

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
PETITIONER

V.

THL HOLDING COMPANY, LLC,
PATENT OWNER

Case No. IPR2024-00399
U.S. Patent No. 11,350,246

DECLARATION OF DR. R. MICHAEL BUEHRER

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CLAIM LISTING

Claim 1:

Claim 1[Pre]: A mobile communication device comprising:

Claim 1(a): a plurality of wireless transceivers including a Bluetooth transceiver, a long-range transceiver configured to send and receive telephone calls via a telephony network and to communicate Internet data, and one or more ultra-wideband transceivers coupled to two or more antennas;

Claim 1(b): a memory that stores operational instructions;

Claim 1(c): a touch screen; and

Claim 1(d)(i): a processor coupled to the plurality of wireless transceivers, the memory, and the touch screen,

Claim 1(d)(ii): wherein the processor is configured to execute the operational instructions, which upon execution, cause the processor to:

Claim 1(d)(iii): present a graphical user interface via the touch screen;

Claim 1(d)(iv): in response to a pair request from a user received at the graphical user interface, pair the mobile communication device with at least one remote device;

Claim 1(d)(v): in response to an audio alert request from the user received at the graphical user interface, transmit an audio alert request signal to the at least one remote device via the Bluetooth transceiver;

Claim 1(d)(vi): estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations;

Claim 1(d)(vii): determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device; and

Claim 1(d)(viii): output to the graphical user interface the estimated distance to the at least one remote device and an arrow pointing in the direction of the at least one remote device.

Claim 2:

The mobile communication device of claim 1, wherein the operational instructions, upon execution, further cause the processor to output to the touch screen an estimated position of the at least one remote device based on

information received at one of the plurality of wireless transceivers via a wireless network.

Claim 3:

The mobile communication device of claim 2, wherein, the operational instructions, upon execution, further cause the processor to output on the touch screen the estimated position of the at least one remote device based on information received from a second mobile communication device.

Claim 4:

The mobile communication device of claim 3, wherein the second mobile communication device is paired with the at least one remote device.

Claim 5:

The mobile communication device of claim 3, wherein the second mobile communication device is not paired with the at least one remote device.

Claim 6:

The mobile communication device of claim 3, wherein the operational instructions, upon execution, further cause the processor to transmit an audio alert request signal to the at least one remote device via the wireless network.

Claim 7:

Claim 7(a): The mobile communication device of claim 6, wherein the at least one remote device includes a plurality of remote devices and wherein the operational instructions further cause the processor to

Claim 7(b): (i) output to the touch screen a representation of the plurality of remote devices,

Claim 7(c): (ii) receive user input from the touch screen selecting one of the plurality of remote devices, and

Claim 7(d): (iii) output to the touch screen the estimated distance to the selected one of the plurality of remote devices and the direction to the selected one of the plurality of remote devices.

Claim 8:

The mobile communication device of claim 7, wherein the operational instructions, upon execution, further cause the processor to receive input from the touch screen defining names for one or more of the plurality of remote devices.

Claim 9:

The mobile communication device of claim 7, additionally comprising an orientation sensor coupled to the processor and wherein the operational instructions further cause the processor to determine a direction to one or more of the plurality of remote devices based on a manual rotation of the mobile communication device.

Claim 10:

The mobile communication device of claim 9, wherein the operational instructions, upon execution, further cause the processor to determine a direction to one or more of the plurality of remote devices based on a strength of a signal received from the one or more of the plurality of remote devices at one or more of the plurality of wireless transceivers.

