presenting a menu display, which user renders the document based on the selected printer having a "user-friendly name" ("attribute") such as HP C Laserjet 4500-HP. EX1009, FIGS. 6A-6B-7, ¶¶[0052]-[0058].

9[d]: selecting a wireless output device found in the search based at least in part on the received device attribute;

250. See 1[e].

**Lexmark, Exhibit 1003
Lexmark v. Flexiworld**

9[e]: conforming at the information apparatus at least part of the content into one or more device independent output images with at least one predefined or standard parameter;

9[f]: generating at the information apparatus an intermediate output data that includes said one or more output images, the intermediate output data conforming at least partly to said supported output device profile of a selected output that is included in said device attribute of the selected wireless output device and received over the wireless communication channel;

251. See 1[f]-1[g]. Regarding 9[e]'s conforming "with at least one predefined or standard parameter," this limitation would have been obvious because Kemp disclosed that "driver rendering engine 14 … ***render[ed] the print job into a neutral printer definition language (NPDL)***[,]… a language that is not specific to any type of printer." EX1009, ¶[0068]. The generation of this type of generic data would have entailed conformance with predefined or standard parameters, as implied by the name "neutral ***printer definition language***."

9[g]: establishing a point to point wireless connection between the information apparatus and the selected output device;

252. See 1[h]. Both Yamaguchi and Kammer taught establishing a wireless Bluetooth connection between wireless devices, and Kammer specifically disclosed "Bluetooth system supports both ***point-to-point*** and point-to-multi-point connections." EX1007, [7:3-4].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

9[h]: delivering the intermediate output data over the wireless connection for rendering at the selected wireless output device;

253. See 1[i].

9[i]: decoding at the output device the intermediate output data;

254. See 13[m] (Ground-1), demonstrating Kammer taught "baseband processing" that a POSITA would recognize involves encoding/decoding of the data suitable for transmission, i.e., decoding on the output side. EX1007, 7:25-8:19.

9[j]: converting at said output device the intermediate output data into an output data format acceptable for rendering by an output engine included in said output device, and

9[k]: sending the output data to the output engine for rendering,

255. See 1[j] and 1[k].

9[l]: whereby the wireless information apparatus is able to pervasively output one or more images representative of said content to an output device without need to install an output device driver specific to that output device.

256. See 1[l].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

4. Claims 10-12

10: The method of claim 9 in which establishing a wireless connection with the selected wireless output device comprises authenticating wireless access to the output device by sending over the wireless communication channel one or more of a name, a password or security code, an ID number or address, a signatures, a physical or digital security key, biometrics, a fingerprints, and a voice.

257. See 13[e]-13[i] (Ground-1).

11: The method of claim 9 in which the receiving at least one attribute over the wireless communication channel comprises receiving one or more of a device name, a device type, an address or ID number, an indication of a supported device profile, a device profile, and a security code.

258. See 1[d], referring to 13[c] (Ground-1).

12: The method of claim 9 in which the intermediate output data conforms at least partly to said at least one device attribute received over the communication channel and relating to the selected output device.

259. See 9[f] and 9[c].

5. Claim 13

13[pre]: A method of mobile wireless data output from an information apparatus with access to at least part of a content to a wireless output device by short range wireless communication, wherein the information apparatus includes at least one wireless communication unit and is a distinct device from the output device, the method comprising:

260. See 13[pre] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

13[a]: opening a wireless communication channel;

261. See 13[a] (Ground-1).

13[b]: discovering wirelessly one or more wireless devices that are available for wireless connection;

262. See 13[b] (Ground-1).

13[c]: receiving over the wireless communication channel an attribute corresponding to each discovered wireless device, the attribute including one or more of a name, a device type, a device address, and an indication of a supported output device profile;

263. See 13[c] (Ground-1) discussing the combination of Yamaguchi and Kammer.

13[d]: selecting a wireless output device from among the one or more discovered wireless devices based at least in part on the received attribute;

264. See 13[d] (Ground-1).

13[e]: obtaining a security key at the information apparatus, the security key enabling wireless data transfer to the selected output device;

265. See 13[e] (Ground-1).

13[f]: sending a security code related at least partly to the security key over the wireless communication channel and requesting the selected wireless output device to open a wireless connection channel for data transfer;

266. See 13[f] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

13[g]: receiving over the wireless communication channel a response related to an authentication; and

13[h]: if the received response is positive,

267. See 13[g]-13[h] (Ground-1).

13[i]: establishing a wireless connection channel between the information apparatus and the selected wireless output device,

268. See 13[i] (Ground-1).

13[j]: conforming, at the information apparatus, at least part of the content into an output data encoded with at least one format, the conforming relating at least in part to the attribute received over the wireless communication channel, and

269. See 1[f]-1[g] (Ground-3). Yamaguchi and Kemp taught this limitation.

13[k]: transferring the output data from the information apparatus to the selected output device over said wireless connection channel for rendering

270. See 1[i] (Ground-3). Yamaguchi and Kemp taught this limitation.

13[l]: receiving at the selected output device the output data,

271. In the combination, the NPDL-rendered data was transmitted by the wireless device and received by the output controller (service provider server). Notably, Kemp disclosed "print driver rendering engine 14 … render[ed] the print job into a neutral printer definition language (NPDL)," (EX1009, ¶[0068]) and that the "rendered NPDL data ***[wa]s packaged in a transport protocol for transport*** …

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

and [was] ***transmitted from print driver 282 to service provider server 20.***" EX1009, ¶[0072]. It would have been obvious that the transmitted content would be received at the output device, which performed additional processing as described below.

13[m]: performing at the selected output device at least one decoding operations on said output data, and

272. See 13[m] (Ground-1) and 9[i] (Ground-3), demonstrating Kammer's "baseband processing" that a POSITA understood involved encoding/decoding. EX1007, 7:25-8:19.

13[n]: converting the output data into an output engine data acceptable for rendering by an output engine included in the selected output device.

273. See 1[j] (Ground-3). The combination of Yamaguchi-Kammer-Kemp taught this limitation. EX1009, ¶[0087], FIG. 10, S125; *see also* ¶¶[0056], [0068].

6. Claims 14-21

14: The method according to claim 13 in which the information apparatus is one of a mobile phone, a digital camera, a laptop, and a PDA.

274. See [14] (Ground-1).

15: The method according to claim 13 in which the output device is one of a printer, a projection, a copier, a speaker, an audio output device, a display screen, and a TV.

275. See [15] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

16: The method of claim 13 in which discovering one or more output devices includes one or more output devices posting their availability as discoverable and the information apparatus finding one or more output devices.

276. See [16] (Ground-1).

17: The method of claim 13 further comprising:

obtaining a payment information at the information apparatus, the payment information enabling data rendering service by the selected output device;

sending the payment information over the wireless communication channel and requesting the selected wireless output device to open a wireless connection channel for enabling data rendering service.

277. See [17] (Ground-1).

18: The method of claim 13 in which the conforming, at the information apparatus, related at least in part to the supported output device profile of the selected output device and included in said attribute received over the wireless communication channel.

278. See 1[f]-1[g] (Ground-3). Yamaguchi and Kemp taught this limitation.

279. See also 13[c] (Ground-1) discussing the combination of Yamaguchi and Kammer's teaching of "attribute" reception.

19: The method of claim 13 in which said security key comprises at least one of a user name, password, ID number, signatures, physical or digital security key, biometrics, fingerprints, and a voice.

280. See 13[e] and 13[f] (Ground 1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

20: The method of claim 13 in which the step of obtaining said security key comprises inputting by a user or retrieving a key that was previously stored in the information apparatus.

281. See 13[e] (Ground 1).

21: The method of claim 13 further comprising:
receiving at the output device and over the wireless communication channel established a security key for authentication;
comparing the received security key with an access control list stored in the output device or input by a user; and
if the step of comparing the received security key with an access control list is successful, granting the information apparatus a secured wireless connection channel access to the output device.

282. See [21] (Ground 1).

7. Claim 23

23[pre]: A pervasive mobile data output method for rendering at an output device content that is at least partly accessible with an information apparatus, the information apparatus being a distinct device from the output device and including a wireless communication unit, the output device including a wireless communication unit for wireless communication, a controller for decoding intermediate output data received at the output device, and a rendering engine, the pervasive mobile output method comprising:

283. See 1[pre] and 9[pre]. 23[pre] differs from 1[pre] by reciting the output device includes "a controller for decoding intermediate output data received at the output device, and a rendering engine."

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

284. Kemp disclosed an output controller in the form of a "service provider server." See 1[i] in this Ground 3 for detailed explanation for how the "service provider server" is integrated into the Yamaguchi-Kammer-Kemp combination and why it forms the claimed "output controller."

285. Regarding the "decoding" and "rendering engine" limitations, Kemp disclosed "the ***service provider server*** [output controller] ***convert[ed]*** the NPDL print data into a printer specific format based on the printer selected by the operator and ***submit[ted] the print data to the printer for printing***." EX1009, ¶[0087], FIG. 10, S125; *see also* ¶¶[0056], [0068]. Thus, Kemp's service provider server (output controller) decoded the NPDL data (intermediate output data) so it would be in a printer-specific format and provided it to the printer, which included a rendering engine.

23[a]: accessing at the information apparatus at least part of said content;

286. See 1[a].

23[b]: opening at the information apparatus a wireless communication channel;

287. See 1[b], referring to 13[a] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

23[c]: searching wirelessly at the information apparatus for wireless output devices available for wireless communication;

288. See 1[c], referring to 13[b] (Ground-1).

23[d]: receiving at the information apparatus and over the wireless communication channel at least one attribute corresponding to each wireless output device found in the search;

289. See 1[d], referring to 13[c] (Ground-1).

23[e]: selecting at the information apparatus a selected wireless output device found in the search based at least in part on a received attribute, the selected wireless output device having an associated output controller;

290. See 1[e]. Also see 1[d], referring to 13[c] (Ground-1).

23[f]: conforming at the information apparatus at least part of the content into one or more output images;

23[g]: generating at the information apparatus an intermediate output data that includes said one or more output images; the intermediate output data being at least partly compatible with said received attribute of the selected wireless output device;

291. See 1[f] and 1[g].

23[h]: establishing a wireless connection between the information apparatus and the selected wireless output device;

292. See 1[h], referring to 13[i] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

23[i]: wirelessly transmitting the intermediate output data from the information apparatus to the selected wireless output device where the intermediate output data are decoded for rendering at the output device.

293. See 1[i]. Also see 9[h] and 9[i].

8. Claims 24-27

24: The method of claim 23 in which establishing a wireless connection with the selected wireless output device comprises authenticating wireless access to the output device by sending over the wireless communication channel one or more of a name, a password or security code, an ID number or address, a signature, a physical or digital security key, biometric, a fingerprint, and a voice.

294. See 13[e]-13[i] (Ground-1).

25: The method of claim 23 in which the receiving at least one attribute over the wireless communication channel comprises receiving one or more of a device name, a device type, an address or ID number, an indication of a supported device profile, a device profile, and a security code.

295. See 1[d].

26: The method of claim 23 in which the conforming at the information apparatus of at least part of the content into one or more output images includes one or more of a rasterization operation, a scaling operation, an interpolation operation, a decoding operation, an encoding operation, a filtering operation and a compression operation.

296. See [5].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

27: The method according to claim 23 in which the information apparatus is one of a personal computer, a mobile phone, a smart phone, a digital camera, a laptop, and a PDA.

297. See [14] (Ground-1).

9. Claim 28

28[pre]: A pervasive mobile data output method for rendering content to an output device from a mobile wireless information apparatus, the content being at least partly accessible with the information apparatus, the output device being a distinct device from the information apparatus and including a wireless communication unit, the method comprising:

298. See 9[pre], also referring to 1[pre] and 1[i].

28[a]: opening a wireless communication channel at the information apparatus;

299. See 9[a], referring to 1[b].

28[b]: searching wirelessly at the information apparatus for wireless output devices available for wireless communication;

300. See 9[b], referring to 1[c].

28[c]: receiving over the wireless communication channel at least one device attribute associated with at least one available wireless output device, the device attribute including at least an indication of a supported output device profile;

301. See 9[c], referring to 1[d], 13[c] (Ground-1), and [4].

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

28[d]: selecting a wireless output device found in the search based at least in part on the received device attribute;

302. See 9[d], referring to 1[e].

28[e]: conforming at the information apparatus at least part of the content into one or more device independent output images with at least one predefined or standard parameter;

28[f]: generating at the information apparatus an intermediate output data that includes said one or more output images, the intermediate output data conforming at least partly to said supported output device profile of a selected output that is included in said device attribute of the selected wireless output device and received over the wireless communication channel;

303. See 9[e] and 9[f], also referring to the discussion at 1[e] and 1[f].

28[g]: establishing a point to point wireless connection between the information apparatus and the selected output device; and;

304. See 9[g], also referring to 1[h].

28[h]: delivering the intermediate output data over the wireless connection for rendering at the selected wireless output device for rendering.

305. See 9[h], referring to 1[i].

**Lexmark, Exhibit 1003
Lexmark v. Flexiworld**

10. Claims 29-32

29: The method of claim 28 in which establishing a wireless connection with the selected wireless output device comprises authenticating wireless access to the output device by sending over the wireless communication channel one or more of a name, a password or security code, an ID number or address, a signature, a physical or digital security key, biometric, a fingerprint, and a voice.

306. See 13[e]-13[i] (Ground-1).

30: The method of claim 28 in which the receiving at least one attribute over the wireless communication channel comprises receiving one or more of a device name, a device type, an address or ID number, an indication of a supported device profile, a device profile, and a security code.

307. See 1[d].

31: The method according to claim 28 in which the information apparatus is one of a personal computer, a mobile phone, a smart phone, a digital camera, a laptop, and a PDA.

308. See [14] (Ground-1).

32: The method according to claim 28 in which the output device is one of a printer, a projection, a copier, a speaker, an audio output device, a display screen, and a TV.

309. See [15] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

11. Claim 33

33[pre]: A method of mobile wireless data output from an information apparatus with access to at least part of a content to a wireless output device by short range wireless communication, wherein the information apparatus includes at least one wireless communication unit and is a distinct device from the output device, the method comprising:

310. See 13[pre] (Ground-1).

33[a]: opening a wireless communication channel at the information apparatus;

311. See 13[a] (Ground-1).

33[b]: discovering wirelessly one or more wireless devices that are available for wireless connection;

312. See 13[b] (Ground-1).

33[c]: receiving over the wireless communication channel an attribute corresponding to each discovered wireless device, the attribute including one or more of a name, a device type, a device address, and an indication of a supported output device profile;

313. See 13[c] (Ground-1), discussing the combination of Yamaguchi and Kammer.

33[d]: selecting a wireless output device from among the one or more discovered wireless devices based at least in part on the received attribute;

314. See 13[d] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

33[e]: obtaining a security key at the information apparatus, the security key enabling wireless data transfer to the selected output device;

315. See 13[e] (Ground-1).

33[f]: sending at least part of the security key over the wireless communication channel and requesting the selected wireless output device to open a wireless connection channel for data transfer;

316. See 13[f] (Ground-1).

33[g]: receiving over the wireless communication channel a response related to an authentication; and

33[h]: if the received response is positive,

317. See 13[g]-13[h] (Ground-1).

33[i]: establishing a wireless connection channel between the information apparatus and the selected wireless output device, and

318. See 13[i] (Ground-1).

33[j]: conforming, at the information apparatus, at least part of the content into an output data encoded with at least one format, the conforming relating at least in part to the attribute received over the wireless communication channel, and

319. See 1[f]-1[g] (Ground-3). Yamaguchi and Kemp taught this limitation.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

33[k]: transferring the output data from the information apparatus to the selected output device over said wireless connection channel for rendering.

320. See 1[i]/23[i] and 9[h]/28[h] (Ground-3).

12. Claims 34-37

34: The method according to claim 33 in which the information apparatus is one of a personal computer, a mobile phone, a smart phone, a digital camera, a laptop, and a PDA.

321. See [14] (Ground-1).

35: The method according to claim 33 in which the output device is one of a printer, a projection, a copier, a speaker, an audio output device, a display screen, and a TV.

322. See [15] (Ground-1).

36: The method of claim 33 in which the conforming, at the information apparatus, related at least in part to the supported output device profile of the selected output device and included in said attribute received over the wireless communication channel.

323. See [18], referring to 1[f]-1[g] (Ground-3) and 13[c] (Ground-1).

37: The method of claim 33 in which said security key comprises at least one of a user name, password, ID number, signature, physical or digital security key, biometric, fingerprint, and a voice.

324. See [19], referring to 13[e] and 13[f] (Ground-1).

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

D. Ground 4: Claim 8 is Obvious Over Yamaguchi, Kammer, Kemp, and Behlok

1. Claim 8

8: The method of claim 1 further comprising performing at the output controller one or more processing operations on the one or more output images included in the intermediate output data, the one or more processing operations including one or more of a color correction operation, a color matching operation, a color management operation, a scaling operation, an interpolation operation, a color space conversion, a compression operation, an audio processing and a halftoning operation.

325. As explained in 1[j], Kemp disclosed "the ***service provider server*** [output controller] ***convert[ed]*** the NPDL print data into a printer specific format based on the printer selected by the operator." EX1009, ¶[0087], FIG. 10, S125; *see also* ¶¶[0056], [0068]. Kemp, however, did not explicitly list the variety of processing operations that can be carried at the output controller to accomplish this task, but Behlok did.

326. Behlok titled, "Post Raster-Image Processing Controls for Digital Color Image Printing," was directed to a "system and method of printing a digital color image." EX1015, 1:8-10. Behlok explained a typical print processing operation that included producing a continuous tone (contone) image via raster image processing, which is sent to the print engine containing ***a half toner*** … [which] renders a raster

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

image for each of the print colors cyan, magenta, yellow and black (CMYK)." EX1015, 1:36-46.

327. Behlok also explained that an image processing station (IPS) 38 performed the "ripping operations" (EX1015, 5:18-22), and could further perform a long list of operations in preparing the image before sending to a print engine:

> IPS includes an image structure analysis processor 50 which selectively performs ***color-space conversion***, black page detection, background detection, segmentation, auto-windowing, auto-image enhancement and the like. Still further, the IPS includes an image manipulation processor 54 which selectively performs window tagging, rotation, filtering, ***scaling***, background suppression, ***color adjustment***, cropping and masking, annotation, and the like.

EX1015, 5:29-37.

Behlok FIG. 1 (annotated)

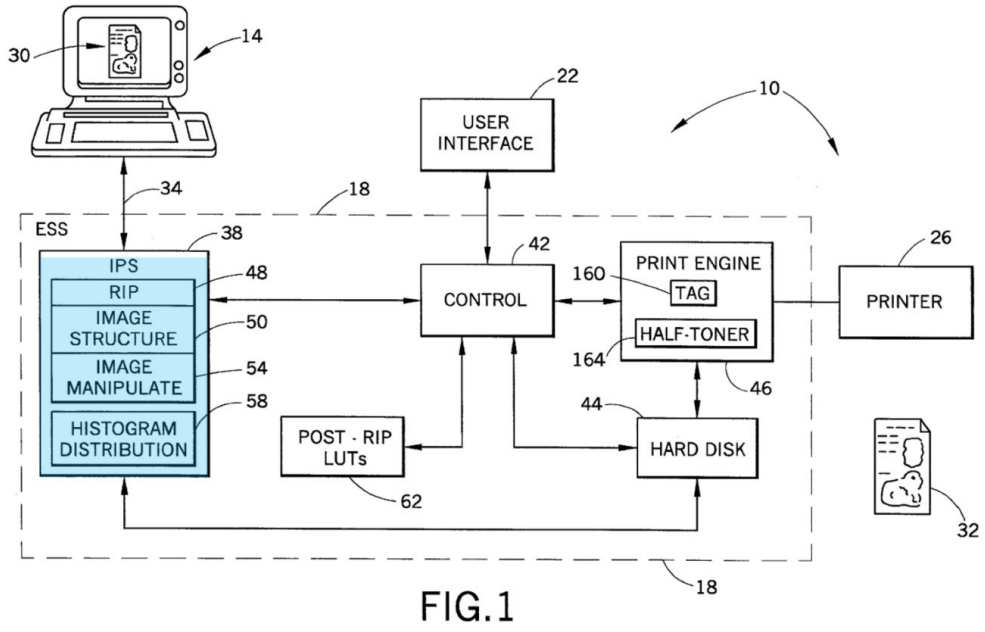


FIG.1

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

328. These common techniques for preparing an image included several operations that are also listed in Claim 8. In the Yamaguchi-Kammer-Kemp-Behlok combination, it would have been obvious to a POSITA to perform at least one of the above operations at the Kemp's service provider server (output controller), as part its processing operations that "***convert[ed]*** the NPDL print data into a printer specific format based on the printer selected by the operator." EX1009, ¶[0087].

329. Operations such a color-space conversion, color adjustment or color matching were common image processing operations that were well-known to a POSITA in the 2001 timeframe because they address the fact that output devices such as printers do not reproduce digital color the same way. For example, different printers may have different color gamuts (i.e., the range of colors they can reproduce). Furthermore, certain color representations, such as Red Green Blue (RGB) captured with a camera, differ from what can be created with another type of representation such as a printer that uses Cyan Magenta Yellow Black (CMYK). Thus, it would have been obvious to a POSITA to perform one or more of these operations in preparing the image before sending to a print engine, like described in Behlok, to create the final output so that it matches the desired and expected color and/or resolution.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

VIII. CONCLUSION

I hereby declare that all the statements made in this declaration are based on my own true knowledge, that all statements made on information and belief are believed to be true, and that all statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under the penalty of perjury under the laws of the United States that all statements made in this declaration are true and correct.

Dated this 20th day of April, 2023

Majid Rabbani
Dr. Majid Rabbani

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Majid Rabbani – Curriculum Vitae

Majid Rabbani
36 Wexford Glen
Pittsford, NY 14534-4206
+1-585-586-7025 Home
+1-585-506-7369 Cell
rabbani6@yahoo.com

Current Employment (since August of 2016)

Visiting Full Professor from 2016-2021 and Professor of Practice from 2021
Electrical Engineering Department
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623-5603

Education

Ph.D.	Electrical and Computer Engineering, 1983 University of Wisconsin-Madison Thesis Title: *Restoration of Nonlinearly Distorted Images* GPA - 4.0/4.0
M.S.	Electrical and Computer Engineering, 1979 University of Wisconsin-Madison GPA - 4.0/4.0
B.S.	Electrical Engineering, 1978 AryaMehr (now Sharif) Institute of Technology, Tehran, Iran GPA - 3.9/4.0 (Ranked 1st, five years in a row, in the entire school of engineering)
College Entrance	Ranked 2nd among 103,000 participants in the nationwide College Entrance Examination (*Concours*) in Iran - 1973.

Research Interests

Image and video compression research and standardization
Digital image & video processing and analysis
Computer vision, pattern recognition, and machine learning
Image security including data hiding, embedding, and encryption
Image and video enhancement, deblurring, and super-resolution

Honors and Awards (in chronological order)

- **SPIE Directors' Award** - presented to an individual who, in the opinion of the SPIE Board of Directors, has rendered a significant service of outstanding benefit to the Society (2016).
- **Electronic Imaging Scientist of the Year Award**, awarded by IS&T and SPIE *for fundamental contributions to image compression and for more than 25 years of sharing this knowledge through courses taught at EI* (2015).
- **Electronic Imaging Distinguished Educator Award**, awarded by IS&T and SPIE for *25 years of educational service to the electronic imaging community* (2012).
- IEEE **Region 1 Technical Award** for pioneering work in *image compression and digital watermarking* (2008).
- Co-recipient of the **Kodak C.E.K. Mees Award** (Kodak's highest honor for scientific research and reporting) for the Technical Report entitled "*Kodak Robust, Invisible Watermarking: Concepts, Performance, and Applications,*" (2005).
- Eastman Innovation Award Nominee for contributions to the JPEG2000 standard (2002).
- Inducted in the Kodak Inventors Gallery as a **Kodak Distinguished Inventor** for achieving the milestone of 20 issued patents (2002) – currently 44 issued patents.
- **Kodak Fellow** (2000)
- **Fellow of IEEE** – Citation: *For the development of image compression technology and products* (1998). *Currently a Life fellow.*
- **Kodak Senior Research Associate** (A rank held at that time by ~3% of Kodak researchers) (1997).
- Lifetime member of the Kodak Research Scientific Council (1997).
- Co-recipient of the **Emmy Engineering Award** granted by the National Academy of Television Arts and Sciences for contributions to and co-editorship role in the JPEG and MPEG standardization committees (1997).
- Kodak *Mittelstadt* instructor of the year award in recognition of excellence in development and teaching of digital image processing courses for the Kodak Image Science Career Development Program (1995).
- Recognition Award for the development and teaching of a course at the request of Kodak CTO on "Introduction to Digital Imaging" for 24 Kodak Senior VP's (1994).
- **Fellow of SPIE** (1993). *Currently a Life Fellow.*
- Co-recipient of the **Emmy Engineering Award** (for providing image compression research) granted by the National Academy of Television Arts and Sciences to Kodak in recognition of the Kodak Still-Video Transceiver System SV9600 (1990).
- Co-recipient of the **Kodak C.E.K. Mees** award (Kodak's highest honor for scientific research and reporting) as the principle author of the Technical Report entitled "*Detective Quantum Efficiency of imaging systems with amplifying and scattering mechanisms*," (1988).
- Recognition Award for achieving the highest GPA in the entire school of engineering and graduating with honors from the EE Department at the AryaMehr University (currently Sharif University), Tehran, Iran (1978).
- Recognition Award (personally received from the Iranian Prime Minister) for achieving the 2nd rank among 103,000 participants in the nationwide College Entrance Examination (*Concours*) in Iran (1973).

APPENDIX A

Newspapers, Magazines and Television Interviews (in chronological order)

- **Information Today** Magazine interview on the status of digital watermarking technology entitled "*The Copyright Capers Continue,*" Vol. 24, No. 9, October 2007.
- **El Pais** Spanish newspaper interview regarding leadership in JPEG2000 entitled "*Majid Rabbani: Es major desarrollar estandares abiertos que propietarious,*" Madrid, Spain, October 2, 2003.
- **Democrat and Chronicle** newspaper interview article for contributions to digital watermarking used in digital cinema entitled "*Kodak builds digital trap for movie pirates*," Rochester, NY, April 2001.
- **Persian Heritage** Magazine interview for technical accomplishments in the field of digital imaging (Majid's picture appeared on the cover page), No 18, Washington D.C., July 2000.
- **Photo Electronic Imaging** Magazine interview regarding the Photo CD product entitled "*A Lossless Explanation of Photo CD*," Vol. 37, No 2, 1994.
- **CBS** (Rochester local Channel 8) interview broadcasted at the Rochester CBS nightly news for directing the efforts of Los Alamos scientists in the digital enhancement of George Holliday's video of the beating of Rodney King and Majid's subsequent testimony as the prosecution expert witness in the Federal Court in Los Angeles, April 1993.
- **Iran Times** newspaper article regarding Majid's expert witness testimony in Rodney King's trial, Washington D.C., April 9, 1993.
- **Democrat and Chronicle** newspaper interview for expert witness testimony in Rodney King's trial, Rochester, NY, March 8, 1993.

Professional Activities

- Judge for granting the ICIP Best Paper Award, October 2020.
- Chair of Search Committee for Editor in Chief of the Journal of Electronic Imaging (2020)
- Chair of the SPIE Commercial + Scientific Sensing and Imaging Symposium, Anaheim, CA, April 2017.
- Associate Editor, IEEE Transactions on Circuits and Systems for Video Technology (CSVT), (2014-2018).
- Chair of the SPIE Fellows Committee responsible for selection of Fellows (2013-2017)
- Vice President, IS&T, (2015-2017).
- Co-Chair of the SPIE Commercial + Scientific Sensing and Imaging Symposium, Baltimore, MD, April 2016.
- Short Course Chair and Co-Chair, SPIE/IS&T Electronic Imaging Symposium, (2014-2016).
- Editorial Member of SPIE eBooks (2014-2015).
- Member of the IEEE IVMSP TC (Image, Video, and Multidimensional Signal Processing Technical Committee, which oversees the ICASSP and ICIP conferences) (2010-2015)
- Member of Electronic Imaging Symposium Steering Committee (EISC), (2010-2016).
- Symposium Chair, SPIE/IS&T Electronic Imaging Symposium (Symposium consisted of 23 conferences in the field of electronic imaging), Burlingame, CA, (January 2012).
- Symposium Co- Chair, SPIE/IS&T Electronic Imaging Symposium, Burlingame, CA, (January 2011).
- Member of the Program Committee of VICP, 2011-2015.
- Member of the SPIE Fellows Committee responsible for selection of Fellows (2010-2012)
- Technical Area Chair of IEEE ICIP 2019, ICIP 2018, ICIP 2016, ICIP 2015, ICIP2011, ICIP 2010, ICASSP 2016, ICASSP 2014, ICASSP 2013, ICASSP 2011.
- Conference co-chair, Visual Communication and Image Processing (VCIP) 2009, San Jose, CA, January 2009, (SPIE Vol. **7257**).
- Board Member of IEEE Signal Processing Magazine (SPM), (2008-2010).
- United States Patent and Trademark Office (USPTO) invited *Chief Technical Expert*. residing on site for one week each summer (2007 and 2008) as a consultant for planning and execution of a comprehensive training program of patent examiners in the field of digital image and video processing, (2007 & 2008).
- Chair of the IEEE Rochester Signal Processing Chapter, Rochester, NY (2007).
- Chair of Western NY Image Processing Workshop, Rochester, NY, (September 2007).
- Awards Committee Chair of the VCIP 2005 and 2006 Conferences, San Jose, CA.
- Industrial Research Chair for the National Sciences and Engineering Research Council (NSERC) of Canada "Digital Cinema" Project, (2004-2009).
- Industry representative to the *Digital Cinema Compression Experts Panel* of DCI (Digital Cinema Initiatives), which selected the digital cinema compression algorithm, (2003-2004).

- Technical Chair of the VCIP Conference, Lugano, Switzerland, (July 2003).
- Tutorial Chair of ICIP, Rochester, NY, (October 2002).
- Book review: "*JPEG2000: Image Compression Fundamentals, Standards and Practice*," Journal of Electronic Imaging, p. 286, Vol. 11, No 2, (April 2002).
- Member of the Program Committee of the IEEE Packet Video, (2000).
- Member of the IEEE IMDSP TC (Image, and Multidimensional Signal Processing Technical Committee, which oversees the ICIP and ICASSP conferences), (2000-2006).
- Chair of the Coding Efficiency subgroup (50 members) of JPEG2000 (1997-2000).
- Guest co-editor, special issue of Journal of Electronic Imaging on *Image/Video Compression and Processing for Visual Communications*, (July 1998).
- Conference co-chair, Visual Communication and Image Processing (VCIP) '98, San Jose, CA, January 1998, (SPIE Vol. **3309**).
- Symposium co-chair of the SPIE/IS&T Electronic Imaging, San Jose, CA, (January 1996).
- Conference co-chair "Still Image Compression: Algorithms and Technologies," SPIE/IS&T EI Symposium, (SPIE Vol. **2418**), (January 1995).
- Organized and chaired a 2-day event at the request of the National Research Council entitled "*Maintaining and Certifying Image and Instrument Integrity.*" Co-authored the Proceedings used by the Computer Science and Telecommunications Board (CSTB) to identify research topics and allocate government funding, Washington D.C., June 15-16, 1995.
- NSF Panelist, *Signal Processing for the National Information Infrastructure (NII)*, 49-page proceedings published by the NSF, August 18-19, 1994.
- NSF NYI Panel reviewer, Washington D.C., May 3, 1994.
- Directed an image processing team in Los Alamos National Laboratory to digitally enhance the George Holliday videotape of the beating of Rodney King, Los Alamos (November 1992-March 1993). Subsequently testified as the prosecution expert witness in Federal court in LA.
- Conference co-chair "Image and Video Compression," SPIE/IS&T EI Symposium, (SPIE Vol. **2186**), January 1994.
- Conference co-chair "Image and Video Processing," SPIE/IS&T EI Symposium, (SPIE Vol. **1903**), January 1993.
- Conference co-chair "Image Processing Algorithms and Techniques III," SPIE/IS&T EI Symposium, (SPIE Vol. **1657**), January 1992.
- Associate Editor, Journal of Electronic Imaging, 1991 (since its foundation)-present.
- Member of the Program Committee of VCIP, 1997-2005.
- Member of the Program Committee of DCC, 1997-present.
- Reviewer for IEEE TIP, Signal Processing Letters, Optical Engineering, Journal of Electronic Imaging, Image Communications Journal, etc.
- Member of technical committee of conferences and workshops (too many to enumerate).
- Session Chair at IEEE, SPIE and IS&T conferences since 1985 (too many to enumerate).
- Active reviewer for ICIP, VCIP, ICASSP, DCC, PCS (too many to enumerate).

