

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Sony Interactive Entertainment LLC
Petitioner

v.

Intellectual Pixels Limited
Patent Owner

Case IPR2021-00237

**DECLARATION OF HENRY FUCHS
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 10,681,109**

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I. INTRODUCTION

1. I have been retained as an expert in this proceeding by counsel for Sony Interactive Entertainment LLC (“Petitioner”). I have been asked for my expert opinions regarding the patentability of claims 1-18 of U.S. Patent No. 10,681,109 (“’109 patent”) (Ex. 1001) (hereinafter, the “challenged claims”). For the reasons explained below, it is my opinion that all the challenged claims are unpatentable.

II. QUALIFICATIONS

2. I am the Federico Gil Distinguished Professor of Computer Science and Adjunct Professor of Biomedical Engineering at the University of North Carolina at Chapel Hill. I am one of two co-directors (together with Professor Nadia Magnenat-Thalmann of NTU) of the NTU-UNC BeingTogether Centre, a collaboration between Nanyang Technological University (NTU) of Singapore and UNC Chapel Hill.

3. I received a Bachelor of Arts degree in Information and Computer Science from the University of California at Santa Cruz in 1970, and a Ph.D. from the University of Utah in 1975.

4. I have over 45 years of experience working in the field of computer graphics. I have worked in the Imaging Lab of Caltech’s Jet Propulsion Laboratory, and have consulted for numerous organizations, including General

Electric, the RAND Corporation, Mitsubishi Electric Research Laboratory, and Xerox Palo Alto Research Center. I have held visiting professorships at ETH Zurich and at TU Wien (the Technical University of Vienna).

5. My research in computer graphics has been supported by Cisco, DARPA, Google, Intel, Microsoft, ONR, NIH, NSF, NVIDIA, U.S. Air Force, and Xerox. I have published about 240 papers, including some in the top journals, such as ACM SIGGRAPH, SIGGRAPH Asia, ACM Transactions on Graphics, and IEEE Computer Vision and Pattern Recognition (CVPR).

6. I have served on the program and papers committees of some of the top conferences in the field, such as SIGGRAPH, SIGGRAPH Asia, and Eurographics. I was instrumental in starting the conference series ACM Interactive 3D Graphics and Games, organizing the first conference in 1986. I helped with the founding of the ACM Transactions on Graphics, the top journal in computer graphics, by serving as the guest editor of its inaugural issue.

7. A number of ideas from my publications have been widely adopted in commercial products. For example, my introduction of Binary Space Partitioning Trees in 1980 enabled real-time 3D games such as Doom and Quake to run on modest-sized PCs, and BSP Trees is now a standard rendering technique taught in major textbooks in computer graphics. The Pixel-Planes hardware graphics engines, which were developed in my UNC research group, pioneered several

rendering techniques, for example, “tiled rendering”, a method now adopted world-wide in the graphics processing units (GPUs) in computers of all sizes.

8. I have been honored with a number of awards, including the ACM SIGGRAPH Steven A. Coons Award, considered the highest award in the field of computer graphics. I am a member of the National Academy of Engineering, one of about 20 computer graphics specialists who are members. I am also a fellow of the American Academy of Arts and Sciences. I received an honorary doctorate from TU Wien, the Technical University of Vienna, in 2018, one of two conferred that year.

9. My C.V. is attached hereto as Attachment A.

10. I have been retained by counsel for the Petitioner as an expert in the field of computer graphics. I am working as an independent consultant in this matter and am being compensated at my normal consulting rate. To the best of my knowledge, I have no financial interest in either party, the named inventors of the ’109 patent, or in the outcome of this proceeding. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

III. MATERIALS CONSIDERED

11. I have reviewed the claims, specifications, file history of the ’109 patent. I understand that the ’109 patent issued on June 9, 2020 from U.S. Patent Application 15/638,020 filed on June 29, 2017. In addition, I have reviewed the

following patents and publications in preparing this declaration:

- a. U.S. Patent No. 6,409,602 (“Wiltshire”) (Ex. 1004), filed on November 24, 1998, and issued on June 25, 2002;
- b. U.S. Patent No. 6,404,817 (“Saha”) (Ex. 1005), filed on November 20, 1997, and issued on June 11, 2002;
- c. Chen, “The Development and Standardization of Asymmetrical Digital Subscriber Line,” IEEE Communications Magazine (May 1999) (“Chen”) (Ex. 1006);
- d. PC Magazine, Vol. 18 No. 16 (September 21, 1999) (“PC Magazine”) (Ex. 1007);
- e. Baron et al., “MPEG Overview,” ITU/SMPTE Tutorial on Digital Terrestrial Broadcasting, January 1, 1994 (“Baron”) (Ex. 1008);
- f. ITU-T Recommendation H.262 (“MPEG Standard”) (Ex. 1009);
- g. Levoy, “Polygon-Assisted JPEG and MPEG Compression of Synthetic Images,” ACM SIGGRAPH 1995 (“Levoy”) (Ex. 1016);
- h. U.S. Patent No. 5,771,238 (“Sutton”) (Ex. 1018), filed on

January 2, 1996, and issued on June 23, 1998;

- i. “A G3 PowerPC™ Superscalar Low-Power Microprocessor,” IEEE 1997 (“PowerPC”) (Ex. 1019);
- j. PC Magazine, April 23, 1996 (“1996 PC Magazine”) (Ex. 1020); and
- k. U.S. Patent No. 6,434,695 (“Esfahani”) (Ex. 1021), filed on December 23, 1998, and issued on August 13, 2002.

12. I have been informed and understand that each of the references above qualifies as prior art to the ’109 patent.

IV. SUMMARY OF OPINIONS

13. I have considered certain issues from the perspective of a person of ordinary skill in the art (“POSITA”) as described below at the time the ’109 patent application was filed. As set forth in my analysis below, I have concluded that every limitation described in the challenged claims of the ’109 patent is disclosed by the prior art, and that the challenged claims are rendered unpatentable by the prior art.

V. RELEVANT LEGAL STANDARDS

14. I am not an attorney. For the purposes of this declaration, I have been informed about certain aspects of the law that are relevant to my opinions. My understanding of the law is as follows.

A. Claim Construction

15. In my analysis, I have given the claim terms their ordinary meaning in light of the entire intrinsic record—the claim language, specification, and prosecution history. I have considered whether any claim term has been defined in the specification, and for those terms which lack a definition in the specification, I have similarly applied the ordinary meaning that one skilled in the art would have applied at the time the '109 patent was filed.

B. Anticipation

16. I have been informed and understand that a patent claim may be “anticipated” if each element of that claim is present either explicitly or inherently in a single prior art reference. I have been informed that to be an inherent disclosure, the limitation must necessarily be present based on the disclosure of the prior art reference, and the fact that the reference might possibly practice or contain a claimed limitation is insufficient to establish that the reference inherently teaches the limitation.

C. Obviousness

17. I have been informed and understand that a patent claim can be considered to have been obvious to a person of ordinary skill in the art at the time the application was filed. This means that, even if all of the requirements of a claim are not found in a single prior art reference, the claim is not patentable if the differences between the subject matter in the prior art and the subject matter in the

claim would have been obvious to a person of ordinary skill in the art at the time the application was filed.

18. I have been informed and understand that a determination of whether a claim would have been obvious should be based upon several factors, including, among others:

- the level of ordinary skill in the art at the time the application was filed;
- the scope and content of the prior art;
- what differences, if any, existed between the claimed invention and the prior art; and
- objective evidence, or secondary considerations.

19. I have been informed and understand that the teachings of two or more references may be combined, if such a combination would have been obvious to one having ordinary skill in the art. In determining whether a combination based on either a single reference or multiple references would have been obvious, I have been informed and understand that it is appropriate to consider, among other factors:

- whether the teachings of the prior art references disclose known concepts combined in familiar ways, which, when combined, would yield predictable results;

- whether a person of ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so;
- whether the claimed elements represent one of a limited number of known design choices, and a POSITA would have had a reasonable expectation of success in combining them;
- whether a person of ordinary skill would have recognized a reason to combine known elements in the manner described in the claim;
- whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and
- whether the alleged invention applies a known technique that had been used to improve a similar device or method in a similar way.

20. I understand that the one of ordinary skill in the art has ordinary creativity, and is not an automaton.

21. I understand that in considering obviousness, it is important not to determine obviousness using the benefit of hindsight derived from the patent at issue.

D. Scope of Opinion

22. I have been informed and understand that the Petitioner in an *inter*

partes review may request cancelation of claims as unpatentable only on grounds that such claims are anticipated or would have been obvious to a person of ordinary skill in the art at the time of the purported invention, and only on the basis of prior art consisting of patents or printed publications. My opinions in this matter address only such requests.

VI. LEVEL OF ORDINARY SKILL IN THE ART

23. Based on my review of the patent and my familiarity with the technical subject matter, a person of ordinary skill in the art at the time of the alleged invention would have had at least (1) an undergraduate degree in computer science, electrical engineering, or an equivalent subject, together with two years of post-graduate experience in computer graphics; or (2) a master's degree in computer science, electrical engineering, or equivalent subject, together with one year of post-graduate experience in computer graphics.

24. This description is approximate, and a higher level of education or skill might make up for less experience, and vice-versa. I was at least a person of ordinary skill in the art by January 24, 2001.

25. My testimony in this declaration is given from the perspective of a person of ordinary skill in the art at the time of the filing of the '109 patent, and for some time before then, unless otherwise specified. This is true even if the testimony is given in the present tense.

VII. TECHNOLOGY BACKGROUND

A. Graphics Processing in Client-Server Systems

26. The technology of the '109 patent generally involves image processing in a client-server computer system. Ex. 1001 ('109), 1:29-33 (“[T]he present invention relates to computer graphics and a graphical image display system that use a visual server to generate and transmit images to a client”).

27. In a client-server system, it was known prior to the '109 patent that graphics can be generated on a server computer, and the generated image can then be compressed and transmitted to a client computer that will decompress that image and display the image on a monitor attached to the computer. For example, in Levoy, the author states that this concept was well known and “straightforward[]”: “Recent advances in realtime image compression and decompression hardware make it possible for the high performance machine to operate as a rendering server for the low-end machines. This can be accomplished straightforwardly by rendering on the server, then compressing and transmitting an image stream to the client. The client decompresses and displays the image stream in a window distinct from its own frame buffer.” Ex. 1016 (Levoy) at 21. Such a system is also described in Wiltshire (Ex. 1004), which describes a gaming system where a remote server executes a game, generates images, and compresses and transmits those images to one or more client computers for display. Ex. 1004,

Abstract.

B. MPEG Compression and Decompression

28. Due to the bandwidth requirements to send graphics data over the network, in the systems described above, some form of image compression and decompression is used to reduce the bandwidth requirements. There were many well-known image compression techniques before the '109 patent. For example, the '109 patent itself recognizes that “real-time image compression” was known in the prior art, such as the “MPEG” standard. Ex. 1001 ('109) at 1:58-61 (describing prior art usage of “real-time image compression an decompression”), 6:55-60 (referencing known compression standards “such as MPEG, JPEG, H.261, or other industry standard codecs”); 9:32-34 (“The use of an industry standard image compression protocol such as MPEG allows us to make use of facilities that are already present....”).

29. MPEG stands for “Moving Pictures Experts Group.” Ex. 1005 (Saha) at 1:64-65. Prior to the '109 patent, MPEG had published multiple standards for compression and decompression of video, including the well-known MPEG-1 and MPEG-2 standards, a general overview of which was provided by Angshuman Saha and Satish Soman in U.S. Patent No. 6,404,817 in 1997 (“Saha”). Ex. 1005 (Saha), 1:64-66; 2:5-13. As explained in Saha, MPEG includes a set of methods that address “compression and decompression of full motion video images.” *Id.*,

1:64-66.

30. As Saha explains, by 1997, there were two “predominant MPEG standards,” commonly referred to as “MPEG-1” and “MPEG-2.” Ex. 1005, 2:5-14. “The MPEG-1 standard generally concerns inter-field data reduction using block-based motion compensation prediction (MCP), which generally uses temporal differential pulse code modulation (DPCM)” *Id.*, 2:6-9. “MPEG-2 standard is similar to the MPEG-1 standard, but includes extensions to cover a wider range of applications, including ... HDTV.” *Id.* at 2:5-14; *see also* Ex. 1008 (Baron) (describing in 1994 the MPEG-2 standard); Ex. 1009 (MPEG-2 Standard). As explained in the MPEG-2 Standard (also published as ITU-T H.262), “[a]ll MPEG-2 Video decoders that comply with currently defined profiles and levels are required to decode MPEG-1 constrained bitstreams” and “[i]n most instances, MPEG-2 represents a super-set of MPEG-1.” *Id.* at 157. For purposes of assessing the validity of the challenged claims of the ’109 patent, as set forth in my opinions below, the technical differences of MPEG-1 and MPEG-2 are not material, as both standards involve compression and decompression of video frames, as I explain below.

31. Both MPEG-1 and MPEG-2 (collectively “MPEG”) provide compression by generating compressed “frames” from video data. In MPEG, frames are formally defined as “spatial information of a video signal.” Ex. 1009 at

14 (“A frame contains lines of spatial information of a video signal. For progressive video, these lines contain samples starting from one time instant and continuing through successive lines to the bottom of the frame. For interlaced video, a frame consists of two fields, a top field and a bottom field. One of these fields will commence one field period later than the other.”). In other words, frames represent the still images that are ordered in a sequence to produce a video or animated sequence.

32. MPEG compression produces a stream of compressed frames using various encoding techniques. As explained in Saha, MPEG compression produces three types of compressed frames called “I frames,” “P frames,” and “B frames”:

An MPEG stream includes three types of pictures, referred to as the *Intra (I) frame, the Predicted (P) frame, and the Bi-directional Interpolated (B) frame. The I (intra) frames* contain the video data for the entire frame of video and are typically placed every 10 to 15 frames. Intraframes provide entry points into the file for random access, and are generally only moderately compressed. *Predicted frames* are encoded with reference to a past frame, i.e., a prior Intraframe or Predicted frame. Thus P frames only include changes relative to prior I or P frames. In general,

P frames receive a fairly high amount of compression and are used as references for future P frames. Thus, both I and P frames are used as references for subsequent frames. *Bi-directional pictures* include the greatest amount of compression and require both a past and a future reference in order to be encoded. Bi-directional frames are never used as references for other frames.

Ex. 1005 (Saha), 2:19-38; 1:64-2:1 (“The compression standard referred to as MPEG (Moving Pictures Experts Group) compression is a set of methods for compression and decompression of full motion video images which uses the *interframe and intraframe compression* techniques described above.”).

33. MPEG also defines how a compressed MPEG stream is decoded (i.e. decompressed) using MPEG decoders, which essentially reverse the encoding process to reconstruct and display the video stream data. Ex. 1005 (Saha), 1:64-66; *see also id.* at 4:9-13 (“The final compressed video data is then ready to be transmitted ... over a transmission medium for reception and decompression by a remotely located decoder.”); 4:51-58 (“The video decoding process is *generally the inverse* of the video encoding process and is employed to reconstruct a motion picture sequence from a compressed and encoded bitstream.”); 4:63-5:4 (“When the MPEG decoder receives the encoded stream, the MPEG decoder reverses the

above operations. Thus the MPEG decoder performs inverse scanning to remove the zigzag ordering, inverse quantization to de-quantize the data, and the inverse DCT to convert the data from the frequency domain back to the pixel domain. The MPEG decoder also performs motion compensation using the transmitted motion vectors to re-create the temporally compressed frames.”); 5:43-45 (“A display processor retrieves the picture data for display by an appropriate display device, such as a TV monitor or the like.”); 5:28-37 (“After all of the macroblocks have been processed by the decoder, the picture reconstruction is complete. ... As noted above, the frames may also need to be re-ordered before they are displayed in accordance with their display order instead of their coding order. After the frames are re-ordered, they may then be displayed on an appropriate display device.”).

C. Asymmetric Digital Subscriber Line

34. By the mid-1990s, broadband transmission technology such as ADSL (“Asymmetric Digital Subscriber Line”) had been developed, which segregated data transmissions across separate channels so that bandwidth could be utilized as efficiently as possible. Ex. 1006 (Chen), 68 (“It has been almost a decade since the original proposal of ADSL was brought to the attention of a telecommunication standards body. During that time, the idea of ADSL has been modified and refined to fit market demand, many generations of ADSL chip set have been developed, and numerous trials has been conducted to prove its viability.”); *id.* at 69 (“Adding

asymmetry to a DSL opened a new dimension to be considered with the system configuration.... More recently, ADSL has been considered as an ideal vehicle for Internet access and telecommuting applications.”).

35. ADSL is a broadband transmission system that was typically used for broadband Internet access during the late 90s and early 2000s. *Id.*, 68-69. ADSL “add[s] asymmetry to a DSL” by using an upstream channel and a downstream channel with different bitrates. *Id.*, 69 (explaining how ADSL was “proposed as having ... an upstream control channel of 16-64 kb/s, occupying the frequency band between 10kHz to 50kHz, and a downstream channel of 1.544 Mb/s, occupying the frequency band between 100 and 500 kHz.” *Id.* As Chen explains in “The Development and Standardization of Asymmetrical Digital Subscriber Line,” IEEE Communications Magazine (May 1999), ADSL provides one bandwidth (upstream) of 16-64 kb/s, and a second bandwidth (downstream) of 1.544 Mb/s. As noted in Chen, such asymmetry is “well suited” for “video-on-demand” applications where the upstream control data require less throughput than the downstream video data.

36. As the '109 patent acknowledges, it was known that DSL provides a “first bandwidth” for transmitting user input data from the client device to the server and a “second bandwidth” for transmitting a compressed image from the server to the client device, where the bandwidths are “asymmetric.” Ex. 1001

(’109), 6:14-16; *see also* claims 2, 14.

VIII. OVERVIEW OF THE ’109 PATENT

A. Alleged Problem

37. The ’109 patent describes its “Field of Invention” as follows:

The present invention generally relates to computer systems. More particularly, the present invention relates to computer graphics and a graphical image display system that use a visual server to generate and transmit images to a client.

Ex. 1001 (’109), 1:29-33. As shown in annotated Figure 1 below, the image display system 10 includes visual server 12 (blue) that communicates with a plurality of client devices 16, 18, and 20 (red):

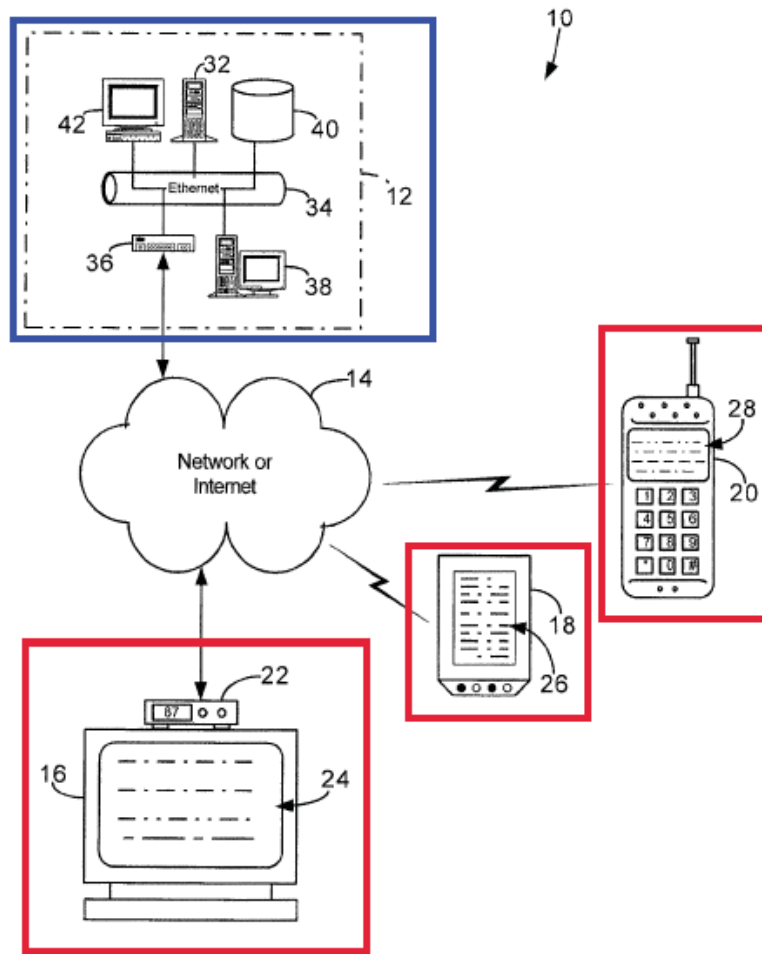


Fig. 1

Id., Figure 1.¹ The '109 patent acknowledges that various existing systems used a client and server to “process and render images at a client display with the

¹ Unless otherwise noted, I have added the color annotations appearing in figures in this declaration. For consistency, I have used the same color to indicate the same element or component across figures (e.g., servers are consistently identified in blue).

assistance of server resources.” *Id.*, 1:56-57. According to the 109 patent, however, existing client-servers employing image transmission “require[] a relatively high bandwidth connection even if real-time image compression and decompression is employed.” *Id.* 1:58-61. In existing systems, according to the ’109 patent, “the image processing does not decrease the storage or processing requirements of the client ... the server does not provide true image generation services. Rather, the server functions primarily as a database server.” *Id.* 1:59-2:1. Consequently, the ’109 patent states that existing systems “make[] inefficient use of available transmission bandwidth and available client storage and computing resources, and the client resources are taxed.” *Id.* 2:64-67. The ’109 patent thus seeks to provide “an improved system and method of displaying images on a client consumer device utilizing the resources of a visual server....” *Id.*, 3:34-37.

B. Alleged Invention

38. Despite the discussion in the ’109 patent’s specification noted above, the *claims* of the patent do not address any of the foregoing issues. Specifically, I understand that the Patent Owner told the Court in its complaint in the -01432 Action (in which the ’109 patent is asserted) that during prosecution it had removed from the claims of the ’109 patent requirements such as “image-modifying data,” “predetermined durations,” and the requirement for a client device that does not perform “three-dimensional graphics processing” that had

been recited in the claims of the parent patent to the '109. Ex. 1017 ¶¶ 32-35.

Patent Owner removed, in other words, the requirements that purportedly addressed the alleged problems in the prior art identified by the specification. I note that none of these requirements are present in the issued '109 patent claims.