Claim 11:

Claim 11[Pre]: A mobile communication device comprising:

Claim 11(a): a plurality of wireless transceivers including a Bluetooth transceiver, a long-range transceiver configured to send and receive telephone calls via a telephony network and to communicate Internet data, and one or more ultra-wideband transceivers coupled to two or more antennas;

Claim 11(b): a memory that stores operational instructions;

Claim 11(c): a touch screen;

Claim 11(d): an orientation sensor to detect rotation of the mobile communication device; and

Claim 11(e)(i): a processor coupled to the plurality of wireless transceivers, the memory, the touch screen and the orientation sensor,

Claim 11(e)(ii): wherein the processor is configured to execute the operational instructions, which upon execution, cause the processor to:

Claim 11(e)(iii): present a graphical user interface via the touch screen;

Claim 11(e)(iv): in response to a pair request from a user received at the graphical user interface, pair the mobile communication device with at least one remote device;

Claim 11(e)(v): in response to an audio alert request from the user received at the graphical user interface, transmit an audio alert request signal to the at least one remote device via the Bluetooth transceiver;

Claim 11(e)(vi): estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations;

Claim 11(e)(vii): determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device and on rotation of the mobile communication device detected by the orientation sensor; and

Claim 11(e)(viii): output to the graphical user interface the estimated distance to the at least one remote device and an arrow pointing in the direction of the at least one remote device.

Claim 12:

Claim 12(a): The mobile communication device of claim 11, wherein the at least one remote device includes a plurality of remote devices and wherein the operational instructions further cause the processor to

Claim 12(b): (i) output to the touch screen a representation of the plurality of remote devices,

Claim 12(c): (ii) receive user input from the touch screen selecting one of the plurality of remote devices, and

Claim 12(d): (iii) output to the touch screen the estimated distance to the selected one of the plurality of remote devices and the direction to the selected one of the plurality of remote devices.

Claim 13:

The mobile communication device of claim 12, wherein the operational instructions, upon execution, further cause the processor to receive input from the touch screen defining names for one or more of the plurality of remote devices.

Claim 14:

The mobile communication device of claim 13, wherein the operational instructions, upon execution, further cause the processor to determine the direction to one or more of the plurality of remote devices based on a strength of a signal received from the one or more of the plurality of remote devices at one or more of the plurality of wireless transceivers.

Claim 15:

The mobile communication device of claim 14, wherein the operational instructions, upon execution, further cause the processor to output to the touch screen an estimated position of the one or more of the plurality of remote devices based on information received at one of the plurality of wireless transceivers from a wireless network.

Claim 16:

The mobile communication device of claim 15, wherein the operational instructions, upon execution, further cause the processor to output on the touch screen an estimated position of the one or more of the plurality of remote devices based on information received from a second mobile communication device.

Claim 17:

The mobile communication device of claim 16, wherein the second mobile communication device is paired with the at least one remote device.

Claim 18:

The mobile communication device of claim 16, wherein the second mobile communication device is not paired with the at least one remote device.

Claim 19:

The mobile communication device of claim 16, wherein the operational instructions, upon execution, further cause the processor to transmit an audio alert request signal to the at least one remote device via the wireless network.

I, Dr. R. Michael Buehrer, declare the following:

I. INTRODUCTION

1. I have been retained by counsel for Petitioner as a technical expert in the above-captioned case. Specifically, I have been asked to render certain opinions regarding the IPR petition with respect to U.S. Patent No. 11,350,246 (the “’246 Patent”). I understand that the Challenged Claims are 1-19, and my opinions are limited to those claims. A true and correct copy of my Curriculum Vitae, which provides further details about my background and experience, is appended to this Declaration.

A. Educational Background and Professional Experience

2. I am currently a Professor of Electrical Engineering and the former (2014-2022) Director of Wireless @ Virginia Tech. My curriculum vitae is provided as Appendix A.

3. My academic and professional background is in Electrical and Computer Engineering, and I have been working in those fields since the completion of my Ph.D. over 25 years ago. Below, I provide a short summary of my education and experience that I believe to be most pertinent to the opinions I have formed in this case.

4. I received a B.S. in Electrical Engineering from The University of Toledo in 1991, an M.S. in Electrical Engineering from The University of Toledo in

1993, and a Ph.D. in Electrical Engineering from Virginia Polytechnic Institute and State University in 1996. The focus of my graduate work was wireless communication systems. My Ph.D. thesis involved the application of multiuser detection (an advanced signal processing approach to interference mitigation) to CDMA-based cellular systems.