Educational and Mentoring Activities

Visiting professor: RIT, EE Department, Fall 2016 - Present

1. Fall 2016	EEEE779 – Digital Image Processing
2. Fall 2016	EEEE678 – Digital Signal Processing
3. Spring 2017	EEEE781 – Image and Video Compression
4. Spring 2017	EEEE794 – Information Theory
5. Spring 2017	EEEE281 – Circuits I
6. Fall 2017	EEEE281 – Circuits I
7. Fall 2017	EEEE779 – Digital Image Processing
8. Fall 2017	EEEE678 – Digital Signal Processing
9. Spring 2018	EEEE281 – Circuits I
10. Spring 2018	EEEE781 – Image and Video Compression
11. Spring 2018	EEEE670 – Pattern Recognition
12. Summer 2018	1-day seminar on Machine Learning
13. Fall 2018	EEEE281 – Circuits I
14. Fall 2018	EEEE779 – Information Theory
15. Fall 2018	EEEE678 – Digital Signal Processing
16. Fall 2018	EEEE781 – Image and Video Compression
17. Summer 2019	1-day seminar on Machine Learning
18. Fall 2019	EEEE281 – Circuits I
19. Fall 2019	EEEE779 – Information Theory
20. Fall 2019	EEEE678 – Digital Signal Processing
21. Spring 2019	EEEE281 – Circuits I
22. Spring 2019	EEEE781 – Digital Image Processing
23. Spring 2019	EEEE670 – Pattern Recognition
24. Fall 2020	EEEE281 – Circuits I - Online
25. Fall 2020	EEEE602 – Random Signals and Noise (Online)
26. Fall 2020	EEEE678 – Digital Signal Processing
27. Spring 2020	EEEE281 – Circuits I - Online
28. Spring 2020	EEEE602 – Random Signals and Noise (Online)
29. Spring 2020	EEEE670 – Pattern Recognition

Adjunct professor: RIT, EE Department Graduate Program – 1985-1992, 2011-2016

1. *Digital Image Processing*, (graduate level course) fall semester 2015, fall semester 2014.
2. *Image and Video Compression* (graduate level course - online version), Spring semester 2016, Spring semester 2015, spring quarter 2014, summer quarter 2013.
3. *Image and Video Compression* (developed online version) winter quarter 2012-2013.
4. *Image & Video Compression* (developed the graduate course) spring quarter 2012.
5. *Information Theory* (graduate level course) winter quarter 2011-2012.
6. *Error Control Coding*, (graduate level course) 1987, 1989 & 1992.
7. *Pattern Recognition* (First time offering; developed the graduate course), 1985 & 1988.
8. *Information Theory and Coding* (First time offering; developed the graduate course), 1986.

Adjunct professor: University of Rochester, EE Department, 2012

1. *Digital Signal Processing* (EE246/446, fall semester 2012).

National Technological University (NTU) Advanced Technology Programs – 1989-2000

1. *Digital Image Compression* (Course MC891016A1), October 16 & 18, 1989.
2. *Digital Image Enhancement* (Course MC921210B1), December 10, 1992.
3. *Image and Video Compression Fundamentals and international Standards* (Course MC930422B1), April 22, 1993.
4. *Introduction to Electronic Imaging* (Course MC95051802), May 18, 1995.
5. *Introduction to Digital Image Processing* (Course MC97111292), November 12 & 19, 1997.
6. *Introduction to Electronic Imaging Systems* (Course EN00082399), August 23, 2000.
7. *Fundamentals of Wavelet Image Compression and the Emerging JPEG-2000 Standard* (Course EN00083091), August 30, 2000.

RIT Center for Imaging Science (CIS) and Technical and Education Center (T&E)

1. *Digital Image Restoration* – (1-day seminar), RIT CIS summer school, July 27, 1988.
2. *Digital Image Enhancement, Restoration and Compression* – (2-day seminar), RIT CIS 1989-1992.
3. *Digital Image Processing*– (4-day seminar), RIT T&E Center, 1998-2000.
4. *Digital Image & Video processing and Compression* – (4-day seminar), in collaboration with RIT T&E Center, VIGC, Turnhout, Belgium, 2001, 2002.
5. *Digital Image Processing* – (4-hour seminar as part of *Printing Process Identification and Image Analysis for Forensic Document Examiners*), twice a year, 2004-2018.

Portland State University (PSU) – 1995-2004

1. *Digital Image & Multimedia Compression* (3-day seminar), 1995-2001.
2. *Digital Image Watermarking & Compression* (2-day IEEE Lecture Series), 2002.
3. *Digital Image & Video Compression* (1-day IEEE Lecture Series), 2003, 2004.

MIT - 1993

Digital Image and Video Compression – 2-day invited seminar (invited by Professor Jae Lim) presented to the Consortium on Advanced Television Systems (CATS), January 11-13, 1993.

U.C. Berkeley Extension - 2003

JPEG2000: Theory and Practice – 2-day course at U.C. Berkeley Extension, March 24-25, 2003.

SPIE Educational Video/CD-ROM (currently marketed by SPIE for corporate training)

1. *Digital Image Enhancement* (5-hour video, VT558), 1993.
2. *Image and Video Compression Fundamentals and International Standards* (5-hour video, VT589), 1993.
3. *Introduction to Electronic Imaging* (5-hour video, VT051895), 1995.
4. *Introduction to Digital Image Processing* (10-hour video, VT245), 1997.
5. *Introduction to Electronic Imaging Systems* (5-hour CD-ROM, CDV064), 2000.
6. *Fundamentals of Wavelet Image Compression and the Emerging JPEG-2000 Standard* (5-hour video, VT080), 2000.

Internal to Eastman Kodak Company

- At the request of Kodak CTO, developed a 2-day class on *Introduction to Digital Imaging* for 24 Kodak Senior VP's (1994), which was also videotaped and used for corporate training.

- *Digital Image Processing* (2-day) class presented once a year to the "Image Science Career Development" Program, **1992-2004**. Majid was awarded the *Mittelstadt* instructor of the year award in 1995 for excellence in development and teaching of these courses.
- Taught courses on various topics of digital imaging at the Kodak Interplant Conference each year (1998-present).

Other Educational Activities

Additionally, Majid has taught about 70 short courses and seminars at the various SPIE, IS&T and IEEE conferences in the past 30 years. In January of 2012 he was awarded the "Electronic Imaging Distinguished Educator Award," by IS&T and SPIE for teaching short courses in the various areas of electronic imaging at the SPIE/IS&T flagship conference, the EI Symposium, for 25 consecutive years in the period of 1988-2012. He has continued teaching at that venue since then for a record 33 consecutive years.

APPENDIX A

Patents

1. Andrew Gallagher, Jiebo Luo, and Majid Rabbani, "Determining a Stereo Image From Video," US Patent 9,113,153 (2015).
2. Andrew Kurtz, Kurt Schroeder, and Majid Rabbani, "Spectral Visible Edge Marking For Steganography or Watermarking," US Patent 8,947,744 (2015).
3. Andrew Kurtz, Kurt Schroeder, and Majid Rabbani, "Spectral Edge Marking For Steganography or Watermarking," US Patent 8,941,886 (2015).
4. Paul Kane, Sen Wang, and Majid Rabbani, "Range Measurement Using Symmetric-Coded Apertures," US Patent 8,330,852 (2012).
5. Z. Sun and Majid Rabbani, "Enhancing Image Resolution of Digital Images," US Patent 8,289,395 (2012).
6. Jiebo Luo, *et al*, "Analyzing Camera Captured Video for Key Frames," US Patent 8,031,775 (2011).
7. Aaron Deever, *et al*, "Digital Camera Using Multiple Image Sensors to Provide Improved Temporal Sampling," US Patent 7,978,239 (2011)
8. Majid Rabbani *et al*, "Image Sequence Stabilization Method and Camera Having Dual Path Image Sequence Stabilization," US Patent 7,755667 (2010).
9. Rajan Joshi and Majid Rabbani, "Transcoding a JPEG2000 Compressed Image," US Patent 7,382,926 (2008).
10. Zhaohui Sun, Gabriel Fielding and Majid Rabbani, "Method and System For Video Filtering with Joint Motion and Noise Estimation," US Patent 7,295,616 (2007).
11. Rajan Joshi and Majid Rabbani, "Method for Transcoding a JPEG2000 Image," US Patent 7,200,277 (2006).
12. Michael Miller, Paul Jones, Jian Yang and Majid Rabbani, "Method and System for Displaying an Image," US Patent 7,075,553 (2006).
13. Thomas Stephany, Majid Rabbani, John Squilla, Donald Olson, "Method for Authenticating Animation," US Patent 6,993,162 (2006).
14. Michael Miller, Paul Jones, Jian Yang and Majid Rabbani, "Method and System for Displaying an Image," US Patent 6,985,158 (2006).
15. Paul Jones, Majid Rabbani, John Hoover, "Method and System for Determining DCT Block Boundaries," US Patent 6,895,122 (2005).
16. Majid Rabbani, Rajan Joshi, Kenneth Parulski, "Selectively Adjusting the Resolution Levels or the quality Levels of Digital Images Stored in a Digital Camera," US Patent 6,885,395 (2005).
17. Paul Jones, Chris Honsinger, Majid Rabbani, "Method and System for Embedding Message Data in a Digital Image Sequence," US Patent 6,870,931 (2005).
18. Majid Rabbani and Aaron Deever, "Digital Image Compression Utilizing Shrinkage of Wavelet Coefficients," US Patent 6,853,318 (2005).
19. Andreas Savakis, Majid Rabbani, Stephen Etz, "System and Method for Controlling Image Compression Based on Image Emphasis," US Patent 6,832,006 (2004).

20. Paul Jones, Chris Honsinger and Majid Rabbani, "System and Method for Embedding a Watermark Signal that Contains a Message Data in a Digital Image," US Patent 6,792,130 (2004).
21. Rajan Joshi, Bernard Brower, Kenneth Parulski and Majid Rabbani, "Producing a Compressed Digital Image Organized Into Layers Having Information Reating to Different Viewing Conditions and Resolution," US Patent 6,785,423 (2004).
22. Andrew Gallagher, Majid Rabbani, Edward Gindele and Robert Gray, "Method for Compressing an Image from a Sparsely Sampled Extended Dynamic Range Image Sensing Device," US Patent 6,765,611 (2004).
23. Thomas Henderson and Majid Rabbani, "Method for Compressing and Decompressing Digital having Text," US Patent 6,625,323 (2003).
24. Chris Honsinger, Majid Rabbani and Paul Jones, "Method for Efficient Rate Control," US Patent 6,356,668 (2002).
25. Paul Jones, Chris Honsinger and Majid Rabbani, "Method and Apparatus for Visually Optimized Compression Parameters," US Patent US Patent 6,349,151 (2002).
26. Chris Honsinger, Paul Jones, Majid Rabbani and James Stoffel, "Lossless Recovery of an Original Image Containing Embedded Data," US Patent 6,278,791 (2001).
27. Chris Honsinger, Majid Rabbani and Paul Jones, "Method and Apparatus for Visually Optimized Rate Control," 6,212,302 (2001).
28. Chris Honsinger and Majid Rabbani, "Method for Generating an Improved Carrier For Use in an Image Data Embedding Application," US Patent 6,044,156 (2000).
29. Jonathan Riek, Majid Rabbani and Arif Erdem, "Method and Apparatus for Encoding High Fidelity Still Images in MPEG Bitstreams," US Patent 5,987,179 (1999).
30. Majid Rabbani and Chris Honsinger, "Encoding Color Image Data for Multipass Color Printers," US Patent 5,956,467 (1999).
31. John Squilla, Omid Moghadam and Majid Rabbani, "Photographic System with Selected Area Authentication," US Patent 5,898,779 (1999).
32. Omid Moghadam, Majid Rabbani and Kevin Townsend, "Secure Photographic Systems," US Patent 5,801,856 (1998).
33. Bhavan Gandhi, Majid Rabbani and Rodney Miller, "Method and Apparatus for Suppressing Blocking Artifacts in Block-Transform Coded Images," US Patent 5,737,451 (1998).
34. Majid Rabbani, "Method and Apparatus for Reducing Quantization Artifacts in a hierarchical Image Storage and Retrieval System," US Patent 5,568,570 (1996).
35. Majid Rabbani and Paul Melnychuck, "Method and Associated Apparatus for Encoding Bitplanes for Improved Coding efficiency," US Patent 5,442,458 (1995).
36. Majid Rabbani and Craig Smith, "Electronic Camera Using Image Compression Feedback for Improved Color Processing," US Patent 5,412,427 (1995).
37. Yushing Tsai, Scott Daly and Majid Rabbani, "Image Compression with Color Interpolation for a Single Sensor Image System," US Patent 5,172,227 (1992).
38. Yushing Tsai, Kenneth Parulski and Majid Rabbani, "Compression Method and Apparatus for Single-Sensor Color Imaging Systems," US Patent 5,065,229 (1991).

APPENDIX A

39. Yushing Tsai, Kenneth Parulski and Majid Rabbani, “Compression Method and Apparatus for Single-Sensor Color Imaging Systems,” US Patent 5,053,861 (1991).
40. Paul Jones and Majid Rabbani, “Delta Modulation Encoder/Decoder Method and System,” US Patent 4,905,002 (1990).
41. Paul Jones and Majid Rabbani, “Differential Pulse Code Modulation scheme Incorporating a Reconstructed Value Constrainer,” US Patent 4,847,866 (1989).
42. Scott Daly, Majid Rabbani and Cheng-Tie Chen, “Digital Image Compression and Transmission System Visually Weighted Transform Coefficients,” US Patent 4,780,761 (1988).
43. Scott Daly, Majid Rabbani and Cheng-Tie Chen, “Adaptive Block Transform Image Coding Method and Apparatus,” US Patent 4,774,574 (1988).
44. Cheng-Tie Chen, Majid Rabbani and Scott Daly, “Image Transmission System with Preview Mode,” US Patent 4,774,562 (1988).

APPENDIX A

Books

1. M. Rabbani and P. W. Jones, *Digital Image Compression Techniques,* SPIE Tutorial Text Series, **TT7**, Bellingham, WA, Feb. 1991. (*This book has gone through seven printings and has sold about 7,000 copies, breaking the sales record of any SPIE publication*).
2. M. Rabbani (editor), *Selected Papers on Image Coding and Compression*, SPIE Milestone Series, **MS48**, Bellingham, WA, Apr. 1992.

Book Chapters

1. Majid Rabbani, Rajan Joshi and Paul W. Jones, "JPEG2000 Core Coding system (Part 1)" *The JPEG2000 Suite*, Schelkens *et al*, Editors, pp. 3-69. John Wiley & Sons, 2009.
2. R. Chandramouli, Nasir Memon, Majid Rabbani, "Digital Watermarking," in *The Encyclopedia of Imaging Science and Technology*, Joseph P. Hornak, Editor, Vol 1, pp. 158-172, John Wiley & Sons, 2002.
3. P. W. Jones and M. Rabbani, "JPEG Compression in Medical Imaging," in *Handbook of Medical Imaging, Volume 3. Display and PACS,* Yongmin Kim and Steven C. Hori, Editors, pp. 221-275, SPIE Press, Bellingham, WA, 2000.
4. P. W. Jones and M. Rabbani, "Digital Image Compression," in *Digital Image Processing: Fundamentals and Applications,* E. Dougherty, Editor, Marcel Dekker, New York, 1995.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Invited Presentations, Plenary or Keynote Speeches

1. Majid Rabbani (invited seminar) "Super-resolution: Traditional and Deep Learning Based Approaches" RIT Center for Imaging Science Seminar Series, April 21, 2021.
2. .Majid Rabbani (RIT MSEE Graduate Seminar Presentation), "Image Understanding" Rochester Institute of Technology, April 6, 2018.
3. Majid Rabbani (invited seminar) "Importance of Motion in Digital Video Processing" IEEE Signal Processing Society Seminar, Rochester Institute of Technology, April 4, 2017.
4. Majid Rabbani (RIT MSEE Graduate Seminar Presentation), "Motion Processing," Rochester Institute of Technology, March 24, 2017.
5. Majid Rabbani (invited speaker), "Advances and Challenges in Image Understanding," Presentation at the SPIE Fellows Luncheon during SPIE DCS, Baltimore, MD, April 18, 2016.
6. Majid Rabbani (invited workshop), "Advanced Image Processing," Image Sensors (IS) Americas Conference, Berkeley, CA, November 17, 2015 (http://www.image-sensors.com/image-sensors-americas/pre-conference-workshop).
7. Majid Rabbani (RIT MSEE Graduate Seminar Presentation), "Image Understanding," Rochester Institute of Technology, November 6, 2015.
8. Majid Rabbani (invited talk), "Event-Based Frameworks for Multimedia Content Management," Penn State University EE Colloquia, February 16, 2012.
9. Majid Rabbani (2-hour invited seminar), "Understanding and Interpreting Images and Video," VCIP Conference, Huangshan, China, July 11, 2010.
10. Majid Rabbani (plenary talk), "Understanding and Interpreting Images – An Overview," ICSCCW, Cypress, September 2, 2009.
11. Majid Rabbani (invited talk at the request of local IS&T Chapter), "Opportunities in Video," RIT Center for Imaging Science, September 26, 2008.
12. Majid Rabbani (invited lecture), "The JPEG2000 Wavelet Based Compression Standard," 2-hour lecture at the US Patent and Trademark Office (USPTO), July 24, 2008.
13. Majid Rabbani (invited lecture), "Video Processing Algorithms," 2-hour lecture at the US Patent and Trademark Office (USPTO), July 23, 2008.
14. Majid Rabbani (invited lecture), "Contrast Enhancement," 2-hour lecture at the US Patent and Trademark Office (USPTO), July 22, 2008.
15. Majid Rabbani (invited lecture), "Image Deblurring and Sharpening Algorithms," 3-hour lecture at the US Patent and Trademark Office (USPTO), July 19, 2007.
16. Majid Rabbani (invited lecture), "Digital Image Watermarking," 3-hour lecture at the US Patent and Trademark Office (USPTO), July 18, 2007.
17. Majid Rabbani (invited lecture), "The JPEG2000 Compression Standard," 3-hour lecture at the US Patent and Trademark Office (USPTO), July 17, 2007.
18. Majid Rabbani (invited talk), "Robust Invisible Watermarking," in Frontiers In Imaging, International Congress of Imaging Science (ICIS'06), Rochester, NY, May 11, 2006.
19. Majid Rabbani (invited talk), "The JPEG2000 wavelet-based still image compression standard", RIT Department of Mathematics and Statistics Colloquia Series, February 3, 2006.

20. Majid Rabbani (distinguished lecture), "Digital Watermarking: Technology and Applications," SPIE Workshop on Images, Buenos Aires, November15, 2005.
21. Majid Rabbani (plenary talk), "Robust Invisible Digital Watermarking of Images", Western New York Image Processing Workshop, RIT, September 30, 2005.
22. Majid Rabbani and Bernie Brower (invited lecture), "The JPEG 2000 Image Compression Standard: A new generation of capabilities," University of Rochester IEEE Student Branch, February 7, 2005.
23. Majid Rabbani (invited seminar), "The Emerging JPEG2000 Compression Standard: Technology and Practice," 3-hour seminar sponsored by IEEE Spain, Madrid, Sep. 19, 2003.
24. Majid Rabbani (invited lecture) "Robust Invisible Digital Watermarking of Images," 1-hour lecture at RIT Center for Imaging Science Seminar Series, March 14, 2003.
25. Majid Rabbani and Bernard Brower (invited lecture) "The JPEG2000 Wavelet-Based Still Image Compression Standard: Status Report and Implementation Demo," 90-minute lecture at the Rochester Chapter of IEEE Signal Processing Society, CEIS, February 19, 2003.
26. Majid Rabbani (invited lecture) "Invisible Digital Watermarking of Images," 1-hour lecture at the request of the Rochester Chapter of IS&T, RIT, November 13, 2002.
27. Majid Rabbani (distinguished lecture) "Invisible Digital Watermarking of Images," Center for Advanced Computer Studies, Distinguished Lecture series, UL Lafayette, Nov. 1, 2002.
28. Majid Rabbani (invited seminar) "Digital Image Watermarking" ECE Graduate Seminar Series, University of Rochester, May 2001.
29. Majid Rabbani (distinguished lecture) "Invisible Digital Watermarking of Images," IEEE Signal Processing Society Colloquia, UT-Dallas, October 26, 2001.
30. Majid Rabbani (invited talk), "A Technical Overview of the JPEG2000 Standard," ISO Meeting, Singapore, March 5, 2001.
31. Majid Rabbani (invited plenary talk), "Review of Watermarking Technologies," Photo Marketing Association (PMA), Las Vegas, Nevada, January 30, 2000.
32. Majid Rabbani (plenary talk), "Review of State-of-the-art Digital Image Watermarking Technologies", Western New York Image Processing Workshop, September 17, 1999.
33. Majid Rabbani (invited lecture), "The Emerging JPEG2000 Compression Standard" 1-hour lecture at the IEEE Colloquium, Cornell University, December 1, 1998.
34. Majid Rabbani (invited lecture), "The JPEG2000 Emerging Still-Image Compression Standard," IEEE Signal Processing Society Rochester Section, September 1997.
35. Majid Rabbani (invited panelist), "Digital Video" IEEE Rochester Section Joint Chapters Meeting, March 12, 1997.
36. Majid Rabbani (invited seminar), "Digital Image Processing," 2-hour seminar for Society for Information Display (SID) Annual Meeting, May 14, 1995.
37. Majid Rabbani (invited lecture), "Image Compression Fundamentals" SMPTE Annual Forum – "The Compression Experience", Rochester, NY, October 28, 1995.
38. Majid Rabbani (distinguished lecture), "Digital Image Compression," 1-hour lecture at Portland State University (PSU), May 26, 1995.

APPENDIX A

39. Majid Rabbani (distinguished lecture), “Digital Image Compression: Research and Standardization,” 90-min lecture at University of Nevada Las Vegas (UNLV), July 28, 1994.
40. Majid Rabbani (invited seminar), “Digital Image Enhancement,” 75-minute seminar for Society for Information Display (SID) Annual Meeting, June 13, 1994.
41. Majid Rabbani (guest lecture), “World Standards in Image Data Compression” IEEE Rochester Section Joint Chapters Meeting, February 5, 1992.
42. Majid Rabbani (invited lecture), “Status of World Standardization in Image Data Compression”, RIT Center for Imaging Science, October 22, 1991.
43. Majid Rabbani (invited lecture), “Digital Image Compression: The New International Standards” Polytechnic University Imaging Colloquia, NYC, October 1, 1991.
44. Majid Rabbani (invited seminar), “Digital Image Compression,” 2-hour seminar for Society for Information Display (SID), Las Vegas, NV, May 14, 1990.
45. Majid Rabbani (invited lecture), “Digital Image Compression” IEEE Computer Society Rochester Chapter, May 9, 1990.
46. Majid Rabbani (invited seminar), “Digital Image Restoration” RIT Electrical Engineering Seminar Series on DSP, March 31, 1987.
47. Majid Rabbani (invited seminar), “Recent Advances in Image Compression Techniques” RIT Center for Imaging Science Seminar Series, November 12, 1986.

Refereed Journal Publications

1. M. Park, J. Luo, A. Gallagher, and Majid Rabbani, "Learning to Produce 3D Media from a Captured 2D Video," *IEEE Transactions on Multimedia*, **15**(7), pp. 1569-1578, Nov. 2013.
2. M. Rabbani and Rajan Joshi (invited paper), "An Overview of the JPEG2000 Still Image Compression Standard" *Signal Processing: Image Communications,* **17**(1), pp. 3-48, Jan. 2002.
3. J. R. Price and M. Rabbani, "Biased reconstruction for JPEG decoding," *Signal Processing Letters*, **6** (12), pp. 297-299, Dec. 1999.
4. M. Rabbani and P. Melnychuck, "Conditioning contexts for the arithmetic coding of bit planes," *IEEE Trans. Signal Proc.*, **40**, pp. 232-236, Jan. 1992.
5. M. Rabbani and P. W. Jones (Invited Paper), "Image compression techniques for medical diagnostic imaging systems," *Journal of Digital Imaging*, **4**, pp. 65-78, May 1991.
6. R. L. VanMetter and M. Rabbani, "An application of multivariate moment generating functions to the analysis of signal and noise propagation in radiographic screen-film systems," *Medical Physics*, **17**, pp. 65-71, Jan/Feb 1990.
7. M. Rabbani and R. L. VanMetter, "An analysis of signal and noise propagation for several imaging mechanisms," *J. Opt. Soc. of Am. A*, **6**, pp. 1156-1164, Aug. 1989.
8. M. I. Sezan, M. Rabbani, and P. W. Jones, "Progressive transmission of images using a prediction/residual encoding approach,"" *Optical Eng.*, **28**, pp. 556-564, May 1989.
9. M. Rabbani, "Bayesian filtering of Poisson noise using local statistics," *IEEE Trans. Acoust. Speech and Signal Proc.,* **36**, pp. 933-937, June 1988.
10. M. Rabbani, R. Shaw, and R. VanMetter, "Detective Quantum Efficiency of imaging systems with amplifying and scattering mechanisms,"" *J. Opt. Soc. Am. A,* **4** pp. 895-901, May 1987.
11. M. Rabbani, L. A. Ray, and J. R. Sullivan, "Adaptive predictive coding with applications to radiographs," *Medical Instrumentation*, **20**, pp. 182-191, Aug. 1986.
12. P. D. Burns, M. Rabbani, and L. A. Ray, "Analysis of image noise due to position errors in laser writers," *Appl. Opt.*, **25**, pp. 2158-2168, July 1986.
13. M. Rabbani and B.E.A. Saleh, "Bayesian filtering of speckled images," *Optics Communications*, **53**, pp. 147-152, Mar. 1985.
14. M. Rabbani and B.E.A. Saleh, "Bayesian restoration of partially coherent imagery in conventional and scanning microscopy," *Optica Acta*, **31**, pp. 63-79, 1984.
15. M. Rabbani and B.E.A. Saleh, "Restoration of bilinearly distorted images. 3: Constrained least-squares method," *Appl. Opt.*, **22**, pp. 3549-3554, Nov. 1983.
16. B.E.A. Saleh and M. Rabbani, "Restoration of bilinearly distorted images: II. Bayesian method," *J. Opt. Soc. Am.*, **73**, pp. 71-75, Jan. 1983.
17. B.E.A. Saleh and M. Rabbani, "Restoration of bilinearly distorted images: I. Finite impulse response linear digital filtering," *J. Opt. Soc. Am.*, **73,** pp. 66-70, Jan. 1983.
18. B.E.A. Saleh and M. Rabbani, "Simulation of partially coherent imagery in the space and frequency domains and by modal expansion," *Appl. Opt.*, **21**, pp. 2770-2777, Aug. 1982.
19. B.E.A. Saleh and M. Rabbani, "Linear filtering of speckled images," *Optics Communications*, **35**, pp. 327-331, Dec. 1980.

Conference Presentations/Proceedings Publications

1. S. Sah, R. Longman, A. Shringi, R. Loce, M. Rabbani, R. Ptucha, "Detection without Recognition for Redaction", *CVPR Workshop The First International Workshop on The Bright and Dark Sides of Computer Vision: Challenges and Opportunities for Privacy and Security*, Honolulu, Hawaii, July 2017.
2. Minwoo Park, Jiebo Luo, Andrew Gallagher, Majid Rabbani, "Learning to Produce 3D Media from a Captured 2D Video," *MM '11 Proceedings of the 19th ACM international conference on Multimedia*, pp 1557-1560, December 2011.
3. Majid Rabbani and Chris Honsinger (invited talk), "Robust Invisible Watermarking," in Frontiers In Imaging, *International Congress of Imaging Science (ICIS'06),* Rochester, NY, May 11, 2006.
4. Peter Burns, Scott Houchin, Ken Parulski, and Majid Rabbani, "Using JPEG2000 in Future Digital Cameras," *Proceedings International Congress of Imaging Science 2002,* Tokyo, SPSTJ, pp. 371, May 2002.
5. Rajan L. Joshi, Majid Rabbani, and Margaret Lepley, "Comparison of multiple compression cycle performance for JPEG and JPEG2000," *Proceedings of SPIE Applications of Digital Image Processing XXIII*, San Diego, **4115**, pp. 492-501, 31 July – 3 August, 2000.
6. K. Parulski and M. Rabbani, "The Continuing Evolution of Digital Cameras and Digital Photography Systems," *IEEE International Symposium on Circuits and Systems - ISCAS 2000*, Geneva, Switzerland, pp. V-101 to V-104, May 2000.
7. Jeffery R. Price and Majid Rabbani (Speaker), "Dequantization bias for JPEG decompression," *IEEE International Conference on Information Technology: Coding and Computing (ITCC2000),* Las Vegas, NV, pp. 30-35, Mar. 2000.
8. Chris Honsinger and Majid Rabbani (Speaker), "Data embedding using phase dispersion," *International Conference on Information Technology: Coding and Computing (ITCC2000),* Las Vegas, NV, Mar. 2000.
9. Majid Rabbani (invited presentation), "Overview of the state-of-the-art watermarking technologies," PMA 2000, Las Vegas, NV, February 2000
10. M. Rabbani, (Invited paper) "Review of the state-of-the-art watermarking technologies," *1999 Western New York Image Processing Workshop*, Rochester, NY, Sept. 1999.
11. M. Rabbani and K. Parulski (Invited paper), "Digital cameras," *IEEE Signal Processing Magazine*, **15**, pp. 28, Mar. 1998.
12. M. Rabbani (Invited paper), "Image compression: past, present, and future," *Image Tech Conference,* Atlanta, GA, Mar. 1996.
13. P. Jones, S. Daly, R. Gaborski, and M. Rabbani, "Comparative study of wavelet and DCT decompositions with equivalent quantization and encoding strategies for medical images," *Proceedings of SPIE Medical Imaging,* **2431**, pp. 571, Feb. 1995.
14. M. Rabbani and S. Dianat, "DPCM image compression using artificial neural networks,'" *Proceedings of SPIE, Image and Video Processing*, **1903**, Feb. 1993.
15. M. Rabbani and R. Shaw, "A parametric image simulation of a radiographic screen-film system," *Proceedings of World Congress on Medical Physics and Biomedical Engineering*, Kyoto, Japan, July 1991.

16. M. Rabbani and P. Jones (Invited Seminar), "Digital image compression," *Seminar Lecture Notes, Society for Information Display,* pp. M-5.1 - M-5.42, Las Vegas, NV, May 1990.
17. R. L. VanMetter and M. Rabbani, "Analysis of the effects of depth dependence of x-ray interactions on the MTF and NPS of radiographic screens," *Proceedings of SPIE, Medical Imaging IV,* **1231**, pp. 271-275, Feb. 1990.
18. M. Rabbani (Invited Paper), "Restoration techniques for quantum limited images," *Proceedings of the Opt. Soc. of Am. Topical Meeting on Quantum-Limited Imaging and Information Processing*, **13**, pp. 30-33, June 1989.
19. M. Rabbani (Speaker) and R. L. VanMetter, "Some new applications of multivariate moment-generating functions to screen-film systems," *Proceedings of SPIE, Medical Imaging III*, **1090**, pp. 86-94, Feb. 1989.
20. M. Rabbani (Speaker) and S. Daly, "An optimized image data compression technique utilized in the KODAK SV9600 still video transceiver," *Proceedings of SPIE, Optical Sensors and Electronic Photography*, **1071,** pp. 246-256, Jan. 1989.
21. P. W. Melnychuck and M. Rabbani, "Survey of lossless image coding techniques," *Proceedings of SPIE, Digital Image Processing Applications,* **1075**, pp. 92-100, Jan. 1989.
22. M. Rabbani (Speaker) and R. L. VanMetter, "Analysis of signal and noise propagation for several imaging mechanisms," *Annual Meeting of the Opt. Soc. of Am.*, Santa Clara, CA, Nov. 1988.
23. M. Rabbani (Speaker) and R. Shaw, "The influence of grain threshold on quantum mottle in radiographic screen-film systems II," *Proceedings of SPIE, Medical Imaging II*, **914 A**, pp. 117-127, Feb. 1988.
24. M. Rabbani (Invited Paper), "Use of local statistics in adaptive filtering of Poisson noise," *Proceedings of The 26th IEEE Conference on Decision and Control*, pp. 1210-1212, Dec. 1987.
25. M. I. Sezan, C. L. Yeh, A. M. Tekalp, M. Rabbani and P. Jones, "Application of vector quantization to progressive encoding and transmission of images," *SPIE Cambridge Symp. on Optics in Med. and Visual Image Proc.,* Oct. 1987.
26. M. Rabbani (Speaker) and R. Shaw, "The influence of grain threshold on quantum mottle in radiographic screen-film systems," *Proceedings of SPIE, Medical Imaging*, **767**, pp. 226-235, Feb. 1987.
27. M. Rabbani (Speaker), R. Shaw, and R. VanMetter, "Detective quantum efficiency of imaging systems with amplifying and scattering mechanisms," *Annual meeting of the Opt. Soc. of Am.*, Seattle, WA, Oct. 1986.
28. M. Rabbani, "Restoration of images degraded by Poisson noise," *Proceedings of the International Electronic Image Week,* **2**, pp. 769-775, Nice, France, Apr. 1986.
29. R. Shaw and M. Rabbani, "Fundamental statistical limitations to x-ray quantum detection," *Proceedings of the Opt. Soc. of Am. Topical Meeting on Quantum Limited Imaging*, pp. 59-62, Apr. 1986.
30. R. Shaw and M. Rabbani, "A comparison of physical autocorrelation and digital Wiener spectrum techniques for screen-film evaluation," *Proceedings of SPIE, Medicine XIV*, **626**, pp. 76-81, Feb. 1986.