39. Nor are the claims of the '109 patent new. Rather, the claimed solution merely recites the routine steps of hosting an interactive application at a server, receiving at the server user input signals from a client device, updating the state of the application based on the received user input signals, generating updated images at the server, compressing those images, and sending those images to the client where the images can be decompressed and displayed. *See, e.g.*, Ex. 1001, claim 1. As explained below, this purported invention was already disclosed and well-known prior to the filing of the '109 patent.

C. The Challenged Claims

40. I have been asked to render my opinions about the patentability of claims 1-18. Independent claim 1 of the '109 patent is shown below:

1[Preamble] 1. A method of hosting an interactive software application comprising:

1[a] running at a server the interactive software application;

1[b] receiving at the server user input signals from a client device, wherein the user input signals are used to control updating of the state of the interactive software application;

1[c] generating at least one updated image at the server in response to updating the state of the interactive software application;

1[d] and compressing the at least one updated image and transmitting the compressed updated image to the client device, wherein the server transmits the updated image as a compressed frame that can be decompressed and displayed as an updated image at the client device.

41. The challenged dependent claims merely add well-known features, such as using asymmetric bandwidths (e.g., claim 2); or receiving user input data and transmitting compressed images “with a plurality of client devices” (e.g., claim 4). However, as I explain below, all the challenged claims are unpatentable over the prior art.

IX. CLAIM CONSTRUCTION

42. For purposes of my analysis in this Declaration, I have given the claim terms their ordinary meaning in light of the entire intrinsic record—the claim

language, specification, and prosecution history. I have considered whether any claim term has been defined in the specification, and for those terms which lack a definition in the specification, I have similarly applied the ordinary meaning that one skilled in the art would have applied at the time the '109 patent was filed.

43. I reserve the right to identify terms for construction to respond to any constructions that Patent Owner may submit.

X. OVERVIEW OF THE PRIOR ART

A. Wiltshire

44. Wiltshire discloses a “computer gaming system and method of operation ... that both drastically reduce the cost of gaming stations and allow contemporaneous access to multiple game programs from a single gaming station.” Ex. 1004, Abstract. Like the '109 patent, Wiltshire discloses a client-server system that generates graphics on a server, compresses those graphics, and transmits the rendered graphics to one or more clients for display. Figure 1D of Wiltshire shows a server (110) hosting gaming programs:

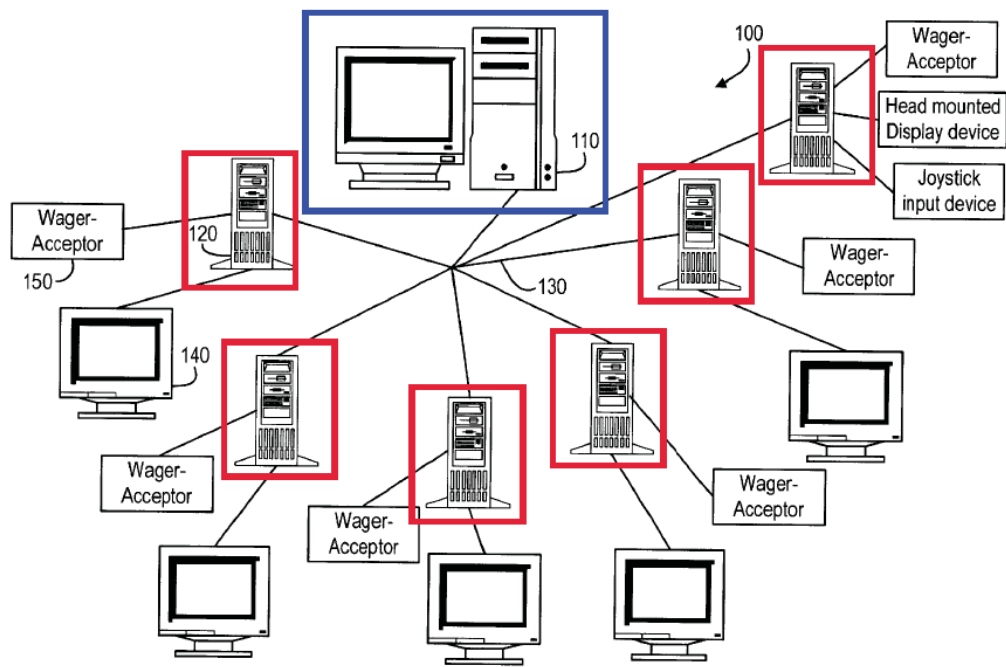


Fig. 1D

Ex. 1004, Figure 1D (showing server 110 in blue and a plurality of clients 120 in red). Figure 2 summarizes the main operation of the system of Wiltshire:

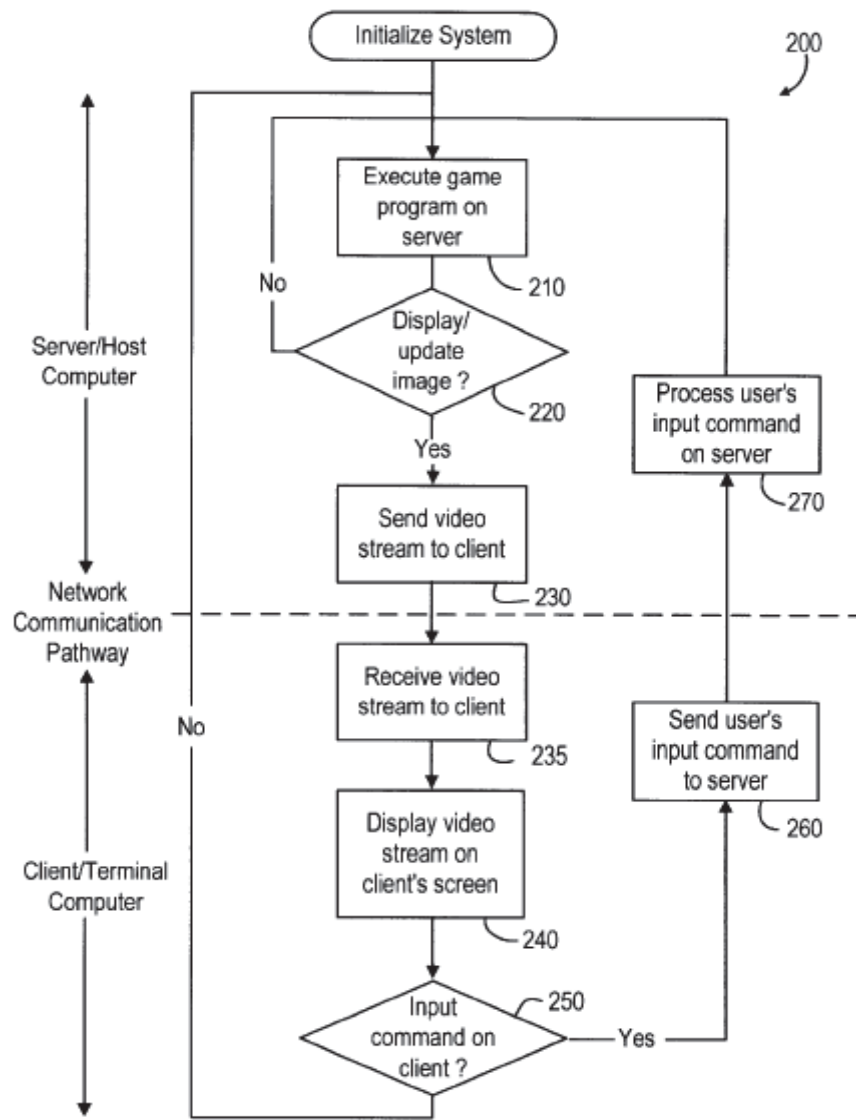


Fig. 2

45. As Figure 2 shows (e.g., in step 210), Wiltshire’s server executes a “game program.” *Id.*, Fig. 2. The server receives user “input commands” from a client. *Id.*, (Steps 250, 260). Based on the received commands, the server updates the state of the game program. *Id.*, 7:40-43 (“In stage 270, game program 122 processes the input command and updates the state of the game accordingly.”).

Based on the updated game state, the server generates an updated image, which is then sent as compressed MPEG “video stream” to the client. *Id.*, 8:61-65 (“Game program 112, then responds to input command 112 by updating the state of the game and possibly modifying the image displayed on screen 140.”); Fig. 2 (Step 230). Wiltshire explains that to reduce bandwidth requirements, the server may also compress the video stream before transmitting it to the one or more clients, including by compressing the graphics into an MPEG stream. Ex. 1004, 7:13-18 (“In stage 230, an image is sent from server/host computer 110 to client/terminal computer 120. The image may include any type of graphical information including a bitmap, a JPEG file, a TIFF file or even an encoded audio/video stream such as a *compressed video MPEG stream.*”);² 7:62-64 (“This bandwidth requirement can be further reduced using data compression techniques”). Finally, the client device receives and displays the graphics on the client’s display. *Id.*, 7:25-27 (“Client/terminal program 120 then causes the images to be displayed on a screen of the client/terminal computer 120.”); Figure 2 (Steps 235, 240).

B. Chen

46. Chen describes the well-known asymmetrical digital subscriber line

² In this declaration, I have added emphases appearing in quotations unless otherwise indicated.

(“ADSL”), which is a common type of a digital subscriber line (“DSL”) and had been known for a decade before the ’109 patent. Ex. 1006 (Chen), Abstract (noting in 1999 that “[i]t has been almost a decade since the original proposal of ADSL was brought to the attention of a telecommunication standards body. During that time, the idea of ADSL has been modified and refined to fit market demand, many generations of ADSL chip set have been developed, and numerous trials have been conducted to prove its viability”).

47. ADSL is “a broadband transmission system” built upon conventional telephone connections. *Id.*, 68. ADSL “add[s] asymmetry to a DSL” by using an upstream channel and a downstream channel with different bitrates and is considered “an ideal vehicle for Internet and telecommuting applications.” *Id.*, 69. Specifically, Chen discloses that ADSL was “proposed as having ... an upstream control channel of 16-64 kb/s, occupying the frequency band between 10kHz to 50kHz, and a downstream channel of 1.544 Mb/s, occupying the frequency band between 100 and 500 kHz.” *Id.*

48. As noted in Chen, ADSL is “an ideal vehicle for Internet access,” and “well suited” for “video-on-demand” applications like Wiltshire where the upstream control signals require less throughput than the downstream video data. *Id.* ADSL is thus well-suited for a system such as Wiltshire.

C. Saha

49. Saha provides an overview of the “two predominant MPEG standards” in 1997, commonly referred to as “MPEG-1” and “MPEG-2.” Ex. 1005, 1:64-5:56. As explained in Saha, these MPEG standards include “compression and decompression of full motion video images.” *Id.*, 1:64-2:1. I further describe the MPEG standard described in Saha in Section VII, above.

D. PC Magazine

50. PC Magazine was a well-known print magazine describing personal computer systems, including Intel processor and Mac-based laptop computers, which Wiltshire contemplates using as the client devices. Ex. 1004 (Wiltshire) 5:14-17 (“Client/terminal computers 120 can also be *any type* of cost effective special purpose or general purpose computer such as an Intel® x86 or Pentium® based computer, a Mac® PowerPC computer, a Sun® SPARC®, etc.”). The September 21, 1999 issue of PC Magazine describes various laptops that could be used as client devices in the Wiltshire system, including an Apple Mac iBook laptop:

PIPELINE

DISPATCHES FROM THE WORLD
OF COMPUTING



Groovy Portables

The rumor mill proved correct: At New York's recent MacWorld trade show, Apple CEO Steve Jobs took the wraps off the company's much-ballyhooed iBook portable computer. Targeted squarely at consumers and students, the new iBook portables will sell for \$1,599 and start shipping in September.

The new iBook itself isn't square, though. It has curved edges and corners, with rubber figuring

prominently in the design. The curves and the Austin Powers-like colors are intended to project a distinctly hip image. The 6.6-pound iBook will be available in two translucent color schemes—tangerine and blueberry—and will have a 12.1-inch TFT display with a resolution of 800 by 600 pixels, an ATI Rage graphics chip, a 300-MHz G3 processor, a CD-ROM drive, 32MB of RAM (expandable to 160MB), a built-in modem, USB and 10/100 Ethernet ports, and a full-size keyboard. The operating system is Mac OS 8.6. Jobs touted the battery life as over 6 hours (Mac OS 8.6 includes advanced power-management schemes).

Just as many portable PCs are shipping with wireless technologies, iBook users can roam up to 150 feet from \$299 base stations that plug into telephone jacks (users must also purchase \$100 cards for their iBooks to communicate with the base stations). Dubbed AirPort, the wireless technology is radio-based and has a data-transfer rate of 11 Mbps. Apple developed the wireless components in partnership with Lucent.



APPLE'S AIRPORT: Wireless networking on a shoestring.



of respondents to a recent PC Magazine Online poll told us the portal they use most is Yahoo!. Of the six other portals we asked about, only two made it into double digits—Excite and MSN.com, with 13 percent each. Trailing far behind were AOL.com (9 percent), Netcenter (8 percent), GO Network (3 percent), and Lycos (3 percent).

IBM's 11-Terabyte Storehouse

Last year, IBM wowed the industry with its matchbook-size 340MB Microdrive. This year, IBM launched what the company claims is the world's largest storage server, the Enterprise Storage Server (code-named Shark), which is about the size of a shower stall and handles up to 11 terabytes of data. In practical terms, the system could hold all the contents of the Library of Congress—and then some. With the announcement, IBM has positioned itself as a serious competitor to EMC, which already dominates the enterprise storage market.

The fledgling enterprise storage market is booming, and all signs point to more of the same. One ripple effect of the Internet's growth is the surge in demand for storage, propelled by the millions of transactions zipping around cyberspace. Companies are eager to capitalize on one-to-one marketing by turning the massive amounts of data that Web sites collect into useful information for targeting customers. According to Forrester Research, the demand for disk storage in large companies is growing more than 100 percent annually.

Sites to Sit On

Sure, you've bought books, CDs, and flowers, but have you started to think bigger? Why not buy a \$3,000 couch online? If you're not crazy about the idea, you're not alone. So far, only 1 percent of the \$75 billion furniture market has found its way onto the Web. Nevertheless, *Forbes* magazine recently identified furniture as

Ex. 1007 (PC Magazine), 9. As shown above, the Apple iBook, announced at the

“MacWorld trade show,” used a 300-MHz PowerPC G3 processor,³ ran “MacOS” as its operating system, and included 11 Mbps (megabits per second) wireless technology to allow users to “roam up to 150 feet from [the] base stations.” *Id.*

XI. SPECIFIC GROUNDS FOR PETITION

51. In this section, I set forth my analysis explaining why the challenged claims are invalid over the prior art. I have organized my opinions as follows:

52. **Ground I:** In Ground I set forth below, I conclude that claims 1, 3-13, and 15-18 are obvious in view of Wiltshire and Saha.

53. **Ground II:** In Ground II set forth below, I have concluded that claims 2 and 14 are obvious in view of Wiltshire, Saha, and Chen. Claim 2 and 14 depend on claims 1 and 13, respectively. Thus, my analysis in Ground I is incorporated into Ground II. As described below, Chen discloses the additional limitations of claims 2 and 14 (which additionally require “asymmetric” bandwidths), and a POSITA would have been motivated to combine the teachings of Chen with Wiltshire and Saha to render obvious claims 2 and 14.

³ The G3 processor is the name of the third generation PowerPC processor. *See* Ex. 1021 (Esfahani), 3:23-25 (“Microprocessor 10 may be ... a ‘G3’ PowerPC processor...”); Ex. 1019 (PowerPC), Abstract (G3 is a “third-generation PowerPC microprocessor”).

54. **Ground III:** In Ground III set forth below, I conclude that claims 6, 11, and 12 are also obvious in view of Wiltshire, Saha, and PC Magazine. If Patent Owner argues that Wiltshire does not disclose the “mobile device” limitations of claims 6, 11, and 12, these claims would also have been obvious in view of the combination of PC Magazine with Wiltshire and Saha, as I explain below. Claim 6 depends on claim 1, and claims 11 and 12 depend on claim 8. Ground III thus incorporates my analysis set forth in Ground I for these claims.

A. Ground I: Claims 1, 3-13, and 15-18 are rendered obvious by Wiltshire and Saha

1. Claim 1

a. 1[preamble]: “A method of hosting an interactive software application comprising:”

55. To the extent the preamble is limiting, Wiltshire discloses the preamble.

56. Wiltshire discloses hosting an interactive software application (a “gaming program”) on a “server/host computer.” Ex. 1004, Abstract (“A patron of a client/terminal computer can access any of the ***gaming programs executed on the server/host computer.***”); 7:8-9 (“Initially, game program 112 is executed on ***server/host computer*** 110 in stage 210”); Fig 2. (stage 210 describing the step of “execut[ing] game program on server”); 2:35-44 (“This functionality is implemented by executing various gaming and related game management programs ***exclusively on a server/host computer....***”).

57. Wiltshire explains that the hosted gaming programs are “interactive software applications.” The gaming programs may include games “such as faro, monte, roulette,” games of strategy or skill “such as chess, checkers, backgammon,” and interactive video games “such as Doom, Pong, Packman, [and] Myst.” Ex. 1004, 1:26-43. The users or patrons interact with the gaming programs on the server by sending input commands “such as mouse movements, mouse clicks or keystrokes” from a client device to the server running the game program, which are used by the game program to “determine[] which images are to be displayed on a screen of the client/terminal computer....” Ex. 1004, 5:57-65. Thus, the gaming programs described in Wiltshire are interactive software applications.

58. Accordingly, I conclude that Wiltshire discloses the preamble.

b. 1[a]: “running at a server the interactive software application;”

59. Wiltshire discloses this limitation.

60. Wiltshire discloses a computer gaming system with a “server/host computer” (“a server” as claimed) as shown below as box 110:

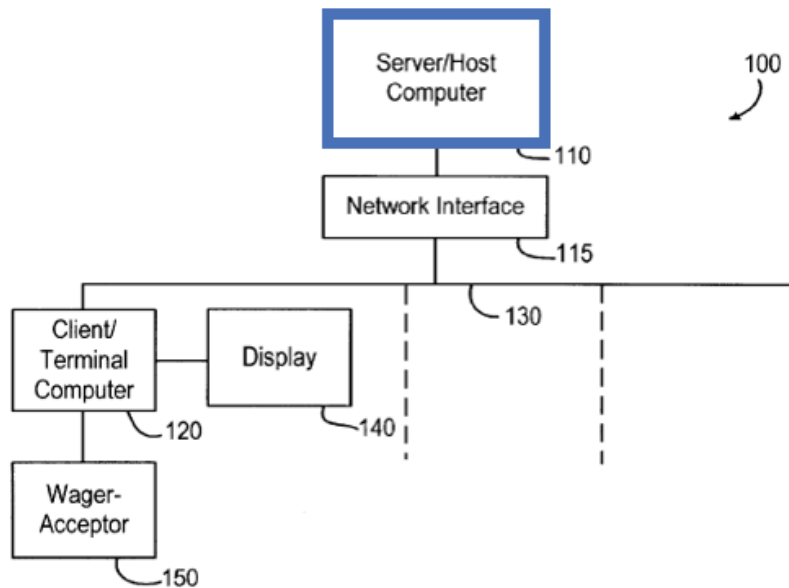


Fig. 1A

Ex. 1004, Figure 1A; 3:62-66 (“A computer gaming system 100, in accordance to one embodiment of the invention, is shown in FIG. 1A. Computer gaming system 100 includes a *server/host computer 110* connected to a plurality of remote client/terminal computers 120 via network interface 115 and communication pathways 130.”); Figure 1D (depicting server/host computer 110).

61. Wiltshire discloses that its server “exclusively” executes the interactive software program (i.e., Wiltshire’s gaming programs), and thus discloses running at the server the interactive software program. Ex. 1004, 2:35-39 (“This functionality is implemented by *executing various gaming and related game management programs exclusively on a server/host computer* connected to

a plurality of remote client/terminal computers via communication pathways.”); Abstract (“A patron of a client/terminal computer can access any of the ***gaming programs executed on the server/host computer.***”); 7:8-9 (“Initially, game program 112 is executed on server/host computer 110 in stage 210”); Fig 2. (stage 210 describing the step of “execut[ing] game program on server”).

62. As explained above, a POSITA would understand that the gaming program is an interactive software application because a player interacts with the gaming program in order to play it. *See* Section XI(A)(1)(a) (1[preamble]).

63. Accordingly, I conclude that Wiltshire discloses this limitation.

c. 1[b]: “receiving at the server user input signals from a client device, wherein the user input signals are used to control updating of the state of the interactive software application;”

64. Wiltshire discloses this limitation.

65. ***First***, Wiltshire discloses “receiving at the server user input signals from a client device.” In particular, Wiltshire discloses that its server receives user input signals such as mouse or keyboard inputs, or other “input commands” from a client device (e.g., such as client/terminal computer 120 with display 140 in Figure 1A), as shown below in Figure 2 and the corresponding descriptions:

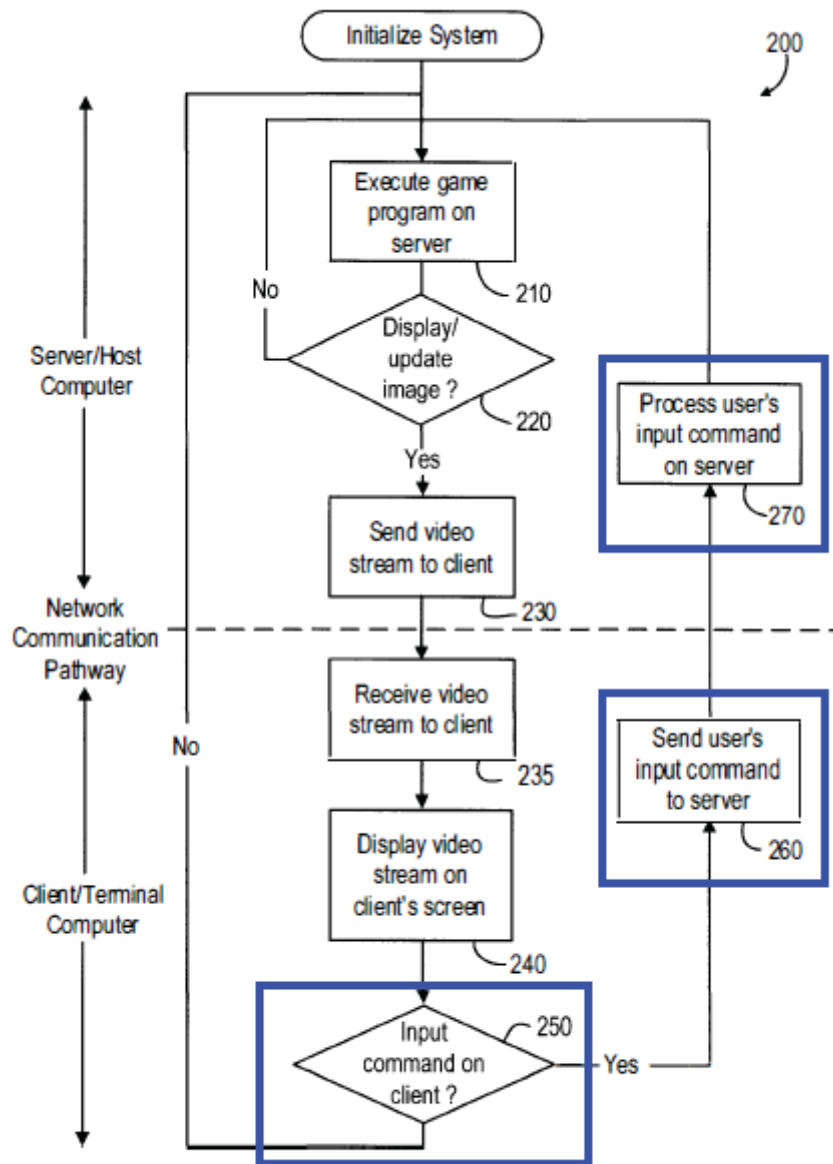


Fig. 2

Ex. 1004, Figure 2.