5. After completion of my Ph.D. in 1996, I joined Bell Laboratories, the research division of Lucent Technologies, where I worked for five years as a Member of Technical Staff and later as a Distinguished Member of Technical Staff. My work there focused on developing advanced technologies for cellular telecommunications, including for 3G cellular standards. For example, while at Bell Labs, I developed and implemented algorithms for intelligent antenna systems that increased the voice capacity (i.e., number of simultaneous phone calls) and data capacity of cellular systems. These algorithms were included in Lucent Technologies' 3G CDMA cellular base station. I also developed techniques known as transmit diversity techniques that increased reliability (i.e., reduced the probability of a dropped call) of cellular systems. These transmit diversity techniques were standardized in the 3GPP2 cellular standard known as cdma2000. During that time, I supported the standardization of my ideas by writing contributions to the working groups developing the standards and attending standards meetings. In particular, I participated in the 3GPP2 standardization

process. During that time, I worked with colleagues to include my ideas on the use of transmit diversity in CDMA systems in the 3GPP2 standard.

6. I am currently a Professor in the Bradley Department of Electrical and Computer Engineering at Virginia Polytechnic Institute and State University, where I have taught and conducted research in the area of wireless communications, geolocation and radar for over 20 years. Specifically, I have taught courses that cover wireless communications and signal processing (including the underlying concepts) at the undergraduate and graduate levels. For example, I teach a sophomore-level course which introduces the concepts of signals and systems, a junior-level course which introduces the basic concepts of communication systems, senior-level and graduate-level courses that cover advanced digital communication topics, and also graduate-level courses that teach the advanced technologies underlying the latest wireless systems, such as Fourth and Fifth Generation (4G/5G) cellular communication standards (e.g., LTE, LTE-Advanced, New Radio) and Wi-Fi. I also teach graduate courses on advanced topics such as Information Theory, Machine Learning Applied to Communication Systems, Spread Spectrum Communications and CDMA. Furthermore, I have taught short courses covering topics such as position location and position location using ultra-wideband signals.

7. Additionally, I have conducted research into Ultra-Wideband (UWB) signal propagation, UWB receiver design, and UWB signal processing across a

number of funded research projects. I also developed a UWB-based ranging system as part of an automated cargo container transfer system for the United States Navy. Further, I have developed geolocation systems in a number of research projects including designing a prototype system for localizing first responders, developing localization techniques for 5G and 6G cellular networks, localization sub-systems for in-home smart health systems, algorithms for enhancing cellular-based localization, algorithms for localization in the presence of interference and harsh propagation, and a second UWB-based positioning system.

8. From 2014 until 2022, I also served as the director of *Wireless @ Virginia Tech*, a comprehensive research group focusing on wireless communications, which consists of 14 faculty members and approximately 85 graduate students. My specific research focuses on advanced wireless communications and geolocation techniques. This research has examined both advanced theoretical concepts as well as the application of these concepts to the latest wireless standards. As an example of the latter, I (along with my students) have conducted research applying multiuser/multi-antenna signal processing to LTE. I have also applied advanced geolocation techniques to LTE systems.

9. My research work has been funded by national agencies including the National Science Foundation (NSF), the Defense Advanced Research Projects

Agency (DARPA), the Office of Naval Research (ONR), the Army Research Lab, the Air Force Research Lab as well as many industrial sponsors.

10. During 2009, I was a visiting researcher at the Laboratory for Telecommunication Sciences (LTS), a Federal Research Lab that focuses on telecommunication challenges for national defense. While at LTS, my research focus was in the area of cognitive radio with a particular emphasis on statistical learning techniques.