APPENDIX A

31. R. VanMetter, P. L. P. Dillon, K. E. Huff, and M. Rabbani, "Computer simulation of radiographic screen-film images," *Proceedings of SPIE, Medicine XIV*, **626**, pp. 82-99, Feb. 1986.
32. P. Jones and M. Rabbani, "Application of adaptive delta modulation to document and text image compression," *Proceedings of the SPSE 25th Fall Symposia Imaging,* pp. 139-142, Nov. 1985.
33. M. Rabbani (Speaker), L. Ray, and J. R. Sullivan, "Low-distortion compression of radiographs," *Proceedings of Image Science '85*, **1**, pp. 99-102, Helsinki, Finland, June 1985.
34. P. L. P. Dillon, J. F. Hamilton, M. Rabbani (Speaker), R. Shaw, and R. L. VanMetter, "`Principles governing the transfer of signal modulation and photon noise by amplifying and scattering mechanisms," *Proceedings of SPIE, Medicine XIII,* **535**, pp. 130-139, Feb. 1985.
35. M. Rabbani (Speaker) and B.E.A. Saleh, "Bayesian filtering of speckled images," *Annual Meeting of the Opt. Soc. of Am.*, San Diego, CA, Oct. 1984.
36. M. Rabbani (Speaker) and B.E.A. Saleh, "Bayesian restoration of partially coherent imagery in microscopy," *Annual Meeting of the Opt. Soc. of Am.*, New Orleans, LA, Oct. 1983.
37. B.E.A. Saleh and M. Rabbani (Speaker), "Bayesian restoration of partially coherent distorted images," *Annual Meeting of the Opt. Soc. of Am.*, Tucson, AZ, Oct. 1982.

APPENDIX B

MOBILE Jamie Spencer

History Of The Cell Phone (1973 to 2023)

Do you remember a time when you didn't have a cell phone?

Although we are all accustomed to having smartphones in our life, there was a time, not so long ago, where we just didn't have such convenient lines of communication.

TRENDING

1 **Screen Resolution Guide – 720p vs 1080p vs 1440p vs 4K vs 8K**

2 **Windows Remote Desktop Part 1: Setting Up**

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

In this guide, we go right back to the very beginning to see how we got to the modern day smartphones such as the iPhones and the Samsung Galaxies.

Come with us as we explore the development of the mobile phone and travel through the history of this life changing device!

2 **Traditional Access**

3 **Windows Remote Desktop Part 2: Setting Up Web Access**

4 **NetIQ's Qcheck**

5 **Using Zeroconf on Linux: What Is It Good For?**

1973 – The Very First Cell Phone

Motorola developed the first portable cell phone in 1973. The hand-held device was shaped like a brick and weighed around 2.4 pounds. It was called the DynaTAC 8000X.

The device only operated for a maximum of 30 minutes talk time, and that was with a huge 10 hours of charging!

The very first call that was made was by Martin Cooper, who was an executive at Motorola. He called Dr. Joel Engel, an engineer at their rival business, Bell Labs.

Screen Resolution Guide – 720p vs 1080p vs 1440p vs 4K vs 8K

A Guide To The Different Types of Monitor Ports

What is PASV mode?

Monitor Jargon Explained

How To Do A Backlight Bleed Test

What's The Difference Between DVI-I and DVI-D?

Computer Turns On But Monitor Says No Signal (How To Fix – No signal to monitor)

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



The very first mobile device wasn't cheap. The cost of the DynaTAC phone was $3,995, which is equivalent to $10,000 in today's money.

In fact, if you wanted to buy the DynaTAC 8000X today, you will need a lot more than $10k!!

CATEGORIES

Computing

Featured

File Sharing

Gaming

General

Guides

Hardware

Home Working

Internet Sharing

Mobile

Networking

News

Questions

Resources

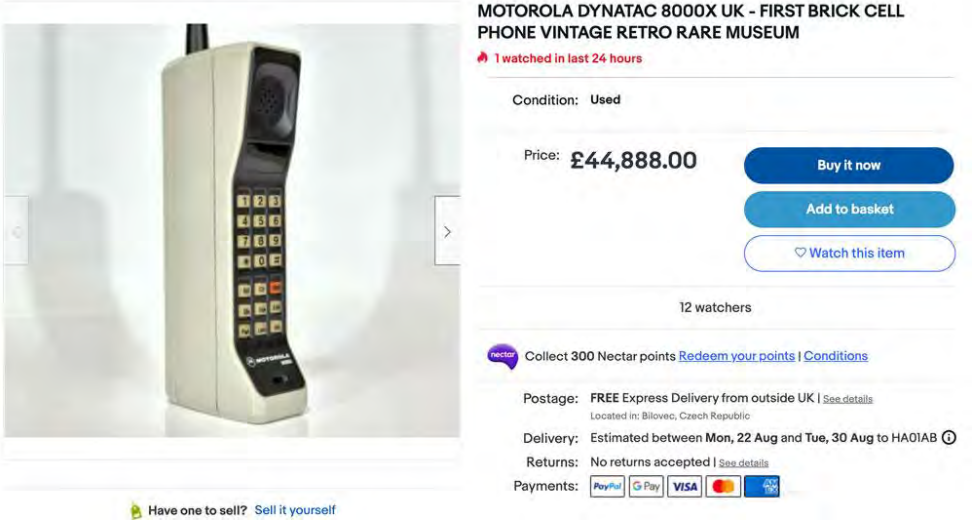
Reviews

Roblox

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Check out this eBay listing!! £44,888 will get you a mint condition Motorola DynaTAC 8000X.



Security
Sharing
Support
Tech Guides
Tools
Troubleshooting
WAN

1983 – Motorola DynaTAC

It took Motorola another 10 years before they brought out the commercially available DynaTAC 8000X.

The DynaTAC, which was still large and expensive ($4,000), was still clunky and heavy. However, it wasn't until 1989 that the Motorola MicroTac, a flip phone small enough to put in a shirt pocket, signalled the start of phones getting smaller.

The DynaTAC became synonymous with the 80s. It featured in so many TV series and movies of that era.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



The phone's most famous appearance was in Wall Street, used by Gordon Gecko (Michael Douglas), and was one of the earliest and undoubtedly the most well-known early cell phones.



The DynaTAC appeared in Saved by The Bell.

APPENDIX B

It served primarily as a status symbol, more than a functioning cell phone.

1985 – Siemens Mobiltelefon C1



The Siemens Mobiltelefon C1, which resembled a briefcase, was the company's first mobile phone. You will probably think this is strange, but people used cell phones that looked like briefcases, as it was the only way to have enough charge when you were out and about town. From this, phones then became more compact in the wake of this model.

1987 – Mobira Cityman 900 – The Very First Nokia

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The Mobira Cityman 900, Nokia's first mobile phone, was introduced in 1987. The phone was seen as pricey and only available to those of a higher status and weighed just 800g (28 oz) when the battery was included. The phone measured 183 × 43 × 79 mm.

The Cityman's movie claim to fame came in the 1987 movie Lethal Weapon, which includes multiple sequences where the Cityman 900 is prominently used.

In Finland, the phone was known as "Gorba."



This was due to the fact that Mikhail Gorbachev, General Secretary of the Communist Party of the Soviet Union, called Moscow during a news conference from the Hotel Kalastajantorppa in October 1989 using a Cityman 900 that had been given to him.

1987 – GSM

In 1987, the common standard agreed upon was called GSM. It got this name from the Groupe Spécial Mobile who came up with it, but eventually changed to Global System for Mobile Communications.

The early cellular networks used analogue signals, but the GSM system transmitted digitally -making it a 'second generation,' or 2G, system.

The new phones would use one radio frequency band, 900 MHz, throughout Europe instead of multiple bands. This would allow users to have a signal no matter where they were. The phone design also included features like SMS (texting) and increased security measures.

Other nations swiftly followed suit, opting to adopt the GSM standard, which was an enormous leap forward compared to what was available in the United States.

1988 – Samsung Releases Their First Phone

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B



Samsung created the SH-100, its first “handphone,” a year later, in 1988. It was the first officially made and designed mobile phone in Korea.

Its display was so small that text messages were impossible to see. Only the dialled or incoming number was able to be seen.

The electronic image on the display was always black back then because all cell phone displays were monochromatic.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The SH-100 was characteristic of the Motorola period, when mobile phones were just starting to become commonplace but were still considered luxury goods.

1989 – The Start Of The Flip Phone Era – Motorola MicroTAC

After many years of the brick phone, Motorola innovated once more by introducing the “flip” design to the market. The name of this model was the **“Motorola MicroTAC”** and was the smallest and lightest phone available at the time.

For a number of years, Motorola produced several comparable brick-style cell phones. Prior to Motorola’s MicroTAC model, the majority of cell phones were large and frequently mounted in vehicles or carried around like briefcases.



The MicroTAC pioneered a revolutionary “flip” design in which the “mouthpiece” flipped over the keypad. However, in later production, the “mouthpiece” and ringer were actually housed in the phone’s base. This established the bar and served as the prototype for contemporary flip phones.

1992 – The first mass-produced GSM (2G) phone

APPENDIX B



The Nokia 1011 was based on the analogue Nokia 101, which had a similar appearance. The day and month of release—10 November 1992—were referenced in the moniker "1011."

By 1992, the antennas and phone bodies had both shrunk from the days of the brick phones. The next significant development was the Nokia 1011, the first

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

GSM (2G) phone to be mass-produced, which was introduced in 1992.

Contrary to popular belief, the Nokia 1011 was not the first GSM phone. A year earlier, the British-made Orbitel TPU 900 was introduced.



Orbitel TPU 900 – The very first GSM phone

1992 – The Year of The First Text Message

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



The first text message on a mobile phone was developed by British software programmer Neil Papworth.

The first text message was also sent that year. The corporate director received it from developer, Neil Papworth, at Vodafone's holiday office party. Neil was asked to develop a messaging system.

Simply put, the SMS message said, "Merry Christmas!"

1994 – Smartphones Arrive

Many more years earlier than most people realise saw the debut of the first smartphone. The IBM Simon, which was introduced in 1994, is regarded as the first smartphone in history because it was the first gadget to include apps and a touchscreen.

Although this first smartphone failed to catch on, “normal” cell phones continued to become more and more popular while being smaller and more diverse in their designs. After the introduction of slider phones and other flip phones, Motorola innovated once again.

1996 – Vibrating Phones



Motorola StarTAC – The first vibrating and clamshell designed phone.

The Motorola StarTAC was the first vibrating phone as well as the first clamshell phone.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

It was hailed as a marvel of ingenuity and was widely regarded as the first flip cell phone. Motorola was praised for once again being ahead of the curve.

In 2005, StarTAC was listed by PC World as one of the top 50 devices of the previous 50 years.

1996 – First Phone With A Keyboard



The Nokia Communicator 9000, which was first made available in 1996, included a QWERTY keyboard. It was Nokia's first smartphone. The Communicator 9000 provided a number of business-related functions in addition to a keyboard, including email, web browsing, faxing, word processing, and spreadsheets.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

And it accomplished this long before Blackberry came to represent the mobile professional.



Nokia 9000 Communicator (left) and Nokia E7 Communicator / Wikipedia

1997 – First Phone With No External Antenna

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B



The Hagenuk GlobalHandy was the first phone to arrive without a discernible external antenna.

It was a stylish, ergonomically designed German phone that created history by becoming the first to do away with an external aerial.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The GlobalHandy is undoubtedly a comfortable phone in the hand, and its practical design is typical of other German goods. The keyboard's simplicity did have one glaring flaw, though. There are only numbers; no letters. This required messaging via an awkward menu system, which was difficult to use.

Can the GlobalHandy still be used today? Yes it still can function as a working phone.

Today's value: $35 – $50

1998 – Launch of Nokia 5110



In 1999, it sponsored London Fashion Week, which was an immediate success and helped establish the trend for customising your phone.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The Nokia 5110 launched the early 2000s demand for mobile phones with interchangeable cases. People wanted the ability to change the color of their phones, without the need to buy a completely new device.

The Nokia 5110 became a popular accessory. It gradually lost its edge, as it was a mid-range phone rather than a luxury device.

The original Nokia covers were metallic and included seven colour ranges: ‘Antiqua Red, ‘Bermuda Blue’, ‘Island Yellow’, ‘Geeko Green’, ‘Shark Silver’ and ‘Tango Orange’.

1998 – Color Comes To Mobile Phone Screens

APPENDIX B



The first cell phone with a colour screen, the Siemens S10, was introduced in 1998 and was a game-changer. It

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

could show up to six lines of text, however the number of lines that could be shown may be reduced if the font size was increased to make the text easier to read.

1998 – 3G Network Launches

The third-generation mobile network's introduction was another significant occasion that year. It's important to note that the same year that personalised ringtones were introduced, they also became the first downloadable material for mobile devices.

1999 – Launch of First tri-band GSM phone

With the introduction of the Motorola Timeport, the first phone with global compatibility, Motorola accomplished yet another advancement.

1999 – Launch of WAP browser cell phone

Not only Motorola, but Nokia also introduced a product with a ground-breaking function this year. The first cell

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

phone with a WAP browser that allowed users to browse the internet was the Nokia 7110.

1999 – Launch of First phone + MP3 player

In 1999, Samsung released the Samsung SPH-M100 Uproar, a revolutionary phone of their own, not happy to let Motorola and Nokia have all the limelight. It gave the user the option of playing music by fusing the characteristics of a cell phone with an MP3 player. Even a dedicated play/pause button was strategically situated on the phone.

1999 – Launch first cell phone to feature a splash-proof case

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



The Nokia 5210 was one of the more popular models at the time and was the first cell phone to have a splash-proof cover.

1999 – First phone ever to feature GPS capabilities

The Benefon Esc! was the first phone to ever have GPS capabilities when it was released in the same year.

1999 – First camera phone

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



There is some disagreement over who invented the first camera phone. Although some claim it was the Sharp J-SH04, it was actually the Kyocera VP-210 VisualPhone, a Japanese phone that had debuted a year earlier. It has a front-facing camera but just 20 photographs' worth of memory.

In the years that followed, other producers started to roll out their own camera phones, which increased in storage capacity and megapixel count.

2000 – A Legend Was Born



The size and weight of phones has increased at the turn of the millennium. Launched in 2000, the Nokia 3310 not only become one of the most recognisable phones ever, but it is still among the top-selling smartphones today.

2001 – The first phone having features for IR, radio, and calendar



The Nokia 8310 was the first phone with all of these features, but it wasn't inexpensive. The cell phone originally cost $500 when it was launched in 2001. It was manufactured by Nokia between 2001 and 2002.

It had high-end capabilities like infrared and a fully functional calendar that were unusual for phones at the time, and it was the first Nokia phone to offer GPRS and an FM radio.

2001 – Cell phone with Bluetooth



The Ericsson T39 was the first Bluetooth cell phone, and other manufacturers soon followed suit in releasing this innovation. It was the follow-up to the T28 and T29.

It came in three colors; Classic Blue (dark blue – photographed above), Icecap Blue (light blue) and Rose White (cream). The T39 was the final Ericsson phone to feature an active flip and an external antenna.

2001 – Symbian OS cell phones arrive

APPENDIX B



The Nokia 7650 was both the first Nokia phone with an integrated camera and the first mass-market Symbian OS phone.

It was just what the industry needed. Basic phones were as cheap as they were going to get and with nearly everyone who wanted one having one. Manufacturers and network providers needed a reason for people to go out and buy another mobile phone. Many hoped the Nokia 7650 would be the reason.

The 7650 was actually a smartphone as well. The UI, which provided messaging, WAP internet access, image management, a calendar, to-do lists, and a coloured version of the well-known Nokia Snake game, was powered by the Symbian OS v6.1.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

2002 – Phones With Photo Display Function



2002 was the year that technology arrived in the form of the Sanyo SCP-5300, a phone that allowed users to view images directly on the screen without connecting the device to a computer. Additionally, this ground-breaking phone had a camera with flash and two colour screens.

Again, with Nokia and Motorola dominating marketplaces all over the world, phones kept getting smaller and more powerful.

When Nokia unveiled the 7610, their first smartphone with a 1-megapixel camera, the camera game also advanced. They also unveiled the Nokia 6630, the first genuine worldwide roaming phone.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

2002 – The First Blackberry Smartphone was Released – BlackBerry 5810

In 2002, the first BlackBerry phones were released. The new “smartphones,” which provide cellular phone service, wireless e-mail functionality, and Internet access, completely revolutionised business communication. BlackBerry-compatible phones rapidly became available from cellular phone companies.



One of the first Java-based devices with a built-in mobile phone, but a headset was needed, was the Blackberry 5810. It debuted in 2002 and was designed more for corporations and businesses than for consumers.

The 5810 sported a monochrome 160 by 160 pixel display and operated on a 2G network. The 5000 series

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

also included the 5790 and 5820.

2002 – Sidekick was released in 2002



The Hiptop was rebranded as the Sidekick by T-Mobile. The Sidekick was like a little computer that individuals could carry around in their pockets, with a full keyboard that slid out from behind the screen.

During a presentation at Stanford in 2004, Joe Britt stated, “It was supposed to be an extraordinarily low-cost item that you could use to carry information with you.” He was a founding member of Danger, the team behind the Sidekick.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

2005 – Fully Waterproof Phone



In 2005, the first water-resistant phone appeared. It was the Casio G'zOne, capable of withstanding submersion up to one metre deep.

The Casio G'zOne phones came in three colours and included a digital camera, 2.2-inch QVGA screen, 1.0-inch round screen on the outside, lighted clock, stopwatch, and electronic compass.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

2007 – Another Legend is Born – iPhone 1



In 2007, one of the most significant occasions in cell phone history happened. Due to the removal of the majority of physical hardware buttons in favour of a touch-based interface, the first iPhone, also known as the iPhone 2G, was released and completely surprised everyone.

Although the iPhone was groundbreaking at the time, the BlackBerry outperformed it and continued to be popular. Everyone was enamoured with the Blackberry thanks to BBM instant messaging, including teenagers, businesspeople, and rappers.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

2008 – The Android Phone Arrives



The HTC Dream was the first Android phone with the Linux-based Android operating system, to be commercially released. Although the Android operating system was critiqued for its lack of functionality and connection with third-party apps, it was nevertheless hailed as revolutionary for its notifications system and Google service integration.

The HTC Dream was also known as the **T-Mobile G1** in the US and Europe. In Poland it was known as **Era G1**.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

2009 – 4G

In 2009, Norway and Sweden were the first countries to commercially implement the Long Term Evolution (LTE) technology, which has now spread to most of the world.

2009 – Samsung Galaxy – The First Galaxy Phone



The first in what would become the long-running **Galaxy** series, the Samsung Galaxy phone, the GT-I7500, was introduced by Samsung the same year.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

2009 – First Phone with Google Maps

The Motorola Droid, which was released in the same year, was the first phone with the free Google Maps Navigator pre-installed. Although the 2009 model was not the first Android phone, it was probably the first significant one.



Additional innovation occurred in the ensuing years. In addition to the Retina display and FaceTime, Apple

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

released the iPhone 4. Additionally, it was the first iPhone with a front-facing camera.

2010 – First Samsung phone without front navigation buttons



The Samsung Galaxy S, the company's new flagship, was introduced in 2010. It boasted the quickest

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

graphical processing at the time and was the thinnest smartphone at 9.9mm.

2010 – First LTE (4G) smartphone

The Samsung SCH-R900, the first 4G smartphone, was also released by Samsung in the same year.

In 2010, several further innovative features hit the market. The Nexus S, the first Android smartphone with NFC, the Moto Defy, the first water-resistant Android smartphone, and Samsung's 8-megapixel Galaxy II were all introduced.

With a thickness of just 7.1 mm, Motorola's Razr was the thinnest phone available at the time, and Apple's iPhone 4S was the first smartphone to include Siri, the first personal digital speech assistant.



Motorola RAZR

The Sony Ericsson Xperia Play, a phone that resembles a gaming console and is targeted at the mobile gaming sector, was developed by Sony Ericsson.

The Motorola Atrix, the first phone with a fingerprint sensor, was produced by Motorola as part of its focus on enhancing security features.

2011 – Xiaomi smartphone

APPENDIX B



The Xiaomi Mi 1 was the company's first phone, released in 2011, and it was solely sold in Asian markets. It was originally priced at ¥1999, with over 300,000 pre-orders in the first 34 hours.

2012 – Galaxy S3



Lexmark, Exhibit 1003
Lexmark v. Flexiworld

A year later, Samsung released the Galaxy S3, a smartphone with its own personal voice assistant and cutting-edge capabilities like eye-tracking.

The groundbreaking Nokia Lumia 920 (which utilised the now-forgotten Windows Phone OS) was introduced at around the same time.



This phone was the first to include optical picture stabilisation, wireless inductive charging, and a highly sensitive capacitive screen (OIS).

2013 – iPhone 5s



In 2013, LG introduced the G2, Sony introduced the Xperia Z, and Apple released the iPhone 5S (their first phone with a fingerprint sensor).

2014



The OnePlus One was introduced in 2014, and then the South Korean goliaths Samsung and LG introduced some new technology. Samsung unveiled the Galaxy S5, the first smartphone with a heart rate monitor, while LG unveiled the G3, the first flagship with a QHD screen.

2015 – Curved Display

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B



The Samsung Galaxy S6 Edge, the first smartphone with curved display edges that enabled additional functionality, was released in 2015, a year later.

The Nexus 5X and Nexus 6P were among the Nexus phones that Google released, and the Google Pixel was the company's first entirely original phone. It was praised for having the best camera in its class and offered limitless cloud storage as an added benefit.

Best selling cell phone in 2015: Samsung Galaxy J7

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

2016 – First Smartphone with HDR Display



Sony introduced the Xperia XZ, the first smartphone with an HDR display, in 2016, and Motorola introduced the Moto Z, a smartphone with magnetic accessories that provide further functionality.

The same year, Apple released the iPhone 7 Plus, the first iPhone that was fully waterproof and had a dual-lens system but no headphone port.

Best selling cell phone in 2016: Samsung Galaxy S7

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

2017 – Face ID



The LG G6 smartphone with Dolby Vision was released in 2017, and Asus Zenfone AR set the standard for smartphones with 8GB of RAM.

A reproduction of the legendary Nokia 3310, which kept the same design aesthetic as the original but included contemporary capabilities like a camera and Bluetooth, likewise caught everyone off guard.

The Galaxy Note 8 was released by Samsung as a “safe bet,” the Pixel 2 was introduced by Google, the V30 was

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

released by LG, and the iPhone 8 was the first iPhone to support wireless charging.

The higher-end iPhone X, a smartphone that replaced the fingerprint sensor (Touch ID) with face unlock technology, may have been more significant to Apple enthusiasts (Face ID).

Axon M, a dual-screen smartphone introduced by ZTE, was unquestionably ahead of its time. Even more groundbreaking at the time was the ability to use many apps simultaneously.

Best selling cell phone in 2017: Xiaomi Redmi Note 4

2018 – First Cell Phone to Feature 3 Cameras

The Huawei P20 Pro, which had a 40 MP primary camera, a 20 MP secondary camera, and an 8 MP front camera, was the first smartphone to feature three cameras.

APPENDIX B



Huawei P20 Pro

The Honor 10 and OnePlus 6 were also announced as flagship devices this year, but the Vivo X20 Plus UD—the first smartphone to use an in-screen fingerprint sensor—may have been the most avant-garde.

The Red Hydrogen One, which could produce “holographic” videos and images but ultimately failed, deserves a mention as well.

The Hubble Phone, a cell phone designed by Turing Space Industries and modelled after the Hubble Space Telescope, was introduced that same year.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Best selling cell phone in 2018: iPhone X



Turning Hubble Phone.

The phone has a built-in 15x optical zoom camera, among other capabilities.

2018 – First Foldable Smartphone

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



The Royole Flexpai, the first commercially accessible foldable smartphone with an OLED display, was released in November 2018 by the Chinese startup Royole. It had a single 7.8-inch display that could be folded outward and was visible when open.

2018 – Largest Battery in a Mobile Phone



The Power 5 from Chinese company Ulefone features the largest battery ever seen in a mobile phone (13,000 mAh), which is more than four times bigger than Apple's flagship, the iPhone XS Max, which was released in the same year.

2019 – Launch of the 5G network

The first 5G phones and the fifth-generation network both debuted in 2019.

The Galaxy S10, iPhone XR, Huawei P30 Pro, OnePlus 7 Pro, Samsung Galaxy Fold, and Huawei Mate X were also introduced in 2019 along with the Xiaomi Mi Note

10, which was the first smartphone to have a 108 MP camera.

Best selling cell phone in 2019: iPhone XR

2020



Although folding display phones are still in their infancy, it appears that manufacturers are committed to making them widely available.

Second-generation folding phones were released by companies like Samsung, Motorola, and Huawei. The Samsung Galaxy Flip Z 5G, is one of the most notable folding display phones on the market in 2020.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Best selling cell phone in 2020: Samsung Galaxy A51

2020 – First Phone to Feature 5 Cameras – Nokia 9 PureView



The cameras on modern smartphones are getting more and more advanced as time goes on. The Nokia 9 PureView pushed the boundaries in camera technology by producing a cell phone that has 5 built in cameras.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

At the back of the Nokia 9 PureView, was five 12MP sensors. Three of these sensors are monochrome for better black-and-white photography, but only two of them are full-color.

It had a new technology called Light's Lux Capacitor camera control chip. This enabled the device to run all the five cameras at the same time smoothly.

2021

2021 was a year of production bottlenecks, shipment holdups, and chip shortages. However, despite all of this, manufacturers were still able to release a variety of new phones in 2021.

The most notable models was the Apple iPhone 13, 13 Pro and the Samsung Galaxy S21.

Apple's A15 Bionic chip, an IP68 water resistant rating, a Super Retina XDR screen with ProMotion and Ceramic Shield, ultra-wideband for using things like digital keys, Bluetooth 5, WiFi 6, and gigabit LTE were all packed in to the iPhone 13 Pro. This model is one of the largest iPhone models ever.

The 6.8-inch Quad HD+ Dynamic AMOLED 2X Infinity-O display on the Galaxy S21 Ultra 5G featured a resolution of 3200 x 1400 pixels and a pixel density of 515ppi (pixels per inch).

Four rear cameras (10-megapixel telephoto F2.4 and F4.9 units, 108-megapixel wide-angle, and 12-megapixel ultra-wide), HDR10+ certification, a 120Hz refresh rate, a 40-megapixel “hole-punch” front camera, and a pressure-sensitive S Pen are notable features.

Best selling cell phone in 2021: iPhone 12

2022

It’s difficult to predict which phones will make the largest impact this year because we are still in 2022, but we can be sure that 5G phones and foldable gadgets are on the rise. Apple is due to release the iPhone 14 later this year with rumours that Apple’s 2022 iPhones will feature a notchless display with a hole-punch camera, A16 chip, flush rear cameras and more.

As demand is anticipated to increase tenfold, Samsung’s foldable market share in 2023 may exceed 75%.

Also watch out for huge advancements in AI, Metaverse, Gaming and Augmented Reality features in 2023.

Share this post



Jamie Spencer

Jamie has been an avid gamer since the release of the Amiga 500 back in the early 1990s. He's the proud owner and author of makeawebsitehub.com a site that provides webmasters with valuable resources on how to build traffic and make money online from their blogs.

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

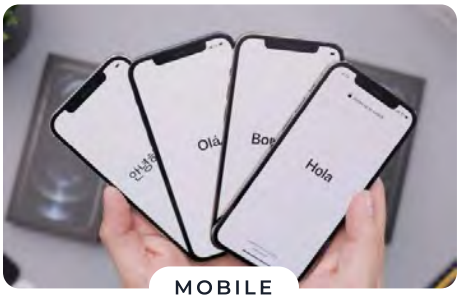
APPENDIX B

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

DO NOT SELL OR SHARE MY INFORMATION

RELATED POSTS

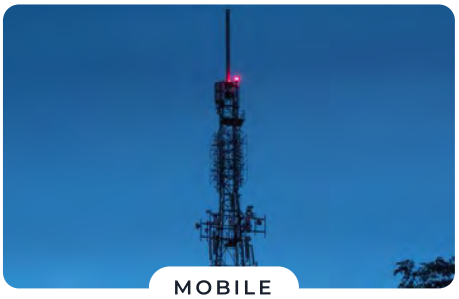


MOBILE

The Complete History of iOS – From Version 1.0 to 16.0

Jamie Spencer

September 14, 2022



MOBILE

What at Is CBRS? A Guide Short Guide on Citizens Broadband Radio Service

Jamie Spencer

October 26, 2021



MOBILE

LTE Not Working? Here's What You Can Do to Fix It

Jamie Spencer July 11, 2022

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B



WiFi Privacy Warning on iPhone/iPad

Jamie Spencer May 4, 2022

Categories

Computing
Featured
File Sharing
Gaming
General
Guides
Hardware
Home Working
Internet Sharing
Mobile
Networking
News
Questions
Resources
Reviews
Roblox
Security

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX B

Sharing

Support

Tech Guides

Tools

Troubleshooting

WAN

PRACTICALLY NETWORKED

Practically Networked Copyright © 2023.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX C

Los Angeles Times SUBSCRIBE LOG IN

BUSINESS

Motorola Has a Pocket-Size Cellular Phone

L.A. TIMES ARCHIVES

APRIL 26, 1989 12 AM PT

FROM ASSOCIATED PRESS

WASHINGTON — Motorola Inc. introduced a dramatically smaller cellular telephone Tuesday that can be carried in a purse or coat pocket.

The device, half the size of any other portable cellular model, is about as wide and long as a checkbook. It is about as thick as a fat wallet at the earpiece while tapering down to half the thickness of a deck of cards at the mouthpiece.

The phone has a shorter-than-usual battery life. The 10.7-ounce model has a 30-minute rechargeable battery, while the 12.3-ounce one has a 75-minute battery. It needs no wires or base to operate.

The device, called the Micro Tac Personal Telephone, is expected to retail for $2,995 and be available six weeks after being ordered. Motorola officials said they were taking orders immediately.

“This is a new category of cellular--the personal cellular,” said Jim Bernhart, vice president and director of distribution for Motorola’s cellular subscriber group. “We view it as the wave of the future.”

Officials of the Schaumburg, Ill.-based company would not reveal development costs for the new device, but said the company had invested about $350 million in development of cellular telephones.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Bob Weisshappel, Motorola vice president and director of the North American subscriber division, said the device has the identical range to the company's larger, Dynatac portable.

Cellular telephones work as radio transmitters and receivers. Metropolitan areas offering cellular service are divided up into sections called cells, with each cell containing a receiving-transmitting antenna to connect many calls simultaneously with the local phone system.

According to the Cellular Telecommunications Industry Assn., the United States has about 2 million cellular subscribers. Nearly 839,000 subscribers were added in 1988, the association said.

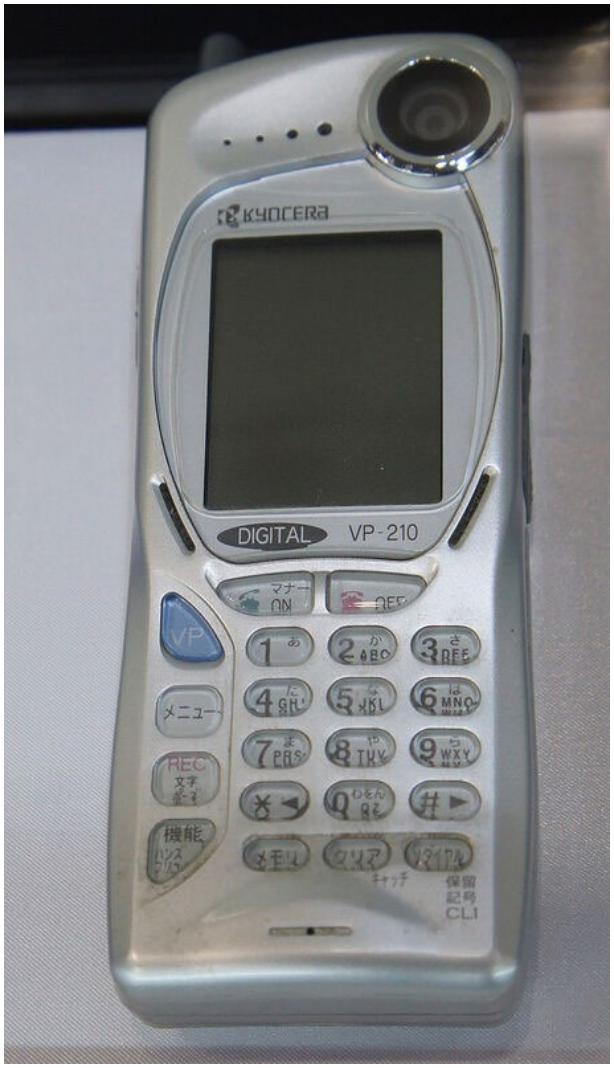
In the last six months of 1988, cellular service revenue was $1.07 billion, and the average monthly cellular phone bill was $98.02, the association said.