66. As shown in the stage labeled 250 in Figure 2 above, Wiltshire discloses that an “input command” is detected at the client device. Ex. 1004, 7:27-30 (“Stage 250 then determines whether *an input command has been entered by*

the patron using client/terminal computer 120, in which case operation 200 proceeds to stage 260.”). The input command “may be a keystroke, movement or clicking of the mouse, a voice activated command or even the clicking of a ‘virtual button’ on a touch screen.” *Id.*, 7:31-34. Thus, the input command (keystrokes, mouse clicks, or other input commands) detected at the client device are “user input signals” as claimed.

67. Next, as shown in the stage labeled 260 in Figure 2, “the client/terminal program 122 causes the input command detected in stage 250 to be *transmitted back to server/host computer 110* via communication pathways 130.” *Id.*, 7:34-37. Once the input command is transmitted from the client terminal to the server, “[t]he command is thus received by the server/host interface program 114, that, in turn, passes the command back to game program 112.” *Id.*, 7:39-41. Thus, Wiltshire discloses “receiving at the server user input signals from a client device.”

68. **Second**, Wiltshire discloses that “the user input signals are used to control updating of the state of the interactive software application.” In particular, the input commands (i.e., user input signals) received by the server are passed to the game program (the interactive software application) to control updating the state of the game program. Wiltshire describes at stage 270 of Figure 2 that “game program 112 *processes the input command* and *updates the state of the game* accordingly.” *Id.*, 7:42-43; *see also* 8:61-63 (“Game program 112, then *responds*

to input command 112 by updating the state of the game and possibly modifying the image displayed on screen 140.”); 5:57-65 (“[I]nput commands such as mouse movements, mouse clicks or keystrokes or lever activation detected by the client/terminal computer are sent directly to the server/host based game program for context interpretive processing.”); 12:44-51 (“[I]n response to the input command, the execution of the computer gaming program on the server/host computer is altered”); 13:51-59 (“[I]n response to the input command, altering the execution of the computer gaming program on the server/host computer”).

69. In sum, Wiltshire discloses “receiving at the server [Wiltshire’s server/host computer] user input signals from a client device [input commands including keystrokes or mouse clicks detected at the client], wherein the user input signals are used to control updating of the state of the interactive software application [the input commands update the game state of the game program running on the server].”

70. Accordingly, I conclude that Wiltshire discloses this limitation.

d. 1[c]: “generating at least one updated image at the server in response to updating the state of the interactive software application;”

71. Wiltshire discloses this limitation.

72. As explained above in limitation 1[b], Wiltshire discloses updating the state of the interactive software application by updating the state of the gaming

program in response to the user input commands sent by the client. *See* Section XI(A)(1)(c) (limitation 1[b]).

73. Wiltshire further discloses that once the state of the game is updated in response to the client's input commands, the server may generate updated images in response to the updated game state, as shown in Figure 2 and its corresponding descriptions:

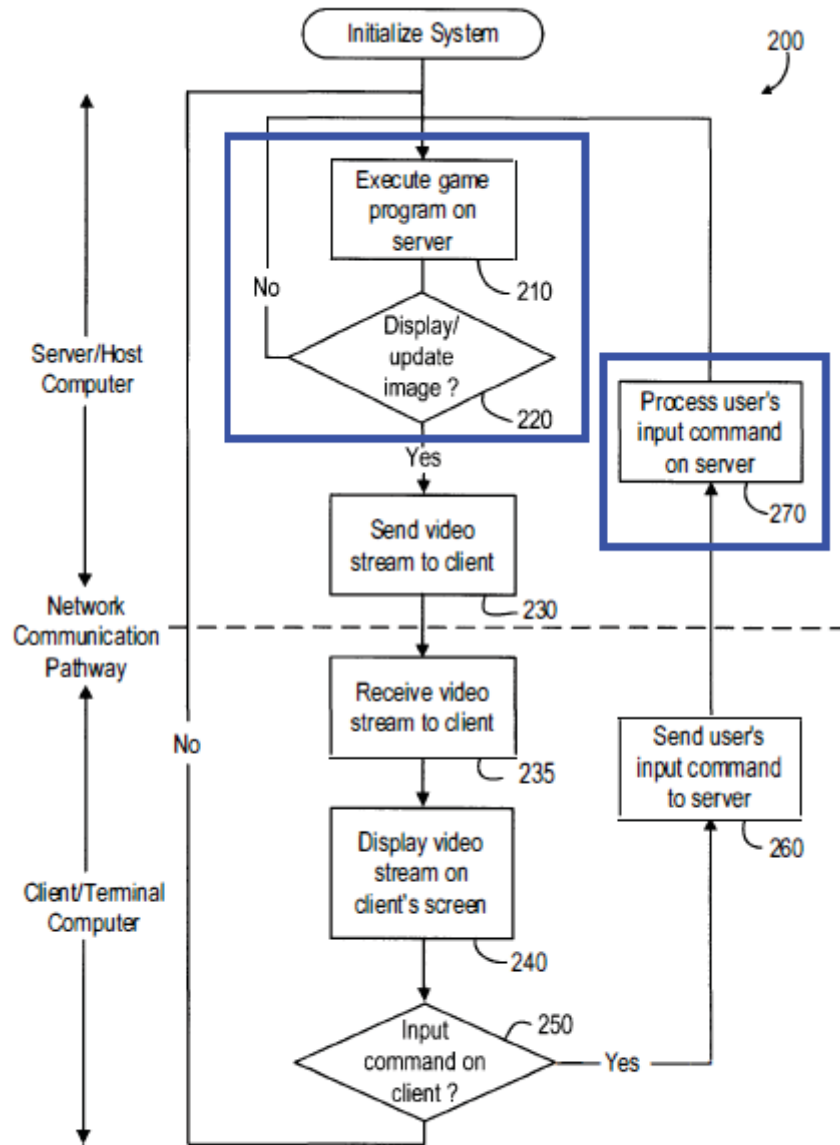


Fig. 2

Ex. 1004, Figure 2.

74. Wiltshire discloses that “[i]n stage 270, game program 112 processes the input command and *updates the state of the game accordingly*. Once the command has been processed, operation 200 proceeds back to stage 210 for further

execution of the game program 112.” *Id.*, 7:41-45.

75. Next, the operation of the game program proceeds to stage 220, during which the game program on the server “**determines whether an image is to be displayed** on the screen of client/terminal computer 120, in which case operation 200 proceeds to stage 230.” *Id.*, 7:9-12; *see also id.*, 5:59-65 (“[T]he game program determines which images are to be displayed on a screen of the client/terminal computer”).

76. The determination of whether an image is to be displayed at stage 220 includes deciding whether to “update” the image. As shown in Figure 2, stage 220 will “display/**update** [the] image” in response to updates to the state of the game. *Id.*, Figure 2 (stage 220). Wiltshire explains that the decision to update an image is tied to the updated game state. *Id.*, 8:61-63 (“Game program 112, then responds to input command 112 by **updating the state of the game and possibly modifying the image** displayed on screen 140.”). Thus, a POSITA would understand from the disclosure above that the game program at the server will determine whether to generate an updated image in response to the updated game state.

77. Wiltshire further makes clear that the updated image is generated by the server. Ex. 1004, 7:8-9 (“Initially, **game program 112 is executed on server**/host computer 110 in stage 210.”); 7:18-20 (“[t]he image is **generated by game computer program 112** and passed to server/host interface program 114”);

2:45-46 (“display generation programs are executed entirely on the server/host computer”); 5:44-46 (“Game program 112 is any type of gaming program that runs on an operating system 116 *executed on server*/host computer 110.”); 2:35-39 (“This functionality is implemented by *executing various gaming and related game management programs exclusively on a server/host computer*”). Because the server is responsible for executing the game program itself, when the updated image is generated by the game program, the server generates the updated image.

78. Finally, I note that Wiltshire has more disclosure of “generating at least one updated image at the server in response to updating the state of the interactive software application” than the ’109 patent specification itself. The ’109 patent specification lacks any description of “the state of the interactive software application”; indeed, the word “state” does not appear anywhere in the ’109 patent specification. *See generally* Ex. 1001.

79. Accordingly, I conclude that Wiltshire discloses this limitation.

e. 1[d]: “and compressing the at least one updated image and transmitting the compressed updated image to the client device, wherein the server transmits the updated image as a compressed frame that can be decompressed and displayed as an updated image at the client device.”

80. The combination of Wiltshire and Saha discloses this limitation.

81. **First**, Wiltshire discloses “compressing the at least one updated image and transmitting the compressed updated image to the client device.” In particular,

Wiltshire discloses that after an image is “update[d]” at stage 220 of Figure 2 (which is updated in response to the updated game state as described above in limitation 1[c]), the operation proceeds to stage 230, where the updated image “is sent from server/host computer 110 to client/terminal computer 120.” Ex. 1004, 7:13-14. Wiltshire explains that to reduce bandwidth requirements, the server may compress the updated image as “a compressed video MPEG Stream.” *Id.*, 7:15-18 (“The image may include any type of graphical information including a bitmap, a JPEG file, a TIFF file or even an encoded audio/video stream such as a ***compressed video MPEG Stream***. The image is generated by game computer program 112 and passed to server/host interface program 114.”); *see also id.*, 7:62-64 (explaining that the “bandwidth requirement can be reduced using data compression techniques”). The ’109 patent identifies MPEG as a specific example of image compression. Ex. 1001 (’109) at 6:56-62.

82. ***Second***, Wiltshire combined with Saha discloses “wherein the server transmits the updated image as a compressed frame that can be decompressed and displayed as an updated image at the client device.”

83. As explained above, Wiltshire discloses that the updated images may be transmitted to the client as “a compressed video MPEG stream,” and the client “causes the image[s] to be displayed on a screen of the client/terminal computer.” Ex. 1004, 7:15-18, 7:26-27. A POSITA would understand from Wiltshire that the

client device must therefore decompress (or decode/restore) the compressed MPEG stream (including the compressed image frame) because without decompression, the compressed MPEG stream would not be able to be displayed at the client as described in Wiltshire. In other words, because Wiltshire discloses that the client can display a compressed video MPEG stream, a POSITA would understand that the client is configured to decompress the received MPEG stream.

84. While Wiltshire does not discuss the details of decompressing the compressed frames at the client, Wiltshire is written for a POSITA, and therefore did not need to include this detail. A POSITA would already have known that a compressed MPEG stream consists of compressed frames, and that to display a compressed MPEG stream at the client, the client would decompress the received stream to display the video stream at the client, as Saha confirms in its description of the predominant MPEG standards at the time of Wiltshire. *See, e.g.*, Ex. 1005 (Saha) at 1:64-2:4; 2:5-14; 2:15-38; 4:9-12; *see also* Ex. 1008 (Baron) (further evidencing the knowledge of a POSITA regarding MPEG compression and decompression); Ex. 1009 (further evidencing knowledge of a POSITA of the MPEG standard).

85. I also note that the '109 patent does not describe the details of the MPEG standard, such as decompressing a compressed frame. Instead, like Wiltshire, the '109 patent merely mentions the MPEG standard, and assumes a

POSITA would be able to understand that the MPEG standard includes decompressing compressed frames from his or her common knowledge.

86. In other words, details about decompression were already within the knowledge of a POSITA and would clearly have been understood by a POSITA from reading Wiltshire's disclosure that the updated image can be a compressed MPEG stream.

87. A POSITA's knowledge of the MPEG standard is confirmed by Saha, which describes in 1997 the details of the predominant MPEG standards at that time (i.e., roughly contemporaneous with Wiltshire, and well before the '109 patent). *See* Section VII. In particular, Saha provides an overview of the two "predominant MPEG standards" at the time of Wiltshire's filing in 1998, called MPEG-1 and MPEG-2. Ex. 1005, 2:5-14 (explaining that the "MPEG-2 standard is similar to the MPEG-1 standard, but includes extensions to cover a wider range of applications, including ... HDTV").

88. Saha discloses that in these MPEG standards, an encoded MPEG stream is a sequence of compressed "frames" (also called "pictures"). Ex. 1005 (Saha), 2:19-35 ("MPEG compression ... encode[s] or *compress[es] frames* in the sequence.... An MPEG stream includes three types of pictures, referred to as the Intra (I) *frame*, the Predicted (P) *frame*, and the Bi-directional Interpolated (B) *frame*. The I (intra) frames ... are generally only *moderately compressed*).

Predicted frames ... *receive a fairly high amount of compression*.... Bi-directional pictures include the *greatest amount of compression*....”); 1:64-2:1 (“The compression standard referred to as MPEG (Moving Pictures Experts Group) compression is a set of methods for compression and decompression of full motion video images which uses the *interframe and intraframe compression* techniques described above.”).

89. A POSITA would understand that a video stream is a sequence of frames (or pictures), where each frame is an image of a video sequence. Ex. 1005 (Saha), 9:47-50 (“The compressed video bitstream stored in the video buffer consists of ‘slices’ each representing a horizontal section of an *image frame*.”); *see also* 2:24-26 (“The I (intra) frames contain the video data for the entire frame of video”). For example, a POSITA would understand that a short clip of an animated cartoon generated by a video game is made up of multiple still images displayed in sequential order. Therefore, a POSITA would understand that a frame of a video stream in MPEG is an image.

90. Saha further discloses that MPEG decoders—which may be located remotely from the encoder—receive the compressed frames and decompress the compressed frames for display. Specifically, Saha explains that “[t]he compression standard referred to as MPEG (Moving Pictures Experts Group) compression is a set of methods for compression and *decompression of full*

motion video images” Ex. 1005 (Saha), 1:64-66; *see also id.* at 4:9-13 (“The final compressed video data is then ready to be transmitted ... over a transmission medium for reception and *decompression by a remotely located decoder.*”); 4:51-58 (“The video decoding process is generally the inverse of the video encoding process and is employed to reconstruct a motion picture sequence from a compressed and encoded bitstream.”); 4:63-5:4 (“When the MPEG decoder receives the encoded stream, the MPEG decoder reverses the above operations. Thus the MPEG decoder performs inverse scanning to remove the zigzag ordering, inverse quantization to de-quantize the data, and the inverse DCT to convert the data from the frequency domain back to the pixel domain. The MPEG decoder also performs motion compensation using the transmitted motion vectors to re-create the temporally compressed frames.”); 5:43-45 (“A display processor retrieves the picture data for display by an appropriate display device, such as a TV monitor or the like.”); 5:28-37 (“After all of the macroblocks have been processed by the decoder, the picture reconstruction is complete. ... As noted above, the frames may also need to be re-ordered before they are displayed in accordance with their display order instead of their coding order. After the frames are re-ordered, they may then be displayed on an appropriate display device.”). In other words, Saha makes clear that MPEG includes decoding (i.e., decompression) as well as compression. MPEG compression uses algorithms (such as motion estimation and

discrete cosine transform) to encode the frames to reduce the total size of the frames, and thus necessarily includes algorithms to decode the encoded frames for display.

91. As Saha confirms in the passages cited above (e.g., as cited in ¶¶ 87-90), a POSITA would have known that MPEG includes “compressed frames” and provides a method for both compression of frames and decompression of compressed frames. Indeed, the ’109 patent admits that MPEG was already an “industry standard” form of video compression that was “already present” in client devices before the patent. Ex. 1001, 9:32-38 (“The use of *industry standard* image compression protocol such as MPEG allows us to make use of facilities that are *already present* in most clients.”); *see also* Ex. 1008 (Baron); Ex. 1009 (MPEG Standard). Thus, a POSITA would have understood that MPEG was well known and widely used to compress and decompress image or video data years before the ’109 patent.

92. A POSITA would thus have understood Wiltshire’s disclosure of “a compressed video MPEG Stream” as teaching compression of image frames by “server/host computer 110,” transmission of those compressed frames to a “client/terminal computer 120,” and decompression of those compressed frames by the client before displaying the image. Ex. 1004, 6:56-62, 7:13-18, 7:25-27, and 7:62-64.

93. At a minimum, a POSITA would have been motivated to apply Saha's teaching of MPEG decompression of compressed frames to Wiltshire's client, and would have had a reasonable expectation of success in doing so, for the following reasons.

94. *First*, Wiltshire expressly teaches that the system may use the MPEG standard for compressing the updated images that are sent to the client (Ex. 1004, 7:15-19), and thus provides an express motivation to combine with Saha, which describes the predominant MPEG standards known at the time of Wiltshire, including additional details on how MPEG (including both MPEG-1 and MPEG-2) includes decompressing compressed frames. If Patent Owner argues that a POSITA would not already have known that MPEG streams must be decompressed, at a minimum a POSITA would have been motivated to look to Saha for those additional details. As explained above, Wiltshire explains that the server compresses the image into an MPEG stream that is later displayed at the client device, and Saha teaches that the MPEG standard includes compressed frames and decompression of the compressed frames at a remotely-located device for display. Ex. 1004, 7:15-18; Ex. 1005 (Saha), 2:21-35; 4:9-13. Wiltshire's teaching to display at a client device frames that had been compressed by a server using MPEG would thus have motivated a POSITA to incorporate Saha's teaching to decompress the compressed frames of an MPEG video stream sent by a server in

order to display those image at the client.

95. ***Second***, decompressing an MPEG stream at the client is one of just a finite number of identified and predictable solutions known to a POSITA. Given Wiltshire's disclosure that the images are sent to the client using a compressed MPEG video stream for display on the client, a POSITA would have recognized that decompressing the stream using MPEG such that the image can be displayed at the client would have been an obvious (if not the only) choice. Without decompressing the MPEG stream, the received stream would be useless, and certainty would not be able to be displayed at the client display. Thus, at a minimum, having read Wiltshire's express teaching to compress an image using MPEG and transmit the compressed image to the client for display, it would have been obvious to try decompressing that image also using the same MPEG standard so that it can in fact be displayed, as described in Saha.

96. ***Third***, there would have been a reasonable expectation of success in applying Saha's teachings of MPEG's decompression of a compressed frame to the teachings of Wiltshire. Wiltshire describes using MPEG to reduce the bandwidth when sending a video stream to the client. Saha's teaching of how MPEG includes compressed frames and decompression of those frames would be used for its intended purpose of providing compression for various applications such as HDTV, DVDs, and video games. Ex. 1005 (Saha) at 2:10-13; 5:46-56. The

combination thus uses MPEG in the intended manner as both Saha and Wiltshire instruct—to reduce the bandwidth requirements when sending a video stream from a video source to another device like a client device. Ex. 1004 (Wiltshire), 7:62-65 (“This bandwidth requirement can be further reduced using data compression techniques....”); Ex. 1005 (Saha), 4:9-13 (“The final compressed video data is then ready to be transmitted ... over a transmission medium for reception and decompression by a remotely located decoder.”). Given that MPEG has been widely used to compress and decompress images in video applications including video games, a POSITA would understand that MPEG would also work for video games involving video graphics, including the video game system of Wiltshire. Thus, a POSITA would have fully expected that MPEG decompression of compressed frames would work as intended in Wiltshire and produce the predictable result of reducing bandwidth requirements as explained in Wiltshire. Accordingly, a POSITA would have had a reasonable expectation of success in making this combination.

97. ***Finally***, Saha and Wiltshire are analogous art to the ’109 patent. I have been informed and understand that a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the

same field of endeavor as the claimed invention). The '109 patent describes its “Field of Invention” as follows: “The present invention generally relates to computer systems. More particularly, the present invention relates to computer graphics and a graphical image display system that use a visual server to generate and transmit images to a client.” Ex. 1001, 1:29-33. Saha relates to the same field of endeavor as the '109 patent because Saha describes MPEG, a technology used for transmission of images and video, just as described in the '109 patent. Ex. 1005 (Saha), 1:64-2:13; 4:9-12; Ex. 1001 ('109), 6:55-60. Saha is also reasonably pertinent to the problem of the '109 patent because, like the '109 patent, Saha's MPEG compression minimizes the bandwidth needed to transmit the images described in the '109 patent. Ex. 1005 (Saha), 1:64-2:1; Ex. 1001 ('109), 6:55-60.

98. Wiltshire also relates to the same field of endeavor as the '109 patent because Wiltshire also describes a client-server system that generates images on a server and transmits those images to one or more clients. Ex. 1004 (Wiltshire), Abstract, Figures 1D, 2. Wiltshire is also reasonably pertinent to the problem of the '109 patent because Wiltshire's client-server system uses MPEG to minimize the bandwidth needed for image transmission and minimizes the need to modify or upgrade client devices to execute game programs. Ex. 1004 (Wiltshire), 2:45-51; Ex. 1001 ('109), 6:55-62; 9:39-53. Finally, as explained above, Wiltshire's disclosure of “a compressed video MPEG Stream” points directly toward using

MPEG as disclosed in Saha. Ex. 1004 (Wiltshire), 7:15-18; Ex. 1005 (Saha), 1:64-2:13.

99. Accordingly, I conclude that Wiltshire in view of a POSITA's knowledge of MPEG, or at a minimum in combination with Saha, discloses this limitation.