11. I have authored and co-authored over 300 publications in my area of expertise, which have been published in the leading journals in my field including *IEEE Transactions on Communications*, *IEEE Transactions on Wireless Communications*, *IEEE Transactions on Information Theory*, *Proceedings of the IEEE*, and *IEEE Transactions on Signal Processing*, and at all of the major conferences in my field. These publications include the areas of wireless position location (i.e., geolocation). This research has been cited over 12,000 times. A complete list of my publications over the last 30 years is included in my Curriculum Vitae. I am a Fellow of the IEEE (so named “for contributions to wideband signal processing in communications and geolocation”). Additionally, in 2023 I received the prestigious MILCOM Lifetime Award for Technical Achievement. This award recognizes individuals who have made important technical contributions to military communications over the course of their careers. Earlier this year I was a co-

recipient of both the Vanu Bose Award for the best paper and the Fred Ellersick Award for the best paper, both at the 2023 Military Communications Conference. I was also a co-recipient of the Vanu Bose Award for the best paper at the 2021 Military Communications Conference.

12. In 2010, I was awarded the Ellersick Best Paper Award in the Unclassified Technical Program, at the IEEE Military Communications Conference. I received the SDR Forum Best Paper Award in 2007 and the Outstanding Paper Award at the SDR Forum in 2008. I received the Dean's Award for Teaching Excellence in April 2014 and the Dean's Award for Outstanding New Assistant Professor, College of Engineering in 2003. While at Bell Laboratories, I was awarded the Bell Labs President's Silver Award for outstanding research contributions and the 1999 Best Paper Award in the Bell Labs Technical Journal.

13. I also hold 18 issued patents in the area of wireless communications, many of which relate to wirelessly locating a wireless device.

14. I formerly served as an area editor for *IEEE Transactions on Wireless Communications* supervising a team of 12 editors. I also recently served as a guest editor for a special issue of the *Proceedings of the IEEE* and as a guest lead editor for a special issue of the *IEEE Journal on Special Topics in Signal Processing* relating to non-cooperative position location networks. I was formerly an associate editor for *IEEE Wireless Communications Letters*, *IEEE Transactions on Vehicular*

Technologies, IEEE Transactions on Communications, IEEE Transactions on Signal Processing, and IEEE Transactions on Education.

15. Additionally, I formerly served as the guest editor for the *IEEE Journal on Special Topics in Signal Processing*. I served as the Technical Program Chair for the Signal Processing for Communications Symposium at the 2017 IEEE International Conference on Communications. Previously, I was the Organizer and Technical Co-Chair for both the 2015 and 2016 IEEE Global Communications Conference Workshop on Localization and Tracking: Indoors, Outdoors and Emerging Networks (LION). I have also served on the technical program committees of several other conferences and workshops in my field.

16. A complete copy of my curriculum vitae, which includes a list of my publications and contains further details on my education, experience, publications, patents, and other qualifications to render an expert opinion, is attached as Appendix A.

II. MATERIALS CONSIDERED

17. I have relied upon my education, knowledge, and experience with mobile communication devices that send and/or receive wireless signals, object-finding location systems, as well as the other materials as discussed in this declaration in forming my opinions.