Copyright © 2023, Los Angeles Times | Terms of Service | Privacy Policy | CA Notice of Collection | Do Not Sell or Share My Personal Information

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Physical, Electrical, Digital

1999: World First Camera Phone the Kyocera VP-210 was released



Date(s)
1999

Tags
Selfie: A Medium Gradually Developing with Technology and Society

The VP-210 was released in May 1999 and used a single 110,000-pixel front-facing camera to send two photos per second via Japan's PHS mobile phone network system. It has a capacity of 20 JPEG photographs. The camera phone was the same size as comparable modern mobile phones, but it had a big camera lens and a 5 cm (2 inch) color TFT display capable of displaying 65,000 colors and processing two video frames per second. The 155-gram (5.5 oz.) camera could also snap 20 images and send them via e-mail, with the camera phone selling for 40,000 yen, approximately $325 in 1999 (Wireless Watch Japan 2014).

Sources
Wireless Watch Japan. 2014. “World First Camera Phone the Kyocera VP-210.” Wireless Watch Japan - Mobile in Tokyo. July 9, 2014. http://wirelesswatch.jp/2014/07/09/world-first-camera-phone-the-kyocera-vp-210/.

Image Source: http://wirelesswatch.jp/2014/07/09/world-first-camera-phone-the-kyocera-vp-210/

Files

APPENDIX D



Added by Bingyan Wan

← Previous Item

Next Item →

Essays Technologies Events Browse Items Browse by Tags Time Visuals About

Course Site | XE | NYU | Proudly powered by Omeka .

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E

Subscribe

TRENDING Galaxy S23 review Galaxy S23+ review Galaxy S23 Ultra review Google I/O 2023

When you purchase through links on our site, we may earn an affiliate commission. Here's how it works.

A history of all the major Bluetooth releases and updates

Advertisement

By Jerry Hildenbrand, Joe Maring last updated November 21, 2019



Skullcandy Riff Bluetooth wireless headphones (Image credit: Andrew Martonik / Android Central)

PAGE 1 OF 5:

Our smartphones are made up out of a lot of different components. When we cover them in reviews and news, we tend to focus on things like display quality, processor speed, cameras, etc. Those are all very important, but one feature that tends to often go unmentioned is Bluetooth.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E

When you think about just how regularly we use Bluetooth, that's kind of silly. We rely on the wireless standard for listening to music on Bluetooth headphones, playing games with controllers, using a mouse and keyboard for productivity work, and so much more.

The core idea of Bluetooth has remained the same since the introduction of version 1.0 back in 1999, and right now, we're going to take a look back at all of Bluetooth's many iterations, starting with the first one and going up to the 5.1 standard that was released in 2019, to understand where it started and how we got to where we are today.

Advertisement

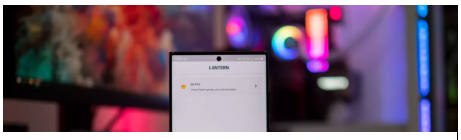
Bluetooth 1.0 — 1.2

After the Bluetooth Special Interest Group (also known as SIG) was formed in 1998, the Bluetooth 1.0 specification was released a year later in 1999.

RECOMMENDED VIDEOS FOR YOU...

The first phone to use Bluetooth was the Ericsson T36, which was unveiled in 2000. However, it wasn't actually available for purchase until 2001 when Ericsson released the revised T39 mobile phone. The Ericsson T39 used Bluetooth 1.0b, which was a mild successor to Bluetooth 1.0a.

MOST READ



1 Lantern is a privacy-focused proxy service that's designed to evade censorship

2 Walmart reveals new Google TV 4K streaming box with an enticing price tag

3 Google Drive makes it easier to organize files with streamlined experience

4 Chrome is now a lot faster on Android phones and Mac

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



Source: Hfiweyh372yer via Wikipedia (Image credit: Source: Hfiweyh372yer via Wikipedia)

Compared to the Bluetooth we know today, Bluetooth 1.0b was *very* slow and unreliable. It had a maximum data transfer speed of 732.2kbs and could only stay connected to devices within a range of 33 feet. It can be easy to complain about Bluetooth being a pain to use today, but back then, the experience was substantially worse.

Also, with such slow data transfer speeds, Bluetooth wasn't really designed for listening to music the way it is now. Instead, its main purpose was for wireless Bluetooth headsets for making/receiving phone calls.

In February 2001, Bluetooth 1.1 hit the market. It set out to fix a lot of the usability complaints with Bluetooth 1.0, and while it still had the same max data transfer speed, it introduced support for up to seven simultaneous connections and made it possible to have Bluetooth connections on non-encrypted channels — one of the biggest drawbacks to Bluetooth 1.0.

Fast forward a couple more years, and Bluetooth 1.2 was ready to shine in November 2003. It was the first Bluetooth update that increased the data transfer speed, kicking things up to 1Mbs.

Bluetooth 1.2 also benefited from making devices faster and easier to discover, was backward compatible with Bluetooth 1.1, and introduced something called "Adaptive Frequency Hopping" that made Bluetooth more resistant to interference from radio frequencies.

Another big win for Bluetooth 1.2 was its use of Extended Synchronous Connections. The main purpose of this was to improve the quality of phone calls over Bluetooth, with it giving users an option to increase latency in favor of better data transfer for high-quality audio.

Get the Android Central Newsletter

devices

5 **Samsung and Jaden Smith's MSFTSrep launch eco-friendly Galaxy accessories for Earth Day**

Advertisement

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E

Instant access to breaking news, the hottest reviews, great deals and helpful tips.

Your Email Address

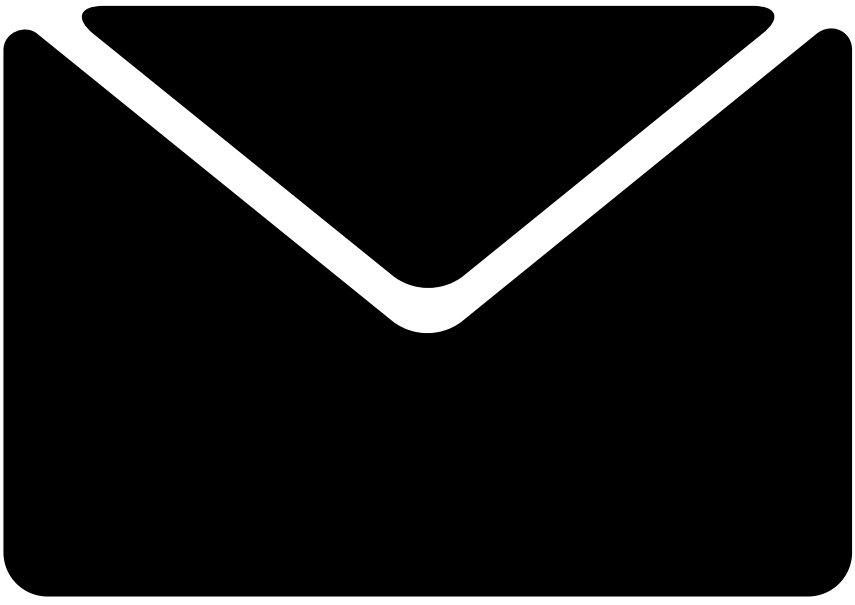
Contact me with news and offers from other Future brands

Receive email from us on behalf of our trusted partners or sponsors

SIGN ME UP

By submitting your information you agree to the Terms & Conditions and Privacy Policy and are aged 16 or over.

Jerry Hildenbrand



Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E

Senior Editor — Google Ecosystem
Jerry is an amateur woodworker and struggling shade tree mechanic. There's nothing he can't take apart, but many things he can't reassemble. You'll find him writing and speaking his loud opinion on Android Central and occasionally on Twitter.

MORE ABOUT PHONES

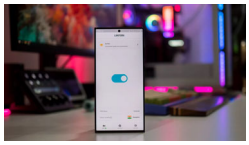


The new ASUS ROG Phone 7 Ultimate captures your gaming highlights with AI ▶



You only have a few more days to snag a free Google Pixel 7 Pro from Verizon ▶

LATEST



Lantern is a privacy-focused proxy service that's designed to evade censorship ▶

SEE MORE LATEST ▶

TOPICS

BLUETOOTH

Wear OS 3 finally fixes the problems Android watches have had for years
Google and Samsung have worked together to create what feels like the perfect smartwatch OS, but it's only that good on a scant few watches.
Androidcentral

New Walk In Tubs On Sale
Best Selling Tubs | Sponsored

What Actually Triggers Tinnitus, You Will Be Shocked
Healthy Guru | Sponsored

How Installers Get Rid of Unsold Walk-In Tubs
Consumer Daily | Sponsored

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E

MOST POPULAR



Vivo may have to stop selling phones in Germany following Nokia patent dispute

By Nickolas Diaz April 13, 2023



Latest Pixel 8 details point to a smaller display size for at least one model

By Derrek Lee April 12, 2023

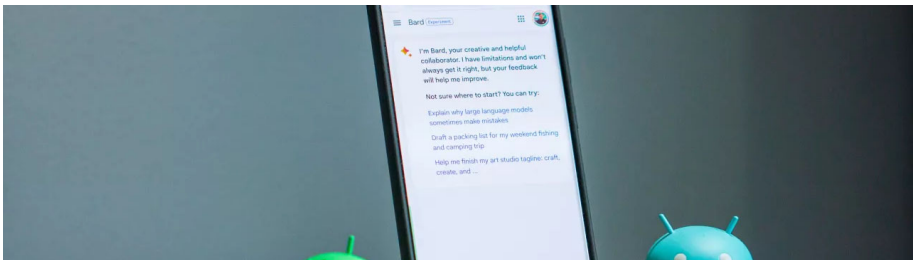
Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E



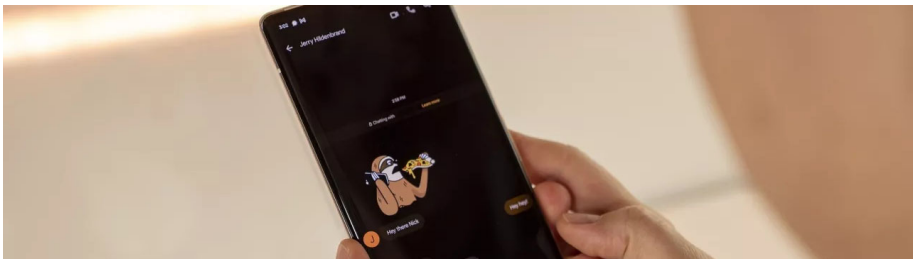
HBO Max and Discovery Plus combine to bring new 'Max' streaming service, coming soon

By Derrek Lee April 12, 2023



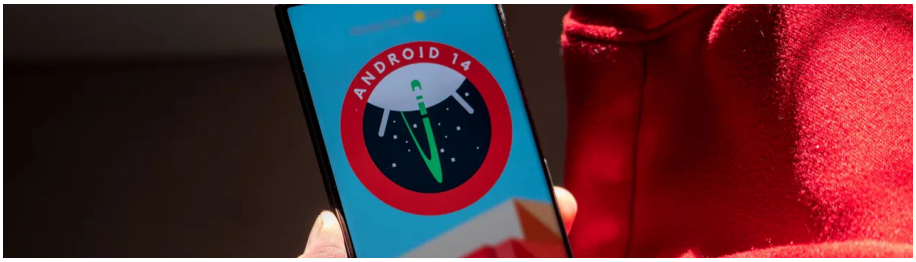
Google Bard gets transparent with its new 'experimental updates' page

By Nickolas Diaz April 12, 2023



New Google Messages feature saves time (and data) when sharing photos

By Derrek Lee April 12, 2023



The first Android 14 beta is available now for Pixels, and it's big on system UI changes

By Jay Bonggolto April 12, 2023

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E



Vivo X Fold 2, X Flip, and Pad 2 are set to launch on April 20

By Vishnu Sarangapurkar April 12, 2023



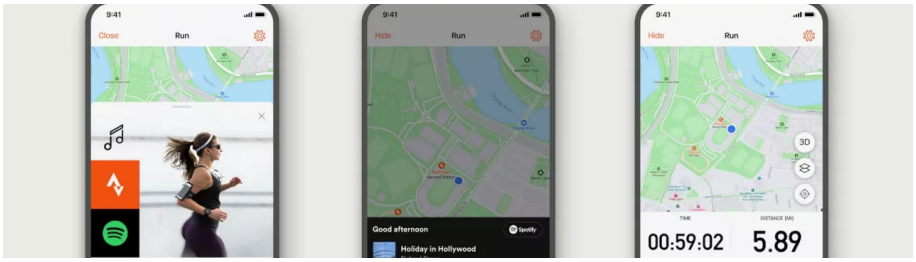
Peacock comes to Quest 2 with giant screens and a free subscription

By Nicholas Sutrich April 12, 2023



Garmin Instinct 2X shines a light on your health, training, and the night

By Michael L Hicks April 12, 2023

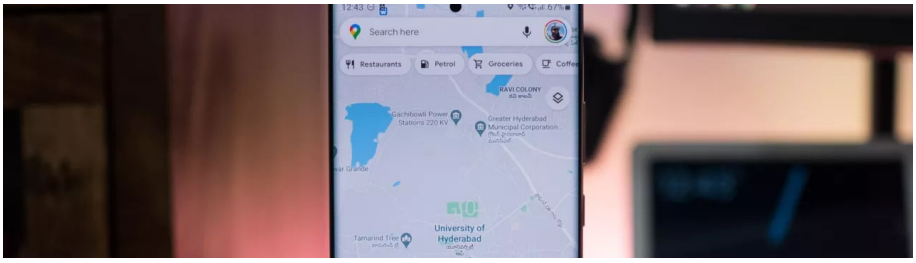


Strava and Spotify partner to bring music controls directly into your workout screen

By Michael L Hicks April 12, 2023

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX E



Google Maps update is perfect for your next trip to a US national park

By Derrek Lee April 11, 2023

Android Central is part of Future US Inc, an international media group and leading digital publisher. **Visit our corporate site**.

Terms and conditions

Contact Future's experts

Privacy policy

Cookies policy

Accessibility statement

Careers

Licensing

External links disclosure

About us

Newsletter

Advertising inquiries

Licensing and reprints

Do not sell or share my personal information

© Future US, Inc. Full 7th Floor, 130 West 42nd Street, New York, NY 10036.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX F

GSMarena Search

ADVERTISEMENTS

PHONE FINDER

SAMSUNG	XIAOMI	ASUS	INFINIX
APPLE	GOOGLE	ALCATEL	TCL
HUAWEI	HONOR	ZTE	ULEFONE
NOKIA	OPPO	MICROSOFT	TECNO
SONY	REALME	VODAFONE	DOOGEE
LG	ONEPLUS	ENERGIZER	BLACKVIEW
HTC	VIVO	CAT	BLU
MOTOROLA	MEIZU	SHARP	PANASONIC
LENOVO	BLACKBERRY	MICROMAX	PLUM

ALL BRANDS RUMOR MILL

ADVERTISEMENTS

Ericsson T39



Released 2001
86g, 18mm thickness
Feature phone
No card slot

0.1%
553,815 HITS

47
BECOME A FAN

101x54 pixels, 4 lines

NO
No video recorder

500mAh
NiMH

OPINIONS COMPARE PICTURES

The replacment for canceled T36

NETWORK	Technology	GSM
LAUNCH	Announced	2001
	Status	Discontinued
BODY	Dimensions	96 x 50 x 18 mm (3.78 x 1.97 x 0.71 in)
	Weight	86 g (3.03 oz)
	SIM	Mini-SIM
DISPLAY	Type	Grayscale graphic
	Size	
	Resolution	101 x 54 pixels, 4 lines, 17:9 ratio
MEMORY	Card slot	No
	Phonebook	510
	Call records	10 received, dialed and missed calls
CAMERA		No
SOUND	Loudspeaker	No
	Alert types	Vibration; Downloadable monophonic ringtones, composer
	3.5mm jack	No
COMMS	WLAN	No
	Bluetooth	1.0b
	Positioning	No
	Infrared port	Yes
	Radio	No
	USB	
FEATURES	Sensors	
	Messaging	SMS, Email
	Browser	WAP 1.2.1
	Clock	Yes
	Alarm	Yes
	Games	Yes
	Languages	37
	Java	No
		Predictive text input
		Organizer
		Voice dialing
		Voice answering
		Profiles
		Helptexts and shortcuts
		Active flip

ADVERTISEMENTS

ADVERTISEMENTS

RELATED DEVICES



Ericsson T28 World



Ericsson T29s



Ericsson T28s

MORE RELATED DEVICES

ADVERTISEMENTS

TIP US 1.5M 109K RSS EV MERCH LOG IN SIGN UP

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX F

	Talk time	up to 11 h
	Type	High Capacity Battery
	Stand-by	up to 29 days
	Talk time	up to 25 h
MISC	Colors	3 - Classic Blue, Icecap Blue, Rose White

Disclaimer. We can not guarantee that the information on this page is 100% correct. Read more

OPINIONS COMPARE PICTURES

POPULAR FROM ERICSSON


Ericsson GA 628


Ericsson T39


Ericsson T28s


Ericsson T10s


Ericsson T68


Ericsson A1018s

MORE FROM ERICSSON

ERICSSON T39 - USER OPINIONS AND REVIEWS

D **AnonD-834088** 27 Nov 2021 iLV

eBay fella 👍

Reply

M **Muhammad Fazil** 27 Oct 2019 X}$

I need this mobile phone, can I get it right? Ericsson T39

Reply

S **SULTAN** 05 Jul 2019 YQL

Looking good in ads original how he is I don't no how much price for these pjone

Reply

READ ALL OPINIONS POST YOUR OPINION Total user opinions: **432**

ADVERTISEMENTS

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX G

The Wayback Machine - https://web.archive.org/web/20020606093157/http://press.nokia.com:80/PR/200103/…



New Nokia style engine makes debut

(March 21, 2001)

The GPRS enabled Nokia 8310 fashion phone combines beauty with brains

Nokia today unveiled its newest phone model in its fashion category, further cementing the company's position as the world's leading design house for mobile communications. The small and light-weight Nokia 8310 is the epitome of style in mobile phones and the first Nokia phone in the market to incorporate GPRS (General Packet Radio Service) technology. It is stylishly provocative, taking phone personalization to an entirely new level with a tridimensional surface and translucent layering for a unique aesthetic look. The phone will be available in the third quarter, 2001.

"We are very excited to introduce our first GPRS phone inside a shell which takes personalization and fashion in mobile phones to unprecedented heights. The Nokia 8310 is the ultimate personal phone, a chameleon that can take on a multitude of potential color combinations with its tridimensional surface decor. It breaks new ground in mobile phone design providing a personal fashion tech accessory for people who want to express their unique personal style while having access to the very latest mobile services," said Frank Nuovo, Chief Designer, Nokia Mobile Phones.

The Nokia 8310 introduces a progressive design language, incorporating the latest look and feel in colors, materials, finishes, and design details. Front and back Xpress-on covers and a translucent window frame offer a dramatically changeable appearance, allowing more freedom than ever to personalize the phone exterior. Overlapping translucent surfaces and colors make the beauty of this phone more than skin deep. Shiny chrome surface finish on the main function keys, power key, bezel around the display, and battery release button afford it dazzling detail. It also flaunts a white backlight. It is urban and independent, focused yet casual, making it a phone as unique as its individual users.

The Nokia 8310 comes with an array of attractive features such as an integrated FM radio and a dual headset. The new headset makes call and radio management convenient: incoming calls are easily managed while the radio is on and it is possible to browse the web, play games, write messages, and use the phonebook while listening to the radio. Advanced voice features include voice dialling and voice activation of the radio. The phone also supports voice commands to activate the infrared function and change user profiles from, for example, "Outdoor" to "Meeting." An additional attraction is the possibility to record voice memos of up to 3 minutes in length.

GPRS technology will allow users to get more out of mobility and personalization. Whenever the phone is turned on and has been GPRS configured, there is an immediate connection to services via the GPRS network, where GPRS networks are available. GPRS sends data in packets, making billing schemes possible based on the amount of information sent or received, rather than on connection time. WAP over GPRS will allow users to do things like browse restaurant guides or see what's showing at the local cinema. The phone also supports HSCSD (High Speed Circuit Switched Data) for flexible data connections.

The Nokia 8310 integrates the latest WAP features with support for WAP release 1.2.1. It enables the phone to receive "service message indicators" where a WAP page alert is displayed with a convenient link to a WAP site. This makes push-based mobile services such as continuous newscasts and shopping tips from favorite retailers possible. WAP release 1.2.1 also enables the Nokia 8310 to store cookies, much in the same way as cookies are stored in a PC web browser. The next time you visit a WAP site, the phone is able to recall what information you specifically looked at and display the same window.

The Nokia 8310 is an EGSM 900/1800 dual band mobile phone and comes in 9 inbox color combinations. It weighs 84g, is 97mm in length and 66cc in size. It has a talk time of up to 4 hours and a standby time of up to 400 hours with the radio off and 20 hours with the radio on.

Nokia is the world leader in mobile communications. Backed by its experience, innovation, user-friendliness and secure solutions, the company has become the leading supplier of mobile phones and a leading supplier of mobile, fixed and IP networks. By adding mobility to the Internet Nokia creates new opportunities for companies and further enriches the daily lives of people. Nokia is a broadly held company with listings on six major exchanges.

Further information:

Nokia Mobile Phones

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX G

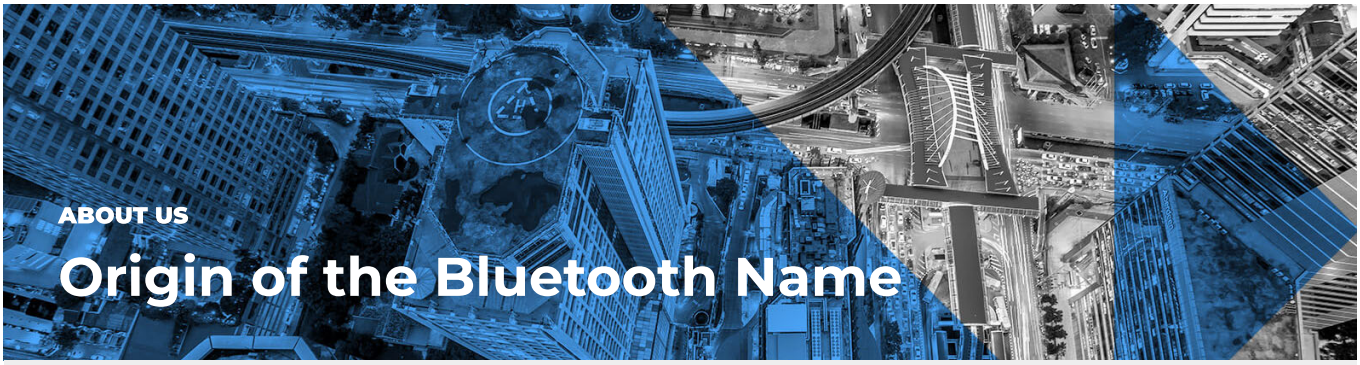
Communications
Tel: +358 7180 08000

www.nokia.com

[main page | products | group | faq | feedback | search]
© Nokia 2001. Read our legal notice.



Lexmark, Exhibit 1003
Lexmark v. Flexiworld



ABOUT US

Origin of the Bluetooth Name

The story behind how *Bluetooth*® technology got its name

We all recognize the “Bluetooth” brand, but we take for granted its significance and how much it impacts our lives. From smartphones to headphones and beyond, we rely on Bluetooth technology to free us from the tether of wired tech.



The Man Behind the Tooth

For how innovative the technology, the name doesn’t sound techie. It’s not an acronym and doesn’t stand for anything. So what does it mean?

Surprisingly, the name dates back more than a millennia to King Harald “Bluetooth” Gormsson who was well known for two things:

- Uniting Denmark and Norway in 958.
- His dead tooth, which was a dark blue/grey color, and earned him the nickname Bluetooth.

Code for Collaboration

In 1996, three industry leaders, Intel, Ericsson, and Nokia, met to plan the standardization of this short-range radio technology to support connectivity and collaboration between different products and industries.

During this meeting, Jim Kardach from Intel suggested Bluetooth as a temporary code name. Kardach was later quoted as saying, “King Harald Bluetooth...was famous for uniting Scandinavia just as we intended to unite the PC and cellular industries with a short-range wireless link.”

Bluetooth was only intended as a placeholder until marketing could come up with something really cool.

The One and Only

Get Help

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Later, when it came time to select a serious name, Bluetooth was to be replaced with either RadioWire or PAN (Personal Area Networking). PAN was the front runner, but an exhaustive search discovered it already had tens of thousands of hits throughout the internet.

A full trademark search on RadioWire couldn't be completed in time for launch, making Bluetooth the only choice. The name caught on fast and before it could be changed, it spread throughout the industry, becoming synonymous with short-range wireless technology.

The 'initial' Bluetooth Logo

The Bluetooth logo is a bind rune merging the Younger Futhark runes (Hagall) (ᚼ) and (Bjarkan) (ᛒ), Harald's initials.

Get Help

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

DEVELOPMENT OF THE BLUETOOTH VERSION 1.0 SPECIFICATION

Michael T. Camp

Efficient Networks, Inc
4849 Alpha Rd, Dallas TX 75244
PH: 972-852-1000 FAX: 972-852-1001
e-mail:mcamp@efficient.com

Abstract - The explosive growth of the digital mobile phone has sharpened the focus of consumer electronics on personal handheld devices. The development of the Bluetooth specification fills a key requirement for this class of device: a versatile, power efficient, short-range wireless connection. This paper will provide an overview of the development of the Bluetooth version 1.0 specification, including example usage cases, an introduction to the technology, and the plans for standardization within the IEEE.

I. INTRODUCTION

Of the handheld electronic devices that are vying for space in your briefcase, how many include some type of proprietary cable? How many include an AC adapter for charging batteries? How many include some kind of cradle or dock?

The answer to one or all of these questions is likely to be a number greater than one. With each of the wires or cables that is required to make a device productive, the benefit of being handheld diminishes. As long as handheld devices remain physically tethered to a desk-bound partner machine, they are unlikely to emerge from the novelty category.

The Bluetooth consortium was formed to provide an alternative to bulky cables, and awkward line-of-sight wireless connections. By eliminating one of the most significant obstacles to the proliferation of these devices, the consortium sought to promote the use of portable PCs, smart phones and handheld computing devices.

As the Bluetooth consortium was being formed, the use of the Internet by mainstream consumers was growing rapidly. Along with a growing acceptance of network connectivity in everyday life, came a growing expectation that network information should remain accessible, even when away from the traditional modem or LAN environment. It became apparent that connecting these portable devices was of paramount importance in developing the market for them.

The Bluetooth consortium brought together leaders in the telecommunications and computer industries to develop a power-efficient, short-range, wireless medium designed to meet the needs of the new generation of portable electronic devices.

II. BLUETOOTH OBJECTIVES

At the highest level, Bluetooth was conceived to specify an RF-based wireless cable replacement for handheld electronic devices. Additionally, the original promoters of the technology required that the media be able to support both voice and data connections simultaneously.

In an environment where collaborators would eventually become competitors, it became imperative that the Bluetooth name should be able to imply a certain level of interoperability. This key objective was embraced as a fundamental principle at the outset of the specification work.

Given the large investment by relatively few founding companies, the objective of commercial viability was implicit. Ultimately this translates into specifications that are designed to support real-world applications

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

III. SPECIFICATION PRINCIPLES

Perhaps the most obvious principle adopted by the Bluetooth Working Groups was the re-use of technology where possible. By adopting existing protocols, the path to working products is shortened considerably. Bluetooth adopted the OBject EXchange protocol from the Infrared Data Association (IrDA) to ease the transition of vertical applications from IR to Bluetooth.

Where more than one way to implement a feature existed, the choice was less obvious. The decision to enable LAN access using the PPP protocol was based on the types of device that were likely to incorporate Bluetooth. Most handheld computers and smart phones already feature a PPP protocol stack, which made the choice significantly easier.

The principles can be summarized as follows:

- Use existing protocols where possible
- Specify only what is necessary to solve the usage cases
- Requirements should be stated without ambiguity in order to ensure interoperability
- Vertical solutions implemented over Bluetooth require interoperability guidelines

IV. USER CENTERED DESIGN

The task of creating a technology specification from the ground up was daunting at the outset. Adopters of the technology and consumers alike would expect a robust, complete specification to emerge from the group of promoter companies. In spite of the tendency to try and solve every possible usage case at once, the working groups were guided by a set of usage cases which, if solved, would provide tremendous value to the end user.

The strategy of designing to solve specific usage cases was not new, but had rarely been applied in the case of a new technology under development by an industry consortium. This approach is partly responsible for the tremendous interest in Bluetooth following the announcement of the Special Interest Group (SIG) on 20 May, 1998.

Instead of announcing a new technology, and expecting the market to find uses for it, Bluetooth was described in terms of the direct benefit to the end user. The message was carried not only to the computer and telecommunications industries, but also to the mass consumer. After all, it is easier to understand: "Dial into the Internet through your cell phone while your phone is still in your briefcase," rather than: "Fast frequency hopping, spread-spectrum RF communications link operating in the 2.4GHz ISM band."

Focusing on the usage cases allowed the problem set to be reduced to a size that was manageable. Although such an approach can potentially lead to tunnel vision and future "backward compatibility" issues, the diversity of the group that developed the specification prevented that from happening.

For example, the general case of *ad-hoc* networking was not addressed because none of the defined usage cases needed such a high level of functionality. However, as network access proposals were evaluated and discarded, the questions: "How will this approach affect *ad-hoc* networking implementation in the future? Is there a clear migration to general case *ad-hoc* networking that will not cause interoperability problems?" were used as the acid test for future development.

With clear objectives and a consistent philosophy, representatives of diverse organizations with diverse, and sometimes competing interests, could begin work in earnest.

V. THE TECHNOLOGY

Development of the technology that became Bluetooth was begun independently at several of the promoter companies. Each had envisioned a short-range wireless connection between consumer devices, but none had the resources to drive the technology to the level of market penetration that would ensure *de facto* standard status. The majority of what became the Bluetooth PHY and Baseband was derived from Ericsson's MC-Link technology. Representatives from the other promoter companies helped to refine the specification and add protocol layers above it.

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Physical and Baseband Layers

Bluetooth, like 802.11 wireless LANs operate in the 2.4 – 2.4835GHz Industrial Scientific and Medical (ISM) band. This band is uniformly defined globally with the exception of France and Spain. Both countries are considering harmonizing their definitions of this band with the global definition. Channels are spaced at 1MHz with upper and lower guard bands defined worldwide.

Three power classes are defined for Bluetooth radios. Classes 1 through 3, differing primarily in their nominal and maximum output power levels. Software power control is required for class 1 devices that transmit above 4dBm. This control is accomplished through the Link Manager Protocol (LMP). The modulation scheme is Gaussian Frequency Shift Keying (GFSK). Bluetooth receivers are required to support a sensitivity of at least –70dBm to a Bluetooth compliant transmitter.[1]

The Bluetooth physical channel is divided in the frequency domain into either 79 or 23 center frequencies, and in the time domain into 625μs time slots. The country that the radio is localized for determines the number of center frequencies.

The Bluetooth Baseband protocol defines the media access rules, and imposes the basic structure of Bluetooth networks on the physical layer.

Each Bluetooth radio is created with a burned-in address referred to in the specification as the BD_ADDR. This address serves as the basis for many of the behaviors of the Bluetooth radio, particularly the frequency-hopping (FH) sequence. The combination of the BD_ADDR and the Bluetooth device's internal clock produce a particular FH sequence. Alternate time slots are reserved for transmitting and receiving by the Bluetooth node. Multi-slot packets are the exception to this rule, and the radio must remain on the same frequency for the duration of the packet. These multi-slot packets may extend for three or five time slots before relinquishing the medium.

The organization of a Bluetooth network is in the form of "piconets." A piconet consists of at least one master node and one slave node. The role of a node in the piconet is determined by assigning the master role to the node that initiated communications. A higher level LMP function is provided for role-reversal. The master node provides the FH sequence and clock which defines the piconet's physical channel. Slave nodes in a piconet follow the master's FH sequence by obtaining the master node's BD_ADDR and clock. The slave then calculates it's own clock offset to generate the correct FH sequence.

Logical links between a master and slave can be one of two types. Synchronous Connection-Oriented (SCO) links consist of a set of pre-reserved time slots. Following this circuit-switching method of operation allows guaranteed bandwidth for voice data. Asynchronous Connection-less (ACL) links use time slots not previously allocated for SCO links. Use of ACL links allows bursty data traffic to contend for the available bandwidth.