* * *

100. For the foregoing reasons, I conclude that claim 1 is unpatentable over Wiltshire combined with Saha.

2. Claim 3

a. 3: "The method as recited in claim 1 wherein the server is configured for bidirectional communications with a plurality of client devices, the bidirectional communication including receiving at the server user input signals and transmitting the compressed updated image."

101. Claim 3 depends on claim 1, and as described above, the combination of Wiltshire and Saha renders obvious claim 1. Wiltshire discloses the additional limitations of claim 3.

102. **First**, Wiltshire discloses a system where the "server is configured for ... communications with a plurality of client devices." As shown in Wiltshire's annotated Figure 1D below, the server 110 (blue) communicates with a plurality of client devices 120 (red):

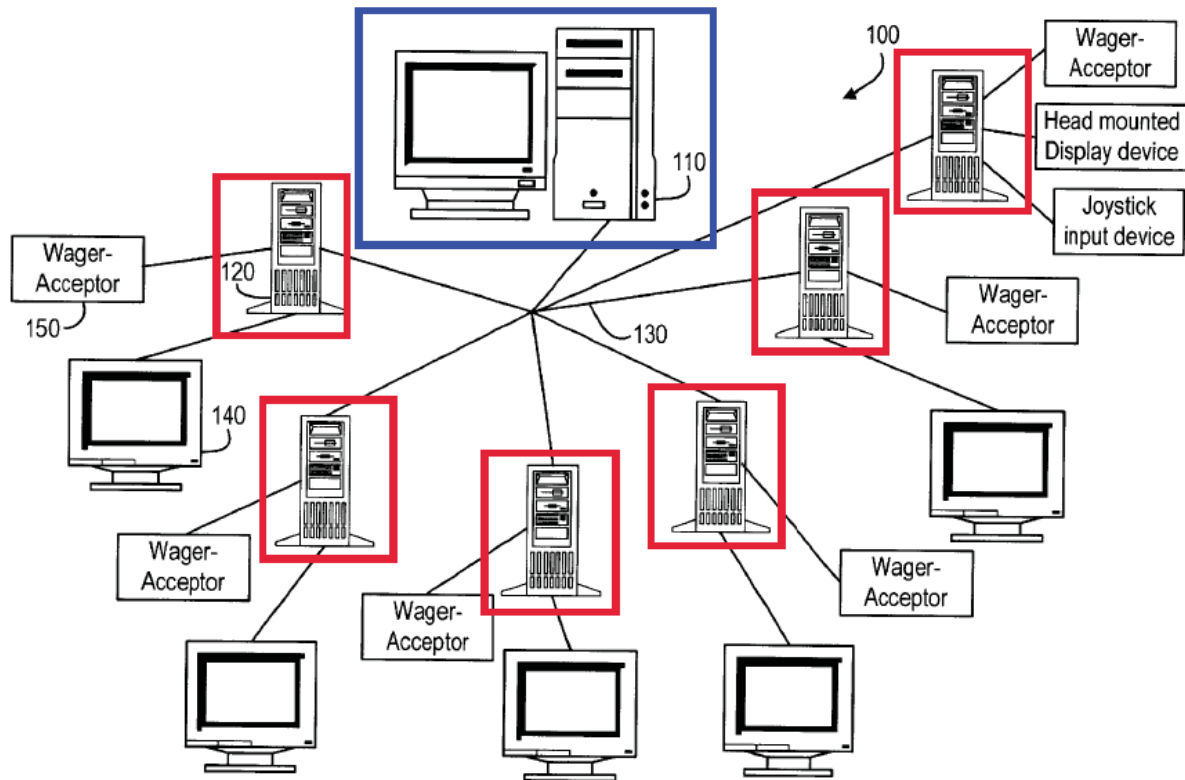


Fig. 1D

Ex. 1004, Figure 1D; 3:62-66 (“Computer gaming system 100 includes a server/host computer 110 connected to a plurality of remote client/terminal computers 120 via network interface 115 and communication pathways 130.”); 4:52-59 (describing how the server is configured “to support the plurality (e.g., at least eight) of client/terminal computers 120.”).

103. **Second**, the connection between the server and the plurality of client devices in Wiltshire is “bidirectional” because data is transmitted both from the server to the client device in one direction and from the client device to the server

in the other direction. Ex. 1004, 7:13-15 (“In stage 230, *an image is sent from server/host computer 110 to client/terminal computer 120.*”); 7:34-39 (“In stage 260, *client/terminal program 122 causes the input command* detected in stage 250 *to be transmitted back to server/host computer 110 via communication pathways 130*, again using network services provided by client operating system 124 on one end and server operating system 116 on the other.”); *see also* Figure 2 (showing data transmissions from the server to the client (step 230) and from the client to the server (step 260)). Therefore, the server is configured for bidirectional communication with a plurality of client devices.

104. *Third*, the bidirectional communications include “receiving at the server user input signals and transmitting the compressed updated image.” *Id.*, 7:13-15 (“In stage 230, *an image is sent from server/host computer 110 to client/terminal computer 120.*”); 7:34-39 (“In stage 260, *client/terminal program 122 causes the input command* detected in stage 250 *to be transmitted back to server/host computer 110 via communication pathways 130*, again using network services provided by client operating system 124 on one end and server operating system 116 on the other.”); *see also* Sections XI(A)(1)(c)-(e) (describing Wiltshire’s disclosures of receiving user input signals and transmitting compressed updated images). As discussed above in conjunction with limitation 1[d], the image transmitted from server 110 to the client terminal 120 is a compressed image

using MPEG compression. *See* section XI(A)(1)(e).

105. Accordingly, I conclude that claim 3 is unpatentable over Wiltshire in combination with Saha.

3. Claim 4

a. 4: “The method as recited in claim 1 wherein the server is configured to receive user input data and transmit compressed updated images with a plurality of client devices.”

106. Claim 4 depends on claim 1, and as described above, claim is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitations of claim 4.

107. As discussed above in connection with claim 3, Wiltshire’s server is “configured to receive user input data and transmit compressed updated images” to “a plurality of client devices.” *See* Section XI(A)(2); *see also* Ex. 1004, 7:13-15 (“In stage 230, *an image is sent from server/host computer 110 to client/terminal computer 120.*”); 7:34-39 (“In stage 260, *client/terminal program 122 causes the input command* detected in stage 250 *to be transmitted back to server/host computer 110 via communication pathways 130*, again using network services provided by client operating system 124 on one end and server operating system 116 on the other.”); Fig. 1D; *see also* sections XI(A)(1)(c)-(e) (describing Wiltshire’s disclosures of receiving user input signals (i.e., user input data) and

transmitting compressed updated images).⁴

108. Accordingly, I conclude that claim 4 is unpatentable over Wiltshire in combination with Saha.

4. Claim 5

a. 5: “The method as recited in claim 1 wherein at least two of the plurality of client devices include different device platforms.”

109. Claim 5 depends on claim 1, and as described above, claim 1 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitation of claim 5 to a POSITA.

110. As explained above for claim 3, Wiltshire discloses a system with a “plurality of client devices.” *See* Section XI(A)(2) (claim 3).

111. Wiltshire further discloses that its plurality of client devices may include “different device platforms.” For example, Wiltshire explains that the clients can be “*any type* of cost effective special purpose or general purpose computer such as an Intel® x86 or Pentium® based computer, a Mac® PowerPC

⁴ I note that the claims of the ’109 patent recite “user input signals” (e.g., claim 1), “user input data” (e.g., claim 4), and “user input control signals” (e.g., claim 13). A POSITA would understand that each of these terms is disclosed by Wiltshire’s disclosure of the client’s input commands, as I describe in Section XI(A)(1)(c) (limitation 1[b]).

computer, a Sun® SPARC®, etc. However, unlike, the server/host computer 110, the client/terminal computers 120 only need to have minimal storage, memory and processing power to ensure optimum functional operation of the overall multi-computer system 100, since the overwhelming majority of the gaming related and regulated processing is performed on the server/host computer 110. As a result, the cost of the hardware required for each client/terminal computer 120 is greatly reduced with respect to prior art computer video gaming systems.” Ex. 1004, 5:14-26. A POSITA would understand that Intel x86 or Pentium based computers, Mac PowerPC computers, and Sun SPARC computers are examples of different device platforms that may be used as client devices in Wiltshire’s system. Wiltshire also discloses that its client terminals may use different operating systems known in the art. *Id.*, 6:55-7:6 (“Client operating system 124 is ***any operating system*** that can be executed on hardware 126 of client/terminal computer 120. In some embodiments, operating system 124 is MS-DOS®, Windows98™ or Windows NT® 4.0, or Windows CE®.... Alternatively, operating system 124 can be any Microsoft Remote Desktop Protocol (RDP™) compatible operating system, ... Mac OS™ 8.5, ... or pSOS+ ... or QNX ... or VRTX Real-time Operating System, ... Applica U2 or Applica Workgroup, ... or any version of the X11 terminal client from OSI developed by MIT, or any other cost effective and functionally suitable operating system known in the art.”). Therefore, Wiltshire discloses that its system

is designed to work with clients regardless of their device platform (hardware and/or software), and thus discloses that at least two of the plurality of client devices would include different device platforms. *See also* Ex. 1004 (Wiltshire), claims 11, 18, 19 (requiring “at least one” of the clients to have certain hardware configurations, and thus contemplating that other clients can have different hardware configurations).

112. Based on Wiltshire’s disclosure of different device platforms for the client devices, a POSITA would have understood Wiltshire to disclose the use of at least two different device platforms as part of its plurality of clients.

113. At a minimum, a POSITA reading Wiltshire’s disclosure would have been motivated to use at least two client devices of different device platforms in connection with Wiltshire’s server and would have had a reasonable expectation of success in doing so for the following reasons.

114. ***First***, a POSITA would understand that because Wiltshire’s server is designed to work with different client device platforms, it would be advantageous to use at least two different device platforms together in the same system. As explained above, Wiltshire’s clients can be “any type” of hardware system running “any operating system,” and need only “minimal storage, memory and processing power to ensure optimum functional operation ... since the overwhelming majority of the gaming related and regulated processing is performed on the server/host

computer 110.” Ex. 1004, 5:14-17; 5:19-25; 6:55-7:6. Wiltshire explains that a user need only “download[] a copy of [the] client/terminal program” and “[o]nce installed on client/terminal computer 120, client/terminal program 122 connects to server/host computer interface program 114 executed on server/host computer ... [and] computer gaming system 100 is executed in a manner analogous to the one described for operation 200 of Fig. 2.” Ex. 1004, 8:24-33. Wiltshire thus contemplates flexibility in types of client device platforms. A POSITA would understand that supporting a game on multiple different client device platforms allows more players to access and play the game, thereby potentially increasing the game provider’s revenue. Given that multiple types of computers were commercially available at the time, a POSITA would be motivated to support multiple types of platforms to make the system accessible to the greatest number of users. For example, video game developers frequently “port” games (e.g., Quake) to multiple platforms (e.g., Windows PC, Mac OS, Sega Saturn) to expand the customer base for their games—thus demonstrating the long-standing motivation

in this art to support multiple device platforms.⁵ Similarly, a POSITA would have recognized that it would be advantageous to be able to implement Wiltshire’s game system such that the same games may be played using different client device platforms.

115. ***Second***, using at least two different device platforms as client devices would have been obvious to try because there was a limited number of options—either all the devices are the same platform, or at least one is a different platform. Either option would have led to a reasonable expectation of success. Wiltshire discloses that “any” client platform can be used, and a user need only “download[] a copy of [the] client/terminal program” onto the client to interact with the server. Ex. 1004, 8:24-33; Figs. 1C, 3; 4:43-48; 6:44-48. Wiltshire thus contemplates a common interface for the server to communicate with client devices of different device platforms. Thus, a POSITA would have had the full expectation that including at least two client devices of different device platforms would have operated predictably and as intended, and thus would have been obvious to try.

⁵ See <https://segaretro.org/Quake> (“Quake is a first person shooter developed by id Software and was originally released for DOS computers in 1996. It was subsequently brought to a variety of other platforms including the Sega Saturn in the following year.”).

116. *Third*, there would have been a reasonable expectation of success using at least two different device platforms as client devices for the following additional reasons. As explained above, Wiltshire's system is expressly designed to operate with a variety of different client device platforms. Wiltshire's system architecture is designed to run games exclusively on a server and then streaming the game to the clients. Ex. 1004, 5:14-23 ("However, unlike, the server/host computer 110, the client/terminal computers 120 only need to have minimal storage, memory and processing power to ensure optimum functional operation of the overall multi-computer system 100, since the overwhelming majority of the gaming related and regulated processing is performed on the server/host computer 110. As a result, the cost of the hardware required for each client/terminal computer 120 is greatly reduced with respect to prior art computer video gaming systems."). This allows for Wiltshire's system to supporting a wide range of client devices that may not otherwise be able to run the game natively. Thus a POSITA would have had the full expectation that including at least two client devices of different device platforms would have operated as intended.

117. Accordingly, I conclude that claim 5 is unpatentable over Wiltshire in combination with Saha.

5. **Claim 6**

a. 6: “*The method as recited in claim 1 wherein the client device is a mobile device.*”

118. Claim 6 depends on claim 1, and as described above, claim 1 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitation of claim 6 to a POSITA.

119. Wiltshire discloses that the client device can be “a mobile device” because Wiltshire’s clients can include “wireless communication pathways” to “allow[] a patron to participate in a *mobile* gaming environment.” Ex. 1004, Abstract; *see also id.*, 13:20-25 (“at least one client/terminal computer further comprises: ... wireless communication pathways”). Based on this disclosure, a POSITA would understand that Wiltshire’s client devices with wireless communication capabilities must be mobile devices in order to be used in the described “*mobile* gaming environment.” For example, a POSITA would understand from this disclosure that a user/patron can use a mobile client device to place bets or otherwise interact with the game while moving around the casino floor.

120. Wiltshire’s disclosure of mobile devices is further confirmed by the fact that Wiltshire discloses that “[c]lient/terminal computers 120 can also be *any type of cost effective special purpose or general purpose computer* such as an Intel® x86 or Pentium® based computer [or] a Mac® PowerPC computer...” *Id.*,

5:14-17. At the time of Wiltshire, a POSITA was well aware and understood that such computers could be, for example, laptops, and that those laptops could be used in a “mobile gaming environment” as Wiltshire describes. Ex. 1007 (PC Magazine), 9 (describing the Apple iBook laptop with a PowerPC processor and wireless connectivity); Ex. 1020 (1996 PC Magazine), 7-12 (describing other suitable mobile laptops including Intel processor-based laptops). Therefore, a POSITA would understand that Wiltshire discloses that the client device is “a mobile device.”

121. Accordingly, I conclude that claim 6 is unpatentable over Wiltshire in combination with Saha.

6. Claim 7

a. 7: “The method as recited in claim 1 wherein the interactive software application is an interactive game that is configured to run at the server, which is in bidirectional communication with a plurality of client devices, and wherein said updating the state of the software application includes updating the game state of the interactive game.”

122. Claim 7 depends on claim 1, and as described above, claim 1 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitations of claim 7.

123. ***First***, as discussed in Section XI(A)(1)(b) for limitation 1[a], Wiltshire discloses that “the interactive software application is an interactive game that is configured to run at the server.” See Section XI(A)(1)(b).

124. ***Second***, as discussed in Section XI(A)(2) for claim 3, the server is also “in bidirectional communication with a plurality of client devices.” *See* Section XI(A)(2).

125. ***Finally***, as discussed in Section XI(A)(1)(d) for limitation 1[c], Wiltshire discloses that “updating the state of the software application includes updating the game state of the interactive game.” *See* Section XI(A)(1)(d).

126. Accordingly, I conclude that claim 7 is unpatentable over Wiltshire in combination with Saha.

7. **Claim 8**

a. 8[preamble]: “An image display system, comprising:”

127. To the extent the preamble is limiting, Wiltshire discloses the preamble. Wiltshire discloses “an image display system,” as shown below:

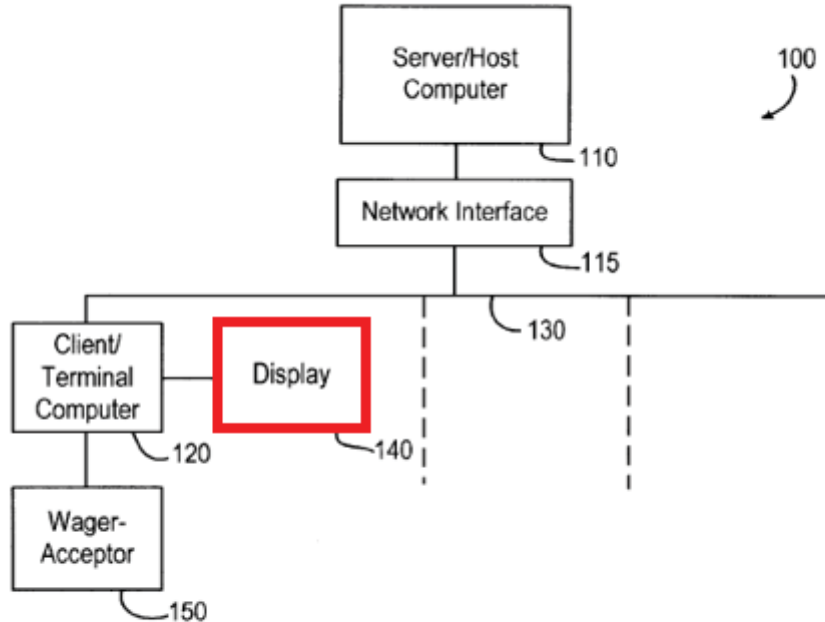


Fig. 1A

Ex. 1004, Figure 1A (showing display 140 in red); *see also* Figure 1D, 2; 3:66-67 (“Each of client/terminal computers 120 is connected to a *display device* 140.”); 7:25-27 (“Client terminal program 122 then causes *the image to be displayed* on a screen of client/terminal computer 120 in stage 240.”).

128. Accordingly, I conclude that Wiltshire discloses the preamble.

b. 8[a]: “a server having a processor and memory configured to execute an interactive software application and further configured for:”

129. Wiltshire discloses this limitation.

130. As explained above for claim 1, Wiltshire discloses that the system includes a “server” (server/host computer) that runs an interactive software

application. *See* Sections XI(A)(1)(a)-(b).

131. Wiltshire further discloses that the server can be any type of computer “having a processor and memory configured to execute an interactive software application” (e.g., a game program). For example, the server can be a computer having a Pentium-based processor and 512 MB of SDRAM memory. Ex. 1004, 4:49-65 (“The server/host computer 110 can be any type of general purpose computer.... [S]erver/host computer 110 should have sufficient storage, **memory and processing power**, to support the plurality (e.g., at least eight) of client/terminal computers 120 ... **in order to provide acceptable response time to random inputs from all the patrons**. For instance, in some embodiments, the **server/host computer 110** has the following hardware configuration: Pentium® II motherboard, **400 Mhz Pentium® II processors, 512 MB of 100 Mhz SDRAM....**”).

132. Accordingly, I conclude that Wiltshire discloses this limitation.

c. 8[b]: “receiving at the server user input signals from a client device, wherein the user input signals are used to control updating the state of the interactive software application;”

133. As explained in Section XI(A)(1)(c) for limitation 1[b], Wiltshire’s server is configured for “receiving at the server user input signals from a client device, wherein the user input signals are used to control updating the state of the interactive software application.” *See* Section XI(A)(1)(c).

d. 8[c]: “generating at least one updated image at the server in response to updating the state of the interactive software application running on the server by the user input signals;”

134. As discussed in Sections XI(A)(1)(c)-(d) for limitations 1[b] and 1[c], Wiltshire discloses that the server is configured for “generating at least one updated image at the server in response to updating the state of the interactive software application running on the server by the user input signals.” See Sections XI(A)(1)(c)-(d).

e. 8[d]: “and compressing the at least one updated image and transmitting the compressed updated image to the client device, wherein the server transmits the updated image as a frame and wherein the client device is configured for decompressing of the compressed updated image and displaying the updated image on a display coupled to the client device.”

135. As discussed in Section XI(A)(1)(e) for limitation 1[d], Wiltshire in combination with Saha discloses that the server is configured for “compressing the at least one updated image and transmitting the compressed updated image to the client device, wherein the server transmits the updated image as a frame and wherein the client device is configured for decompressing of the compressed updated image and displaying the updated image on a display coupled to the client device.” See Section XI(A)(1)(e).

136. ***First***, as explained for limitation 1[d], Wiltshire discloses a server that is configured for transmitting the updated image as an encoded image in a “compressed MPEG video stream,” and thus discloses that the server is configured

for “compressing the at least one updated image and transmitting the compressed updated image to the client device, wherein the server transmits the updated image as a frame.” *See* Section XI(A)(1)(e).

137. ***Second***, as explained in Section XI(A)(1)(e) for limitation 1[d], the combination of Wiltshire and Saha discloses that the client device receiving and displaying the compressed MPEG stream is configured “for decompressing of the compressed updated image and displaying the updated image on a display coupled to the client device.” *See* Section XI(A)(1)(e).