18. In developing my opinions, I have considered the following materials:

Exhibit	Description
1001	U.S. Patent No. 11,350,246 (the “’246 Patent”)
1002	File History of the ’246 Patent (the “’246 File History”)
1004	U.S. Patent Publication No. 2008/0068265A1 to Kalliola et al. (“Kalliola”)
1005	U.S. Patent No. 6,487,595 to Turunen (“Turunen”)
1006	U.S. Patent Publication No. 2008/0204322 to Oswald et al. (“Oswald”)
1007	U.S. Patent Publication No. 2008/0320587A1 to Vauclair et al. (“Vauclair”)
1008	U.S. Patent Publication No. 2008/0125040A1 to Kalayjian (“Kalayjian”)
1009	U.S. Patent Publication No. 2009/0058651 to Thorn (“Thorn”)
1010	U.S. Patent Publication No. 2010/0279652 to Sharp et al. (“Sharp”)
1014	ISO/IEC 24730-2:2006(E) <i>Information technology – Real-time locating systems (RLTS) – Part 2: 2,4 GHz air interface protocol</i> . International Organization for Standardization and the International Electrotechnical Commission (2006) (“ISO/IEC 24730”)
1015	Hui Liu, Houshang Darabi, Pat Banerjee, and Jing Liu, <i>Survey of Wireless Indoor Positioning Techniques and Systems</i> , IEEE Transactions on Systems, Man, and Cybernetics-Part C: Applications and Reviews, Vol. 37, No. 6 (November 2007) (“Liu”)
1016	<i>A Comprehensive Look into the RTLS System</i> , https://www.mokosmart.com/look-into-rtls-system/ (August 2021, retrieved August 25, 2023) (“Moko Smart”)
1017	Roy Want, Andy Hopper, Veronica Falcão, and Jonathan Gibbons, <i>The Active Badge Location System</i> , ACM Transactions on Information Systems, Vol. 10, No. 1 (January 1992) (“Want”)
1018	Paramvir Bahl and Venkata N. Padmanabhan, <i>RADAR: An In-Building RF-based User Location and Tracking System</i> , Proceedings IEEE INFOCOM 2000. Conference on Computer Communications. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies pp. 775-784 vol.2, (March 2000) (“Bahl”)
1019	Bob Paddock, <i>A Guide to online information about: Radio Frequency Identification (RFID)</i> , https://web.archive.org/web/20060513161655/http://archive.chipcenter.com/circuitcellar/october00/c1000rp52.htm (August 2001, retrieved September 7, 2023) (“Paddock”)

1020	Gwen Moritz, <i>Larry W. Fullerton: World Class Innovator, Arkansas Business</i> , https://www.arkansasbusiness.com/article/58921/larry-w-fullerton-world-class-innovator (Apr. 15, 2002) (“Moritz”).
1021	IEEE Standard for Information technology– Local and metropolitan area networks– Specific requirements– Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs): Amendment 1: Add Alternate PHYs, IEEE Std 802.15.4a-2007 (Amendment to IEEE Std 802.15.4-2006) (2007) (“802.15.4a Standard”)
1022	Kaveh Pahlavan, Xinrong Li, and Juha-Pekka Mäkelä, <i>Indoor Geolocation Science and Technology</i> , IEEE Communications Magazine (March 2002) (“Pahlavan”)
1023	Jeffrey Hightower and Gaetano Borriello, <i>A Survey and Taxonomy of Location Systems for Ubiquitous Computing</i> , Technical Report UW-CSE 01-08-03 (August 2001) (“Hightower”)
1024	<i>PARC History – A Legacy of Innovation and Inventing the Future</i> , https://www.parc.com/about-parc/parc-history/ (retrieved June 26, 2023) (“PARC History”)
1025	Guifx, <i>Touchscreens That Changed the World</i> , https://www.guifx.com/touchscreens-that-changed-the-world/ (retrieved June 26, 2023) (“Guifx”)
1026	<i>iPhone User’s Guide</i> , Apple Inc. (2007) (“iPhone User’s Guide”)
1027	<i>Majority of smart phones now have touch screens</i> , https://www.canalys.com/newsroom/majority-smart-phones-now-have-touch-screens 2/7 (February 8, 2010, retrieved October 11, 2023) (“Canalys”)
1028	Steve Kolokowsky and Trevor Davis, <i>Touchscreens 101: Understanding Touchscreen Technology and Design</i> , Cypress Semiconductor Corp. (June 2009) (“Kolokowsky”)
1029	U.S. Patent Publication No. 2006/0026521A1 to Hotelling et al. (“Hotelling”)
1030	<i>The History of Bluetooth</i> , The History of Bluetooth - Auris, Inc (theauris.com) Auris, Inc. (retrieved June 26, 2023) (“Auris”)
1031	<i>Ericsson T39 User’s Guide First Edition</i> , Ericsson Mobile Communications AB (March 2001) (“Ericsson T39 User’s Guide”)
1032	<i>How does Bluetooth work?</i> , Scientific American https://www.scientificamerican.com/article/experts-how-does-bluetooth-work/#:~:text=Bluetooth%20technology%20uses%20the%20principl