The piconet master controls access to the medium, within the piconet. When no piconet exists, access to the medium is by contention. There are two procedures available for adding slaves to a piconet: Inquiry and Page.

The inquiry procedure allows an individual node to obtain the BD_ADDR and clock information for all devices within range. In this procedure, a Bluetooth node transmits an Inquiry request, which contains an Inquiry Access Code (IAC), rather than a Device Access Code (DAC). The number of responses can be limited by using a Dedicated Inquiry Access Code (DIAC), rather than the General Inquiry Access Code (GIAC).

In order for an individual node to be visible to the inquiry process, it must spend some part of its time in inquiry scan mode. In this mode, the node is actively soliciting inquiry requests.

If a Bluetooth node wishes to re-connect to a node that was previously part of the piconet, the master can use the page procedure. The page procedure differs from the inquiry procedure in that the requester already knows the DAC of the target node. As with the inquiry process, the target node must enter page scan mode periodically in order to receive these requests.

The slave handles contention in the inquiry mode. After receiving the inquiry request, the node waits up to 1024 time slots before sending

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

the response in order to avoid collisions with other respondent nodes.

The Bluetooth master can be actively communicating with up to seven slaves. The piconet, however, may contain up to 262 nodes. In order to maintain a piconet of this size the master can selectively place nodes into park mode. While in park mode, a node continues to follow the master's FH sequence and timing, but does not exchange data with the master. The master may choose to take the node out of park mode, or the node may request to be removed from park mode.

Power efficiency is a key feature of the Bluetooth technology. In addition to low transmit power levels, the Bluetooth baseband supports two additional operational modes that can be used in a power-saving strategy.

The hold mode allows the slave node to cease exchange of ACL packets for a specified time length. During this time period, the slave node is able to participate in paging, and inquiry procedures, or even participate in another piconet.[1] Most likely, the node will enter a power conservation mode until the hold time has elapsed.

Sniff mode is a variation of the hold mode. Ordinarily, a Bluetooth device in active state will examine every ACL time slot for data. Sniff mode reduces this requirement to certain slots that fall within a specified time interval. The node ignores all ACL time slots that fall outside the sniff interval. The sniff interval recurs for a negotiated number of iterations, or until the node requests that sniff mode end.

Link Management Protocol

The Link Management Protocol provides additional structure on top of the baseband medium access rules. LMP Helps reinforce the node roles that were established during baseband link formation. Finally, LMP provides the structure for implementing link-level security. In this capacity, LMP serves a similar function to control frames in a link layer implementation.

LMP Protocol Data Units (PDU) are defined for authentication of the remote device, entering and leaving specific baseband modes, power management, establishing and destroying connections, and feature support information exchange.

Security

The Bluetooth specification depends on a number of elements to prevent interception of data flowing on the channel.

The most fundamental technique is the use of spread-spectrum technology on the physical channel. Bluetooth radios change frequency 1600 times a second when actively exchanging data. Additionally, the use of a pseudo-random hopping sequence makes it more difficult for the casual observer to follow the data exchange process.

Authentication of the link partner is an important component of Bluetooth security. This process allows a Bluetooth device to determine if a potential connection partner is authorized to connect. Authentication begins when one of the participant nodes (the verifier) issues a challenge to the other node (the claimant).

The verifier provides a random number to the claimant, which is used as the input to the E_{22} algorithm along with the verifier's BD_ADDR, and a password. The password is provided programatically or obtained from the user. The claimant then returns the result of the E_{22} algorithm to the verifier. The verifier performs the same processing locally, and the claim is confirmed if both nodes result is the same.

The process results in the generation of the "initialization link key" this key is used temporarily until the Bluetooth units create the actual link key.

The structure of the Bluetooth security mechanisms permits the use of external key exchange techniques such as Diffie-Hellman, to enhance the level of security supported by the device.

Logical Link Control Adaptation Protocol (L2CAP)

L2CAP Occupies the upper portion of the Data Link Layer in a Bluetooth implementation. In this role, L2CAP provides multiplexing support for higher level protocols, connectionless and connection-oriented services, and segmentation

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

and re-assembly of transmission units. Other functions include a basic group abstraction, a master-only group multicast facility, and basic Quality of Service parameter negotiation.

L2CAP uses Channel Identifiers (CID) to define a single pathway for data flowing between Bluetooth nodes. Reserved CID values are used to designate a connectionless transmission, and CID values are otherwise dynamically assigned. The mapping between a CID and higher layer protocol is performed using the protocol/service multiplexer (PSM) field of the L2CAP packet. The PSM is based on the ISO 3309 address extension definition.

Service Discovery

A key element of any mobile communications environment is the ability to find other nodes with which to communicate. While the Bluetooth Baseband protocol allows devices to discover each other's existence, very little information is provided to indicate the type or function of the device.

The Bluetooth specification provides a facility for exposing the capabilities of a device, and querying the capabilities of other devices. The Bluetooth Service Discovery Protocol (SDP) consists of two components. The first is the service record, a structure in which attributes describing the function and operation of the service are stored. The second is the set of operations which SDP client devices can invoke on SDP server devices to obtain the service records.

The Bluetooth SDP provides the ability to organize the available services into a hierarchical structure that can be browsed by client devices. These "Browse Groups" can be used to logically associate related services for convenient browsing. Alternatively, client devices can find specific characteristics by using unique identifiers (UUID).

Supporting Higher Protocols

The Bluetooth specification also includes the accommodation of higher level protocols and vertically-oriented software layers.

In order to speed adoption of Bluetooth into systems that use legacy technology, the Bluetooth specification describes a method for emulating the behavior of an RS-232 communications medium. This emulation uses as its basis the ETSI TS 07.10 specification for multiplexing a physical channel between DTE and DCE. Incorporated into this specification is a method for encapsulating V.24 signal state information over a logical channel.

Many of the devices that are expected to incorporate Bluetooth are currently supporting infrared wireless communications. In order to simplify the process of including Bluetooth support in these devices, existing protocols developed by the Infrared Data Association (IrDA) were adopted for use in Bluetooth. By accommodating a common protocol layer, applications developed for the infrared medium can be easily ported for use over Bluetooth.

The common layer selected was the IrDA OBject EXchange (OBEX) session layer. OBEX Provides a set of service primitives for a session-oriented exchange of arbitrary data objects. Similar in function to Hypertext Transfer Protocol (HTTP), OBEX provides the ability to move data while leaving the handling of object data formats to higher layers.

In addition to support for infrared protocols, other features were included in the Bluetooth specification for the purpose of adding value to Bluetooth when implemented in mobile phones and other telephony-oriented devices. Notably, the Telephony Control Specification (TCS) was included to support such features as remote dialing control, volume control, and user group management.

VI. DESIGNING FOR INTEROPERABILITY

Developing a specification that includes such an ambitious combination of horizontal platform and vertical applications support, was undertaken with an explicit objective of interoperability. The promoting companies were very concerned that the Bluetooth medium would become a launching pad for numerous proprietary solutions. In an attempt to prevent divergent approaches to solving the Bluetooth-defined usage cases, use of the Bluetooth name and logo were tied to interoperability.

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Interoperability of devices within individual usage cases is ensured through the use of Profiles.

The Bluetooth specification profiles are documents that describe how the Bluetooth core specification protocols are used to solve the individual usage cases. Unlike the Interoperability Requirements documents in the Bluetooth core specification, Profiles describe the mandatory and optional behaviors that a device must exhibit when claiming conformance with a specific Bluetooth usage case. Interoperability requirements only define what portions of an external specification are suitable for use in the Bluetooth environment.

The rules that all implementations of Bluetooth must follow are specified in the Generic Access Profile (GAP). The GAP defines standard procedures for idle behavior, connection establishment, and security modes.

The danger inherent in creating a specification that includes defined behavior on a user level, is an undesirable homogeneity of the resulting implementations. To the greatest extent possible, the authors of the profiles reduced the restrictions on the implementations necessary to guarantee interoperability. After all, each of the contributors represented different business and technology interests. As a result, the published profiles are intended to establish a functional baseline, rather than a product definition.

VII. OBSTACLES TO DEPLOYMENT

Any emerging technology faces numerous obstacles to widespread adoption in the marketplace. These may range from prohibitive pricing to technical compatibility problems. Bluetooth faces similar obstacles as it moves from the specification phase into development and marketing.

The most significant obstacle is Bluetooth's use of the 2.4GHz ISM band. This portion of the electromagnetic spectrum is unlicensed around the world, and is subject to a great deal of noise. Bluetooth's sensitivity to this noise is mitigated somewhat by it's frequency hopping strategy. Instances of narrowband noise result in occasional packet loss, and is easily compensated for.

The effect of Bluetooth transmissions on other devices operating within the ISM band are potentially more problematic. Devices using radio protocols within the ISM band may view Bluetooth transmissions as short bursts of narrowband noise. Their ability to function in the presence of this interference will depend on a number of factors including physical channel dimensions, spreading technology, and error correction capabilities.

Other obstacles to deployment arise from the projected use of the technology. Bluetooth is intended to be a wireless cable replacement, with roughly the same capabilities of the cable that is being replaced. The fundamental implication is that Bluetooth nodes participate in point-to-point connections with other nodes.

Bluetooth's approach to networking reflects this philosophy. Serial-line networking through a dialed modem is expected to be the most prevalent use of Bluetooth. To a lesser extent, Bluetooth devices are expected to connect to a LAN access point (LAP), which provides indirect access to a wired network.

The convenience and portability of Bluetooth devices will naturally lead to the expectation of mobile *ad-hoc* networking between them. An already complex situation will further be complicated by the expectation of using the Internet Protocol (IP) as the OSI Layer 3 technology.

The current Bluetooth specification makes no attempt to solve the general problem of *ad-hoc* networking. Additionally, Bluetooth's Layer-2 does not support some facilities that IP requires in order to form a highly functional IP network. Bluetooth is not a shared access medium, it is an arbitrated access medium under the control of the Piconet master device. This prevents peer-to-peer addressability using layer 2 addresses, which is necessary for IP networking. A number of networking services, which are built on top of IP, also require multicasting or broadcasting. While possible within the Bluetooth specification, there is no standard way of implementing this functionality. Finally, there is no standard mechanism for forwarding Layer-2 frames between piconets, a capability that is required for the support of *ad-hoc* networks.

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

VIII. FROM SPECIFICATION TO STANDARD

It is important to remember that although Bluetooth enjoys widespread support within the industry, it is not a recognized standard. In order for a specification to become a standard, the documented specification must be adopted by a recognized Standards Defining Organization (SDO), and subjected to the rigorous process of review and refinement.

The IEEE convened a Study Group (SG) under P802.11 with the objective of investigating technologies for Wireless Personal Area Networks (WPAN).[2] This study group concluded that there were sufficient differences between the needs of WPAN and Wireless LAN to warrant a separate working group. As a result of the SG inputs, the executive committee of IEEE 802 agreed to form a new Working Group under the designation P802.15.

The objective of this working group is to set the definitions of the Physical layer and Medium Access Control sublayer within the OSI reference model.

In response to a Call For Proposal, the Bluetooth SIG indicated an interest in being a candidate for the future 802.15 standard. Members of the SIG joined with members of the IEEE working group to transform the Bluetooth specification into an IEEE standard.

The result is an ongoing effort to deliver a standard that provides: a coexistence strategy between 802.xx compliant radios in the ISM band, and harmonization between the Bluetooth specification and formal 802 format for standards.

CONCLUSION

The evolution of the Bluetooth SIG and the specifications that it created will serve as a model for future technologies as they try to balance the competing interests of business and standardization. A number of key lessons were learned from the development of the version 1.0 Bluetooth specification:

1. Keep the end user foremost in the process. The eventual customer must see obvious benefit for a technology to be commercially viable. Usability and usefulness must be considered at every stage of development.

2. Allow room for future enhancements. Do not specify yourself into a corner. Keep a clear upgrade path in mind when writing the specification.

3. Resist the urge to over-specify. Allow room for product differentiation and innovation within the confines of the specification.

4. Interoperability. Insist on an interoperability baseline to ensure that the end user can do useful work, even if not all features are supported.

REFERENCES

(1) Haartsen, Jaap, et. al, Bluetooth Core Specifcation version 1.0b, Bluetooth Special Interest Group, 1999.

(2) Siep, Thomas, et. al, Paving the Way for Personal Area Networks, 2000

Authorized licensed use limited to: Perkins Coie LLP. Downloaded on April 15,2023 at 17:18:23 UTC from IEEE Xplore. Restrictions apply.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX J

Technology | Basics

What is Infrared Data Association (IrDA)?

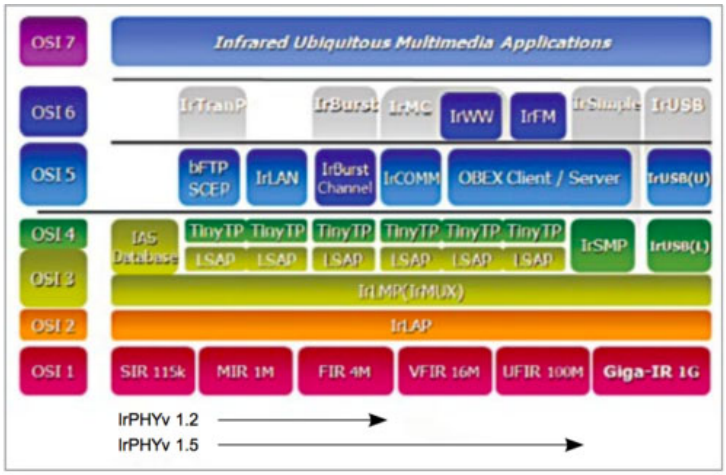
March 25, 2018 24712

- Advertisement -

Infrared Data Association, or IrDA in short, is a group of device manufacturers that developed a standard for transmitting data via infrared (IR) light waves. It provides specifications for the complete set of protocols for wireless IR communication. The main reason for using IrDA had been wireless data transfer over the "last one meter" using point-and-shoot principles. It is famous for secure data transfer, line-of-sight and very low bit error rate that makes it very efficient [1].

IR communication is an inexpensive and widely adopted short-range (1-3m) wireless technology. It is widely used in consumer electronics, automobiles, computers, medical devices, household appliances, commercial services, etc.

IrDA-enabled devices can communicate and are bi-directional. IrDA is inexpensive, secure and fast (supporting speeds of up to 100Mbps and even more).



Infrared Data Association (IrDA)-protocol-stacks

- Advertisement -

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX J

The Open Systems Interconnection (OSI) model of IrDA protocol stack is shown in Fig. 1. Some of the specifications based on the OSI model are given below:

Infrared physical layer (IrPHY)

This specification is intended to facilitate point-to-point communication between electronic devices. It specifies the optical media interfaces for Serial Infrared (SIR) data transmission and is part of the first layer of the OSI model.

Infrared link access protocol (IrLAP)

This specification is part of the second layer of IrDA specifications. It lies on top of the IrPHY layer and below the IrLMP layer. It represents the data link layer.

Infrared link management protocol (IrLMP)

It is the third layer of IrDA specifications. It defines link management multiplexer and link management information access service.

Transport protocol (TinyTP)

This optional protocol specified in the fourth layer lies on top of the IrLMP layer.

Infrared communication protocol (IrCOMM)

The IrCOMM protocol specified in the fifth layer lets the infrared device act like either a serial or parallel port.

Infrared Financial Messaging (IrFM)

This protocol specified in the sixth layer is a wireless payment standard developed by the Infrared Data Association.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

WIKIPEDIA
The Free Encyclopedia

Infrared Data Association

The **Infrared Data Association** (**IrDA**) is an industry-driven interest group that was founded in 1994[1] by around 50 companies. IrDA provides specifications for a complete set of protocols for wireless infrared communications, and the name "IrDA" also refers to that set of protocols. The main reason for using the IrDA protocols had been wireless data transfer over the "last one meter" using point-and-shoot principles. Thus, it has been implemented in portable devices such as mobile telephones, laptops, cameras, printers, and medical devices. The main characteristics of this kind of wireless optical communication are physically secure data transfer, line-of-sight (LOS) and very low bit error rate (BER) that makes it very efficient.

Infrared Data Association



Infrared via USB

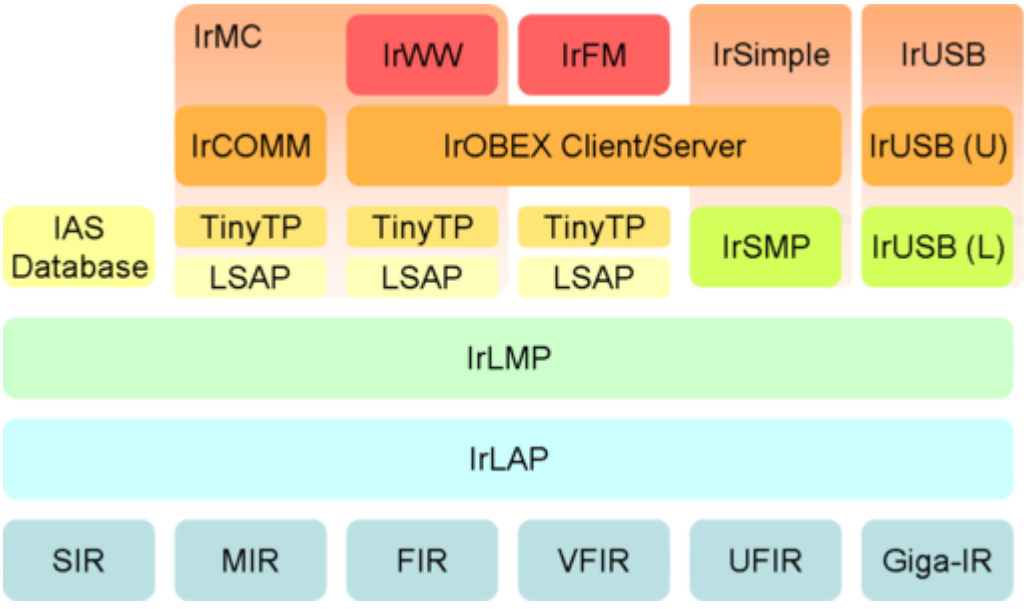
Abbreviation	IrDA
Formation	1994[1]
Type	Non-profit organisation consisting of multiple Special interest group

Specifications

IrPHY

The mandatory **IrPHY** (**Infrared Physical Layer Specification**) is the physical layer of the IrDA specifications. It comprises optical link definitions, modulation, coding, cyclic redundancy check (CRC) and the framer. Different data rates use different modulation/coding schemes:

- SIR: 9.6–115.2 kbit/s, asynchronous, RZI, UART-like, 3/16 pulse. To save energy, the pulse width is often minimized to 3/16 of a 115.2KBAUD pulse width.
- MIR: 0.576–1.152 Mbit/s, RZI, 1/4 pulse, HDLC bit stuffing
- FIR: 4 Mbit/s, 4PPM



IrDA protocol stack

- VFIR: 16 Mbit/s, NRZ, HHH(1,13)
- UFIR: 96 Mbit/s, NRZI, 8b/10b
- GigaIR: 512 Mbit/s – 1 Gbit/s, NRZI, 2-ASK, 4-ASK, 8b/10b

Further characteristics are:

- Range:
  - standard: 2 m;
  - low-power to low-power: 0.2 m;
  - standard to low-power: 0.3 m.
  - The 10 GigaIR also define new usage models that supports higher link distances up to several meters.
- Angle: minimum cone ±15°
- Speed: 2.4 kbit/s to 1 Gbit/s
- Modulation: baseband, no carrier
- Infrared window (part of the device body transparent to infrared light beam)
- Wavelength: 850–900 nm

The frame size depends on the data rate mostly and varies between 64 B and 64 kB. Additionally, bigger blocks of data can be transferred by sending multiple frames consecutively. This can be adjusted with a parameter called "window size" (1–127). Finally, data blocks up to 8 MB can be sent at once. Combined with a low bit error rate of generally $<10^{-9}$, that communication could be very efficient compared to other wireless solutions.

IrDA transceivers communicate with infrared pulses (samples) in a cone that extends at least 15 degrees half angle off center. The IrDA physical specifications require the lower and upper limits of irradiance such that a signal is visible up to one meter away, but a receiver is not overwhelmed with brightness when a device comes close. In practice, there are some devices on the market that do not reach one meter, while other devices may reach up to several meters. There are also devices that do not tolerate extreme closeness. The typical sweet spot for IrDA communications is from 5 to 60 cm (2.0 to 23.6 in) away from a transceiver, in the center of the cone. IrDA data communications operate in half-duplex mode because while transmitting, a device's receiver is blinded by the light of its own transmitter, and thus full-duplex communication is not feasible. The two devices that communicate simulate full-duplex communication by quickly turning the link around. The primary device controls the timing of the link, but both sides are bound to certain hard constraints and are encouraged to turn the link around as fast as possible.

IrLAP

The mandatory **IrLAP** (**Infrared Link Access Protocol**) is the second layer of the IrDA specifications. It lies on top of the IrPHY layer and below the IrLMP layer. It represents the data link layer of the OSI model.

The most important specifications are:

- Access control
- Discovery of potential communication partners
- Establishing of a reliable bidirectional connection
- Distribution of the primary/secondary device roles
- Negotiation of QoS parameters

On the IrLAP layer the communicating devices are divided into a "primary device" and one or more "secondary devices". The primary device controls the secondary devices. Only if the primary device requests a secondary device to send, is it allowed to do so.

IrLMP

The mandatory **IrLMP** (**Infrared Link Management Protocol**) is the third layer of the IrDA specifications. It can be broken down into two parts. First, the LM-MUX (Link Management Multiplexer), which lies on top of the IrLAP layer. Its most important achievements are:

- Provides multiple logical channels
- Allows change of primary/secondary devices

Second, the LM-IAS (Link Management Information Access Service), which provides a list, where service providers can register their services so other devices can access these services by querying the LM-IAS.

Tiny TP

The optional **Tiny TP** (**Tiny Transport Protocol**) lies on top of the IrLMP layer. It provides:

- Transportation of large messages by SAR (Segmentation and Reassembly)
- Flow control by giving credits to every logical channel

IrCOMM

The optional **IrCOMM** (**Infrared Communications Protocol**) lets the infrared device act like either a serial or parallel port. It lies on top of the IrLMP layer.

OBEX

The optional **OBEX** (**Object Exchange**) provides the exchange of arbitrary data objects (e.g., vCard, vCalendar or even applications) between infrared devices. It lies on top of the Tiny TP protocol, so Tiny TP is mandatory for OBEX to work.

IrLAN

The optional **IrLAN** (**Infrared Local Area Network**) provides the possibility to connect an infrared device to a local area network. There are three possible methods:

- Access point
- Peer-to-peer
- Hosted

As IrLAN lies on top of the Tiny TP protocol, the Tiny TP protocol must be implemented for IrLAN to work.

IrSimple

IrSimple achieves at least 4 to 10 times faster data transmission speeds by improving the efficiency of the infrared IrDA protocol. A 500 KB normal picture from a cell phone can be transferred within 1 second.[2]

IrSimpleShot

One of the primary targets of **IrSimpleShot** (**IrSS**) is to allow the millions of IrDA-enabled camera phones to wirelessly transfer pictures to printers, printer kiosks and flat-panel TVs.

Infrared Financial Messaging

Infrared Financial Messaging (**IrFM**) is a wireless payment standard developed by the Infrared Data Association. It was thought to be logical because of the excellent privacy of IrDA, which does not pass through walls.

Power meters

Many modern (2021) implementations are used for semi-automated reading of power meters. This high-volume application is keeping IrDA transceivers in production. Lacking specialized electronics, many power meter implementations utilize a bit-banged SIR phy, running at 9600 BAUD using a minimum-width pulse (i.e. 3/16 of a 115.2KBAUD pulse) to save energy. To drive the LED, a computer-controlled pin is turned on and off at the right time. Cross-talk from the LED to the receiving PIN diode is extreme, so the protocol is half-duplex. To receive, an external interrupt bit is started by the start bit, then polled a half-bit time after following bits. A timer interrupt is often used to free the CPU between pulses. Power meters' higher protocol levels abandon IrDA standards, typically using DLMS/COSEM instead. With IrDA transceivers (a package combining an IR LED and PIN diode), even this crude IrDA SIR is extremely resistant to external optical noise from incandescents, sunlight, etc.

Reception

IrDA was popular on PDAs, laptops and some desktops from the late 1990s through the early 2000s. However, it has been displaced by other wireless technologies such as Wi-Fi and Bluetooth, favored because they don't need a direct line of sight and can therefore support hardware like mice and keyboards. It is still used in some environments where interference makes radio-based wireless technologies unusable.

An attempt was made to revive IrDA around 2005[3] with IrSimple protocols by providing sub-1-second transfers of pictures between cell phones, printers, and display devices. IrDA hardware was still less expensive and didn't share the same security problems encountered with wireless technologies such as Bluetooth. For example, some Pentax DSLRs (K-x, K-r) incorporated IrSimple for image transfer and gaming.[4]

See also

- Consumer IR
- Li-Fi
- List of device bandwidths
- RZI

References

1. "About IrDA" (https://web.archive.org/web/20040610101333/http://www.irda.org/displaycommon.cfm?an=1). Archived from the original (http://www.irda.org/displaycommon.cfm?an=1) on 2004-06-10.
2. http://irdajp.info/irsimple.html Archived (https://web.archive.org/web/20130412010508/http://irdajp.info/irsimple.html) 2013-04-12 at the Wayback Machine IrDA IrSimple Specifications (Infrared Data Association - irda.org)
3. "Irdajp.info" (http://irdajp.info/irsimpleprdenhance.html).
4. http://www.pentaximaging.com/about-us.aspx?p=press&pid=PENTAXANNOUNCESK-rDIGITALSLRANDNEW35MMLENS20100908174223 Archived (https://web.archive.org/web/20110927143215/http://www.pentaximaging.com/about-us.aspx?p=press&pid=PENTAXANNOUNCESK-rDIGITALSLRANDNEW35MMLENS20100908174223) 2011-09-27 at the Wayback Machine Pentax K-r

Further reading

- *IrDA Principles and Protocols*; Knutson and Brown; MCL Press; 214 pages; 2004; ISBN 978-0975389201.

External links

Official

- List of official specifications (https://web.archive.org/web/20191115171139/http://www.irdajp.info/specifications.html), physical layer specification is US$100

Other

- Linux Infrared HOWTO (http://www.tldp.org/HOWTO/Infrared-HOWTO/)
- Linux Infrared Remote Control (http://www.lirc.org)
- Linux status of infrared devices (IrDA, ConsumerIR, Remote Control) (https://web.archive.org/web/20130425030439/http://tuxmobil.org/ir_misc.html)
- IrDA project of Universidad Nacional de Colombia SIE board (https://web.archive.org/web/20110902095151/http://wiki.linuxencaja.net/wiki/Academico/Embebidos/IrDA_SIE)

APPENDIX K

Retrieved from "https://en.wikipedia.org/w/index.php?title=Infrared_Data_Association&oldid=1144039021"

The IrDA Standards for High-Speed Infrared Communications

Iain Millar
Martin Beale
Bryan J. Donoghue
Kirk W. Lindstrom
Stuart Williams

As more data communications products, such as printers and laptop PCs, are released with infrared capability, support for a core set of IrDA standards has strong support from many manufacturers because, among other things, they want to ensure that their products will interoperate in a transparent and user-friendly manner.

The use of infrared techniques for data communications has been around for several years, and by 1993 several commercial products were available with this capability. However, each company has tended to have its own infrared standard, and although devices from the same manufacturer could communicate with each other, competing systems tended not to be interoperable. Examples of such proprietary infrared systems include Hewlett-Packard's HP SIR (serial infrared), Sharp's ASK systems, and General Magic's MagicBeam. The resulting confusion in the marketplace meant that users viewed infrared as having only limited utility.

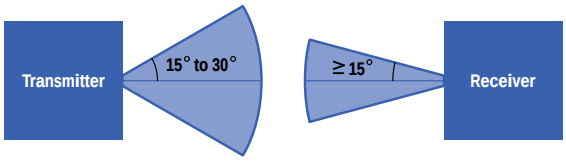
On June 28, 1993, the Infrared Data Association (IrDA) had its first meeting with the purpose of establishing a ubiquitous, low-cost, point-to-point serial infrared standard. Some 50 representatives from 20 interested companies were expected, but over 120 people representing more than 50 companies actually attended. It was clear that the industry was interested in developing a standard that would allow the true value and utility of infrared to be realized. At the culmination of this process—and due in no small part to the enthusiasm and spirit of cooperation of the participating companies—the first IrDA standards were published, just one year and two days after the initial meeting.

To date, IrDA has specified the physical and protocol layers necessary for any two devices that conform to the IrDA standards to detect each other and exchange data. The initial IrDA 1.0 specification detailed a serial, half-duplex, asynchronous system with transfer rates of 2400 bits/s to 115,200 bits/s at a

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

range of up to one meter with a viewing half-angle of between 15 and 30 degrees (see **Figure 1**). More recently, IrDA has extended the physical layer specification to allow data communications at transfer rates up to 4 Mbits/s.

Figure 1
Viewing angle specified in IrDA specification 1.0.



This paper presents details of the individual IrDA specifications, focusing specifically on the high-speed extensions that allow data communications at up to 4 Mbits/s. The first section gives details of the objectives that resulted in the series of IrDA specifications. The specifics of the user model and the technical requirements of the specification are also presented. Next the IrDA architecture is introduced, highlighting how the IrDA specifications together provide overall functionality. The infrared physical-layer specification with particular emphasis on modulation format, packet framing, transceiver design, and clock recovery is discussed in the next section. The transceiver design for the HP HDSL-1100 IrDA transceiver is also described in this section. The last section covers the protocol layers of the IrDA specifications. Finally, IrDA's current status is summarized.

IrDA Objectives

When IrDA was established, it set for itself the following objective:

"To create an interoperable, low-cost infrared data interconnection standard that supports a walk-up, point-to-point user model* that is adaptable to a broad range of mobile appliances that need to connect to peripheral devices and hosts."[1]

IrDA chose the short-range, walk-up, point-and-shoot directed infrared communications model for two main reasons. First, it was perceived that the initial target market for IrDA-enabled devices would be the mobile

professional who is also a computer user. The environment for the use of such devices would be in a typical working environment in which the majority of stationary devices, such as printers or computers, would be located within the user's own reach space, on the desktop or in the immediate vicinity. Typical use of such devices would consist of short, conscious interactions such as file transfer or printing. Such use scenarios do not require the devices to be continually connected to each other, and a directed model of communications was adopted in which the user consciously points the infrared device at the target.

Previously, mobile professionals might connect their laptops to various peripherals using parallel or serial cables. Connecting such devices using LAN connections might also be possible if cost were not an issue. However, a problem arises when the user becomes mobile—for example, when visiting customers in their office. Setting up a laptop at the customer office to achieve even simple tasks, such as printing or file transfer, would more than likely require significant reconfiguration. IrDA aimed to change this by providing standards for ubiquitous access to such devices.

Second, IrDA chose this communications model to minimize cost. The use of a single LED and photodiode in the transceiver enables an extremely low-cost implementation. The model simplifies the protocol software by restricting the number of visible devices, hence limiting the contention and interference between IrDA devices. The limited range also allows reuse of the infrared medium, allowing multiple pairs of devices to communicate at the same time.

* The phrase "walk-up, point-to-point user model" refers to the fact that to ensure data transfer between devices with infrared capabilities, they must be placed close together (< 2 m) with their infrared transceivers pointed at one another.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Glossary

Cell. A symbol in PPM.

Chip. A pulse within a symbol (cell) in PPM.

ENDEC. The encoder-decoder used in the IrDA physical layer.

HTTP Hypertext Transfer Protocol.

HDLC. A bit-oriented, synchronous High-level Data Link Control protocol that applies to the message-passing (data link) layer of the Open Systems Interconnect (OSI) model for computer-to-computer communications.

IAS. The information access service maintains information about the services available on the host device and provides services that allow access to information on remote devices.

IrCOMM. IrDA specification for the emulation of serial and parallel port communications.

IrLAN. IrDA specification for accessing a LAN over an infrared medium.

IrLAP. IrDA specification for Link Access Protocol. This document specifies an HDLC-based protocol for controlling access to the infrared medium.

IrLMP. IrDA specification for Link Management Protocol. This protocol provides the LM-MUX and LM-IAS services.

IrOBEX. IrDA specification that defines the protocol for generic object exchange in an IrDA-enabled device.

IrPHY. The specification that describes the physical layer properties of the IrDA standard.

LM-IAS. The Link Management Information Access Service allows a pair of IrDA devices to interrogate each other to determine the services available on each device.

LM-MUX. The Link Management Multiplexer allows any pair of IrDA devices to simultaneously and independently use a single IrDA connection between themselves.

LSAP. Link Service Access Ports are address fields that uniquely identify applications on the source and destination devices.

LSAP-SEL. Link Service Access Port Selector.

PPM. Pulse position modulation.