138. For the reasons I have discussed above, a POSITA would have been motivated to combine Wiltshire and Saha to arrive at this limitation, with a reasonable expectation of success, to form the claimed combination. *See id.*

* * *

139. For the foregoing reasons, I conclude that claim 8 is unpatentable over Wiltshire in combination with Saha.

8. Claim 9

- a. 9: “The image display system of claim 8, wherein the user input signals are generated at the client device to update the state of the interactive software application from the state that initiated the current image displayed on the display coupled to the client device.”***

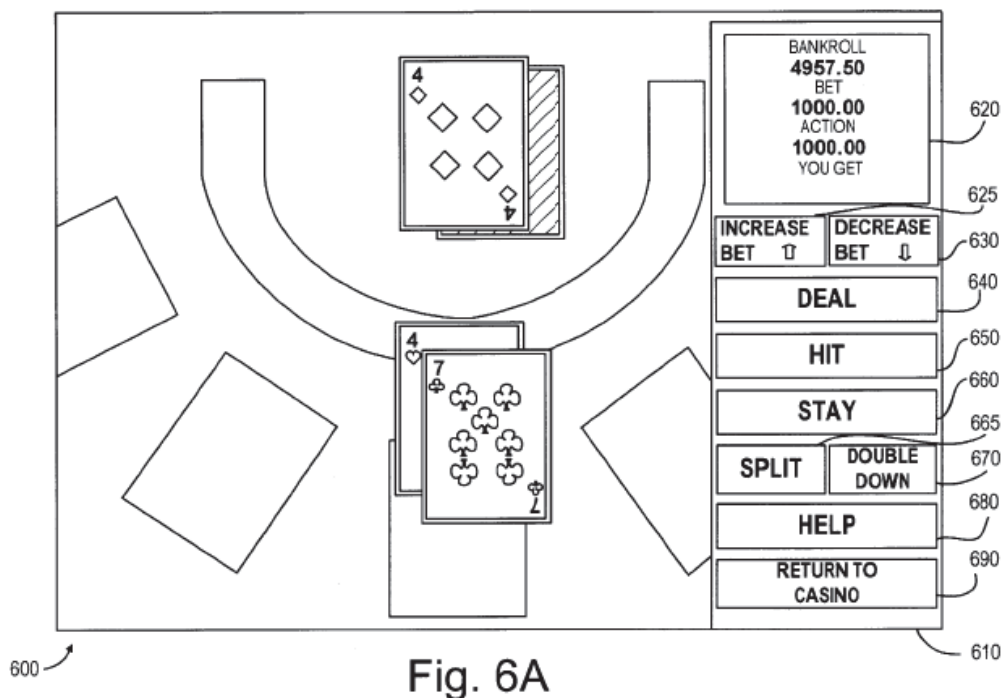
140. Claim 9 depends on claim 8, and as described above, claim 8 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the

additional limitation of claim 9.

141. As explained in Sections XI(A)(1)(c)-(d) for claim 1, Wiltshire discloses that user input signals are generated at the client device, those user input signals update the state of the game at the server, updated images are generated at the server and transmitted to the client as a compressed MPEG video stream, and finally displayed on the client device. *See* Section XI(A)(1)(c)-(d).

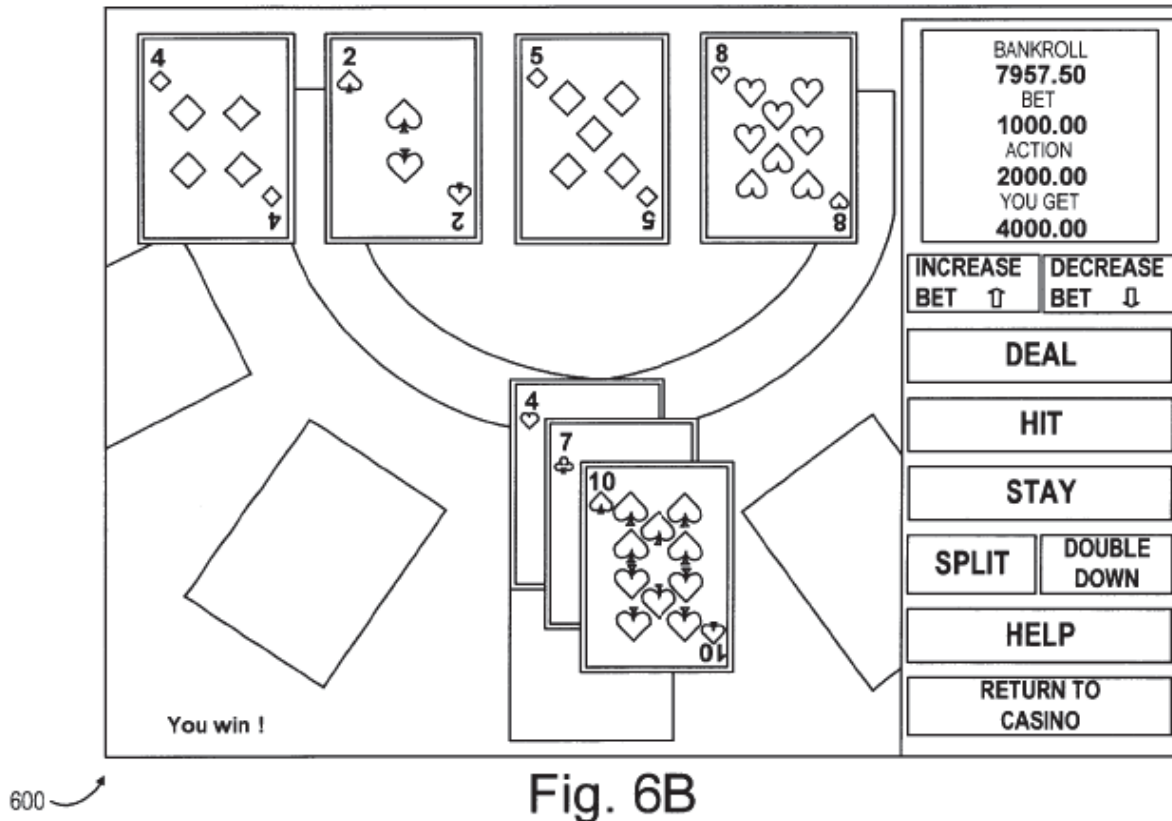
142. Wiltshire further discloses that “the user input signals are generated at the client device to update the state of the interactive software application from the state that initiated the current image displayed on the display coupled to the client device.” Wiltshire provides examples showing how a user input signal at the client is generated to update the current image displayed at the client with a new state of the game, as described by Figure 2 for claim 1 above. *See* Ex. 1004, 8:39-11:54 (describing various games that “illustrate the images displayed on screen 140 of client/terminal computer 120 during operation 200 of computer gaming system 100”); *id.*, 7:7-8 (“FIG. 2 is a flow diagram of operation 200....”).

143. One example is illustrated with a blackjack game that initially shows an image of a blackjack table on a display coupled to the client device, as depicted in Figure 6A:



Ex. 1004, Fig. 6A; 9:13-14 (“FIG. 6A illustrates black jack table image 600, that is displayed in response to the patron pressing blackjack virtual button 430 (FIG. 4B).”); 7:25-27 (“Client/terminal program 122 then causes the image to be displayed on a screen of client/terminal computer 120 in stage 240.”). Figure 6A thus shows a current image on the client display based on an initial state of the blackjack game.

144. Wiltshire then discloses that when the user presses the “double down button” (button 670 in Figure 6B), the button press action is transmitted to the server as a user input signal, updating the state of the game, and resulting in the display of a modified image of the black jack table, shown in Figure 6B:



Ex. 1004, Fig. 6A; 9:63-65 (“FIG. 6B illustrates black jack table image 600 after the patron has elected to double down by pressing double down button 670.”).

Wiltshire explains that Figures 6A and 6B illustrate the operation described in Figure 2. Ex. 1004, 8:39-41 (explaining that Figures 6A and 6B are examples using “operation 200,” which is described in Figure 2 and corresponding descriptions). As explained in Section XI(A)(1) for claim 1, Figure 2 and the corresponding descriptions show that the user input signals generated from the client device (e.g., pressing the “double down” button) are sent to the game program at the server to update the state of the game, resulting in a modified image at the client (e.g., the updated black jack table shown in Figure 6B). *See Sections*

XI(A)(1)(b)-(e).

145. Accordingly, I conclude that claim 9 is unpatentable over Wiltshire in combination with Saha.

9. Claim 10

a. 10: “The image display system of claim 8 wherein the server is configured to exchange user input data and compressed updated images with a plurality of client devices.”

146. Claim 10 depends on claim 8, and as described above, claim 8 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitation of claim 10.

147. As explained in Section XI(A)(1) for claim 1, Wiltshire discloses that the server receives user input signals (i.e., user input data) and transmits compressed updated images to a client terminal. *See* Sections XI(A)(1)(c), XI(A)(1)(e).

148. As explained for claim 3, Wiltshire discloses that the system includes a plurality of client terminals. *See* Section XI(A)(2).

149. Thus, Wiltshire discloses that the compressed images are “exchange[d] ... with a plurality of client devices.” *See also* Ex. 1004, 7:65-8:2 (“In some embodiments, ***images transmitted between server/host computer 110 and client/terminal computers 120*** are cached on client/terminal computers 120 to reduce the amount of network bandwidth required for the operation of computer

gaming system 100.”).

150. Accordingly, I conclude that claim 10 is unpatentable over Wiltshire in combination with Saha.

10. Claim 11

a. 11: “The image display system of claim 8 wherein the interactive software application is a game and wherein the client device is a mobile device.”

151. Claim 11 depends on claim 8, and as described above, claim 8 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitation of claim 11.

152. As discussed in Section XI(A)(1) for claim 1, the interactive software application in Wiltshire is a game program. *See* Section XI(A)(1)(a)-(b).

153. Furthermore, as discussed in Section XI(A)(5) for claim 6, Wiltshire discloses that the client device can be a mobile device. *See* Section XI(A)(5).

154. Accordingly, I conclude that claim 11 is unpatentable over Wiltshire in combination with Saha.

11. Claim 12

a. 12: “The image display system of claim 10 wherein the interactive software application is a game and wherein at least one of the plurality of client devices is a mobile device.”

155. Claim 12 depends on claim 10, and as described above, claim 10 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitation of claim 12.

156. As discussed in Section XI(A)(1) for claim 1, the interactive software application is a game program. *See* Section XI(A)(1)(a)-(b).

157. Furthermore, as discussed in Section XI(A)(5) for claim 6, Wiltshire discloses that at least one of the plurality of client devices can be a mobile device. *See* Section XI(A)(5).

158. Accordingly, I conclude that claim 12 is unpatentable over Wiltshire in combination with Saha.

12. Claim 13

a. 13[preamble]: “A method of displaying interactive video, comprising:”

159. To the extent the preamble is limiting, Wiltshire discloses the preamble.

160. As explained in Section XI(A)(1) for claim 1, Wiltshire discloses a method of hosting and executing an interactive game. *See* Sections XI(A)(1)(a), XI(A)(1)(c).

161. In Wiltshire, the interactive game is displayed as an interactive video. In Wiltshire, images for the interactive game are sent to the client device as a “video stream.” *See* Ex. 1004, Figure 2 (describing operations “Send **video** stream to client” and “Receive **video** stream [from] client”); *see also* Section XI(A)(1)(e), (describing how the server sends a “compressed **video** MPEG stream” to the client). As explained above for claim 1, the video stream is received at the client

device, and the user interacts with the video stream via keyboard, mouse, buttons, or other input commands, which are sent back to the game program executing on the server. *See* Sections XI(A)(1)(c)-(d). A POSITA would understand that a player's input will affect what is displayed on screen when playing a video game because, as disclosed in Wiltshire, the user inputs change the state of the game resulting in different updated images which are compressed and sent to the client for display. Thus, a POSITA would understand that the video stream displayed on the client device is an "interactive video."

162. Accordingly, I conclude that Wiltshire discloses the preamble.

b. 13[a]: "receiving at a server user input control signals from a client device, wherein the user input control signals are used to control at least one image in a sequence of images generated from the running of a software gaming application on the server;"

163. Wiltshire discloses this limitation.

164. ***First***, as explained in Section XI(A)(1)(c) for limitation 1[b], Wiltshire discloses receiving at a server user input control signals ("input commands") from a client device. *See* Section XI(A)(1)(c) (explaining how Wiltshire discloses user input control signals in the form of "input commands").

165. ***Second***, Wiltshire discloses that "the user input control signals are used to control at least one image." Wiltshire discloses that its server uses the received user input signals to control at least one image in a sequence of images

generated from running a software gaming application on the server. For example, Wiltshire describes that the game program running on the server “*responds to input command 112* by updating the state of the game and *possibly modifying the image displayed on screen 140.*” Ex. 1004, 8:61-63; *see also* Section XI(A)(1)(d) (explaining how Wiltshire discloses generating an updated image). Thus, Wiltshire discloses that “the user input control signals control are used to control at least one image” by modifying that image.

166. *Third*, the at least one image is part of a “sequence of images generated from the running of a software gaming application on the server.” The modified image generated by the server is part of a video stream that is a compressed MPEG video stream. *See* Ex. 1004 Figure 2 (describing operations “Send video stream to client” and “Receive video stream [from] client”); *see also* Section XI(A)(1)(e) (describing how the server sends a “compressed video MPEG stream” to the client). A POSITA would understand that a video stream is made up of a sequence of ordered images, where each image is a frame. *See* Ex. 1005 (Saha), Figure 1 (showing how an MPEG video stream comprises multiple “frames” or “pictures”). For example, a POSITA would understand that an animated cartoon generated by a game is made up of multiple still images displayed in sequential order. Thus, a POSITA would understand that the modified image generated by Wiltshire’s server is part of a sequence of images.

167. Accordingly, I conclude that Wiltshire discloses this limitation.

c. 13 [b]: “generating a modified image at the server in response to the user input control signals;”

168. Wiltshire discloses this limitation.

169. As explained in Sections XI(A)(1)(c)-(d) for limitations 1[b] and 1[c], Wiltshire discloses generating a modified image at the server in response to the user input control signals (“input commands”). *See* Sections XI(A)(1)(c)-(d) (explaining how the server generates an updated image in response to the updated game state, which is in turn in response to the “input commands” received from the client).

170. Accordingly, I conclude that Wiltshire discloses this limitation.

d. 13[c]: “and transmitting the modified image to the client device for display as compressed data, wherein the transmitting step comprises compressing the at least one modified image and sending the compressed modified image to the client device once the modified image is generated, and wherein the client device is configured for decompressing of the compressed modified image and displaying the modified image on a display coupled to the client device”

171. Wiltshire in combination with Saha discloses this limitation.

172. ***First***, as explained in Section XI(A)(1)(e) for limitation 1[d], Wiltshire discloses “transmitting the modified image to the client device for display as compressed data, wherein the transmitting step comprises compressing the at least one modified image and sending the compressed modified image to the

client device once the modified image is generated.” *See* Section XI(A)(1)(d)-(e) (explaining how Wiltshire discloses generating a modified image, and once generated, compressing the modified image as an MPEG video stream for transmission to the client device).

173. ***Second***, as explained in Section XI(A)(1)(e) for limitation 1[d], Wiltshire discloses “wherein the client device is configured for decompressing of the compressed modified image and displaying the modified image on a display coupled to the client device” in combination with Saha *See* Section XI(A)(1)(e); Ex. 1004, 3:66-67 (“Each of client/terminal computers 120 is ***connected to a display device*** 140.”); 7:25-27 (“Client terminal program 122 then causes ***the image to be displayed*** on a screen of client/terminal computer 120 in stage 240.”).

174. For the reasons provided in Section XI(A)(1)(e) for limitation 1[d], a POSITA would have been motivated to apply Saha’s teaching of MPEG decompression to Wiltshire’s client device so that the client would be configured to decompress the compress modified image, with a reasonable expectation of success, to form the claimed combination. *See* Section XI(A)(1)(e).

175. Accordingly, I conclude that Wiltshire in combination with Saha discloses this limitation.

* * *

176. For the foregoing reasons, I conclude that claim 13 is unpatentable

over Wiltshire in combination with Saha.

13. Claim 15

a. 15: “The method as recited in claim 13 wherein the server is configured to exchange user input data and compressed modified images with a plurality of client devices.”

177. Claim 15 depends on claim 13, and as described above, claim 13 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitations of claim 15.

178. As explained in Section XI(A)(9) for claim 10, Wiltshire discloses that its server is configured to exchange user input data (Wiltshire’s input commands) and compressed modified images with a plurality of client devices. *See* Section XI(A)(9).

179. Accordingly, I conclude that claim 15 is unpatentable over Wiltshire in combination with Saha.

14. Claim 16

a. 16: “The method as recited in claim 15 wherein at least two of the plurality of client devices include different platforms.”

180. Claim 16 depends on claim 15, and as described above, claim 15 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitations of claim 16 to a POSITA.

181. As discussed in Section XI(A)(4) for claim 5, Wiltshire further discloses that “at least two of the plurality of client devices include different

platforms,” and at a minimum, a POSITA would have been motivated to implement the system of Wiltshire to arrive at this limitation with a reasonable expectation of success. *See* Section XI(A)(4).

182. Accordingly, I conclude that claim 15 is unpatentable over Wiltshire in combination with Saha.

15. Claim 17

a. 17: “The method as recited in claim 1 wherein the interactive software application is a game running on the server and wherein updating of the state of the interactive software application includes changing the game state.”

183. Claim 17 depends on claim 1, and as described above, claim 1 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitations of claim 17.

184. As discussed in Section XI(A)(6) above for claim 7, Wiltshire discloses that the interactive software application is a game running on the server and wherein updating of the state of the interactive software application includes changing the game state. *See* Section XI(A)(6).

185. Accordingly, I conclude that claim 17 is unpatentable over Wiltshire in combination with Saha.

16. **Claim 18**

- a. 18: “The method as recited in claim 13 wherein the user input control signals are used to control a plurality of images in the sequence of images generated from the running of a software gaming application on the server.”*

186. Claim 18 depends on claim 13, and as described above, claim 13 is obvious based on Wiltshire in combination with Saha. Wiltshire discloses the additional limitations of claim 18.

187. As discussed in Section XI(A)(12)(b) for limitation 13[a], Wiltshire discloses that the user input signals are used to control at least one image in a sequence of images (video stream) generated from running the game on the server. *See* Section XI(A)(12)(b).

188. Wiltshire further discloses that the user input control signals are used to control a ***plurality*** of images in the sequence of images. In particular, Wiltshire discloses that the game program—in response to user input commands—determines which “images” (plural) are to be displayed on the screen of the client. Ex. 1004, 5:59-65 (“[T]he game program determines which ***images*** are to be displayed on a screen of the client/terminal computer and that input commands such as mouse movements, mouse clicks or keystrokes or lever activation detected by the client/terminal computer are sent directly to the server/host based game program for context interpretive processing.”). Further, because Wiltshire discloses that an updated image can be a “video stream,” a POSITA would

understand that there would be a plurality of updated images because a stream consists of multiple images. *See* Ex. 1004, Figure 2 (describing operations “Send **video** stream to client” and “Receive **video** stream [from] client”); *see also* Section XI(A)(1)(e), (describing how the server sends a “compressed **video** MPEG stream” to the client).

189. As another example, Wiltshire describes a virtual casino slot machine game using the system described in Figure 2, which provides an animated sequence of images in response to user input control signals sent by the client. *See* Ex. 1004, 11:7-30 (“To play the virtual slot machine, the patron first places a bet by pressing either one coin button 865 or two coin button 870. The patron then presses pull button 875, causing reels 850 to ‘*spin*.’ ... Prize window 890 is a sub-window of slots image 830 that displays an **animated** and **dynamically variable image** of a prize that also appears on reels 850.”); 8:39-41 (explaining the slot machine game is an example using “operation 200,” which is described in Figure 2 and corresponding descriptions).

190. Thus, Wiltshire discloses that in response to user input control signals, the server can control a plurality of images (such as in an animation or output stream of images). *See also id.*, 2:39-44 (“Each client/terminal computer comprises a client/terminal program that allows the computer gaming program executed on the server/host computer to **accept input from the patrons**, and

control the gaming content of an *output information stream* directed to the client/terminal computers.”).

191. Accordingly, I conclude that claim 18 is unpatentable over Wiltshire in combination with Saha.

B. Ground II: Claims 2 and 14 are obvious in view of Wiltshire, Saha, and Chen

192. As explained above in Ground I, Wiltshire in combination with Saha renders unpatentable claims 1, 3-13, and 15-18. *See* Section XI(A). Claim 2 and 14 depend on claims 1 and 13, respectively. Thus, my analysis in Ground I is fully incorporated into Ground II. As described below, Chen discloses the additional limitations of claims 2 and 14, and a POSITA would have been motivated to combine the teachings of Chen with Wiltshire and Saha to render obvious claims 2 and 14.

1. Claim 2

a. 2: “The method as recited in claim 1 wherein a first bandwidth for transmitting the user input data between the client device and the server and a second bandwidth for transmitting the compressed updated image from the server to the client device are asymmetric.”

193. Claim 2 depends on claim 1, and as described above, claim 1 is obvious based on Wiltshire in combination with Saha. The combination of Wiltshire, Saha, and Chen discloses the additional limitations of claim 2.

194. As discussed in Sections XI(A)(1)(c)-(e) and XI(A)(3) above for

limitations 1[b]-1[d] and claim 4, Wiltshire discloses (1) transmitting user input signals (user input data) between the client device and the server and (2) transmitting the compressed updated image from the server to the client device. *See* Ground I, Sections XI(A)(1)(c)-(e), XI(A)(3). While Wiltshire does not expressly disclose using a first bandwidth for the client to server transmissions and a second different bandwidth for the server to client transmissions, Chen provides this teaching via the ADSL standard.

195. Chen describes the ADSL standard, which uses a first (upstream) bandwidth and a second (downstream) bandwidth that are asymmetric.⁶ Ex. 1006 (Chen), 69 (“ADSL was proposed as having the traditional duplex POTS channels, occupying the frequency band between 300 Hz to 4 kHz, *an upstream control channel of 16-64 kb/s, occupying the frequency band between 10 kHz to 50 kHz, and a downstream channel of 1.544 Mb/s, occupying the frequency band between 100 and 500 kHz.*”). Chen thus discloses a “first bandwidth” for upstream transmissions (16-64 kb/s) and “second bandwidth” for downstream transmissions (1.544 Mb/s) and that the bandwidths are “asymmetric” (the

⁶ Chen refers to transmissions from client to server as “upstream” transmissions, and refers to transmissions from server to client as “downstream” transmissions. Ex. 1006 (Chen), 68-69.

upstream bandwidth of 16-64 kb/s is different than the downstream bandwidth of 1.544 Mb/s). Indeed, the '109 patent admits that DSL was already known and is an example of an asymmetric bandwidth connection. Ex. 1001 ('109 patent), 6:14-16 (“However, *the client bandwidth can be asymmetric*, with the high-bandwidth reserved for visual server 12 to client 16, 18, 20 communication, *an example being a DSL.*”).

196. A POSITA would have been motivated to apply Chen’s teaching of a first bandwidth and a second bandwidth that are asymmetric to Wiltshire alone or in combination with Saha, and would have had a reasonable expectation of success in doing so, for the following reasons.