	es, devices%20that%20are%20actively%20inquiring, (November 5, 2007, retrieved September 8, 2023) (“Scientific American”)
1033	IEEE Std. 802.15.1-2005, entitled “IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 15.1: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)” (“802.15.1-2005”)
1034	<i>Specification of the Bluetooth System</i> , Bluetooth Core Specification version 1.2 (05 November 2003) (“Bluetooth Specification”)
1035	Varun Almaulu and David Cheng, <i>Bluetooth Triangulator</i> , Department of Computer Science and Engineering, University of California, San Diego, (2006) (“Almaulu”)
1036	Josef Hallberg, Marcus Nilsson, Kåre Synnes, <i>Positioning with Bluetooth</i> , 10 th International Conference on Telecommunications (April 2003) (“Hallberg”)
1037	Julie A. Kientz, Shwetak N. Patel, Arwa Z. Tyebkhan, Brian Gane, Jennifer Wiley, and Gregory D. Abowd, <i>Where’s My Stuff? Design and Evaluation of a Mobile System for Locating Lost Items for the Visually Impaired</i> , Proceedings of the 8 th international ACM SIGACCESS conference on Computers and accessibility (October 2006) (“Kientz”)
1038	Harry Newton, <i>Newton’s Telecom Dictionary</i> (20th updated and expanded edition ed. 2004) (“Newton”)
1039	P. Orsatti, F. Piazza & Q. Huang, <i>A 20-mA-Receive, 55-mA-Transmit, Single-Chip GSM Transceiver in 0.25-μm CMOS</i> , 34 IEEE Journal of Solid-State Circuits 1869 (1999) (“Orsatti”)
1040	Aaron Beach, Mike Gartrell & Richard Han, <i>Solutions to Security and Privacy Issues in Mobile Social Networking</i> , 4 in 2009 International Conference on Computational Science and Engineering 1036 (2009) (“Beach”)
1041	Christian Bettstetter, Hans-Jorg Vogel & Jorg Eberspacher, <i>GSM Phase 2+ General Packet Radio Service GPRS: Architecture, Protocols, and Air Interface</i> , 2 IEEE Communications Surveys 2 (1999) (“Bettstetter”)
1042	J.C. Haartsen & S. Mattisson, <i>Bluetooth-a New Low-Power Radio Interface Providing Short-Range Connectivity</i> , 88 Proceedings of the IEEE 1651 (2000) (“Haartsen”)

1043	T.Q.S. Quek & M.Z. Win, <i>Analysis of UWB Transmitted-Reference Communication Systems in Dense Multipath Channels</i> , 23 IEEE Journal on Selected Areas in Communications 1863 (2005) (“Quek”)
1044	S. Venkatesh and R. M. Buehrer, <i>Multiple-access insights from bounds on sensor localization</i> , 2006 International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM'06), Buffalo-Niagara Falls, NY, USA, (2006) (“Venkatesh”)
1045	Christian Gehrmann, Joakim Persson & Ben Smeets, <u>Bluetooth Security</u> (2004) (“Gehrmann”)

19. I have considered these materials from the viewpoint of a POSITA as of the priority date of the '246 Patent. For the purposes of this declaration, I have been asked to assume that the priority date of the '246 Patent is February 26, 2010. I note that my opinions provided in this Declaration are made from the perspective of a POSITA as of this priority date of the '246 Patent unless expressly stated otherwise. To the extent that I use any verb tense in this Declaration that is present tense (e.g., “a POSITA would understand” instead of “a POSITA would have understood”), such verb tense should be understood to be my opinion as of the '246 Patent's priority date (again, unless expressly stated otherwise). I merely use the present verb tense for ease of reading.

III. OVERVIEW AND LEGAL STANDARDS

20. In formulating my opinions, I have been instructed to apply certain legal standards. I am not a lawyer. I do not offer any testimony regarding what the law is. Instead, the following sections summarize the law as I have been instructed

to apply it in formulating and rendering my opinions found later in this declaration.