SIR. Serial infrared.

Tiny TP. Lightweight transport protocol specification.

IrDA aimed to allow its standards to support a wide class of computing devices and peripherals that might be used by mobile professionals. These devices would range from very sophisticated, high-power notebook or laptop personal computers, through palmtop computers and personal digital assistants, to simple single-function devices like electronic business cards or phone dialers. Target peripheral devices would include conventional computer-oriented devices like printers and modems, as well as automatic teller machines and public and mobile telephones. It was also envisaged that IrDA would enable new classes of devices such as information access points.

To target such a broad range of devices, a set of general requirements was placed on any prospective standard. These requirements included:

- Low cost
- Industry standard
- Compact, lightweight, low-power

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

- Intuitive and easy to use
- Noninterfering.

Using these requirements, the IrDA committee developed a series of standards aimed at providing ubiquitous, low-cost, directed infrared communications for all classes of mobile computing devices. In IrDA's vision of the world, the user of such devices would be able to roam across international boundaries using IrDA communications to access information, computing, and communications services in a uniform and transparent manner. The days of the mobile computer user travelling the globe with a multitude of modem, serial, and parallel cables, including adapters, will be gone.

The remainder of this paper presents details of the standard IrDA has put in place to achieve this vision.

The IrDA Architecture

After the initial marketing requirements had been specified, the technical committee within IrDA moved quickly towards the development of the initial standards. In April 1994, the first IrDA standard was published covering the physical layer properties. This document, the Infrared Physical Layer (IrPHY) specification,[2] describes an infrared transmission system based on a UART modulation strategy. The document specifies the necessary parameters to provide an asynchronous half-duplex serial communications link over distances of at least one meter at data rates between 2400 bits/s and 115.2 kbits/s. The cone half-angle of the infrared transmission is specified as being at least 15 degrees, but no more than 30 degrees. The IrPHY specification was quickly followed with the publication of the Infrared Link Access Protocol (IrLAP) in June 1994.[3] IrLAP specifies an HDLC-based protocol for controlling access to the infrared medium and providing the basic link-level connection between a pair of devices.

During the development of IrPHY and IrLAP, it was realized that some additional functionality was required in addition to the ability to provide a single connection between a pair of devices. The Infrared Link Management (IrLMP) layer was conceived.[4] This layer has two primary functions.

First, it provides the mechanism by which multiple entities within any pair of IrDA devices can simultaneously and independently use the single IrLAP connection between those devices. This function is called the link management multiplexer (LM-MUX).

Second, it provides a way for entities using the IrDA services to discover what services are offered by a peer device and to register available services within the local device. This link management information access service (LM-IAS) considerably benefits the ease of use of portable devices, allowing pairs of devices to interrogate each other to discover information about the applications within each device.

These three standards—IrPHY, IrLAP, and IrLMP—form the core of the IrDA architecture, and all are required for a device to be IrDA-compliant. Since the core documents were published, several extensions have been added. The current complete IrDA architecture is shown in **Figure 2**.

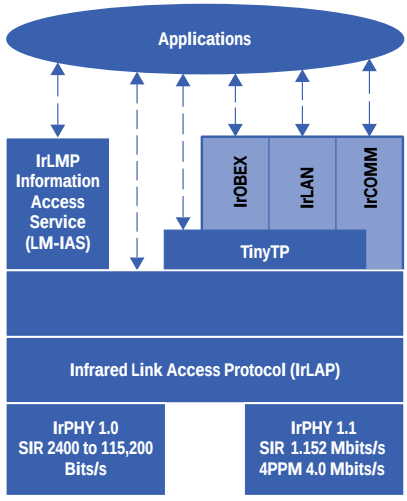
In October 1995, optional extensions to the physical layer, adding data transmission speeds of up to 4 Mbits/s, were accepted by the IrDA committee. These changes resulted in the IrDA IrPHY 1.1 specification.[5] The IrLAP and IrLMP documents have also recently been updated to version 1.1 to incorporate various improvements that resulted from practical experience in implementing and using the IrDA protocols.[6,7]

In addition to the base standards, IrDA has specified a protocol called Tiny TP.[8] This protocol is an extremely lightweight transport protocol designed to provide application-level flow control as well as segmentation and reassembly of application data units. This protocol has proved to be useful and is now implemented by most applications that support the IrDA architecture.

To complement the functionality of the main components of the IrDA architecture, several application-level protocols have been and are in the process of being developed. These protocols are aimed at providing convenient and uniform interfaces to the functionality of the IrDA protocols for both old and new applications.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Figure 2
The IrDA architecture.



The original target for IrDA was cable replacement. The need for a protocol to support the redirection of serial and parallel cable traffic resulted in the IrCOMM serial and parallel port emulation protocol specification.[9] This protocol enabled the redirection of conventional serial and parallel ports over the infrared medium, allowing many existing applications to operate unchanged over an IrDA link. Another area seen as a suitable application of IrDA, particularly as a result of the high-speed extensions, is wireless access to local area networks. The protocol IrLAN was developed to allow an IrDA-enabled device to access a LAN over the infrared medium.[10] The protocol, in combination with an IrLAN-compatible LAN access device, provides the IrDA device with the equivalent functionality of a LAN card and the advantages of wireless connectivity.

Both IrCOMM and IrLAN address legacy-style applications. However, it is envisioned that many new applications will be enabled by the IrDA standards. Using IrDA on low-end devices gives rise to the need for a flexible, lightweight information exchange protocol suitable for devices with varying resource capabilities. A protocol for generic object exchange, IrOBEX, is currently under development within IrDA.[11] This protocol is based on HTTP (Hypertext Transfer Protocol) but is more compact. When completed, IrOBEX will provide a device independent method for exchanging arbitrary units of data between IrDA-enabled devices.

The IrDA Physical Layer

The IrDA physical layer is split into three distinct data rate ranges: 2400 to 115,200 bits/s, 1.152 Mbits/s, and 4 Mbits/s. Initial protocol negotiation takes place at 9600 bits/s, making this data rate compulsory. All other rates are optional and can be added if a device requires a higher data rate. The links are designed to be used in a line-of-sight, point-and-shoot manner and hence have a modest minimum coverage of one meter, with a ±15° viewing angle. This modest coverage is advantageous, since it allows a low-cost, high-data-rate link to be produced in a small package.

2400-to-115,200-bit/s Link

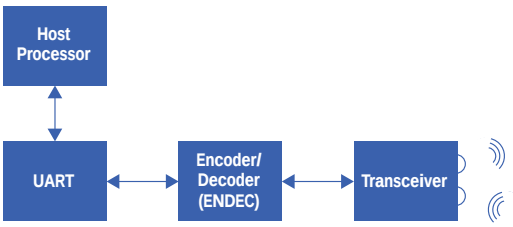
This is based on the HP-SIR link developed for HP calculators.[12] All IrDA-compliant devices implement this type of link since initial protocol negotiation takes place at 9600 bits/s. The architecture of the link (**Figure 3**) is designed for easy implementation and low cost. Hardware costs can be kept to a minimum by implementing the protocol, packet framing,

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

and CRC calculation in software on the host processor. Bytes of data from the processor are converted to a serial data stream by a UART (universal asynchronous receiver-transmitter). Since many systems already include a UART for RS-232 communications, this places no extra cost burden on the system. Only the ENDEC (encoder-decoder) and transceiver represent an additional hardware cost for the system.

Figure 3

The 2400-to-115,200-bit/s link architecture.



Infrared receivers contain a high-pass filter to remove background daylight. This high-pass filter forces the use of encoding on the link to ensure that long strings of zeros or ones are not lost in transmission. The encoding used on this link is return-to-zero (RZ). Zeros are represented by a pulse of 3/16-bit duration, and ones by the absence of a pulse (**Figure 4**). For example, 3/16 of a pulse width at 115,200 bits/s is 1.6 µs. The code is power-efficient since infrared light is only transmitted for zeros. The tall narrow pulse has better signal-to-noise ratio performance than a short wide pulse of the same energy.

Figure 4

The coding on a 2400-to-115,200-bit/s link.



The 1.152-Mbit/s Link

At speeds above 115,200 bits/s, packet framing and CRC generation and checking become a significant burden to the host processor. At 1.152 Mbits/s, these tasks are performed in hardware by a packet framer (see **Figure 5**). The packet format is slightly different from that used in the 2,400-to-115,200-bit/s link, but the line code remains similar.[5] Higher-level protocols are less processor intensive than packet framing or CRC generation and are still implemented in software on the host processor.

The 4-Mbit/s Link

The 4-Mbit/s link architecture is shown in **Figure 6**. As in the 1.152-Mbit/s link, packet framing and CRC generation and checking are performed in hardware to relieve the burden on the host processor, while higher-level protocols are implemented in software on the host processor. The link uses a new encoding scheme (described below) and a new, more robust packet structure. A phase-locked loop replaces edge detection as the means of recovering the sampling clock from the received signal. The packet framer, ENDEC, and phase-locked loop are more complex than the UART and ENDEC in the 2400-to-115,200 bit/s link. However, this added complexity need not be expensive. The components are specified in a

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Figure 5

The 1.152-Mbit/s link architecture.

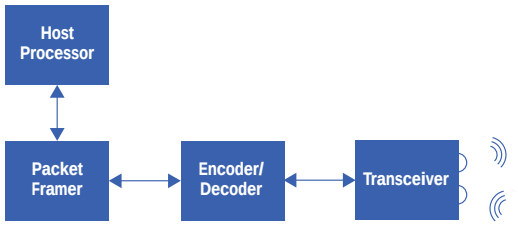
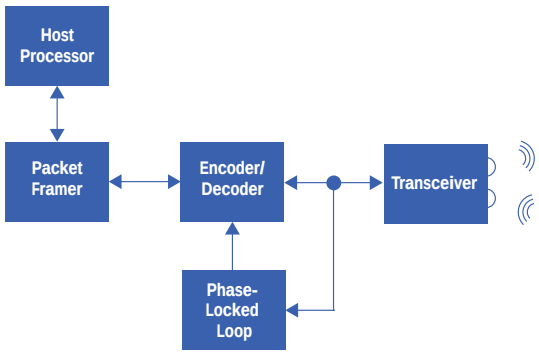


Figure 6

4-Mbit/s link architecture.

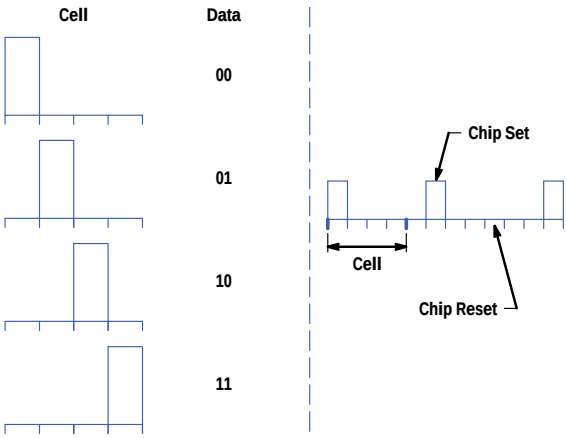


hardware description language and can be added quickly and inexpensively to one of the host system's ASICs. PC chip-sets including the 4-Mbit/s hardware are already available from leading semiconductor manufacturers.

Coding and Packet Format. Pulse position modulation (PPM) was chosen as the line code for the 4-Mbit/s link. Data is transmitted within a PPM signal by varying the position of a pulse (referred to here as a chip) within a symbol (referred to here as a cell). The PPM modulation for the 4-Mbit/s link allows one chip to be set in one of four possible positions; thus it is known as 4PPM. Since a chip can be set in one of four possible positions, four different messages can be sent within one cell, allowing two bits of data to be encoded per cell. **Figure 7** shows the four possible messages that can be transmitted by 4PPM.

Figure 7

4PPM message encoding.



Pulse position modulation has many properties that make it attractive for use on the free-space optical channel. One of the main properties is the sparseness of the code. Sparse code allows high peak powers to be employed for set chips while maintaining a reasonable average power. The eye-safety rules stipulate a maximum average optical power, and LEDs tend to be average-power-limited at moderate duty cycles.

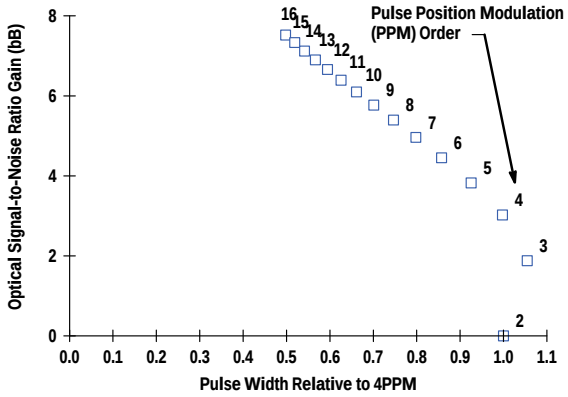
Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Pulse position modulation also contains significant and regular timing content, which facilitates synchronous clock recovery using a phase-locked loop. It is a modulation format that has very little dc content and can be high-pass filtered at 100 kHz, avoiding interference generated by fluorescent lighting without adversely affecting the receiver's eye diagram. A particularly interesting feature of PPM—one that had important ramifications in the choice of end delimiters—is its ability to detect line code errors.

Higher orders of PPM give lower duty cycles and theoretically greater signal-to-noise ratio gains on the infrared medium. **Figure 8** illustrates the interesting relationship between signal-to-noise ratio gain achievable with various orders of PPM and the required pulse width. It is interesting to note that the optimum order of PPM from a bandwidth efficiency perspective would be 3PPM. This result might be of theoretical interest, but is fairly useless in a practical system. Since the fastest bright LEDs have a rise time of around 40 ns, and the rise time of an LED is proportional to the pulse width, the use of high-order PPMs at 4 Mbits/s becomes impractical. The decision to adopt the order four for the PPM was motivated by knowledge of the range of duty cycles over which LEDs are peak-power-limited, the rise and fall time of available LEDs, and the frequent timing content provided at order four.

Figure 8

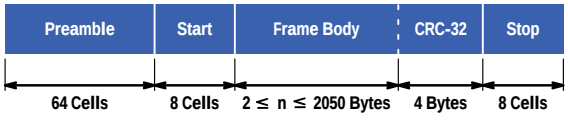
The signal-to-noise ratio gain and pulse width trade-off.



Packet Format. The 4-Mbit/s physical layer packet has distinct features that perform a useful and well-defined role (see **Figure 9**). A preamble allows dc balance to be attained, and more important, permits the phase-locked loop to achieve chip-level synchronization. The length of the preamble was considered carefully such that the preceding two goals could be achieved without a significant impact on efficiency. The start and stop delimiters provide cell and frame synchronization and were chosen so as not to compromise overall packet robustness or adversely affect the receiver eye diagram. To distinguish the preamble and the end delimiters from the frame body, these fields contain code violations. The body of

Figure 9

The 4-Mbit/s packet format.



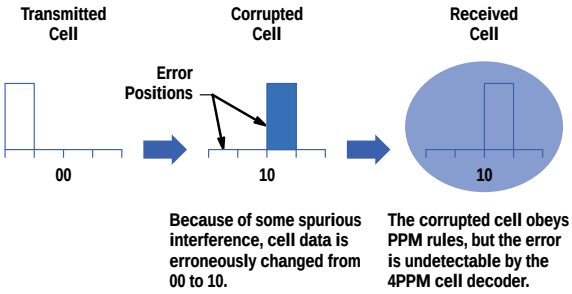
Lexmark, Exhibit 1003
Lexmark v. Flexiworld

the packet is 4PPM-coded and has a 32-bit cyclic redundancy check (CRC) field appended to it. The choice of a 32-bit CRC provides a guaranteed level of robustness to undetected data errors over the range of error rates expected on a free-space infrared channel. The CRC is performed on the data bits rather than on the PPM-encoded chips.

Error Detection and Delimiters. A decoder may choose to exploit the error detection capabilities of 4PPM. The only portions of the packet allowed to contain violations are the preamble and the frame delimiters. If a decoder finds code violations within the frame body or CRC portion of the packet, it can flag that packet as being corrupted. In the same way that a sufficient number of carefully positioned errors can produce a correct-looking CRC for a corrupted packet, there are some error patterns that a 4PPM decoder cannot detect. An example is shown in **Figure 10**.

Figure 10

An undetectable 4PPM error.



The role of the CRC is to detect those error patterns that the PPM cell decoder cannot detect. Owing to the combined distance structure of the CRC and the pulse position modulation, the packet can be made very robust to withstand either random or burst errors at any signal-to-noise ratio.

A more worrisome error mechanism that had to be considered was the possibility of the corruption of the frame delimiters. The frame delimiters are not in themselves protected by the CRC. If the situation arose whereby a false Stop delimiter appeared in a valid position within the data and CRC portion of the packet, the packet would be protected solely by the scrambling effect of the CRC. In this case, a corrupted packet would be flagged as correct with a probability of $(0.5)^{32}$. Thus, it is important to ensure the unlikelihood of either random or burst errors causing a false delimiter to appear within the data portion of the packet. This is achieved by choosing delimiters with a large Hamming distance from the data (or shifted versions of the data, to ensure serial uniqueness) and with a sufficient number of chips such that "bursty" channel error models can be tolerated. A further constraint on the delimiter choice is that delimiters must not adversely affect the eye diagram of the complete packet. The lack of long strings of contiguous set or reset chips within the 4-Mbit/s delimiters allows this goal to be attained. The delimiters chosen ensure packet robustness at any signal-to-noise ratio, for any length of packet, over random and burst-error models—all without affecting the receiver eye diagram.

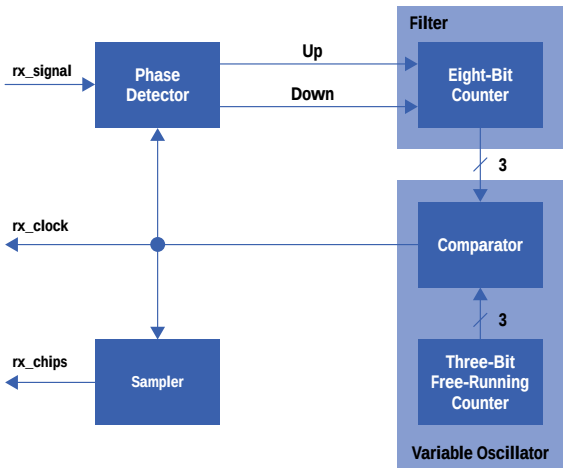
Clock Recovery. The UART-style clock recovery of the 2400-to-115,200-bit/s link uses a single signal edge to set the phase of the recovered sampling clock. This inevitably gives rise to phase jitter on the recovered clock and a consequent signal-to-noise ratio penalty. The phase-locked loop used by the 4-Mbit/s link generates a sampling clock with much less jitter because it uses timing information from many signal edges to set the phase of the clock. An analog phase-locked loop could have been used for clock recovery and might have achieved a low phase jitter, but it would have been unable to achieve the rapid phase lock of a digital phase-locked loop. Rapid phase lock is important in a packetized data system, because it determines the length of the training sequence, or preamble, required at the start of every packet to allow the phase-locked loop to lock.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The lock time is dictated by the accuracy with which the nominal frequency of the phase-locked loop's variable oscillator can be set. The nominal frequency of the variable oscillator in an analog phase-locked loop is highly variable, since it is determined by the (usually poor) tolerance of the resistors and capacitors. By contrast, the nominal frequency of the variable oscillator in a digital phase-locked loop can be locked to a crystal reference with a tolerance of less than 100 ppm. Implementations of digital phase-locked loops have the additional advantage that they can be quickly and easily ported between ASIC designs. The architecture of a typical digital phase-locked loop for the 4-Mbit/s link is shown in **Figure 11**.

Figure 11

4-Mbit/s digital phase-locked loop.



The phase detector is a state machine that compares the edges in the received signal (rx_signal) with those of the recovered clock (rx_clock). Rising edges only occur in rx_signal at PPM chip boundaries. Rising edges of rx_clock should occur halfway between chip cell boundaries. If rx_signal is earlier than expected, then the phase detector produces a Down signal, thereby advancing the phase of rx_clock. If rx_signal is later than expected, then the phase detector produces an Up signal.

The three most significant bits of the 8-bit counter set the phase of rx_clock. The five least significant bits ensure that the counter acts as a low-pass filter, since many Up and Down signals are required to change the phase of rx_clock. The three-bit free-running counter and the comparator together act as a variable phase oscillator. All blocks within the phase-locked loop are clocked by the same system clock. The system clock can be either 40, 48, 56 or 64 MHz, the choice being set by the rollover point of the three most-significant bits of the 8- and 3-bit counters (100, 101, 110, or 111). A 40-MHz system clock means that rx_clock should be very granular, with only five possible phase steps within a chip period. The effective number of phase steps is, however, doubled by making use of both the positive and negative edges of the system clock in the phase detector and sampler. The choice of whether to use positive or negative edges can be made by examining the fourth most-significant bit of the 8-bit counter.

The fast lock of the digital phase-locked loop is further aided by using a dual control loop within the digital phase-locked loop. A lock state machine within the phase detector decides whether the digital phase-locked loop is in or out of lock by examining the average deviation of the rx_clock edges from the rx_signal edges. If the digital phase-locked loop is out of lock, then multiple Up or Down pulses are generated for each edge in rx_signal to ensure rapid lock. Once locked, only single Up or Down pulses are generated since multiple pulses would increase phase jitter on rx_clock.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

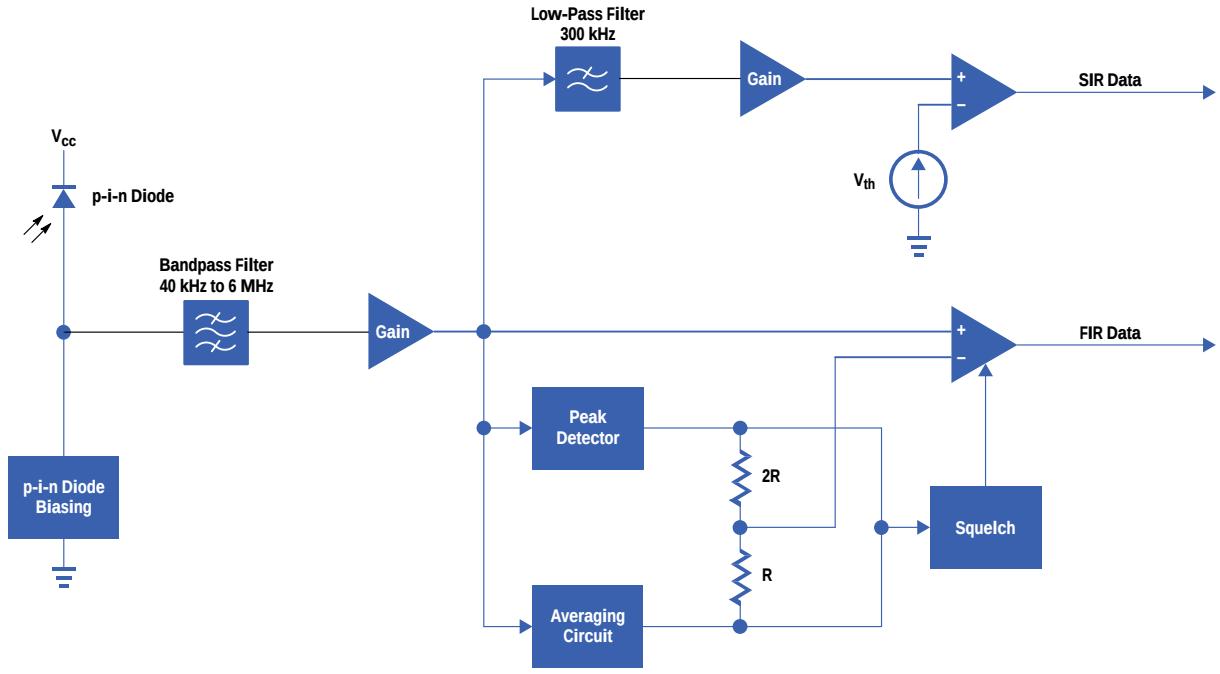
The Hewlett-Packard HSDL-1100 IrDA Transceiver

The HP HDSL-1100 from HP's Communication Semiconductor Solutions Division is the world's first fully IrDA-compliant transceiver capable of operating at all IrDA data rates from 2400 bits/s to 4 Mbits/s. The HSDL-1100 fits within the same small package as its predecessor, the HSDL-1000, which operated at data rates from 2400 bits/s to 115,200 bits/s. The small package size available for pins, IC, passive components, and heat dissipation imposed design constraints on the complexity of the transceiver. The IC uses a low-density bipolar in-house process, which is low in cost and allows quick turn times on wafers for IC development.

Transmitter design was straightforward. However, the multiple data rates, line codes, and large dynamic range made receiver design much more challenging. The receiver's dual-channel architecture is shown in **Figure 12**. A shared p-i-n diode detects all infrared signals with a modulation frequency between 40 kHz and 6 MHz. An amplifier boosts this signal before it is split into separate receiver channels. IrDA signals at 2400 to 115,200 bits/s pass through the serial infrared (SIR) channel*, while 1.152-to-4-Mbit/s signals pass through the fast infrared (FIR) channel. The lower bandwidth of the SIR channel (40 to 300 kHz) means lower noise and allows the SIR channel to meet the IrDA 4 $\mu W/cm^2$ sensitivity requirement. The higher-bandwidth (40 kHz to 6 MHz) FIR channel has higher noise, but still meets the 10 $\mu W/cm^2$ sensitivity requirement for 1.152-to-4-Mbit/s IrDA links. Since the different data rate IrDA links overlap in their modulation spectra, the received signal will appear on both channels. The ENDEC relies on information provided by the protocol to ensure that it listens on the correct channel.

Figure 12

The HDSL-1100 receiver architecture.



* At low rates, such as 2400 or 9600 baud, only the leading edge of the signal passes through the 40-kHz to 6-MHz bandpass filter. The signal is still correctly decoded since the ENDEC is able to tolerate received SIR pulses as short as 1 to 4 µs.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The receiver converts signals from an analog to a digital form by comparing them with a threshold voltage. The two channels have different threshold detection circuits to meet the different requirements for the signals. The SIR channel has a fixed threshold set at the level of the weakest received signals. Although the fixed threshold tends to extend the duration of high-level pulses, the line code for the 2400-to-115,200-bit/s ENDEC is tolerant of pulses that extend to five times their nominal width. The 4-Mbit/s ENDEC is far less tolerant of pulse extension, so a dynamic threshold is required on the FIR channel. The dynamic threshold tracks the 50% level between the peak extensions of the 4PPM signal. A peak detector tracks the 100% level of the signal and an average circuit tracks the 25% level. The 50% threshold level is derived from a 2R-R voltage divider connected to these levels. Between packets, the dynamic threshold drops to zero. This would allow the FIR_Data output to "chatter" on noise or on feedback between the output pin and the p-i-n diode. The 1.152-Mbits/s ENDEC is intolerant of the extra pulses produced by such chatter, so a squelch circuit was added to switch off the FIR_Data output at low signal levels. The dynamic threshold also takes time to settle at the start of a packet, which causes some of the packet's initial infrared pulses to be lost or distorted. While this would be disastrous for the 2400-to-115,200-bit/s link, the 1.152- and 4-Mbit/s packets include a preamble to allow the receiver to settle before decoding data.

Another challenge for receiver design was the dynamic range of infrared signals. IrDA specifications allow received signal strength to vary between 4 $\mu W/cm^2$ and 500 mW/cm^2. This is a dynamic range of 51 dB. Since the p-i-n diode is a square law detector, this dynamic range doubles to 102 dB within the receiver. The receiver achieves this dynamic range by allowing the signal to be clipped while maintaining the timing of the signal. The impedance of the p-i-n diode biasing circuit decreases with signal level, reducing the signal voltage and the receiver amplifier's limit without saturating. The p-i-n diode has also been carefully designed to ensure that the induced signal decays rapidly once an infrared pulse disappears.

The IrDA Protocol Layers

The Infrared Link Access Protocol

IrLAP is the IrDA protocol that provides the basic link layer connection between a pair of IrDA devices. It is based on the HDLC protocol providing functions like connection establishment, data transfer, and flow control.[13,14] However, IrLAP has significant additional features as a result of the specific properties of the infrared medium.

The infrared medium over which IrLAP is required to operate is a point-to-point, half-duplex medium. While the narrow cone angle of IrPHY limits the number of other devices that can be seen, it does increase the probability of hidden devices. In such a situation, one device may see many other devices. However, it does not follow that those devices will see each other. This can result in collisions where transmissions from devices hidden from each other may overlap, resulting in the inability of the receiving device to decode those frames correctly. The characteristics of the infrared medium also result in there being no reliable way to detect transmission collisions. Conventional carrier sensing with collision-detection protocols would therefore be unsuitable, and IrLAP provides a mechanism for ensuring contention-free access to the medium, at least during data transfer.

The IrLAP has three distinct phases of operation: link initialization, nonoperational mode, and operational mode. Nonoperational and operational modes are distinguished by the absence or presence of a connection with another device. During link initialization, the IrLAP layer chooses a random 32-bit device address. This address is randomly chosen to negate the need to select and maintain fixed device addresses for all IrDA devices. Although it is unlikely that two or more devices within range of each other will choose the same address, procedures are defined to detect and resolve address collisions. After the link is initialized, the IrLAP layer enters nonoperational mode.

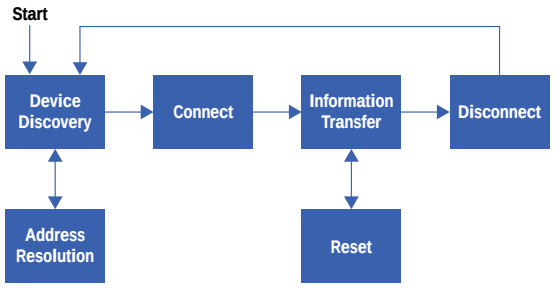
Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The nonoperational mode is derived from HDLC's normal disconnect mode (NDM). In this mode, all devices contend for the medium. To do this, each device must check that the medium is not busy before transmission. This is achieved by listening for activity—that is, listening for physical layer transitions for at least 500 ms. Transmissions in the normal disconnect mode use link parameters that can be supported by all IrDA devices at a rate of 9600 bits/s. In this mode, the device will initiate device discovery, address resolution (if required), and connection establishment.

Once the connection has been established, the IrLAP layer moves into the operational or, in HDLC terms, normal response mode. This mode is an unbalanced mode of operation in which one device assumes the role of primary station and the other assumes a secondary role. This is the phase in which information is exchanged under control of the primary station. The link parameters are negotiated during the connection setup procedure and remain constant during the connection. During this phase, all other devices within range of either the primary or secondary stations remain idle in the normal disconnect mode. The two communicating devices therefore have unrestricted access to the medium for the duration of the connection. Once the information has been transferred, the link is disconnected and the device returns to the normal disconnect mode. The flow of procedures for the IrLAP layer is shown in **Figure 13**.

Figure 13

The IrLAP procedure flow.



Device Discovery and Address Resolution. The discovery procedure is the process an IrDA device uses to determine whether or not there are any devices within communications range. In doing so, the device discovers the address of any device within range, the version number of the IrLAP protocol operating in each device, and some discovery information specified by the IrLMP layer in each device. The discovery procedure is controlled by the initiating device, which divides the discovery process into equal periods or time slots. The slotted nature of the discover procedure minimizes the likelihood of collisions when there are multiple devices within range.

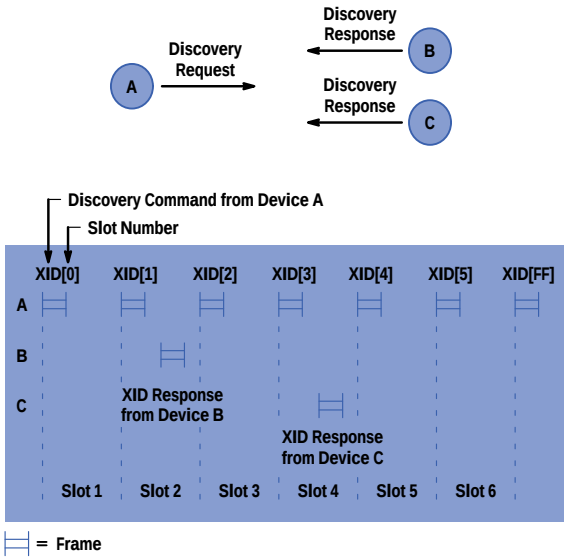
After waiting for a period of 500 ms (normal disconnect mode rules), the initiating device starts the discovery procedure and broadcasts frames marking the beginning of each slot. On hearing the initial discovery slot (which also details the number of slots in the discovery process: 1, 6, 8 or 16), a device randomly selects one of the slots in which it will respond. When the device receives the frame marking its chosen slot, it transmits a discovery response frame. All frames in the discovery procedure use the HDLC unnumbered format of type XID (exchange identification).* An example of the discovery process is shown in **Figure 14**.