197. *First*, Wiltshire describes using a communication pathway between the server and clients such as the Internet, and Chen teaches that ADSL is an “ideal vehicle for Internet access” and other “telecommuting applications.” Ex. 1004, 5:30-32 (Wiltshire) (“The communication pathways 130 is any type of local area, wide area or global communication pathways, *including the Internet and the World Wide Web.*”); Ex. 1006 (Chen), 69 (“Most recently, *ADSL has been considered as an ideal vehicle for Internet access* and telecommuting applications.”). Wiltshire and Chen thus teach toward one another, and a POSITA would have been motivated to apply Chen’s ADSL teachings to implement the Internet communication access described in Wiltshire. A POSITA would also

have been aware that Saha's MPEG compression and decompression would be compatible for use with Wiltshire (which explicitly mentions MPEG) (Ex. 1004, 7:15-18) and Chen's ADSL (which also mentions MPEG) (Ex. 1006, 69); *see also* Section XI(A)(1)(e) (explaining reasons a POSITA would have been motivated to apply Saha's teaching of decompressing compressed frames to Wiltshire's disclosure of using MPEG).

198. ***Second***, as described in Chen, ADSL is "well suited to the concept of video-on-demand service" and Wiltshire's system provides a form of "video-on-demand"—again teaching toward the combination of the two references. Ex. 1006 (Chen), 69. As explained in Chen, ADSL is well suited for video-on-demand because the upstream control signals for interactive commands (e.g., pause, play, etc.) only need "low transmission throughput" relative to the higher bandwidth requirements of downstream video and audio transmissions. Ex. 1006 (Chen) 69 ("For this service [signaling the network, scanning archives on programming, and receiving video on demand], only ***a low transmission throughput upstream control channel*** is necessary ***to send back control signals for interactive commands such as pause, play***, and so forth."); *id.* ("The video, an audio channel, and associated overhead can be transmitted within a 1.5 Mb/s signal.").

199. ADSL is thus well-suited to exchange the same type of information (i.e. user input controls on one hand and image/video data on the other) as

disclosed in Wiltshire. For example, ADSL is configured “to send back control signals for interactive commands such as pause, play, and so forth,” and “[t]he video ... can be transmitted within a 1.5 Mb/s signal.” Ex. 1006, 69. As discussed in for claim 1, Wiltshire’s system also includes sending user input commands to the server and transmitting an updated image to the client device. Sections XI(A)(1)(c)-(e). Wiltshire explains that the user input commands are “mouse movements, mouse clicks or keystrokes.” Ex. 1004, 5:57-65.

200. A POSITA would understand that these upstream input commands would—like the pause and play commands referenced in Chen—require less bandwidth than the downstream video transmissions. For example, a POSITA would understand that keyboard data (such as the data from a key press) is typically encoded as 8-bit ASCII data. *See* Ex. 1018 (Sutton), Abstract (describing transmission of “eight bit ASCII” data). Even assuming a user presses a key rapidly twice per second, this would only be 16 bits per second. In contrast, a video stream would typically require significantly more than 8 or 16 bits per second. As mentioned in Chen, a POSITA would understand that an MPEG stream may require rates of at least 1.3 megabits per second (a megabit is approximately a million bits), which is many times greater than the typical 8 or 16 bits per second required for transmitting a user input command. Ex. 1006 (Chen), 69 (“The CCITT H.261 recommendation and the ISO Moving Picture Experts

Group (MPEG) recommendation both provide full motion video at rates of around *1.3 Mb/s.*”). Thus, a POSITA would understand that sending compressed updated images from the server to the client requires higher bandwidth than the bandwidth required for sending user input control signals from the client to the server. A POSITA would therefore be motivated to use the smaller bandwidth of ADSL for exchanging user input commands and the larger bandwidth of ADSL for transmitting the compressed image using MPEG. A POSITA would understand that by providing a dedicated larger bandwidth for the video stream transmissions, there would be a better user experience (particularly for real-time interactive games).

201. *Third*, using ADSL would have been just one of a finite number of known options for providing Internet connectivity described in Wiltshire. Specifically, at the time of Wiltshire, broadband Internet access was typically provided by one of two options: ADSL or cable networks. *See* Ex. 1007 (PC Magazine), 76 (explaining that in September 1999, “[c]able modems and DSL lines are proliferating faster than anyone predicted....”). A POSITA would have known that ADSL was a widespread and common choice for broadband Internet access in the 1998-2000 time frame. As explained in Chen, ADSL was recognized as the “ideal” vehicle for providing Internet Access, particularly for streaming video, and thus would have been—at a minimum—obvious to try when

implementing Wiltshire's system with an Internet connection. Ex. 1006 (Chen), 69.

202. *Fourth*, a POSITA would have had a reasonable expectation of success with the combination of Chen with Wiltshire and Saha. Wiltshire describes using a communication pathway such as the Internet. Ex. 1004, 5:30-32 (“The communication pathways 130 is any type of local area, wide area or global communication pathways, *including the Internet and the World Wide Web.*”). Chen discloses that ADSL is ideal for providing Internet access. Ex. 1006 (Chen), 69 (“Most recently, *ADSL has been considered as an ideal vehicle for Internet access and telecommuting applications.*”).

203. Further, Chen discloses that ADSL is configured to transmit control commands and video, and Wiltshire is also designed to transmit control commands and video. Ex. 1006 (Chen) at 69.

204. Chen also contemplates video on demand applications using MPEG, just like Wiltshire. Ex. 1006 (Chen) at 69 (“[T]he ISO Moving Pictures Experts Group (*MPEG*) recommendation ... provide full motion video rates of around 1.3 Mb/s. The video, an audio channel, and associated overhead can be transmitted with a 1.5 Mb/s signal.”). As discussed above for claim 1, the combination of Wiltshire and Saha disclose a video on demand system that uses MPEG compression and decompression for transmitting video streams. *See* Section

XI(A)(1)(e). Thus, the combination of Chen with Wiltshire and Saha uses ADSL in the intended manner, and MPEG would be compatible with use of ADSL.

205. Further, the Internet generally and ADSL in particular were well-understood technologies by the middle of the dot-com boom, 1998, when Wiltshire was filed. *See* Ex. 1006 (Chen), Abstract.

206. In sum, the combination of Chen with Wiltshire and Saha uses ADSL in the intended manner, and MPEG would be compatible with use of ADSL.

207. ***Finally***, Chen, Wiltshire, and Saha, are analogous art to the '109 patent. I have been informed and understand that a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention). As discussed above for limitation 1[d], both Wiltshire and Saha are analogous art to the '109 patent. *See* Section XI(A)(1)(e). Chen relates to the same field of endeavor as the '109 patent because Chen describes a communications technology (ADSL) that is used for transmissions of images and video. Ex. 1006 (Chen), 68; Ex. 1001 ('109), 1:29-33 (describing "Field of Invention" as including "a visual server to generate and transmit images to a client"). Further, Chen is reasonably pertinent to the problem of the '109 patent because it describes a communications technology that provides

asymmetric bandwidths for transmitting user input commands and video streams, just like the '109 patent. Ex. 1006 (Chen), 68; Ex. 1001 ('109), 6:11-28.

208. Accordingly, I conclude that claim 2 is unpatentable over the combination of Wiltshire, Saha, and Chen.

2. Claim 14

a. 14: “The method as recited in claim 13 wherein a first bandwidth available for receiving user input control signals at the server and a second bandwidth available for transmitting the modified image to the client device is asymmetric with the second bandwidth available for transmitting the modified image from the server being greater than the first bandwidth.”

209. Claim 14 depends on claim 13, and as described above, claim 13 is obvious based on Wiltshire in combination with Saha. The combination of Chen with Wiltshire and Saha discloses the additional limitation of claim 14.

210. As discussed in Sections XI(A)(12)(b)-(d) for limitations 13[a]-13[c], Wiltshire discloses receiving user input control signals at the server and transmitting the modified image to the client device. *See* Sections XI(A)(12)(b)-(d).

211. As discussed in Section XI(B)(1) for claim 2, Chen describes a first bandwidth and a second bandwidth that are asymmetric such that the second bandwidth is greater than the first bandwidth. *See* Section XI(B)(1). As also discussed above for claim 2, a POSITA would have been motivated to apply Chen’s teachings of ADSL to Wiltshire in combination with Saha, to arrive at the

additional limitation recited in claim 14 and would have had a reasonable expectation of success in doing so. *See* Section XI(B)(1).

212. Accordingly, I conclude that claim 14 is unpatentable over the combination of Wiltshire, Saha, and Chen.

C. Ground III: Claims 6, 11, and 12 are obvious in view of Wiltshire, Saha, and PC Magazine

213. As explained above in Ground I, Wiltshire in combination with Saha renders obvious claims 6, 11, and 12. *See* Section XI(A).

214. If the Patent Owner argues that Wiltshire does not disclose the “mobile device” limitations of claims 6, 11, and 12, these claims would also have been obvious in view of the combination of PC Magazine with Wiltshire and Saha. Claim 6 depends on claim 1, and claims 11 and 12 depend on claim 8. Ground III thus incorporates my analysis set forth in Ground I for these claims.

1. Claim 6

a. 6: “The method as recited in claim 1 wherein the client device is a mobile device.”

215. Claim 6 depends on claim 1, and as described above, claim 1 is obvious based on Wiltshire in combination with Saha. *See* Section XI(A)(1). The combination of PC Magazine with Wiltshire and Saha discloses the additional limitation of claim 6.

216. PC Magazine discloses various laptop computers, including the Apple “iBook” shown below:

PIPELINE
DISPATCHES FROM THE WORLD OF COMPUTING



Groovy Portables

The rumor mill proved correct: At New York's recent MacWorld trade show, Apple CEO Steve Jobs took the wraps off the company's much-ballyhooed iBook portable computer. Targeted squarely at consumers and students, the new iBook portables will sell for \$1,599 and start shipping in September.

The new iBook itself isn't square, though. It has curved edges and corners, with rubber figuring

prominently in the design. The curves and the Austin Powers-like colors are intended to project a distinctly hip image. The 6.6-pound iBook will be available in two translucent color schemes—tangerine and blueberry—and will have a 12.1-inch TFT display with a resolution of 800 by 600 pixels, an ATI Rage graphics chip, a 300-MHz G3 processor, a CD-ROM drive, 32MB of RAM (expandable to 160MB), a built-in modem, USB and 10/100 Ethernet ports, and a full-size keyboard. The operating system is Mac OS 8.6. Jobs touted the battery life as over 6 hours (Mac OS 8.6 includes advanced power-management schemes).

Just as many portable PCs are shipping with wireless technologies, iBook users can roam up to 150 feet from \$299 base stations that plug into telephone jacks (users must also purchase \$100 cards for their iBooks to communicate with the base stations). Dubbed AirPort, the wireless technology is radio-based and has a data-transfer rate of 11 Mbps. Apple developed the wireless components in partnership with Lucent.



APPLE'S AIRPORT: Wireless networking on a shoestring.



of respondents to a recent PC Magazine Online poll told us the portal they use most is Yahoo!. Of the six other portals we asked about, only two made it into double digits—Excite and MSN.com, with 13 percent each. Trailing far behind were AOL.com (9 percent), Netcenter (8 percent), GO Network (3 percent), and Lycos (3 percent).

IBM's 11-Terabyte Storehouse

Last year, IBM wowed the industry with its match-book-size 340MB Microdrive. This year, IBM launched what the company claims is the world's largest storage server, the Enterprise Storage Server (code-named Shark), which is about the size of a shower stall and handles up to 11 terabytes of data. In practical terms, the system could hold all the contents of the Library of Congress—and then some. With the announcement, IBM has positioned itself as a serious competitor to EMC, which already dominates the enterprise storage market.

The fledgling enterprise storage market is booming, and all signs point to more of the same. One ripple effect of the Internet's growth is the surge in demand for storage, propelled by the millions of transactions zipping around cyberspace. Companies are eager to capitalize on one-to-one marketing by turning the massive amounts of data that Web sites collect into useful information for targeting customers. According to Forrester Research, the demand for disk storage in large companies is growing more than 100 percent annually.

Sites to Sit On

Sure, you've bought books, CDs, and flowers, but have you started to think bigger? Why not buy a \$3,000 couch online? If you're not crazy about the idea, you're not alone. So far, only 1 percent of the \$75 billion furniture market has found its way onto the Web. Nevertheless, *Forbes* magazine recently identified furniture as

Ex. 1007 (PC Magazine) at 9. As shown in the excerpt above, PC Magazine describes the Apple iBook as a “portable” laptop computer for mobile use, and it includes “wireless technology” (called AirPort, which Apple developed with Lucent) that allows users to “*roam* up to 150 feet” from a base station. Further, the article emphasizes the iBook’s 6-hour battery life, which a POSITA would understand to confirm that the iBook is a mobile device capable of operating when

not connected to a power outlet. *Id.* Thus, a POSITA would understand that a laptop, such as the Apple iBook, is a mobile device.

217. A POSITA would have been motivated to use laptops, such as the iBook disclosed in PC Magazine, as the “client/terminal computers” in Wiltshire, and would have had a reasonable expectation of success in doing so, for the following reasons.

218. *First*, Wiltshire describes that “[c]lient/terminal computers 120 can also be *any type* of cost effective special purpose or general purpose computer *such as ... a Mac® PowerPC computer ... etc.*” Ex. 1004, 5:14-17. The Apple iBook described in PC Magazine uses a 300-MHz PowerPC “G3 processor,” and is thus squarely within what Wiltshire teaches to use as “client/terminal computers.” Ex. 1007 (PC Magazine) at 9; Ex. 1019, Abstract (G3 is a “third-generation PowerPC microprocessor”); Ex. 1021 (Esfahani), 3:23-25 (G3 is a “PowerPC processor”). Further, PC Magazine was a popular print publication at the time of Wiltshire, and described a variety of consumer mobile computers that the general public could buy. Given Wiltshire’s instruction that the “client/terminal computers” could be “any” general purpose computer—and specifically mentions “PowerPC”-based computers—a POSITA would understand that “any” of the consumer laptops described in PC Magazine, including the iBook, could be used as described in Wiltshire. Indeed, the Apple iBook was noteworthy when it was

announced in 1999, further supporting why a POSITA would have envisioned the iBook as a suitable client device when reading Wiltshire.

219. **Second**, Wiltshire explains that its system can be used for “mobile gaming” when the client devices have “wireless communication pathways.” Ex. 1004, Abstract; 13:20-25 *see also* Section XI(A)(5) (describing Wiltshire’s disclosures relating to mobile gaming for claim 6). The iBook described in PC Magazine is equipped with wireless communication technology called AirPort to allow users to “roam.” Ex. 1007 at 9. Because these laptops are designed for mobile use, a POSITA would have been motivated to implement Wiltshire’s system using these laptops as client devices specifically to support “*mobile* gaming” as Wiltshire describes. The computer specifications for the iBook (300-Mhz Power PC computer, ATI graphics chip, 32 MB RAM, etc.) were more than sufficient to play interactive games. Moreover, in the context of Wiltshire, where the games are running exclusively on the server, even lower-power laptops that normally would not be capable of playing certain games natively, could be used as the client devices in Wiltshire’s system. Thus, a POSITA would recognize that Wiltshire’s system can allow games that normally could not be played on a mobile laptop to be played on such mobile devices, expanding the customer base and revenue for those games.

220. **Third**, using a mobile device for a client device would have been just

one of a finite number of known options contemplated by a POSITA for use in Wiltshire—either the client devices can be non-mobile, or the client devices can be mobile. As can be seen in commercial magazines such as PC Magazine, the personal computer industry had already begun shifting towards offering viable mobile laptop products to the general public. Ex. 1007 (PC Magazine), 9 (iBook targeted at students and consumers). Indeed, many businesses competed to offer their own laptop models to potential customers. *See generally*, Ex. 1007 (PC Magazine). Given that mobile devices like laptops were so well known at the time (as described in PC Magazine), using mobile devices would have been a predictable and identified option that was obvious to try.

221. ***Fourth***, using a known mobile device such as the iBook laptop described in PC Magazine would have been a simple substitution of one known element for another to obtain predictable results. As explained above, PowerPC-based mobile laptops were well known before the '109 patent, and Wiltshire expressly contemplates that “any” known PowerPC-based computer may be used, since the game programs run exclusively on the server. Additionally, a POSITA would understand that a laptop could already be used to perform some of the same processes as a stationary desktop computer.

222. ***Fifth***, there would have been a reasonable expectation of success in using laptops described in PC Magazine as the “client terminal computers” of

Wiltshire's computing system. Wiltshire describes "a mobile gaming environment" and describes using "any type of cost effective special purpose or general purpose computer such as an Intel® x86 or Pentium® based computer, a Mac® PowerPC computer, a Sun® SPARC®, etc." Ex. 1004, Abstract, 5:14-17. PC Magazine explains that PowerPC laptops were commercially available well before the earliest date of the '109 patent. Ex. 1007 at 9 (noting iBook release in September 1999). Given Wiltshire's broad language and the fact that laptops were commercially available at the time, a POSITA would have understood that Wiltshire's description of "any type of cost-effective special purpose or general purpose computer" would include mobile laptops.

223. Further, a POSITA would have understood that the iBook's "300-MHz G3 processor" would be more than sufficient to decode MPEG-1 and MPEG-2 encoded video streams, as taught by the combination of Wiltshire and Saha. Ex. 1007 at 9; Ex. 1019 (PowerPC) at 324 ("This third generation PowerPC microprocessor ... offers both the high performance required for high end desktop systems, as well as the low typical power dissipation needed for portable systems."). Indeed, even earlier-generation laptops from 1996 with less powerful specifications were already capable of handling MPEG decoding. Ex. 1020 (1996 PC Magazine) at PDF page 8 (describing laptop with 75 to 120 MHz Pentium processor that can "effortlessly handle full-screen MPEG video and CD-quality

sound, you can give a presentation that's worthy of a sequel"). Thus, a POSITA would have fully expected the iBook to be able to decode MPEG streams as taught by Wiltshire combined with Saha.

224. Further, as described in PC Magazine, the iBook's AirPort wireless technology supports data rates of 11 megabits per second. Ex. 1007 at 9. Wiltshire's stated bandwidth requirement may be as low as "100 KB/sec" (kilobytes per second), which is well under the iBook's 11 megabits per second wireless data-rate because 10 kilobytes (KB) is equivalent to .08 megabits. Thus, a POSITA would have fully expected the iBook's wireless connectivity to work with the system in Wiltshire.

225. Thus, a POSITA would have fully expected that laptops such as those advertised in PC Magazine would work as intended in Wiltshire, including to provide "mobile gaming" contemplated by Wiltshire.

226. **Finally**, PC Magazine, Wiltshire, and Saha are analogous art to the '109 patent. I have been informed and understand that a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention). As discussed above for limitation 1[d], Wiltshire and Saha are analogous art to the '109 patent. *See*

Section XI(A)(1)(e). PC Magazine relates to the same field of endeavor as the '109 patent because it describes computer systems (laptop PCs) that can operate as client devices to display images and video. Ex. 1007 (PC Magazine) at 9 (explaining that the iBook contains a 12.1 inch display, graphics chip, G3 processor, Ethernet, and wireless connectivity); Ex. 1001 ('109), 1:29-33 (describing “Field of Invention” as including “computer systems” and “a visual server to generate and transmit images to a client”). PC Magazine is also reasonably pertinent to the problem of the '109 patent because the '109 patent's claimed invention involves “one or more client computers” (Ex. 1001, Abstract) and “common consumer client devices” (*id.*, 3:34-37) and PC Magazine describes known types of consumer devices (PCs). Ex. 1007 (PC Magazine), 9 (iBook “[t]argeted squarely at consumers and students”).

227. Accordingly, I conclude that claim 6 is unpatentable over the combination of Wiltshire, Saha, and PC Magazine.

2. Claim 11

a. 11: “The image display system of claim 8 wherein the interactive software application is a game and wherein the client device is a mobile device.”

228. Claim 11 depends on claim 8, and as described above, claim 8 is obvious based on Wiltshire alone or in combination with Saha. *See* Section XI(A)(7). The combination of PC Magazine with Wiltshire and Saha discloses the

additional limitation of claim 11.

229. As discussed in Section XI(A)(1) for claim 1, Wiltshire discloses that the server may run a variety of games. *See* Section XI(A)(1)(a).

230. As discussed in Section XI(C)(1) for claim 6, PC Magazine describes known PowerPC-based laptops, which a POSITA would understand are mobile devices. As also discussed above for claim 6, a POSITA would have been motivated to use the laptops described in PC Magazine as the client devices in the combination of Wiltshire and Saha with a reasonable expectation of success. *See* Section XI(C)(1).

231. Accordingly, I conclude that claim 11 is unpatentable over the combination of Wiltshire, Saha, and PC Magazine.

3. Claim 12

a. 12: “The image display system of claim 10 wherein the interactive software application is a game and wherein at least one of the plurality of client devices is a mobile device.”

232. Claim 12 depends on claim 10, and as described above, claim 10 is obvious based on Wiltshire in combination with Saha. *See* Section XI(A)(9).

233. The combination of PC Magazine with Wiltshire and Saha discloses the additional limitation of claim 12.

234. As discussed in Section XI(A)(1) for claim 1, Wiltshire discloses that the server may run a variety of games. *See* Section XI(A)(1)(a).

235. As discussed in Section XI(C)(1) for claim 6, PC Magazine describes known PowerPC-based laptops, which are mobile devices. Section XI(C)(1). A POSITA would have been motivated to use the laptops described in PC Magazine as at least one of the plurality of client devices in the combination of Wiltshire and Saha with a reasonable expectation of success for the same reasons described above for claim 6. *See* Section XI(C)(1).

236. Accordingly, I conclude that claim 12 is unpatentable over the combination of Wiltshire, Saha, and PC Magazine.

XII. AVAILABILITY FOR CROSS-EXAMINATION

237. In signing this declaration, I recognize that the declaration will be filed as evidence in a case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time allotted for cross examination.

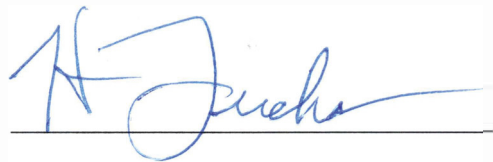
XIII. RIGHT TO SUPPLEMENT

238. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner raises and to take into account new information as it becomes available to me.

XIV. JURAT

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: December 4, 2020



Henry Fuchs, Ph. D.

Attachment A

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Citizenships: USA and Hungary

Education

- 1975 Ph.D, Computer Science, University of Utah
- 1970 B.A., Information and Computer Science, University of California at Santa Cruz

Positions Held

- 2017-2018 Guest Professor, TU Wien
- 2003-2004 Guest Professor, ETH Zurich
- 1978 - present University of North Carolina at Chapel Hill
 Federico Gil Distinguished Professor (1988-present)
 Adjunct Professor of Biomedical Engineering (2000-)
 Adjunct Professor of Radiation Oncology (1988-2008)
 Professor of Computer Science (1983-1988)
 Associate Professor of Computer Science (1978-83)
- 1975 -1982 University of Texas at Dallas, Programs in Mathematical Sciences
 Adjunct Associate Professor (1978-82)
 Computer Science Coordinator (1977-78)
 Assistant Professor (1975-78)
- 1979 -1982 University of Texas Health Science Center at Dallas,
 Southwestern Medical School
 Adjunct Associate Professor of Medical Computer Science
- 1970 - 74 University of Utah, Department of Computer Science
 Research Assistant and Teaching Fellow
- 1976 - Present Former consulting and advisory board memberships (selected):
 Fraunhofer: IGD, Darmstadt, Germany; and CRCG, USA
 Harvard Neuroimage Analysis Center

Lockheed-Georgia
Mersive Technologies
Mitsubishi Electric Research Lab
RAND Corp.
Research Triangle Institute
ShoGraphics
Stellar Computer
Thomson Corp.
Xerox Palo Alto Research Center

1968 - 74	NASA Jet Propulsion Lab of Caltech Engineer and Consultant (mostly summers)
1968 - 70	University of California at Santa Cruz Programmer and Consultant, Computer Center Undergraduate Research Assistant for Prof. Harry Huskey

Honors

- Career Impact Award, ISMAR 2018 ("Based on the profound impact that he has continued to have on AR/MR for well over forty years and on ISMAR since its inception")
- Honorary doctorate (Dr. h.c.), TU Wien, 2018.
- ACM SIGGRAPH Academy - inaugural class, 2018 ("For contributions to augmented and virtual reality, telepresence and graphics hardware, and for educating the leaders in the field of computer graphics.")
- The 2015 ACM SIGGRAPH Steven A. Coons Award ("It is considered the field's most prestigious award" - ref: Wikipedia article: Steven A. Coons).
- Fellow, IEEE 2015 ("For contributions to computer graphics, virtual and augmented reality")
- The 2013 IEEE VGTC Virtual Reality Career Award ("In recognition of his lifetime contributions to research and practice of virtual environments, telepresence and medical applications").
- Fellow, American Academy of Arts and Sciences, 1997.
- Member, National Academy of Engineering, 1997.
- The 1997 Satava Award, Medicine Meets Virtual Reality Conferences. ("For your commitment to the transformation of medicine through visionary applications of interactive technology").
- ACM Fellow, 1994. ("For distinguished contributions in the field of computer graphics").
- The 1992 Computer Graphics Achievement Award, ACM/SIGGRAPH. ("In recognition of his outstanding contribution to high-performance, parallel display architecture").
- The 1992 National Computer Graphics Association (NCGA) Academic Award. ("For his outstanding leadership in the development and promotion of computer graphics applications in the academic community").

Patents Awarded

17. H. Fuchs, M. Dou, G. Welch, J. M. Frahm, "Methods, Systems, and Computer Readable Media for Unified Scene Acquisition and Pose Tracking in a Wearable Display," US Patent No. 10,365,711 (Jul. 30, 2019).
16. H. Fuchs, D. Dunn, C. Tippetts, "Wide Field of View Augmented Reality Head- Mounted Display with Distance Accommodation," US Patent No. 9,983,412 (May 29, 2018).
15. H. Fuchs, N. Dierk, J. M. Frahm, A. Lastra, D. Perra, "Low-Latency Stabilization for Head-Worn Displays," US Patent No. 9,898,866 (Feb. 20, 2018).
14. A. Maimone, H. Fuchs, "Methods, Systems, and Computer Readable Media for Generating an Augmented Scene Display," US Patent No. 9,858,721 (Jan. 2, 2018).
13. G. Welch, K. Keller, A. State, H. Fuchs, R. Schubert, "Methods, Systems, and Computer Readable Media for Utilizing Synthetic Animatronics", US Patent No. 9,792,715 (Oct. 17, 2017).
12. G. Welch, H. Fuchs, P. Lincoln, A. Nashel, A. State, "Methods, Systems, and Computer Readable Media for Shader-Lamps Based Physical Avatars of Real and Virtual People", US Patent No. 9,538,167 (Jan. 3, 2017).
11. H. Fuchs, L. McMillan, A. Nashel, "Methods, systems, and computer readable media for generating autostereo three-dimensional views of a scene for a plurality of viewpoints using a pseudo-random hole barrier," US Patent No. 9,361,727 B2 (June 7, 2016).
10. H. Fuchs, H. Yang, T. Peck, A. Bulysheva, A. State, "Methods, systems, and computer readable media for image guided ablation," US Patent No. 9,265,572 B2 (Feb. 23, 2016).
9. J. M. Frahm, H. Fuchs, M. Marathe, B. Mauchly, "System and Method for providing depth adaptive video conferencing," U.S. Patent No. 8,896,655 (Nov. 25, 2014).
8. K. Keller, H. Fuchs, L. McMillan, L. Vicci, "Methods, systems, and computer program products for full spectrum projection," U.S. Patent No. 8,152,305 (April 10, 2012).
7. H. Fuchs, D. Cotting, M. Naef and M. Gross, "Methods, systems and computer program products for imperceptibly embedding structured light patterns in projected color images for display on planar and nonplanar surfaces," U.S. Patent No. 7,182,465 (Feb. 27, 2007).
6. K. Keller, J. Ackerman, M. Rosenthal, H. Fuchs and A. State, "Methods and systems for real-time structured light depth extraction, and endoscope using real-time structured light depth extraction," U.S. Patent No. 6,503,195 (Jan. 7, 2003).
5. H. Fuchs, M. Livingston, T. Bishop, and G. Welch, "Dynamic generation of imperceptible structured light for tracking and acquisition of three dimensional scene geometry and surface characteristics in interactive three dimensional computer graphics applications," U.S. Patent No. 5,870,136 (Feb. 9, 1999).
4. H. Fuchs, "Image buffer having logic-enhanced pixel memory cells and method for setting values therein." U.S. Patent No. 4,827,445 (May 2, 1989).
3. H. Fuchs and J. Poulton, "VLSI Graphic Display Image Buffer Using Logic Enhanced Pixel Memory Cells," U.S. Patent No. 4,783,649 (Nov. 8, 1988).

2. H. Fuchs and S. Pizer, "A 3-D Display Based on Conventional 2-D Graphics Equipment," U.S. Patent No. 4,607,255 (Aug. 19, 1986).

1. H. Fuchs, "Graphics Display System Using Logic-Enhanced Pixel Memory Cells," U.S. Patent No. 4,590,465 (May 20, 1986).

Patent Applications

6. H. Fuchs, "Three Dimensional Gaze and Focus from Deep Learning for Improving Near Eye Displays for Mixed Reality," Appl. No. 62/569,157 (Oct. 6, 2017).

5. H. Fuchs, A. Lastra, A. State, J. T. Whitted, F. Zheng, "Minimal-Latency Tracking and Display for Matching Real And Virtual Worlds in Head-Worn Displays," Appl. No. 15/522,765 (April 27, 2017).

4. H. Fuchs, G. Welch, "Methods, Systems, and Computer Readable Media for Improved Illumination of Spatial Augmented Reality Objects," Appl. No. 15/036,005 (May 11, 2016).

3. H. Fuchs, M. Dou, J. Frahm, G. Welch, "Methods, Systems, and Computer Readable Media for Unified Scene Acquisition and Pose Tracking in a Wearable Display," Appl. No. 14/401,833 (Nov. 17, 2014).

2. H. Fuchs, J. Frahm, M. Marathe, B. Mauchly, "System and Method for Providing Depth Adaptive Video Conferencing," Appl. No. 12/873,100 (Aug. 31, 2010).

1. H. Fuchs, P. Lincoln, M. Marathe, B. Mauchly, A. Nashel, H. Towles, G. Welch, "System and Method for Depth Perspective Image Rendering," Appl. No. 12/366,593 (Feb. 5, 2009).

Recent Grants & Contracts (Selected)

1. National Science Foundation: "FW-HTF: Collaborative Research: Enhancing Human Capabilities through Virtual Personal Embodied Assistants in Self-Contained Eyeglasses-Based Augmented Reality (AR) Systems," CMMI-1840131, Sept. 2018 - Sept. 2021 (Fuchs and J-M Frahm, PIs)
2. National Science Foundation: "CHS: Small: Collaborative Research: 3D Audio Augmentation for Limited Field of View Augmented Reality Systems for Medical Training," IIS-1718313, Sept. 2017 - Aug. 2020 (Fuchs, UNC PI; collaboration with University of Florida).
3. National Science Foundation: "SCH: INT: Collaborative Research: Computer Guided Laparoscopy Training" IIS-1622515, 2017-2021 (Fuchs, UNC PI; collaboration with University of Arizona)
4. National Science Foundation: "EAGER: Wide Field of View Augmented Reality Display with Dynamic Focus" IIS-1645463 (Fuchs, PI)
5. National Science Foundation: "CHS: CGV: Small: Minimal-latency Tracking and Display for Matching Real and Virtual Worlds in Head-worn Displays" IIS-1423059, Sept. 2014 – Aug. 2017 (Fuchs, PI)
6. National Science Foundation: "II-New: Seeing the Future: Ubiquitous Computing in EyeGlasses" CRI-1405847, Sept. 2014 – Aug. 2017 (Fuchs, Co-PI)
7. National Science Foundation: "HCC: CGV: Small: Eyeglass-Style Multi-Layer Optical See-Through Displays for Augmented Reality" CHS-1319567, Sept. 2013-Aug. 2016 (Fuchs, PI).
8. NVIDIA Research: Cooperative Agreement & Support (Fuchs, PI) ca. 2013 - current
9. Cisco Systems: "Telepresence Systems," 2006 – 2015; 2017 (Fuchs, PI).

10. National Science Foundation: "II-NEW: A Robot Testbed for Real-time Motion Strategies and Autonomous Personal Assistants" CRI-1305286, Sept. 2013-Aug. 2015 (Fuchs, co-PI)
11. National Science Foundation: "CRI:IAD Integrated Projector-Camera Modules for the Capture and Creation of Wide-Area Immersive Experiences" CRI- 0751187, April 2008-March 2011 (Fuchs, PI)
12. Naval Air Systems Command-NAVAIR: SBIR Phase 2: "Deployable Intelligent Projections Systems for Training" Renaissance Science Corporation, Prime; (Fuchs, PI of UNC subcontract)
13. Office of Naval Research: "3D Display and Capture of Humans for Live-Virtual Training" (Fuchs joint PI)
14. Office of Naval Research: "Behavioral Analysis and Synthesis for Intelligent Training" (Fuchs joint UNC PI; Project lead by Naval Postgraduate School, A. Sadagic, PI)

OTHER FORMER GRANTS AND CONTRACTS (selected): DARPA (Defense Advanced Research Projects Agency); NIH (National Institutes of Health), NCI (National Cancer Institute); NSF (National Science Foundation); U.S. Air Force; DOE (U.S. Dept. of Energy).

Professional Activities (Selected)

- Member, Editorial Advisory Board, Computers & Graphics, 2013-
- Member, Steering Committee, ISMAR, International Symposium on Mixed and Augmented Realities, 2008 - present.
- Member, External Advisory Board, Harvard's Neuroimage Analysis Center, 2004-2012.
- Member, External Advisory Board, Mersive Technologies. ~2008 - ~2010.
- Member, Dept. of Energy Blue Ribbon Panel for Evaluation of ASCI Program, 1998-1999.
- UNC Delegate, New Vistas in Transatlantic Science and Tech Cooperation, Washington D.C., 1998.
- Member, DARPA's Information Science and Technology Study Group, (Defense Advanced Research Projects Agency), 1994.
- Member, Computer Science and Telecommunications Board, National Research Council of the National Academies, 1993-1997.
- Co-Director (with Gary Bishop), NSF Invitational Workshop on Research Directions in Virtual Environments, Chapel Hill, NC, March 1992.
- Co-Director (with K.H. Höhne and Steve Pizer), NATO Advanced Research Workshop in 3D Imaging in Medicine, Travemünde, Germany, June 1990.
- Chairman, 1986 Workshop on Interactive 3D Graphics, UNC Chapel Hill, Oct. 1986 (the initial meeting of what has become the annual ACM Symposium on Interactive 3D Graphics and Games).
- Distinguished Visitor, IEEE Computer Society, 1985-1986.
- Chairman, 1985 Chapel Hill Conference on VLSI, May 1985. (7th Annual. All previous conferences held at Caltech and MIT). Conference now called S.I.S.
- Chairman, Tutorial on VLSI and Computer Graphics, SIGGRAPH'83, SIGGRAPH'84, SIGGRAPH'85.

- Associate Editor, ACM Transactions on Graphics, 1983-1988.
- Guest Editor, ACM Transactions on Graphics, Vol.1, No. 1, January 1982.
- Technical Program Chairman, SIGGRAPH'81.
- Member, Advisory Committee, National Science Foundation, Division of Microelectronic Information Processing Systems.
- Member, Special Study Sections, National Institutes of Health; Review Panels and Site Visit Committees, National Science Foundation: 1978-Present.

Program Committee Memberships (Selected)

- ACM SIGGRAPH Asia (2013)
- ACM SIGGRAPH (1979, 1980, 1981, 1985-1992, 1998-2001, 2005) Annual Conferences on Computer Graphics and Interactive Techniques
- Symposium on Interactive 3D Graphics, 2001 in Chapel Hill, N.C.
- Symposium on Interactive 3D Graphics, 1990 at Snowbird, Utah
- Workshop on Volume Visualization, 1989 at UNC-Chapel Hill
- Conference on Advanced Research in VLSI (1986 at MIT, 1987 at Stanford, 1988 at MIT, 1989 at Caltech)
- Eurographics, 1997
- International Electronic Image Week (CESTA, SIGGRAPH) FRANCE (1986 and 1987)
- Computer Graphics International (1987 in Japan; 1988 in Switzerland)

Publications

240. A. State, H. Towles, T. Johnson, R. Schubert, B. Walters, G. Welch, H. Fuchs. "The A-Desk: A Unified Workspace of the Future," IEEE Computer Graphics and Applications, vol. 40, issue 1, pp. 56-71, January 2020.

239. P. Chakravarthula, Y. Peng, J. Kollin, H. Fuchs, F. Heide. "Wirtinger Holography for Near-Eye Displays," ACM Trans. Graph., Vol. 38, No. 6, Art. 13, Nov. 2019.

238. K. Rathinavel, G. Wetzstein, and H. Fuchs. "Varifocal Occlusion-Capable Optical See-through Augmented Reality Display based on Focus-tunable Optics," IEEE Transactions on Visualization and Computer Graphics, Nov. 2019, vol. 25, issue 11, pp. 3125-3134, doi: [10.1109/TVCG.2019.2933120](https://doi.org/10.1109/TVCG.2019.2933120).

237. R. Chabra, J. Straub, C. Sweeney, R. Newcombe, H. Fuchs. "StereoDRNet: Dilated Residual Stereo Net", in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 11786-11795) 2019.

236. X. Xia, Y. Guan, A. State, P. Chakravarthula, K. Rathinavel, T.J. Cham, H. Fuchs. "Towards a Switchable AR/VR Near-eye Display with Accommodation-Vergence and Eyeglass Prescription Support,"

in IEEE Transactions on Visualizations and Computer Graphics, Nov. 2019, vol. 25, issue 11, pp 3114-3124, doi: 10.1109/TVCG.2019.2932238.

235. A.S. Rose, H. Kim, H. Fuchs, J.M. Frahm. "Development of Augmented Reality Applications in Otolaryngology-Head and Neck Surgery," The Laryngoscope, Jul. 2019.

234. K. Aksit, P. Chakravartula, K. Rathinavel, Y. Jeong, R. Albert, H. Fuchs, D. Luebke. "Manufacturing Application-Driven Foveated Near-Eye Displays," in IEEE Transactions on Visualization and Computer Graphics, vol. 25, no. 5, pp. 1928-1939, May 2019. doi: 10.1109/TVCG.2019.2898781

233. H. Jiang, S. Xu, A. State, F. Feng, H. Fuchs, M. Hong, and J. Rozenblit. "Enhancing A Laparoscopy Training System with Augmented Reality Visualization," 2019 Spring Simulation Conference (SpringSim), 29 April - 2 May, 2019, Tucson, Arizona. doi: 10.23919/SpringSim.2019.8732876

232. A. Blate, M. Whitton, M. Singh, G. Welch, A. State, T. Whitted, and H. Fuchs. "Implementation and Evaluation of a 50 kHz, 28 μ s Motion-to-Pose Latency Head Tracking Instrument," in IEEE Transactions on Visualization and Computer Graphics, vol. 25, 5 May 2019, pp. 1970-1980. doi: 10.1109/TVCG.2019.2899233

231. G. Song, J. Cai, T.J. Cham, J. Zheng, J. Zhang, H. Fuchs. "Real-time 3D Face-Eye Performance Capture of a Person Wearing a VR Headset," Proceedings of the 26th ACM International Conference on Multimedia, Oct. 28, 2018. pp. 923-391. doi: 10.1145/3240508.3240570

230. P. Chakravarthula, D. Dunn, K. Aksit, H. Fuchs. "FocusAR: Auto-focus Augmented Reality Eyeglasses for both Real and Virtual," Proceedings of ISMAR 2018 and IEEE Transactions on Visualization and Computer Graphics. **Best Paper Award.**

229. K. Rathinavel, H. Wang, A. Blate, H. Fuchs. "An Extended Depth-of-Field Volumetric Near-Eye Augmented Reality Display," Proceedings of ISMAR 2018 and IEEE Transactions on Visualization and Computer Graphics.

228. Y-W. Cha, T. Price, Z. Wei, X. Lu, N. Rewkowski, R. Chabra, Z. Qin, H. Kim, Z. Su, Y. Liu, A. Ilie, A. State, Z. Xu, J. Frahm, H. Fuchs. "Towards Fully Mobile 3D Face, Body, and Environment Capture Using Only Head-worn Cameras," Proceedings of ISMAR 2018 and IEEE Transactions on Visualization and Computer Graphics.

227. K. Rathinavel, P. Chakravarthula, K. Aksit, J. Spjut, B. Boudaoud, T. Whitted, D. Luebke, H. Fuchs. "Steerable Application-Adaptive Near Eye Displays," SIGGRAPH '18: ACM SIGGRAPH 2018 Emerging Technologies, August 2018, pp. 1-2. doi: 10.1145/3214907.3214911

226. X. Xia, Y. Guan, A. State, T-J. Cham, H. Fuchs. "Towards Efficient 3D Calibration for Different Types of Multi-view Autostereoscopic 3D Displays," Proceedings of Computer Graphics International, CGI 2018, June 11-14, 2018, Bintan Island, Indonesia, pp. 169-174.

225. K. Kroesl, D. Bauer, M. Schwarzler, H. Fuchs, G. Suter, M. Wimmer. "A VR-based User Study on the Effects of Vision Impairments on Recognition Distances of Escape-Route Signs in Buildings," The Visual Computer, June 2018. Vo. 34, Issue 6-8, (Proceedings of Computer Graphics International, CGI 2018, June 11-14, 2018, Bintan Island, Indonesia), pp. 911-923

224. H. Chen and H. Fuchs. "Supporting Free Walking in a Large Virtual Environment: Imperceptible Redirected Walking with an Immersive Distractor," Proceedings of Computer Graphics International (CGI '17),

223. H. Chen and H. Fuchs. "Towards Imperceptible Redirected Walking: integrating a distractor into the immersive experience," Proceedings of the 21st ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games (I3D 2017).
222. G. Aweduto, F. Tecchia, H. Fuchs. "Real-world Occlusion in Optical See-through AR Displays," ACM Symposium on Virtual Reality Software and Technology 2017 (Gothenburg, Sweden, Nov. 8-10, 2017).
221. T. Arce, H. Fuchs, K. McMullen. "The Effects of 3D Audio on Hologram Localization in Augmented Reality Environments," Proceedings of the Human Factors and Ergonomics Society 2017 Annual Meeting (Austin, TX, October 9–13, 2017) pp. 2115-2119.
220. R. Chabra, A. Illie, N. Rewkowski, Y. Cha, H. Fuchs. "Optimizing Placement of Commodity Depth Cameras for Known 3D Dynamic Scene Capture," IEEE Virtual Reality 2017 (Los Angeles, CA, March 18-22, 2017).
219. D. Dunn, C. Tippetts, K. Torell, P. Kelnhofer, K. Aksit, P. Didyk, K. Myszkowski, D. Luebke, H. Fuchs. "Wide Field of View Varifocal Near-Eye Display using See-Through Deformable Membrane Mirrors," IEEE Virtual Reality 2017 (Los Angeles, CA, March 18-22, 2017). **Best Paper Award.**
218. P. Lincoln, A. Blate, M. Singh, A. State, M. Whitted, T. Whitted, H. Fuchs. "Scene-Adaptive High Dynamic Range Display for Low Latency Augmented Reality," ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games 2017 (San Francisco, CA, Feb. 25-27, 2017). **2nd-Best Paper Award.**
217. Y-W. Cha, M. Dou, R. Chabra, F. Menozzi, A. State, E. Wallen, MD, H. Fuchs. "Immersive Learning Experiences for Surgical Procedures," Medicine Meets Virtual Reality / NextMed 2016 (Los Angeles, April 7-9, 2016).
216. Y. Ren and H. Fuchs. "Faster Feedback for Remote Scene Viewing with Pan-Tilt Stereo Camera," IEEE Virtual Reality 2016 Conference (Greenville, SC, March 19-23, 2016).
215. P. Lincoln, A. Blate, M. Singh, T. Whitted, A. State, A. Lastra, H. Fuchs. "From Motion to Photons in 80 Microseconds: Towards Minimal Latency for Virtual and Augmented Reality," IEEE Virtual Reality 2016 Conference (Greenville, SC, March 19-23). **Best Paper Award.**
214. M. Dou, J. Taylor, H. Fuchs, A. Fitzgibbon, S. Izadi. "3D Scanning Deformable Objects with a Single RGBD Sensor," CVPR 2015-Computer Vision and Pattern Recognition Conference (Boston, MA, June 7-12, 2015).
213. A. Ullah Naweed, L. Chen, M. Dou, H. Fuchs. "Enhancement of 3D Capture of Room-sized Dynamic scenes with Pan-Tilt-Zoom Cameras," International Symposium on Visual Computing (ISVC) 2014 (Las Vegas, Nevada, Dec. 8-10, 2014).
212. F. Zheng, T. Whitted, A. Lastra, P. Lincoln, A. State, A. Maimone, H. Fuchs. "Minimizing Latency for Augmented Reality Displays: Frames Considered Harmful," IEEE ISMAR, International Symposium on Mixed and Augmented Reality, September 2014.
211. H. Fuchs, A. State, J. Bazin. "Immersive 3D Telepresence," IEEE Computer. Vol.47, No. 7, pp. 46-52. July 2014.
210. D. Sonnenwald, H. Söderholm, G. Welch, B. Cairns, J. Manning, H. Fuchs. "Illuminating Collaboration in Emergency Health Care Situations: Paramedic-Physician Collaboration and 3D Telepresence Technology," Information Research, 19(2) paper 618, 2014.