Figure 14 shows a three-device scenario in which device A is within range of devices B and C. Device A initiates the discovery process by transmitting a discovery XID command frame which, in this case, indicates that this is a six-slot discovery process and that this is the initial slot. Device A continues to transmit discovery command XID frames indicating the appropriate slot number. The final frame, after slot 6, is indicated by a slot number 0xFF. The final slot also contains information about the initiating device.

* In this context XID is a type of HDLC frame as specified in the ISO standard.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Figure 14
The discovery procedure.



When the initial discovery XID command frame is received, devices B and C randomly choose slots in which to respond—in this example, slots 2 and 4. Device B then waits until it hears the discovery XID command indicating slot 2, and responds with a discovery XID response frame containing information about itself. Similarly, device C transmits a response during slot 4. Once the discovery process is over, all devices have the address and other information of all the devices within range: that is, device A has information about devices B and C, while devices B and C each have knowledge of device A. However, devices B and C are mutually hidden and as a result have no information about each other. This discovery information is passed to the upper layers whose responsibility it is to determine if there are any address collisions that need to be dealt with.

Should any of the devices that participated in the discovery process have duplicate addresses, then an address resolution process can be initiated. Address resolution follows a procedure similar to the discovery process, except that the device detecting the address conflict initiates the procedure, and resolution involves only the devices that have conflicting addresses. In this case, the initiating device transmits an address resolution XID command directed at the conflicting address. Devices with this address select another random address and a slot in which to respond. The initiator transmits the slot markers as before, and the previously conflicting devices respond in the appropriate slot. Once the process is over, each device should have a unique address. In the unlikely event that an address conflict still exists, the procedure can be repeated.

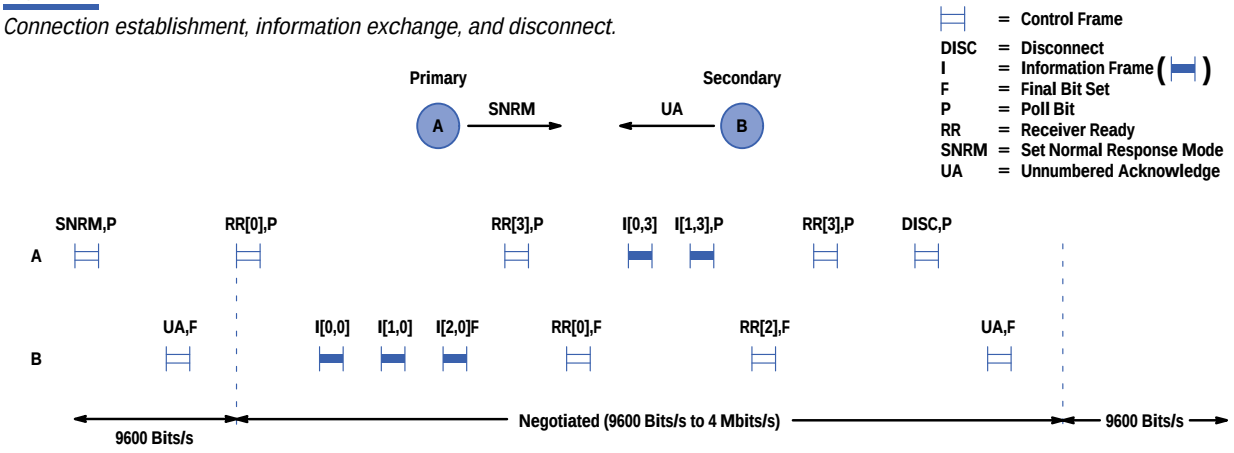
Connection Establishment. Once the discovery and address resolution processes are complete, the application layer may decide that it wishes to connect to one of the discovered devices. To connect, the application layer will issue a connection request which will ultimately result in the appropriate IrLAP service primitive being invoked. The IrLAP layer connects to the remote device by transmitting a set normal response mode (SNRM) command frame with the poll bit set. This command informs the remote device that the source wishes to initiate the connection and the poll bit indicates that a response is required. Assuming the remote device can accept the connection, it responds with an unnumbered acknowledge (UA) response frame with the final bit set. This indicates that the connection has been accepted. Under normal circumstances, the device that initiates the connection (transmits the set normal response mode) will become the

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

master, or primary, device, and the other device will become the slave, or secondary device. An example of connection establishment is shown in **Figure 15**.The notation used in the frames in **Figure 15** has the general form I(x,y) and RR(y), where x is the sequence number of the information frame and y is the sequence number of the next frame the source device expects to receive from the destination device.

Figure 15

Connection establishment, information exchange, and disconnect.



The connection establishment takes place in normal disconnect mode (9600 bits/s), and once this is completed, the two devices will be in normal response mode. While in normal response mode, the devices can exchange data at any IrDA defined rate. However, not all IrDA devices will support all IrDA data rates or link parameters. It is therefore necessary for the devices to negotiate the parameters for normal response mode during connection setup. IrDA has defined several link parameters that can be negotiated:

- Data rate
- Maximum turnaround time
- Data size
- Window size
- Number of additional start of frame symbols (BOFs)
- Minimum turnaround time
- Link disconnect threshold time.

Data rate defines the data transfer rate during normal response mode (9600 bits/s to 4 Mbits/s), while maximum turnaround time defines the length of time either device may transmit before giving the other device a chance to transmit (50, 100, 250, or 500 ms). Data size determines the maximum length of the data field in an information frame (64 to 2048 bytes), and, in combination with the retransmission window size, which defines the number of outstanding frames that may be unacknowledged, allows devices with only limited resources to restrict the rate at which they will receive data. Number of additional BOFs and minimum turnaround time relate to physical layer restrictions, while link disconnect threshold time determines how long a device will wait without receiving a response from another device before assuming the link has failed and informing the upper layer that the link has disconnected.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Well-defined rules exist that ensure that after the set normal response mode-UA exchange has been completed, both devices will know the negotiated normal response mode parameters. Once both devices are in normal response mode, the primary device polls the secondary device by transmitting a receiver ready (RR) frame with the poll bit set, thereby initiating the information exchange phase.

Information Exchange and Link Reset. The information exchange procedure operates in a master-slave mode in which the primary device controls the secondary device's access to the medium. The primary device issues command frames to the secondary device which responds with response frames. To ensure that only one device can transmit frames at any one time, a permission-to-transmit token is exchanged between the primary and secondary devices. The primary device passes the permission-to-transmit token to the secondary by sending a command frame with the poll bit set. The secondary device returns the token by transmitting a response frame with the final bit set. The secondary device can only retain the token while it is transmitting data, and it must return it to the primary device if it has no data to transmit or if it reaches the maximum turnaround time. The primary device, however, within the limits imposed by the maximum turnaround time, can hold the token even if it has no data to transmit.

Although the physical layer has been designed to provide a low bit error rate channel, the dynamic nature of the infrared connection results in a possibility that frames may be lost in transit because of corruption by noise. To cope with this, the IrLAP protocol uses a sequenced information exchange scheme with acknowledgments. Should a frame be corrupted by noise, the CRC will highlight this error and the frame will be discarded. At the IrLAP layer, this error will be detected by virtue of the noncontiguous sequence numbers on the information frames. The IrLAP protocol implements an automatic repeat request strategy in the same manner as HDLC with options of using stop and wait, go back to N, and selective reject retransmission schemes.[13] This strategy allows the IrLAP layer to provide an error-free, reliable link to the IrLMP layer. An example of an error-free information exchange between two devices is shown in **Figure 15**.

Under exceptional circumstances, however, it may not be possible for the IrLAP entities in each device to recover from an error condition while maintaining the sequenced delivery of error-free information (I) frames. In this case, the IrLAP entity is allowed to reset the link. This reset involves discarding any undelivered information and reinitializing the sequence numbers and timers for the link. Although this may result in the loss of data, which the higher-level layer must deal with, it does allow the link to recover without the need for a total disconnection.

Connection Termination. Once the data exchange has taken place, the IrLAP link may be disconnected by either the primary or secondary devices. Should the primary wish to disconnect, it sends a disconnect command to the secondary device with the poll bit set. The secondary responds by returning an unnumbered acknowledge frame with the final bit set. Both devices will now be in normal disconnect mode, and the default normal disconnect mode parameters (9600 bits/s data rate) will apply. If the secondary wishes to disconnect, it transmits a request disconnect response with the final bit set when it is polled by the primary. The primary will then respond by transmitting a disconnect command, and both devices will be in normal disconnect mode. An example of a primary-initiated disconnection is shown in **Figure 15**. Once the two devices are in normal disconnect mode, the medium is free for any other device to initiate the discovery, address resolution, or connection procedures.

The Infrared Link Management Protocol

The Link Management Protocol (IrLMP) is layered on top of IrLAP, and has two main functions: application and service discovery and multiplexing of application level connections over the single IrLAP connections. The IrLMP layer allows individual service users (applications) to connect and exchange information with similar entities in the peer device, independent of any other service users that may be using the IrLAP connection. The IrLMP layer provides multiple independent channels to the IrLMP layer in the remote device. The IrLMP layer also provides a service with which applications can locally register themselves and some significant parameters in an information base. Services are also provided that enable those applications to access equivalent information in the information base of remote devices. Using this service, an application does not need prior knowledge of the applications in a remote device. This is an extremely useful feature for the kind of ad-hoc interactions typical of IrDA devices.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The two main functions provided by IrLMP are split between two sublayers. The Link Management Multiplexer (LM-MUX) provides the facilities for multiplexing application level connections over a an IrLAP connection between a pair of devices. The Link Management Information Access Service (LM-IAS) provides the services necessary to allow applications to discover devices and access the information in the information base of a remote device.

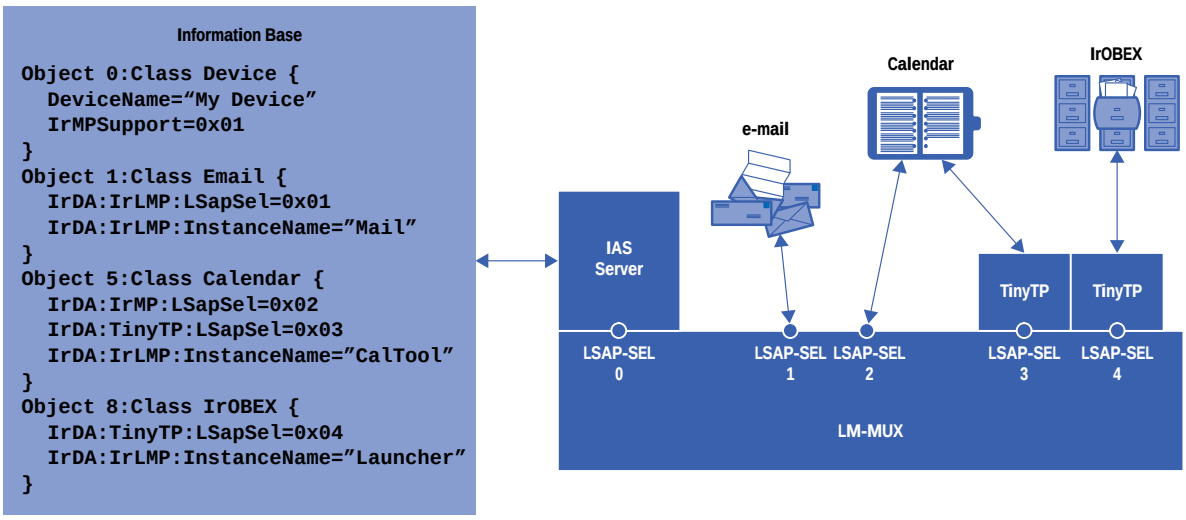
The Link Management Multiplexer. The LM-MUX adds two bytes of overhead to the IrLAP information frame, which are primarily used for addressing the individual multiplexed connections. The address fields uniquely identify the link service access points (LSAPs) in both the source and destination devices. Each LSAP is addressed by a seven-bit selector (LSAP-SEL), and LSAP-SELs within the range 0x01 to 0x6F can be used by applications. LSAP-SELs 0x00 and 0x70 are reserved for the information access service server and the connectionless data service respectively. The remaining LSAP-SEL values, 0x71 to 0x7F, are reserved for future use. Connections between IrLMP service users are called LSAP connections, and although an LSAP may terminate other LSAP connections, there is only one LSAP connection between any pair of LSAPs. All LSAP connections use the single IrLAP connection between the pair of devices.

Information Access Service. The information access service maintains information about the services provided by the host device and provides services that allow access to the information base on remote devices. The information access service allows devices to discover which services are available on the host device and provides the configuration information necessary to access those services. As an example, the most common piece of information required is the LSAP-SEL value, which tells where a particular service is located.

The information stored in the information base consists of a number of objects. Each object belongs to a specific class, and there may be several objects of the same class in the information base. The class defines the attributes that are present in each object, and these attributes can be assigned a particular value. The attributes of a class can be of type user string, octet sequence, signed integer, or missing. **Figure 16** shows an example of the information access service database for a device offering three unique services.

Figure 16

Example information access service database.



Lexmark, Exhibit 1003
Lexmark v. Flexiworld

The example shows a device with three individual applications: e-mail, calendar, and IrOBEX (file transfer application). The information base contains three objects associated with these applications. The required Object 0 is always present within the information access service database, and it provides information about the device name and the version of IrLMP the device supports. All other devices can address Object 0 to get this information. Objects in the information base typically detail information about the services provided—for example, the LSAP-SEL where these services can be accessed. In the case of the calendar application, this service can be accessed using the Tiny TP flow-control mechanism on LSAP-SEL 3, or directly on LSAP-SEL 2. The difference is encoded in the attribute name.

The IrLMP layer provides several service primitives to access information access service data. However, the only mandatory service is GetValueByClass. This service requires the service user to provide the class and attribute names of the service it is interested in. The service returns a list of object identifiers and attribute values for all objects in the information base with the requested class and attribute name. Referring to the example in **Figure 16**, if a peer device issued a GetValueByClass with parameter Calendar for the class name and IrDA:IrLMP:LSapSel for the attribute name, the service would return a single element list with the entry containing object identifier 5 and attribute value 2.

Tiny TP Flow Control Mechanism

Although the IrLAP layer does have provisions for flow control, its use can result in deadlock situations, particularly where more than one IrLMP connection is operating. Such a deadlock situation can occur if an application in one device is waiting for its peer application to send it some data before releasing its buffer space. However, another connection may use up the remaining buffer space, causing the IrLAP layer to flow-control the link until buffer space becomes available. If both connections are waiting for data from the remote device before freeing the buffers, then clearly a deadlock has occurred that cannot be resolved without some form of higher-level intervention such as a system reset.

To overcome this problem, IrDA provides the lightweight transport protocol called Tiny TP.[8] Tiny TP adds a single byte of overhead to each frame and provides a per-LSAP-connection credit-based flow control mechanism with the possible segmentation and reassembly of service data units of up to 4 Gbytes in size. When a Tiny TP connection is initiated, the maximum service data unit size is negotiated and some initial credit is extended to each connection endpoint. Sending data causes the credit to be decreased by one, and periodically the receiver issues more credit. Without credit, the transmitter cannot send any data. It must wait until such times as the receiver extends it some more credit. Using Tiny TP, a device can ensure that credit is distributed among its applications, ensuring that the applications can communicate without reducing the buffer space to such a degree that IrLAP flow control must be used.

Conclusion

IrDA has completed the core standards necessary to enable any mobile computing platform with ad-hoc, point-and-shoot infrared communications from 2400 bits/s to 4 Mbits/s. Support for the IrDA platform from a wide variety of manufacturers is now becoming apparent, as many products—ranging from printers to laptop PCs and PDAs to mobile phones—are being released with IrDA capability. All these devices will have the ability to interoperate with one another should that be required. With over 130 companies actively maintaining membership in IrDA, currently released IrDA-enabled products represent only the tip of the iceberg. In the coming months and years, it is expected that more and more computing and other devices will be released with built-in IrDA capability.

However, providing the hardware platform to support IrDA is only half the story. Current activity within IrDA is directed at finishing off the IrDA series of standards to enable application-level developers to access the IrDA features in a uniform and efficient manner. The needs of legacy serial/parallel applications have been addressed with the IrCOMM standard. Legacy networking applications will be able to use the IrDA features implemented in the forthcoming IrLAN protocol. However, it is expected that a new class of applications will be developed with the express purpose of using the unique features of IrDA-enabled devices. The IrOBEX protocol, when completed, will provide application programmers with a generic method by which data can be exchanged with other applications without having to know the details of the destination application. As an example, transferring a graphic to another PDA (which will display it) or to a printer

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

(which will print it) will be no different from the source application's point of view. Alternately, a more flexible approach to accessing the IrDA communications facilities will be to directly access them through the operating system's application programming interface. An example of this is the WinSock-style API to IrDA, called IrSock,[15] currently being developed for the Microsoft® Windows 95 operating system.

In conclusion, the future for infrared is bright. With cross-industry support, IrDA is fast becoming the ubiquitous infrared communications system for portable and peripheral devices. Although legacy support for other infrared systems will persist for some time to come, the IrDA standard is now used on so many platforms that it is unlikely any new systems will be anything other than IrDA-enabled.

References

1. *IrDA Marketing Requirements—Basis for the IrDA Technical Standards*, Version 3.2, The Infrared Data Association, November 23, 1993.

2. *Serial Infrared (SIR) Physical Layer Link Specification*, Version 1.0, The Infrared Data Association, April 27, 1994.

3. *Serial Infrared Link Access Protocol (IrLAP*), Version 1.0, The Infrared Data Association, June 23, 1994.

4. *Link Management Protocol (IrLMP)*, Version 1.0, The Infrared Data Association, August 12, 1994.

5. *Serial Infrared Physical Layer Link Specification*, Version 1.1, The Infrared Data Association, October 17, 1995.

6. *Link Management Protocol (IrLMP)*, Version 1.1, The Infrared Data Association, January 23, 1996.

7. *Serial Infrared Link Access Protocol (IrLAP)*, Version 1.1, The Infrared Data Association, June 16, 1996.

8. *Tiny TP: A Flow-Control Mechanism for use with IrLMP*, Version 1.0, The Infrared Data Association, October 25, 1995.

9. *IrCOMM: Serial and Parallel Port Emulation over IR (Wire Replacement)*, Version 1.0, The Infrared Data Association, November 7, 1995.

10. *LAN Access Extensions for Link Management Protocol (IrLAN)*, Proposal, Version 1.0, The Infrared Data Association, January 1, 1996.

11. *Object Exchange Protocol (IrOBEX)*, Draft, Version 0.5f, The Infrared Data Association, July 24, 1996.

12. S. L. Harper and R. S. Worsley, "The HP 48SX Calculator Input/Output System, *Hewlett-Packard Journal*, Vol. 42, no. 3, June 1991.

13. *Information technology—Telecommunications and information exchange between systems—High-level data link control (HDLC) procedures—Elements of procedures*, ISO/IEC 4335, International Organization for Standardization, December 15, 1993.

14. *Information technology—Telecommunications and information exchange between systems—High-level data link control (HDLC) procedures—Classes of procedures*, ISO/IEC 7809, International Organization for Standardization, December 15, 1993.

15. *Infrared Sockets (IrSockets) Specification: Functional Specification*, Revision 1.0, The Microsoft Corporation, July 10, 1996.

Microsoft is a U.S. registered trademark of Microsoft Corporation.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



Iain Millar
As a member of the technical staff at HP Laboratories in Bristol, England, Iain Millar is involved in the development of protocols for the next generation of IrDA systems. He attended the University of Aberdeen in Scotland where he received a BSc (Eng.) degree (1988) in electrical and electronic engineering and a PhD (1995) in the area of fault tolerant protocols for LANs.



Martin Beale
Martin Beale is a member of the technical staff at Hewlett-Packard Laboratories in Bristol, England. He is working on the physical layer for the next generation IrDA systems. He earned a PhD degree (1994) in reduced complexity decoding of convolutional codes from the University of Cambridge. Outside of work he enjoys rock climbing, walking, cycling, skiing.



Bryan J. Donoghue
Bryan Donoghue is a member of the technical staff at HP Laboratories in Palo Alto where he is working on the digital system design for high-speed wireless radio LANs. He received a MEng degree (1991) in electrical and electronic engineering from Loughborough University in England. Bryan was born in Llanelli, Wales and outside work he enjoys traveling, learning foreign languages, backpacking, and cycling.



Kirk W. Lindstrom
A member of the technical staff at HP's Communication Semiconductor Solutions Division, Kirk Lindstrom is responsible for the design of ICs for infrared products. He joined HP in 1978 and since that time he has worked on the design of optocouplers, fiber-optic modules, and infrared transceivers. He holds a BS degree in EECS (1979) from the University of California at Berkeley. Besides being an ardent windsurfer, he also has an interest in doing and writing about investing.



Stuart Williams
A project manager at HP Laboratories in Bristol, England, Stuart Williams is responsible for the infrared communications group. He has worked on various infrared protocol-related projects since he joined HP in 1992. He has a PhD degree (1986) from the University of Bath. Stuart was born in Rugby, Warwickshire, England, is married and has two sons. Biking and sailing occupy his free time.

▶ Go to Next Article
▶ Go to Journal Home Page

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX M

The Online Library Learning Center website is no longer being maintained, so information may be out-of-date.
This website should now be used as an historical reference.

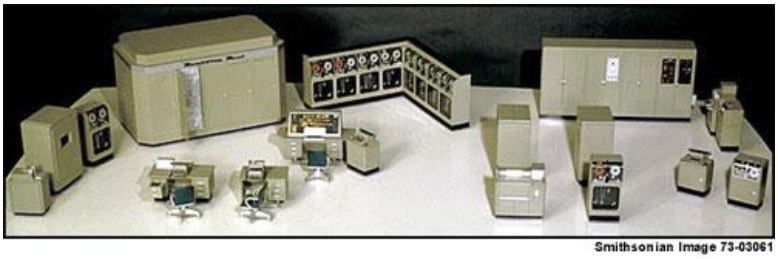
A Brief History of the Internet

Sharing Resources

The Internet started in the 1960s as a way for government researchers to share information. Computers in the '60s were large and immobile and in order to make use of information stored in any one computer, one had to either travel to the site of the computer or have magnetic computer tapes sent through the conventional postal system.

Another catalyst in the formation of the Internet was the heating up of the Cold War. The Soviet Union's launch of the Sputnik satellite spurred the U.S. Defense Department to consider ways information could still be disseminated even after a nuclear attack. This eventually led to the formation of the ARPANET (Advanced Research Projects Agency Network), the network that ultimately evolved into what we now know as the Internet. ARPANET was a great success but membership was limited to certain academic and research organizations who had contracts with the Defense Department. In response to this, other networks were created to provide information sharing.

January 1, 1983 is considered the official birthday of the Internet. Prior to this, the various computer networks did not have a standard way to communicate with each other. A new communications protocol was established called Transfer Control Protocol/Internetwork Protocol (TCP/IP). This allowed different kinds of computers on different networks to "talk" to each other. ARPANET and the Defense Data Network officially changed to the TCP/IP standard on January 1, 1983, hence the birth of the Internet. All networks could now be connected by a universal language.



Smithsonian Image 73-03061

The image above is a scale model of the UNIVAC I (the name stood for Universal Automatic Computer) which was delivered to the Census Bureau in 1951. It weighed some 16,000 pounds, used 5,000 vacuum tubes, and could perform about 1,000 calculations per second. It was the first American commercial computer, as well as the first computer designed for business use. (Business computers like the UNIVAC processed data more slowly than the IAS-type machines, but were designed for fast input and output.) The first few sales were to government agencies, the A.C. Nielsen Company, and the Prudential Insurance Company. The first UNIVAC for business applications was installed at the General Electric Appliance Division, to do payroll, in 1954. By 1957 Remington-Rand (which had purchased the Eckert-Mauchly Computer Corporation in 1950) had sold forty-six machines.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX M

5. The Great GALILEO
10. For Distance Education Students

A project of the Board of Regents of the University System of Georgia

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



WEB MARKETING SERVICES

Web Site Links Menu

^ top of page

INTERNET GROWTH STATISTICS

Today's road to e-Commerce and Global Trade
Internet Technology Reports

And the "Global Village" became a Reality

Internet has made real what in the 1970's that visionary of the communications Marshall McLuhan (1911-1980) called the "Global Village".

The Internet is defined as the worldwide interconnection of individual networks operated by government, industry, academia, and private parties. Originally the Internet served to interconnect laboratories engaged in government research, and since 1994 it has been expanded to serve millions of users and a multitude of purposes in all parts of the world.

In a matter of very few years, the Internet consolidated itself as a very powerful platform that has changed forever the way we do business, and the way we communicate. The Internet, as no other communication medium, has given an International or, if you prefer, a "Globalized" dimension to the world. Internet has become the Universal source of information for millions of people, at home, at school, and at work.

Internet is changing all the time. Two things, in our opinion, have marked it's evolution recently: the social web and mobile

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

the number of Internet users everywhere.

The Internet continues to be the most democratic of all the mass media. With a very low investment, anyone can have a web page in Internet. This way, almost any business can reach a very large market, directly, fast and economically, no matter the size or location of the business. With a very low investment, almost anybody that can read and write can have access and a presence in the World Wide Web. Blogging has consolidated the social media and the people everywhere are expressing and publishing their ideas and opinions like never before.

Secure Your Business Today

Business Intrusion Detection Package. Pro Install $99*. 36mo. Agm't. Term & Install Fees.

"When I took office, only high energy physicists had ever heard of what is called the World Wide Web... Now even my cat has it's own page."
- Bill Clinton

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

History and Growth of the Internet from 1945 to 1995

Before getting into the numbers, let's take a look at the fascinating history of the Internet, from 1945 to 1995, by courtesy of the World Wide Web Consortium (W3C).

History and Growth of the Internet from 1995 till Today

Today the Internet continues to grow day by day making McLuhan's Global Village a reality. The following table shows the incredibly fast evolution of the Internet from 1995 till the present time:

DATE	NUMBER OF USERS	% WORLD POPULATION	INFORMATION SOURCE
December, 1995	16 millions	0.4 %	IDC
December, 1996	36 millions	0.9 %	IDC
December, 1997	70 millions	1.7 %	IDC
December, 1998	147 millions	3.6 %	C.I. Almanac
December, 1999	248 millions	4.1 %	Nua Ltd.
March, 2000	304 millions	5.0 %	Nua Ltd.
July, 2000	359 millions	5.9 %	Nua Ltd.
December, 2000	361 millions	5.8 %	Internet World Stats
March, 2001	458 millions	7.6 %	Nua Ltd.
June, 2001	479 millions	7.9 %	Nua Ltd.
August, 2001	513 millions	8.6 %	Nua Ltd.
April, 2002	558 millions	8.6 %	Internet World Stats
July, 2002	569 millions	9.1 %	Internet World Stats
September, 2002	587 millions	9.4 %	Internet World Stats
March, 2003	608 millions	9.7 %	Internet World Stats
September, 2003	677 millions	10.6 %	Internet World Stats
October, 2003	682 millions	10.7 %	Internet World Stats
December, 2003	719 millions	11.1 %	Internet World Stats
February, 2004	745 millions	11.5 %	Internet World Stats
May, 2004	757 millions	11.7 %	Internet World Stats
October, 2004	812 millions	12.7 %	Internet World Stats
December, 2004	817 millions	12.7 %	Internet World Stats
March, 2005	888 millions	13.9 %	Internet World Stats
June, 2005	938 millions	14.6 %	Internet World Stats

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

September, 2005	957 millions	14.9 %	Internet World Stats
November, 2005	972 millions	15.2 %	Internet World Stats
December, 2005	1,018 millions	15.7 %	Internet World Stats
March, 2006	1,023 millions	15.7 %	Internet World Stats
June, 2006	1,043 millions	16.0 %	Internet World Stats
Sept, 2006	1,086 millions	16.7 %	Internet World Stats
Dec, 2006	1,093 millions	16.7 %	Internet World Stats
Mar, 2007	1,129 millions	17.2 %	Internet World Stats
June, 2007	1,173 millions	17.8 %	Internet World Stats
Sept, 2007	1,245 millions	18.9 %	Internet World Stats
Dec, 2007	1,319 millions	20.0 %	Internet World Stats
Mar, 2008	1,407 millions	21.1 %	Internet World Stats
June, 2008	1,463 millions	21.9 %	Internet World Stats
Sept, 2008	1,504 millions	22.5 %	Internet World Stats
Dec, 2008	1,574 millions	23.5 %	Internet World Stats
Mar, 2009	1,596 millions	23.8 %	Internet World Stats
June, 2009	1,669 millions	24.7 %	Internet World Stats
Sept, 2009	1,734 millions	25.6 %	Internet World Stats
Dec, 2009	1,802 millions	26.6 %	Internet World Stats
June, 2010	1,966 millions	28.7 %	Internet World Stats
Sept, 2010	1,971 millions	28.8 %	Internet World Stats
Mar, 2011	2,095 millions	30.2 %	Internet World Stats
Jun, 2011	2,110 millions	30.4 %	Internet World Stats
Sept, 2011	2,180 millions	31.5 %	Internet World Stats
Dec, 2011	2,267 millions	32.7 %	Internet World Stats
Mar, 2012	2,336 millions	33.3 %	Internet World Stats
June, 2012	2,405 millions	34.3 %	Internet World Stats
Sept, 2012	2,439 millions	34.8 %	Internet World Stats
Dec, 2012	2,497 millions	35.7 %	I.T.U.
Dec, 2013	2,802 millions	39.0 %	Internet World Stats
June, 2014	3,035 millions	42.3 %	Internet World Stats
Dec, 2014	3,079 millions	42.4 %	Internet World Stats
June, 2015	3,270 millions	45.0 %	Internet World Stats
Dec, 2015	3,366 millions	46.4 %	Internet World Stats
Jun. 2016	3,631 millions	49.5 %	Internet World Stats
Dec. 2016	3,696 millions	49.5 %	Internet World Stats
June, 2017	**3,885 millions**	**51.7 %**	Internet World Stats

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Dec 2017	**4,156 millions**	**54.4 %**	Internet World Stats
Jun 2018	**4,208 millions**	**55.1 %**	Internet World Stats
Dec 2018	**4,313 millions**	**55.6 %**	Internet World Stats
Mar 2019	**4,383 millions**	**56.8 %**	Internet World Stats
Jun, 2019	**4,536 millions**	**58.8 %**	Internet World Stats
Jun, 2020	**4,833 millions**	**62.0 %**	Internet World Stats
Dec, 2020	**5,053 millions**	**64.2 %**	Internet World Stats
Mar, 2021	**5,168 millions**	**65.6 %**	Internet World Stats
Dec, 2021	**5,252 millions**	**66.2 %**	Internet World Stats
Mar, 2022	**5,382 millions**	**67.8 %**	Internet World Stats
July, 2022	**5,473 millions**	**69.0 %**	Internet World Stats
Dec, 2022	**5,544 millions**	**69.0 %**	Internet World Stats

Ad adroll.com More ▼

Lexmark, Exhibit 1003
Lexmark v. Flexiworld



Statis

The Internet has made distances shorter and the world smaller. However, the great divider that stands in the way of a truly global society is fact that there are many different different languages spoken in our planet Earth. The following table shows the ten most numerous languages spoken by the **Internet users**.

To see old (Historic) Internet World Usage Statistics **click here**.
For detailed information on the Internet from Wikipedia.org **click here**.
For more on the Internet's history and its relationship with the information revolution read **NetValley's** informative nine part report.

For current up to date Internet User Statistics **click here**.

Click here for information on the 1995 to 2005 **domain count growth**.
For 1993-1996 domain count data see **Internet Growth Summary**.

History of the Internet

The fastest and easiest way to learn what the internet is and how it works, all about the creation of the Internet, its development, and evolution, is to see the many videos available at You Tube on the subject:

Internet Growth Summary You can also read a **Brief History of the Internet** , at the **Internet Hall of Fame**, a website sponsored by the **Internet Society**, which features an excellent resume about the story behind the wide world web. Recommended reading.

Here you will find the **Internet History** in a few links
Learn about Leonard Kleinrock who in 1962 invented the packet-switching technology that made it all possible.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

You can see a timetable highlighting some of the Internet key events and technologies that helped shape the Internet as we know it today at the **Hobbes Internet Timeline**.

The Internet Virtual Library also features a very complete page with links about the **Internet History**.

The **Living Internet** is a free web site, including more than 700 pages about the Internet's history, design, advanced use, key features, security issues, help resources, and references to additional information about the Internet.

The **Internet Archive** is another interesting website. They are building a digital library of Internet sites and other cultural artifacts in digital form, like a paper library. Free access is provided to researchers, historians, scholars, and the general public. The Internet Archive is huge and growing every day. They have received help from Sun Microsystems for storing the database, in what could be called, literally **Internet in a Box** . See this three minute video where Brewster Kahle talks about how the Wayback Machine is preserving the History of Web Pages.

The first commercial book about the Internet was published in 1992. It was written by Ed Krol and it's attractive title was **The Whole Internet User's Guide and Catalog**.

The Internet today is based on huge **Data Centers** that can rightly be called the brains of the Internet. A modern Data Center is an industrial style facility that uses as much electricity as a small town, and houses many thousands of interconnected computers. The above link shows a video of one of Googles data centers.

World Wide Web Consortium

The World Wide Web Consortium (W3C) develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential. W3C is a forum for information, commerce, communication, and collective understanding. On the W3C page, you'll find news, links to W3C technologies, help and ways to get involved. Public participation is welcome at the **W3C**

Internet Technology Reports

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

A Complete Web ICT Reference Library

These reports condense the major technologies of the World Wide Web.
Take a look at the executive summaries for the full content details.

Internet Independence

Declaration of the Independence of Cyberspace

Birth of an Internet Independence Movement

Law and the Internet (Book Presentation)

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX N

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

APPENDIX N

Telecommunications Research Reports

LINKS PAGE ***Internet World Stats - Web Site Directory*** **^ TOP OF PAGE**

WEBSITE LINKS - STATS TABLES

World Stats | Africa Stats | America Stats | Asia Stats | Europe Stats | European Union | Middle East Stats
Oceania Stats | Top Internet Usage | Top Internet Penetration | Top Ten Languages | Social Media Stats
Arabic Speakers | Chinese Speakers | French Speakers | German Speakers | Portuguese Speakers
Spanish Speakers | OECD Countries | G20 Countries | Caribbean Stats | Central America Stats
North America Stats | South America Stats | Latin America Stats | Facebook Stats | NATO

REGIONS AND COUNTRY DIRECTORY

Africa | Asia | North America | Central America | Caribbean | Europe | European Union
Middle East | South America | South Pacific and Australia | United States | EU Enlargement

WORLD - DATA TABLES

Geographical Country List | Alphabetical Country List | World COVID-19 | USA COVID-19 | Inflation Rates
Broadband Internet | Mobile Internet | ICT Reports | World Languages | World Population

TELECOMMUNICATIONS REPORTS

Africa | Asia | North America | Central America | Caribbean | Europe
Middle East | South America | South Pacific and Australia

INTERNET MARKETING INFORMATION

World News | Internet Coaching | Internet Usage | Digital Divide | **Internet Growth** | Market Research
AI | Apps | Internet Associations | Internet Security Stats | Market Reports | B2B Trade Exchanges
Innovation | SEM | SEO | Search Engines | Web Browsers | Information Sources | Abbreviations

OTHER INTERNET RESOURCES AND SERVICES

Travel Stats | Dictionaries | Webmaster Tools | Internet Telephone Calls | Conference Calls | Copyrights
Make Money Online | Software | Press Room | Press Release Coaching | Newsletter Archive
Translations | Tutorials | Web Services | Web Stats | Time | Weather | Privacy | Links Page

INDIVIDUAL COUNTRY PAGES

Africa | Asia | Caribbean | Europe | Middle East | North America | South America | South Pacific | USA

Our Newsletter | ***Internet World Stats*** | ***About Us***

Copyright © 2023, Miniwatts Marketing Group. All rights reserved worldwide. Page updated Jan 21, 2023

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

INTERNATIONAL STANDARD

ISO/IEC 16485

First edition
2000-09-15

Information technology — Mixed Raster Content (MRC)

Technologies de l'information — Contenu des rasters-multiples (MRC)

Reference number
ISO/IEC 16485:2000(E)

© ISO/IEC 2000

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

© ISO/IEC 2000

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

CONTENTS

		Page
Foreword		iv
Introduction and background		v
1	Scope	1
2	References	1
3	Definitions	2
4	Conventions	3
5	Image representation	3
6	Stripe structure	4
6.1	Three-layer stripe (3LS)	4
6.2	Two-layer stripe (2LS)	4
6.3	One-layer stripe (1LS)	5
7	Image coding	5
7.1	Spatial resolution	5
7.2	Stripe width and layer width	5
7.3	Stripe height and layer height	6
7.4	Layer combination	6
8	Layer transmission order	6
9	Data format	6
9.1	Overview	6
9.2	Page data structure	7
9.2.1	Start of page marker segment	7
9.2.2	Optional marker segments	9
9.2.2.1	Layer base colour gamut range marker segment (OMSg), MRC10 entry	9
9.2.2.2	Layer base colour illuminant marker segment (OMSi), MRC11 entry	10
9.2.2.3	MRC3 to MRC9 and MRC12 to MRC254 entry for future extensions	11
9.2.3	TN (Termination Number)	11
9.3	Stripe data structure	11
9.4	EOP (End of Page)	13
9.5	Layer data structure	13
9.6	Data format summary	13
9.6.1	High-level data format summary	13
9.6.2	Detail data format summary	13
Annex A - Mixed Raster Content (MRC) Modes 2 and 3		22

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 16485 was prepared by the International Telecommunication Union (ITU) (as ITU-T Recommendation T.44) and was adopted, under a special “fast-track procedure”, by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

Annex A forms a normative part of this International Standard.

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

Introduction and background

The Mixed Raster Content (MRC) Recommendation is a way of describing raster-oriented (scanned and/or rasterized synthetic images) documents with both bi-level (text and/or line-art) and multi-level (colour/continuous-tone) data within a page. The goal of this MRC Recommendation is to make exchange of raster-oriented mixed content colour documents among users with varied communication systems possible with higher speed, higher image quality and modest computing resources (memory, storage and processing power).

The dramatic increase in exchange of electronic documents has raised customer expectations and requirements for raster-oriented documents. Colour must be exchanged just as graceful and efficiently as black & white (bi-level) and quickly reproduce a copy of the original at the best possible image quality for that output device. The following technical relations can be associated with the customer requirements:

- efficient exchange of the raster data is directly related to the file size and compression ratios;
- image quality in a scan anywhere - print anywhere environment is directly related to the exchange of device independent data forms and the rendering compromises made by the output engine;
- fast printing with modest resources is related to low complexity of the format.

The best approach to achieve high compression ratios and retain quality is to compress the different segments of the raster data according to their individual attributes. Text and line-art data (bi-level data) would be compressed with an approach that puts high emphasis on maintaining the detail and structure of the input. Pictures and colour gradients (multi-level data) would be compressed using an approach that puts a high emphasis on maintaining the smoothness and accuracy of the colours. These different data types (bi-level and multi-level) are often conceptualized as being on separate layers/planes within the page.

This separation of the data by importance of content (spatial detail vs. colour) also directly implies that it is advantageous to use different resolutions for the different data, with a high spatial resolution used for text/line-art and high colour resolution for images/gradients.

This concept of data separation by importance of content has led to development of the base mode 3-layer model on which the MRC Recommendation is built. Provisions to extend the model beyond the base mode are defined in Annexes to this Recommendation. The base mode 3-layer model identifies three basic data types that may be contained within a page. These are multi-level data associated with contone colour (continuous-tone and/or palletized colour) image for which mid-to-low spatial and high colour resolution is typically appropriate for good reproduction; bi-level data associated with high detail of text/line-art for which high spatial and low colour resolution is typically appropriate for good reproduction; multi-level data associated with multi-level colours of the text/line-art data for which mid-to-high spatial and mid-colour resolution is typically appropriate for good reproduction. Each page within the MRC model is processed independently. The data types within each page are represented in distinct layers (also referred to as planes) to be image processed, compressed and transmitted independently. Multi-level contone data may be represented in the lower layer, bi-level in the middle layer and multi-level data of text/line-art colours in the upper layer. The lower and upper layers will from here on be referenced as the background and foreground layers respectively, see Figure 1. The process of image regeneration is controlled by the middle bi-level layer that acts as a mask or selector to select whether pixels from the background contone layer or foreground text/line-art colour layer will be reproduced. Due to its selection function this layer is referenced as the mask or selector layer, throughout this Recommendation the middle layer will be referenced as the mask layer. When the value of a mask layer pixel is one (1), the corresponding pixel from the foreground is selected and reproduced. When the value

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

of the mask layer pixel is zero (0) the corresponding pixel from the background is selected and reproduced, see Figure 2.

Given limited device memory in many facsimile implementations and that mixed content pages often have a mixture of: text/line-art (monochrome or coloured) regions; contone image regions; text/line-art (monochrome or coloured) and contone image regions. There are provisions to subdivide the page into horizontal stripes that span the entire width of the page and isolate individual regions, see Figure 3. Stripes are composed of one or more layers as determined by the image type within the stripe. The mask layer must span the entire width and height of the stripe. The background and foreground layers need not span the width and height of the stripe. Reduction in the amount of white space coded in the background or foreground layers can be realized by taking advantage of the image width and height data included in the layer data stream and a horizontal and vertical offset provision. The default of the foreground base colour is black (layer base colour can be changed to any colour). The base colour is defined such that at mask pixel locations (value = 1) where a corresponding foreground pixel is not present, the foreground layer base colour is applied. The default of the background base colour is white (layer base colour can be changed to any colour). The base colour is defined such that at mask pixel locations (value = 0) where a corresponding contone image is not present, the background layer base colour is applied, see Figure 4.

The 3-layer model has 3 types of horizontal stripes that are implemented according to the type of data being addressed:

- 3-layer stripe (3LS), so referenced since it contains all three of the foreground, mask and background layers as in Figure 1. The 3LS is appropriate when addressing an image that contains both multi-coloured text/line-art and contone image or monochrome text/line-art on coloured background and contone image, as in stripes 3 and 5 of Figures 3 and 8;
- 2-layer stripe (2LS), so referenced since it contains coded data for two of the three layers (the third is set to a fixed value). The two layers may be mask and background, as in Figure 6a or mask and foreground layers, as in Figure 6b. All combination of multiple layers shall include the mask layer. The 2LS is appropriate when addressing an image that contains monochrome text/line-art and contone image or coloured text/line-art and no contone image, as in stripes 2 and 7 of Figures 3 and 8;
- 1-layer stripe (1LS), so referenced since it contains coded data for only one of the three layers (the other two are set to fixed values). The one layer may be mask, as in Figure 7a, background, as in Figure 7b or foreground, as in Figure 7c. The 1LS is appropriate when addressing an image that contains one of monochrome text/line-art, contone image or possibly richly coloured graphics, as in stripes 1, 4 and 6 of Figures 3 and 8.

Figure 8 provides an illustration of the various stripe types that may apply to the various image regions within a page.

The 3-layer model requires application of a multi-level coding scheme to the background and foreground layers. Any ITU multi-level coding (such as JPEG or JBIG, as defined in Recommendation T.81 and T.43, respectively) may be used for the background or foreground. A bi-level coding scheme is required for the mask layer, any ITU bi-level coding (such as JBIG or MMR, as defined in Recommendations T.85 and T.6, respectively) may be used, see Figure 5. The specific coders used throughout the page and over the various layers are identified at the start of each page. This information is provided by parameters in a Start of Page (SOP) Marker Segment. The spatial resolution of the mask layer, to be used throughout the page, is also identified by a SOP parameter. Layers with varied spatial resolutions may be combined within a stripe, the resolution of the foreground and background layers must be integral factors of the mask resolution layer, see Figure 5. The specific resolutions being used in the foreground and background layers are identified within a marker segment at the start of each layer within a stripe. A Start of Stripe marker segment contains parameters indicating type of stripe (1LS, 2LS or 3LS), the foreground and

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

background layer base colour, offset of the foreground and/or background, the stripe height (number of lines) and the mask layer coded data length (number of octets).

An SOP marker segment denotes the beginning of an MRC page. This is followed by page data and terminated with a EOP (End of Page). The page data consists of stripes. During transmission, stripes are sent sequentially from the top of the page, stripe 1 through N, where N is an integer. Within a stripe, the mask layer is transmitted first, followed by the background and then the foreground as appropriate.

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

This is a preview - click here to buy the full publication

Information technology — Mixed Raster Content (MRC)

1 Scope

This Recommendation defines a means to efficiently represent raster-oriented pages that contain a mixture of multi-level and bi-level images. Any of the many ITU-T recommended encoding schemes, such as T.81 (JPEG) for the encoding of multi-level images and T.6 (MMR) for the encoding of bi-level images, may be combined within the context of this Recommendation. Similarly, ITU-T spatial and colour resolutions may be combined within a page. This Recommendation does not define new encodings or resolutions. The method of image segmentation is beyond the scope of this Recommendation, segmentation is left to manufacturers' implementation.

2 References

The following ITU-T Recommendations, and other references contain provisions, which through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendation and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendation and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

– ITU-T Recommendation T.4 (1996) - *Standardization of Group 3 facsimile terminals for document transmission.*

– CCITT Recommendation T.6 (1988) - *Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus. (Commonly referred to as MMR standard.)*

– ITU-T Recommendation T. 42 (1996) - *Continuous-tone colour representation method for facsimile*.

– ITU-T Recommendation T.43 (1997) - *Colour and gray-scale image representation using lossless coding scheme for facsimile.*

– CCITT Recommendation T.81 (1992) | ISO/IEC 10918-1:1994 - *Information technology - Digital compression and coding of continuous-tone still image - Requirements and guidelines. (Commonly referred to as JPEG standard.)*

– ITU-T Recommendation T.82 (1993) | ISO/IEC 11544:1993 - *Information technology - Coded representation of picture and audio information - Progressive bi-level image compression. (Commonly referred to as JBIG standard.)*

– ITU-T Recommendation T.86 (1998) | ISO/IEC 10918-4:1999 - *Information technology - Digital compression and coding of continuous-tone still images: Registration of JPEG profiles, SPIFF profiles, SPIFF tags, SPIFF colour spaces, APPN markers, SPIFF compression types and Registration Authorities (REGAUT).*

– ITU-T Recommendation T.85 (1995) - *Application profile for Recommendation T.82 - Progressive bi-level image compression (JBIG coding scheme for facsimile apparatus).*

© ISO/IEC 2000 – All rights reserved

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

Give a Gift

The Atlantic

TECHNOLOGY

A Brief History of the ATM

How automation changed retail banking, an Object Lesson

By Bernardo Bátiz-Lazo

MARCH 26, 2015

SHARE SAVED STORIES SAVE

Eyes glaze over when I mention my interest in researching automated teller machines. Yet after I explain why I think they're relevant, many people can easily recall personal anecdotes in which an ATM plays a central role: a chance encounter with a long-lost friend while waiting in a queue, or the fear of being robbed in an unfamiliar location, or the feeling of seeing an insufficient funds notice displayed on the screen.

Most urbanites have interacted with the ubiquitous "cashpoint." Paul Volcker, of the U.S. Federal Reserve fame, even considered it the "only useful innovation in banking." Cashpoints appear frequently on TV and in printed news because, for most consumers, they're one of the few points of contact with today's otherwise-ephemeral financial services.

In spite of their cultural significance, ATMs recede into the noise of everyday memory. Few stop to reflect on how they—and the computer infrastructure that supports them—became the backbone of contemporary retail payments.

The cash dispenser was born almost 50 years ago, in 1967. For many, this was the first tangible evidence that retail banking was changing; the introduction of the ATM

marked the dawn of contemporary digital banking. Several lay claim to the invention of the cashpoint, including John Shepherd-Barron and James Goodfellow in the U.K.; Don Wetzel and Luther Simjian in the U.S.; and even engineering companies like De La Rue, Speytec-Burroughs, Asea-Metior, and Omron Tateisi. But the ATM is a complex technology. There was no single eureka moment that marked its arrival.

The ATM finds its origins in the 1950s and 1960s, when self-service gas stations, supermarkets, automated public-transportation ticketing, and candy dispensers were popularized. The first cash machine seems to have been deployed in Japan in the mid-1960s, according to a *Pacific Stars and Stripes* account at the time, but little has been published about it since. The most successful early deployments took place in Europe, where bankers responded to increasing unionization and rising labor costs by soliciting engineers to develop a solution for after-hours cash distribution. This resulted in three independent efforts, each of which entered use in 1967: the Bankomat in Sweden, and the Barclaycash and Chubb MD2 in the U.K.

Never before had electronic equipment been so exposed to the elements.

Cashpoints materialized thanks to a long chain of innovations. Some were of a general nature, such as steel, video-display units, plastic, magnetic tape, or (more recently) the Windows operating system. Others were purpose-made, such as the cash output mechanism and, in the 1960s, the previously non-existent algorithm that associated an encrypted PIN with a customer account. These components were developed through active collaboration between groups of bankers and engineers, each of which attempted to solve different aspects of the complex challenges inherent in the development of the ATM.

Never before had electronic equipment been so exposed to the elements. The necessity of human intervention in early systems invited further automation. For instance, they could easily jam or run out of product. They could erroneously dispense several bank notes instead of just one—all without the owner's knowledge. They were activated by plastic or paper tokens that would only activate for the operating bank and, in some cases, only that particular bank location. Some banks would keep the token in the machine and return it to the customer (by post) once the account had been debited. As a result, early ATMs were standalone, clunky, unfriendly, and inflexible. They could do one thing: dispense cash when activated by a token.

Given these constraints, it's not surprising that it took more than a decade for banks to deploy cashpoints beyond a handful of experiments. In its early days, few believed that the cashpoint would make a difference to the average consumer. In context, this prediction might have seemed sure; cashpoints appeared before credit or debit cards were a popular alternative to bills and coins, at a moment in time when most of the world's citizens worked in a cash economy. With the exception of the U.S. and France, even personal checks were largely limited to the wealthy.

RECOMMENDED READING



The Bleak Truth Behind My 'Inspiring' Path From Oakland to Yale

AKINTUNDE AHMAD



Modern Life Has Made It Easier for Serial Killers to Thrive

RENE CHUN



Climate Change Is Going to Be Gross

JENNA SCATENA

Updating central records from the point of a transaction is easy in today's world of mobile banking and e-commerce, but the cashpoint was one of the first devices to use real-time networking. Early in the ATM's development, creating a way to communicate with a central computer (and therefore inform customers of their account balances) became an overriding design concern. In cooperation with IBM, Swedish savings banks began testing a networked cashpoint in 1968. A collaboration between IBM and Lloyd's Bank followed, and that bank deployed several networked devices in the United Kingdom in 1973. But widespread online authorization still had a long way to go. Throughout the 1970s, IBM engineers developed the rails, pipes, and standards on which other elements of the payments ecosystem (such as credit cards and point-of-sale terminals) would eventually depend.

The ATM freed the average consumer from lengthy queues for services that had previously been limited to bank hours. As devices spread, this convenience steadily changed patterns of consumption, enabling unplanned weekend shopping and impromptu dining. At the same time, it allowed retail banks to grow their customer base by granting access to consumers who'd previously been excluded from using a current account or a credit card. The nature of work in bank branches also changed as employees relocated away from teller services and into sales. High-margin services and products like car insurance, credit cards, investment funds, and mortgages owe a debt to the outsourcing of ordinary banking to ATMs. But when such sales opportunities failed to materialize, banks also began to cut costs by reducing branch staff and closing down branches. This process continues even today, with so-called "branch transformation" remaining a hot topic in the industry.

Bank regulators across the world have actively shaped ATM technology by dictating who can own and operate them, monitoring the cost of withdrawals as well as where they can be physically located. But the average person has also influenced ATMs: the

way they look, the way they work, and their role as a platform for today's plethora of balance inquiries, deposits, transfers, and (in some European countries) airtime top ups for pay-by-minute cellphones.



Arnd Wiegmann/Reuters

In 1971, a handful of years after the first machines appeared in England and Sweden, manufacturers were operating in Britain (Speytec-Burroughs), the U.S. (Docutel and Diebold), and Japan (Omrom Tateisi). Together, they deployed cash machines in their home countries and across Europe, Canada, Israel, Cyprus, and Latin America. However, by the early 1980s, pioneers such as Chubb, De La Rue, Docutel, and Asea-Metior had left the industry as each failed to keep up with developments in computing and electronics. Other manufacturers, such as Burroughs, hadn't achieved their deployment targets. Citibank abandoned plans to commercialize its proprietary CAT-1 and CAT-2 devices and, instead, continued to use them in its global, proprietary network until the 1990s.

Not so with IBM, which had the marketing muscle, engineering expertise, and business contacts to dominate the market. The company seemed poised to overwhelm

its competitors until executives decided to deploy a new model—the IBM 4732 family—which were incompatible with previous models, including the already-successful and widely deployed IBM 3624. Many banks evaluated the machine and refused to buy it because, in a stroke, IBM had made the banks' significant capital investments in the older computer infrastructure obsolete. This obsolescence extended beyond the physical devices inside bank branches to the machines and software that supported communication across the bank's network, and even to standards for shared cashpoint networks. IBM's move soured banks, inadvertently, opening the ATM market to new cashpoint manufacturers. Eventually, IBM abandoned payment-technology systems entirely.

Around this time, two Ohio-based companies, NCR and Diebold, were working on technology that would enable them to dominate the supply of cashpoints for the next two decades. As a result of the IBM 4732 fiasco, NCR built its business on software that emulated the IBM 3624. Meanwhile, IBM and Diebold formed a joint venture in 1984, called InterBold. Its aim was to unite Diebold's self-service technology with IBM's global distribution system. Seven years later, and in spite of growing sales, the joint venture ended: Diebold hadn't achieved the international market breakthrough it'd hoped for and IBM's returns fell short of its expectations, in part due to the growth in local processing architectures, which had invalidated IBM's strategy to link ATMs to its expensive mainframes.

NCR and Diebold were instrumental in turning the cash-dispenser dinosaur into today's sleek, multi-function ATM. The companies' innovations included customer-friendly video display units, programmable buttons alongside the screen, a shift toward dispensing cash horizontally (which reduced jams), and expanded functionality, including money transfers and balance inquiries.

But NCR and Diebold were not alone. Growth in the number of banks deploying ATMs across the world promoted an increase in the number of manufacturers: Honeywell in the U.S.; Phillips, Olivetti, and Siemens-Nixdorf (today, Wincor) in Europe; and Fujitsu, GRG, Hyosung, and Hitachi in Asia. Large European banks also

developed proprietary networks, numbering in the thousands of ATMs, which U.S. banks favored shared networks (and their subsequent interconnection fees).

> The ATM freed the average consumer from lengthy queues for services that had previously been limited to bank hours.

Despite innovations in modular manufacturing, speedier ways to identify delinquent accounts, and the associated reduction in service costs, however, ATMs remained a significant capital investment. The use of dedicated telephone lines limited them to bank branches or high volume non-bank locations, such as busy train stations and big airports. This limitation finally lifted with the advent of digital telephony and the industry's adoption of the Windows operating system. These two seemingly simple modifications transformed the ATM, enabling remote diagnostics and integration with credit card clearance networks. They also enabled the advent of the Independent ATM Deployer (IAD)—ATM vendors unaffiliated with a major financial institution—and renewed growth in the machine's deployment in the late 1990s.

Still, not everything is rosy for the ATM industry. In a cost-reduction move in 2014, for instance, Chilean banks reduced the size of their ATM fleets (as well as the frequency of cash resupplies for existing machines) while encouraging the use of government-sponsored cash remittance networks in mom-and-pop retail stores. This move led to public outcry and anti-bank campaigns on social media. The success of mobile banking in Africa has also created doubt about the need to deploy ATMs in developing countries. Mobile banking and remittances—which alleviate the need for cash and bank branches in rural areas—offer the chance to increase financial inclusion in Africa, Asia, and Latin America while obviating the substantial investment required to install and maintain proprietary ATM networks. Despite these advantages, the fate

of mobile banking and remittances, for many developing countries, remains uncertain.

From its humble and uncertain beginning nearly 50 years ago, the ATM has become pervasive. But it wasn't until the 1980s, more than 15 years after the machine's invention, that the ATM's success was assured. Today, we're asked for our PINs in libraries, on the Internet, and in every sort of retail store, for which debit cards have become the *de facto* currency. The near-total global integration of ATM networks means that we can travel almost anywhere in the world with just a piece of plastic in our pocket, confident that we'll have access to cash in places as far afield as Hong Kong, Easter Island, Giza, Paris, and even Antarctica. Some machines now act as Internet kiosks, while others display an advertising by third parties or allow users to purchase minutes for their mobile phones. Yet for all its digital innovations, the quick dispensing of physical cash remains the core, transformative function of the ATM.

OBJECT LESSONS

An ongoing series about the hidden lives of ordinary things

Bernardo Bátiz-Lazo teaches business history at Bangor University in Wales. He is the co-author of *Cash Box: The Invention and Globalization of the ATM*.

MOST POPULAR

The Myth of the Broke Millennial



X.509 certificate: What is It and How It Works?

By **eMudhra Editorial** on **March 05, 2023**



What is X.509 Certificate?

X.509 certificates are digital documents that are used to verify the identity of individuals, organizations, or devices over the internet. They are widely used in various applications like secure email, web browsing, online banking, and electronic transactions.

An X.509 certificate contains information about the **certificate holder's identity**, such as their name, **public key**, **digital signature**, and the name of the **certificate authority (CA)** that issued the certificate. The public key is used to encrypt messages, and the digital signature is used to verify that the message was sent by the holder of the private key associated with the public key.

In other words, an X.509 certificate acts like a **digital identity card** that enables secure communication and transaction between two parties. The **use of X.509 certificates** ensures that the communication is encrypted and authenticated, thereby providing a high level of security for online transactions.

What is X.509 Certificates used for?

X.509 certificates are used for various purposes related to secure communication and digital identity verification. Some of the most common uses of X.509 certificates include:

1. **SSL/TLS Encryption**: X.509 certificates establish secure communication between a web browser and a web server. When you visit a website with "https" in the URL, the website uses SSL/TLS encryption, and X.509 certificates are used to authenticate the website and encrypt the communication between the browser and the server.
2. **Code Signing**: X.509 certificates are used to digitally sign software code, ensuring that the code is from a trusted source and has not been tampered with.
3. **Email Security**: X.509 certificates are used to provide secure email communication by encrypting email messages and verifying the identity of the sender.
4. **VPN Authentication**: X.509 certificates are used to authenticate users in virtual private network (VPN) connections.

Recent Blogs

Future of eSignatures: What to Expect in the Next 5 Years

Trust Service Provider: Definition, Roles and Use Case, Explained!

Certificate Lifecycle Management: What is It and Why It Is Important?

Zero Trust Architecture Explained: Never Trust, Always Verify

emSigner: Workflow Management Software for Paperless Office Solutions & Digital Transformation

What is Identity as a Service (IDaaS)?

IAM trends in 2023: Emerging Trends in Identity and Access Management

Digital Banking Trends in 2023: Top Trends in Digital Banking to Be Aware of in 2023

View All Blogs

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

5. **Document Signing**: X.509 certificates are used to sign electronic documents, providing assurance that the document is from a trusted source and has not been modified since it was signed.
6. **User Authentication**: X.509 certificates are used to authenticate users in various applications, including online banking, e-commerce, and other online services.

In summary, X.509 certificates are essential for ensuring secure communication and verifying digital identities across various applications and services.

What does an X.509 Certificate contain?

An X.509 certificate contains several pieces of information, including:

1. **Version Numbe**r: The version number of the X.509 certificate.
2. **Serial Number**: A unique identifier assigned to the certificate by the issuer.
3. **Signature Algorithm**: The algorithm used to create the digital signature.
4. **Issuer**: The name of the organization or entity that issued the certificate.
5. **Validity Period**: The period during which the certificate is valid, including the start and end dates.
6. **Subject**: The name of the certificate holder or entity.
7. **Public Key**: The public key associated with the certificate holder.
8. **Extensions**: Additional information included in the certificate, such as the intended usage of the certificate, the certificate revocation list (CRL), or other custom data.
9. **Digital Signature**: The digital signature created by the issuer to verify the authenticity of the certificate.

An X.509 certificate is a digital document that contains essential information about the certificate holder's identity, public key, and digital signature, enabling secure communication and digital identity verification.

What are the benefits of X.509 Certificates?

There are several benefits of using X.509 certificates:

1. **Secure communication**: X.509 certificates enable secure communication between two parties, ensuring that the communication is encrypted and authenticated, and preventing unauthorized access or interception of data.
2. **Digital identity verification**: X.509 certificates provide a secure and reliable way to verify the digital identity of individuals, organizations, or devices, ensuring that the data or transaction is from a trusted source.
3. **Interoperability**: X.509 certificates are widely used and recognized by various applications and platforms, providing interoperability across different systems and ensuring that the certificate can be used in different environments.
4. **Scalability**: X.509 certificates can be easily scaled to support large-scale deployments, enabling organizations to manage and authenticate a large number of users or devices securely.
5. **Compliance**: X.509 certificates are often required by industry standards and regulations, ensuring that organizations comply with security and privacy requirements.
6. **Flexibility**: X.509 certificates can be customized to include additional information or extensions, enabling organizations to add specific requirements or information as needed.

Overall, X.509 certificates provide a secure and reliable way to establish trust and ensure secure communication and digital identity verification in various applications and industries.

How does an X.509 Certificate work?

An X.509 certificate works through a process called public-key cryptography. Here are the basic steps of **how an X.509 certificate works**:

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

1. **Certificate Request**: The certificate holder generates a public-private key pair and submits a certificate request to a trusted certificate authority (CA).
2. **Verification**: The CA verifies the identity of the certificate holder and validates the certificate request.
3. **Certificate Issuance**: The CA issues an X.509 certificate containing the certificate holder's public key and other identifying information, digitally signed by the CA's private key.
4. **Certificate Distribution**: The CA distributes the X.509 certificate to the certificate holder and other relevant parties as necessary.
5. **Certificate Verification**: When the certificate holder attempts to establish a secure communication or transaction, the recipient verifies the certificate's authenticity by checking the digital signature of the CA and the validity period of the certificate.
6. **Key Exchange**: Once the certificate is verified, the recipient encrypts a session key using the certificate holder's public key and sends it back to the certificate holder.
7. **Secure Communication**: The certificate holder uses their private key to decrypt the session key and establishes a secure communication session using the session key.

An **X.509 certificate** provides a secure and trusted way to verify the identity of individuals or entities and establish secure communication or transactions using **public-key cryptography**. The X.509 certificate contains the public key of the certificate holder and other identifying information, **digitally signed by a trusted CA.** It is used to verify the authenticity of the certificate holder and establish secure communication.

What is the role of X.509 Certificates in Cryptography?

X.509 certificates play a critical role in cryptography, particularly in public-key cryptography. Here are some of the **key roles of X.509 certificates in cryptography**:

- **Digital Identity Verification**: X.509 certificates provide a secure and trusted way to verify the digital identity of individuals, organizations, or devices, ensuring that the data or transaction is from a trusted source.
- **Key Distribution**: X.509 certificates enable the secure distribution of public keys, ensuring that the public key of the certificate holder is authentic and has not been tampered with.
- **Digital Signature**: X.509 certificates are used to create and verify digital signatures, ensuring that the data or transaction is authentic and has not been modified since it was signed.
- **Secure Communication**: X.509 certificates enable secure communication through the use of public-key cryptography, ensuring that the communication is encrypted and authenticated, and preventing unauthorized access or interception of data.
- **Certificate Management**: X.509 certificates provide a standardized way to manage digital certificates, including issuance, revocation, and renewal, ensuring that the certificates are up-to-date and valid.

Overall, X.509 certificates play a crucial role in providing secure communication, digital identity verification, and **digital signature validation in cryptography**. They are widely used in various applications and industries to ensure secure and reliable communication and transactions.

How do I get an x.509 Certificate?

To get an X.509 certificate, you need to follow these steps:

1. **Generate a public-private key pair**: You need to generate a public-private key pair using a cryptographic algorithm such as RSA or ECC. This key pair will be used to create and verify digital signatures and encrypt and decrypt data.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld

2. **Create a certificate request**: Once you have generated a key pair, you need to create a certificate request that contains information about the key pair and the identity of the certificate holder.
3. **Submit the certificate request**: You must submit the certificate request to a trusted Certificate Authority (CA) that can verify your identity and issue a valid X.509 certificate. You can choose a public CA like Let's Encrypt, or a private CA for your organization.
4. **Verify your identity**: The CA will verify your identity and validate the certificate request, typically by sending an email or performing other forms of identity verification.
5. **Receive the X.509 Certificate**: Once the CA has validated your identity and the certificate request, they will issue an X.509 certificate that contains your public key, identity information, and other metadata, digitally signed by the CA's private key.
6. **Install the certificate**: Finally, you need to install the X.509 certificate on your server or device, typically by importing the certificate file into the appropriate certificate store or configuration file.

The process of getting an **X.509 certificate** involves generating a key pair, creating a certificate request, submitting the request to a **trusted CA**, verifying your identity, receiving the X.509 certificate, and installing it on your server or device. The process may vary depending on the CA and the specific application or use case.

Contact Us Now

Are you ready to embrace digital? Let's Connect

What We Do

eSignatures
Trust Services
Authentication and Access
Artificial Intelligence

Products

emSigner
emAS
emCA
Digital Certificates

Industries

Banking & Financial Services
Insurance
Education
Government & Public Sector
Manufacturing
Healthcare

Services

Trust Services
Data Analytics
Cyber Security

About eMudhra

Board of Directors
Careers
About
Blog
Contact us

Support

Terms of Use
End User License
Privacy Policy
Disclaimer

Connect with us

News and Updates
Media Contacts
Partners

© eMudhra. All Rights Reserved.

Lexmark, Exhibit 1003
Lexmark v. Flexiworld