209. C. Fleury, T. Popa, T. Cham, H. Fuchs. "Merging Live and pre-Captured Data to Support Full 3D Head Reconstruction for Telepresence," Eurographics 2014, (Strasbourg, France, April 7-11, 2014), pp. 9-12, 2014.
208. A. Maimone, D. Lanman, K. Rathinavel, K. Keller, D. Luebke, H. Fuchs. "Pinlight Displays: Wide Field of View Augmented Reality Eyeglasses Using Defocused Point Light Sources," SIGGRAPH 2014 (Vancouver, Canada, August 10-14, 2014)
207. M. Dou and H. Fuchs. "Temporally Enhanced 3D Capture of Room-sized Dynamic Scene with Commodity Depth Cameras," IEEE Virtual Reality 2014 Conference. **Best Short Paper Award.**
206. A. Maimone, R. Chen, H. Fuchs, R. Raskar, G. Wetzstein. "Wide Field of View Compressive Light Field Display using a Multilayer Architecture and Tracked Viewers," Society of Information Display Week 2014 (San Diego, CA, June 1-6, 2014)
205. T. Deng, H. Li, J. Cai, T. Cham, H. Fuchs. "Kinect Shadow Detection and Classification," 2013 IEEE International Conference on Computer Vision Workshops (ICCVW) 2013 (Sydney, Australia December 1-8, 2013)
204. A. Maimone and H. Fuchs. "Computational Augmented Reality Eyeglasses," International Symposium on Mixed and Augmented Reality (ISMAR) 2013 (Adelaide, Australia, October 1-4, 2013).
203. M. Dou, H. Fuchs, J.-M. Frahm. "Scanning and Tracking Dynamic Objects with Commodity Depth Cameras," International Symposium on Mixed and Augmented Reality (ISMAR) 2013 (Adelaide, Australia, October 1-4, 2013).
202. A. Sadagic, M. Kolsch, G. Welch, C. Basu, C. Darken, J. Wachs, H. Fuchs, H. Towles, N. Rowe, J.-M. Frahm, L. Guan, R. Kumar, H. Cheng. "Smart Instrumented Training Ranges: Bringing Automated System Solutions to Support Critical Domain Needs," The Journal for Defense Modeling and Simulation (JDMS), Vol. 10 No. 3, July 2013.
201. A. Maimone, G. Wetzstein, M. Hirsch, D. Lanman, R. Raskar, H. Fuchs. "Focus 3D: Compressive Accommodation Display," ACM Transactions on Graphics. 32, 5. Article 153 (September 2013).
200. A. Maimone, X. Yang, N. Dierk, A. State, M. Dou, H. Fuchs. "General-Purpose Telepresence with Head-Worn Optical See-Through Displays and Projector-Based Lighting," IEEE Virtual Reality 2013 (Orlando, FL, USA, March 16-23, 2013) **Best Short Paper Award.**
199. D. Rivera-Gutierrez, G. Welch, P. Lincoln, M. Whitton, J. Cendan, D. Chesnutt, H. Fuchs, B. Lok. "Shader Lamps Virtual Patients: The Physical Manifestation of Virtual Patients," Medicine Meets Virtual Reality 19 – NextMed, Studies in Health Technology and Informatics, IOS Press, 2012, 173:372-378.
198. R. Schubert, G. Welch, P. Lincoln, A. Nagendran, R. Pillat, and H. Fuchs. "Advances in Shader Lamps Avatars for Telepresence," Proceedings of 3DTV-Conference 2012: The True Vision: Capture, Transmission and Display of 3D Video, (ETH Zurich, Zurich, Switzerland), October 15-17 2012.
197. A. Maimone and H. Fuchs. "Real-Time Volumetric 3D Capture of Room-Sized Scenes for Telepresence," 3DTV Conference: The True Vision - Capture, Transmission and Display of 3D Video (3DTV-CON) 2012 (Zurich, Switzerland, October 15-17, 2012). doi: 10.1109/3DTV.2012.6365430
196. A. Maimone, J. Bidwell, K. Peng, H. Fuchs. "Enhanced Personal Autostereoscopic Telepresence System using Commodity Depth Cameras," Computers & Graphics, Volume 36, Issue 7, November 2012, pp. 791-807.

195. T. Peck, H. Fuchs, and M. Whitton. "The Design and Evaluation of a Large-Scale Real-Walking Locomotion Interface," IEEE Transactions on Visualization and Computer Graphics 18(7), July 2012, 1053-1067.
194. A. Maimone and H. Fuchs. "Reducing Interference Between Multiple Structured Light Depth Sensors Using Motion," IEEE Virtual Reality 2012 (Orange County, CA, USA, March 4-8, 2012) **Best Short Paper Award.**
193. M. Dou, L. Guan, J.-M. Frahm, H. Fuchs. "Exploring High-Level Plane Primitives for Indoor 3D Reconstruction with a Hand-held RGB-D Camera," ACCV (Asian Conference on Computer Vision) Workshops (2) 2012.
192. M. Dou, Y. Shi, J.-M. Frahm, H. Fuchs, B. Mauchly, M. Marathe. "Room-sized informal telepresence system," IEEE Virtual Reality 2012 Conference (Orange County, CA, March 4-8, 2012), pp. 15-18.
191. A. Maimone and H. Fuchs. "A First Look at a Telepresence System with Room-Sized Real-Time 3D Capture and Life-Sized Tracked Display Wall," 21st International Conference on Artificial Reality and Telexistence (ICAT) (Osaka, Japan, November 28-30, 2011).
190. P. Lincoln, G. Welch, A. Nashel, A. State, A. Ilie, H. Fuchs. "Animatronic shader lamps avatars," Virtual Reality 15(2-3): 225-238 (2011).
189. C. Burke, J. Cullen, A. State, S. Gadi, K. Wilber, R. Michael, A. Bulysheva, A. Pease, M. Mauro, H. Fuchs. "Development of an Animal Model for Radiofrequency Ablation of Primary, Virally Induced Hepatocellular Carcinoma in the Woodchuck," Journal of Vascular and Interventional Radiology, 22(11), p. 1613-1618, November 2011.
188. A. Maimone and H. Fuchs. "Encumbrance-free Telepresence System with Real-time 3D Capture and Display using Commodity Depth Cameras," International Symposium on Mixed and Augmented Reality (ISMAR) 2011 (Basel, Switzerland, October 26-29, 2011).
- 187 P. Lincoln, G. Welch, H. Fuchs. "Continual Surface-Based Multi-Projector Blending for Moving Objects," IEEE Virtual Reality 2011 (Singapore, March 19-23, 2011).
186. T. Peck, H. Fuchs, M. Whitton. "An Evaluation of Navigational Ability Comparing Redirected Free Exploration with Distractors to Walking-in-Place and Joystick Locomotion Interfaces," IEEE Virtual Reality 2011 (Singapore, March 19-23, 2011).
185. G. Ye, A. State, H. Fuchs. "A Practical Multi-viewer Tabletop Autostereoscopic Display," Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR) 2010 (Seoul, South Korea, October 13 -16, 2010).
184. T. Peck, H. Fuchs, M. Whitton. "Improved Redirection with Distractors: A Large-Scale-Real-Walking Locomotion Interface and its Effect on Navigation in Virtual Environments," IEEE Virtual Reality 2010.
183. P. Lincoln, G. Welch, A. Nashel, A. State, A. Ilie, H. Fuchs. "Animatronic Shader Lamps Avatars," Virtual Reality (2010), Springer, London, pp. 10-14.
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41. J. Goldfeather and H. Fuchs. "Quadratic Surface Rendering on a Logic-Enhanced Frame Buffer Memory System," IEEE Computer Graphics and Applications, vol. 6, pp. 48-59, 1986.
40. J. Goldfeather, J. Hultquist, H. Fuchs. "Fast Constructive-Solid Geometry Display in the Pixel-Powers Graphics System," Computer Graphics, vol. 20, (Proceedings, SIGGRAPH 1986), pp. 107-116, 1986.
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36. H. Fuchs, editor. "Proceedings of the 1985 Chapel Hill Conference on Very Large Scale Integration." Rockville, MD: Computer Science Press, 1985, pp. 476.
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29. G. Abram and H. Fuchs. "VLSI Architectures for Computer Graphics," NATO Advanced Study Institute on Microarchitecture of VLSI Computers, Sogesta-Urbino, Italy, 1984.
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27. H. Fuchs and S. Pizer. "Systems for Three-Dimensional Display of Medical Images," 1984 International Joint Alpine Symposium on Medical Computer Graphics and Image Communications and Clinical Advances in Neuro CT/NMR, 1984.
26. E. Heinz, D. Osborne, B. Drayer, A. Yeates, H. Fuchs, S. Pizer. "Examination of the Extracranial Carotid Bifurcation by Thin-Section Dynamic CT: Direct Visualization of Intimal Atheroma in Man (Part 2)," American Journal of Neuroradiology, American Roentgen Ray Society, vol. 0195-6108/84/0504-0361, pp. 361-366, 1984.
25. E. Heinz, S. Pizer, H. Fuchs, E. Fram, P. Burger, B. Drayer, D. Osborne. "Examination of the Extracranial Carotid Bifurcation by Thin-Section Dynamic CT: Direct Visualization of Intimal Atheroma in Man (Part 1)," American Journal of Neuroradiology, American Roentgen Ray Society, vol. 0195-6108/84/0504-0355, pp. 355-359, 1984.
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20. H. Fuchs, Guest Editor. ACM Transactions on Graphics, Vol. 1, No. 1 (premier issue), 1982.
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18. H. Fuchs, S. Pizer, E. Heinz, L. Tsai, S. Bloomberg. "Adding a True 3-D Display to a Raster Graphic System," IEEE Computer Graphics and Applications, vol. 2, pp. 73-78, 1982.

17. H. Fuchs, J. Poulton, A. Paeth, A. Bell. "Developing Pixel-Planes, a Smart Memory-Based Raster Graphics System," MIT Conference on Advanced Research in VLSI, Artech House, Dedham, MA, 1982.
16. S. Pizer, H. Fuchs, E. Heinz, S. Bloomberg, L. Tsai. "Varifocal Mirror Display of Organ Surfaces from CT Scans," World Congress of Nuclear Medicine and Biology, Paris, France, 1982.
15. H. Fuchs and J. Poulton. "Pixel-Planes: A VLSI-Oriented Design for a Raster Graphics Engine," VLSI Design (formerly called Lambda), vol. 2, pp. 20-28, 1981.
14. J. Rosenberg and H. Fuchs. "Survey and Evaluation of Color-Display Terminals for VLSI," VLSI Design (formerly called Lambda), vol. 2, pp. 58-60, 1981.
13. H. Fuchs and J. Poulton. "Pixel-Planes: A VLSI-Oriented Design for 3-D Raster Graphics," Proceedings of the Canadian Man-Computer Communications Society 7th Conference (Waterloo, Ontario, 10-12 June 1981), pp. 343-347.
12. H. Fuchs, Z. Kedem, B. Naylor. "On Visible Surface Generation by a Priori Tree Structures," Proceedings of ACM SIGGRAPH '80, Seattle, Washington, 1980.
11. Z. Kedem and H. Fuchs. "On Finding Several Shortest Paths in Certain Graphs," Eighteenth Annual Allerton Conference on Communication, Control, and Computing, Champaign-Urbana, IL, 1980.
10. J. Barros and H. Fuchs. "Generating Smooth 2-D Monocolor Line Drawings on Video Displays," Proceedings of ACM SIGGRAPH '79, Chicago, IL, 1979.
9. H. Fuchs and B. Johnson. "An Expandable Multiprocessor Architecture for Video Graphics (Preliminary Report)," 6th Annual ACM-IEEE Symposium on Computer Architecture, 1979.
8. H. Fuchs, Z. Kedem, B. Naylor. "Predetermining Visibility Priority in 3-D Scenes (Preliminary Report)," Proceedings of ACM SIGGRAPH '79, Chicago, IL, 1979.
7. H. Fuchs, S. Pizer, J. Cohen, J. Brooks. "A Three-Dimensional Display of Medical Images from Slices," Vth International Conference on Information Processing in Medical Imaging (Traitement Des Informations en Imagerie Medicale), Paris, France, 1979.
6. H. Fuchs, J. Duran, B. Johnson, Z. Kedem. "Acquisition and Modeling of Human Body Form Data," 1978 NATO Symposium on Applications of Human Biostereometrics, Paris, France, 1978.
5. H. Fuchs and Z. Kedem. "The 'Highly Intelligent' Tablet as an Efficient Pointing Device for Interactive Graphics (Preliminary Report)," 1978 Annual ACM Conference, 1978.
4. H. Fuchs. "Distributing a Visible Surface Algorithm over Multiple Processors," Proc. 1977 ACM Annual Conference.
3. H. Fuchs, J. Duran, B. Johnson. "A System for Automatic Acquisition of Three-Dimensional Data," 1977 National Computer Conference, 1977.
2. H. Fuchs, Z. Kedem, S. Uelson. "Optimal Surface Reconstruction from Planar Contours," Communications of the ACM, vol. 20, pp. 693-702, 1977. (One of only two papers from SIGGRAPH'77 Conference selected to be published in Communications of the ACM.)
1. H. Fuchs, "The Automatic Sensing and Analysis of Three-Dimensional Surface Points from Visual Scenes," Ph.D. Dissertation, Department of Computer Science, University of Utah, Salt Lake City, 1975.

Technical Reports (Selected)

D. Cotting, I. Nebel, M. Gross, H. Fuchs, "Towards a Continuous, Unified Calibration of Projectors and Cameras," Computer Graphics Laboratory, ETH Zurich, Switzerland, and University of North Carolina at Chapel Hill, Department of Computer Science, Chapel Hill, NC, 2011.

T. Johnson, H. Towles, A. State, F. Wu, G. Welch, A. Lastra, H. Fuchs. "A Projector-based Physical Sand Table for Tactical Planning and Reviewing," UNC Department of Computer Science, Chapel Hill, NC, 2009.

D. Bandyopadhyay, R. Raskar, A. State, and H. Fuchs, "Dynamic Spatially Augmented 3D Painting," UNC Department of Computer Science, Chapel Hill, NC, 2001.

R. Raskar, H. Fuchs, G. Welch, A. Lake, and M. Cutts, "3D Talking Heads: Image Base Modeling at Interactive Rates Using Structured Light Projection," UNC Department of Computer Science, Chapel Hill, NC, 1998.

W. Dally, L. McMillan, G. Bishop, and H. Fuchs, "The Delta Tree: An Object-Centered Approach to Image-Based Rendering," MIT Artificial Intelligence Laboratory, Technical Memo 1604, Cambridge, MA, May 1996.

U. Neumann, A. State, H. Chen, H. Fuchs, T. Cullip, Q. Fang, M. Lavoie, and J. Rhoades, "Interactive Multimodal Volume Visualization for a Distributed Radiation-Treatment Planning Simulator," UNC Department of Computer Science, Chapel Hill, NC, 1994.

H. Fuchs, J. Poulton, "Supercomputing Power for Interactive Visualization," Report of Research Progress October 1990 – March 1991, UNC Department of Computer Science, Chapel Hill, NC, 1994.

H. Fuchs, F. Brooks. "Advanced Technology for Portable Personal Visualization," Report of Research Progress, April – December 1991, UNC Department of Computer Science, Chapel Hill, NC, 1991.

H. Fuchs, J. Poulton, A. State, E. Hill, and R. Brusq. "An Architecture for Advanced Avionics Displays," Wright Research and Development Center, Wright Patterson Air Force Base, OH TR90-7006, May 1990. 1990.

Invited Talks (Selected)

60. Keynote, 2019 World Conference on VR Industry, Nanchang, China, October 2019.

59. Keynote, ISMAR 2018, Munich, Germany, October 2018.

58. Google, SF, Aug. 2018.

57. Disney Research, Zurich, Switzerland, May 2018.

56. Snap Research, Venice, CA, Feb. 2018.

55. Vuforia, Vienna, Austria, Jan. 2018.

54. Keynote, ACM Multimedia Systems 2017, Taipei, Taiwan, June 2017.

53. Keynote, Eurographics 2016, Lisbon, Portugal, May 2016.

52. Technical University of Vienna, Symposium of Visual Computing Trends, January 2015

51. Samsung Developer Conference, San Francisco, November 2014
50. University of Maryland, Department of Computer Science, Distinguished Colloquia, October 2014.
49. Keynote (1 of 4), 5th International Conference on Remote Sensing in Archeology, Duke University, October 2014.
48. Keynote, IEEE VR 2014, Minneapolis, MN, March 2014.
47. Keynote, BEAMING Workshop, Barcelona, Spain, June 2011, "Toward Improved Telepresence: BeingThere International Research Center for Telepresence and Telecollaboration...and related work."
46. Keynote, Japan VR, Tokyo, Japan, December 2010.
45. Keynote, ISMAR 2010, Seoul, Korea, October 2010.
44. Keynote, IEEE International Symposium on Multimedia (ISM2010), Taichung, Taiwan, December 2010, "Physical and Digital Media of Telepresence."
43. ISMAR Symposium Workshop, Orlando, Florida, October 2009.
42. AMI-ARCS Workshop, London, England, September 2009.
41. NAIST, Japan, July 2009.
40. Keynote, NOSSDAV, Williamsburg, Virginia, June 2009, "Experiences Building Telepresence Systems."
39. University of Pennsylvania, Franklin Institute Symposium, RoboFest: A Celebration of Robotics at the GRASP Laboratory, April 2009.
38. NASA Langley Research Center, Initiated the Speaker Series on Virtual Worlds, April 2009.
37. 9th Marconi Research Conference, Office Ergonomics Research Committee (OERC), Marconi Center, Marshall, CA, January 2009.
36. Keynote, Graphics Hardware 2008, Sarajevo, Bosnia and Herzegovina June 20, 2008.
35. Keynote, PROCAMS 2008, Los Angeles, CA, August 9, 2008.
34. Keynote (1 of 2), Eurographics 2004, Grenoble, France, September 2004.
33. J. Barkley Rosser Distinguished Lecture, University of Wisconsin, Madison, WI, March 2001.
32. Distinguished Lecture, National Science Foundation (NSF), February 2001.
31. Address, Sesquicentennial Anniversary, University of Rochester, October 2000 (1 of 2 in Computer Science).
30. Distinguished Lecture, Stanford University Department of Computer Science, June 2000.
29. Keynote Address, Virtual Reality Software and Technology (VRST '99), London, England, December 1999.
28. Keynote, 1st International Symposium on Mixed Reality (ISMIR'99), Yokohama, Japan. Mar. 9, 1999.
27. University of Utah Department of Computer Science Distinguished Lecture, December 8, 1998.

26. Invited Paper, Advanced Multimedia Content Processing (AMCP'98), Osaka, Japan. Nov. 9, 1998.
25. Keynote, Advanced School for Computing and Imaging (ASCI'98), Lommel, Belgium. June 11, 1998.
24. Fraunhofer Inauguration Symposium, Virtual Environments Panel, Darmstadt, Germany, Oct. 30, 1997.
23. Keynote, Eurographics '97, Budapest, Hungary, September 6, 1997.
22. Keynote, Computer Graphics International'97, Hasselt, Belgium, June 25, 1997.
21. Keynote, 2nd Visualization Conference, Technicon, Haifa, Israel, June 30, 1996.
20. Keynote, 1995 Symposium on Interactive 3D Graphics, Monterey, CA, April 10-12, 1995.
19. University of Southern California Department of Computer Science Distinguished Lecture, Los Angeles, CA, Dec. 2, 1994.
18. Invited talk, The London VR User Show, VR in Medicine Workshop, London, England, September 1994.
17. IEEE EMBS 1994 International Summer School on Three-Dimensional Biomedical Imaging, to teach course on Virtual Reality in Medical Imaging, July 7-8, 1994.
16. Invited talk, ATR Workshop on Virtual Space Teleconferencing Systems, Kyoto, Japan, Dec. 3, 1993.
15. Invited talk, Computer Graphics International '92 (CGI '92), Tokyo, Japan, June 24, 1992.
14. NATO Advanced Research Workshop, Travemünde, Germany, June 26, 1990.
13. Keynote, First Conference on Visualization in Biomedical Computing, Atlanta, Georgia, May 23, 1990.
12. Keynote Address, Computer Graphics International, Leeds, UK, June 1989.
11. World Congress on Medical Physics and Biomedical Engineering, San Antonio, Texas, August 1988.
10. Member of panel on "Parallel Processing for Computer Vision and Display" at SIGGRAPH'88, August 1988.
9. Member of panel on "3D Imaging in Medicine: Pitfalls and Possible Remedies" at the National Computer Graphics Association annual conference, Anaheim, California, March 1988.
8. International Conference and Exhibition on Parallel Processing for Computer Vision and Display (sponsored by IBM - UK Labs, Univ. of Leeds, British Computer Society, Computer Graphics Society, Eurographics), University of Leeds, UK (January 1988).
7. NATO International Advanced Study Institute on Theoretical Foundations of Computer Graphics and CAD, Il Ciocco, Lucca, Italy (July 1987).
6. NATO International Advanced Study Institute on Mathematics and Computer Science in Medical Imaging, Il Ciocco, Lucca, Italy, (September 1986).
5. International Summer Institute (British Computer Society), State of the Art in Computer Graphics, Stirling, Scotland (June 1986).
4. NATO International Advanced Study Institute on Fundamental Algorithms for Computer Graphics, Ilkley, England (April 1985).

3. Qualitative Changes in the Future of Interactive Graphics. [COMPCON 1985](#), San Francisco, California (February 1985).
2. Eurographics'85, Nice, France (September 1985) (1 of 4 keynotes).
1. NATO International Advanced Study Institute on Microarchitecture of VLSI Computers, Urbino, Italy (July 1984).