I understand that, in an *inter partes* review (“IPR”) proceeding, patent claims may be deemed unpatentable if it is shown that they are anticipated or rendered obvious in view of the prior art. I understand that prior art in an IPR review is limited to patents or printed publications that predate the priority date of the patent at issue. I understand that questions of claim clarity (definiteness) and enablement cannot be considered as a ground for considering the patentability of a claim in these proceedings.

A. Person of Ordinary Skill in the Art

21. I understand that the '246 Patent, the record of the proceedings at the Patent Office (which I understand is called the “File History” or “Prosecution History”), and the teachings of the prior art are evaluated from the perspective of a person of ordinary skill in the art (“POSITA”). I understand that the factors considered in determining the ordinary level of skill in the art may include: (i) the levels of education of the inventor; (ii) the types of problems encountered in the art; (iii) prior art solutions to those problems; (iv) the rapidity with which innovations are made; (v) the sophistication of the technology; and (vi) the educational level of persons working in the field.

22. I understand that a person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the qualities reflected by

the factors above. The hypothetical person is presumed to have the same level of skill as the typical practitioner of the art and is presumed to have knowledge of all prior art in the relevant field. I understand that the inventor's actual knowledge or lack of knowledge of prior art reference is irrelevant to the obviousness determination.

B. Obviousness

23. I understand that a claim may be invalid under 35 U.S.C. § 103(a) if the subject matter described by the claim as a whole would have been “obvious” to a POSITA in view of a single or combination of prior art references at the time the claimed invention was made. I further understand that a POSITA is assumed to know and to have all relevant prior art in the field of endeavor covered by the patent-in-suit and all analogous prior art. I understand that obviousness in an IPR review proceeding is evaluated using a preponderance of the evidence standard, which means that the claims must be more likely obvious than nonobvious.

24. I also understand that an obviousness determination includes the consideration of various factors including: (1) the scope and content of the prior art, (2) the differences between the prior art and the claim at issue, and (3) the level of ordinary skill in the pertinent art. I understand that secondary considerations of non-obviousness such as commercial success, long-felt but unresolved needs, failure of others, and so forth may be assessed as well. I have been informed that an

obviousness analysis must consider the full scope of the claims to avoid impermissibly using hindsight to invalidate a patent.

25. In considering whether certain prior art renders a particular patent claim obvious, I have been informed that I can consider the scope and content of the prior art, including the fact that a POSITA would regularly look to the disclosures in patents, trade publications, journal articles, conference papers, industry standards, product literature and documentation, texts describing competitive technologies, requests for comment published by standard setting organizations, and materials from industry conferences, as examples.

26. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. A reference is analogous art 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). For a reference to be “reasonably pertinent” to the problem, it must logically have commended itself to an inventor’s attention in considering the problem. In determining whether a reference is reasonably pertinent, one should consider the problem faced by the inventor, as reflected either explicitly or implicitly, in the specification. I believe that the documents I considered in forming my opinions in this IPR are well within the

range of documents a POSITA would have consulted to address the type of problems described in the Challenged Claims.

27. I have been informed that to establish that a claimed invention was obvious based on a combination of prior art elements, an articulation of the reason(s) why a claimed invention would have been obvious must be provided. Specifically, I have been informed that the prior art, either as a single reference or a combination of multiple items of prior art, renders a patent claim obvious when there was an apparent reason for a POSITA, at the time of the invention, to combine or modify the prior art. Rationales for combining or modifying the prior art include, but are not limited to, any of the following: (A) combining prior art methods according to known methods to yield predictable results; (B) substituting one known element for another to obtain predictable results; (C) using a known technique to improve a similar device in the same way; (D) applying a known technique to a known device ready for improvement to yield predictable results; (E) trying a finite number of identified, predictable potential solutions, with a reasonable expectation of success; (F) identifying that known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; or (G) identifying an explicit teaching, suggestion, or motivation in the prior art that

would have led one of ordinary skill to modify the prior art reference or to combine the prior art references to arrive at the claimed invention.

28. I have also been informed that where there is a motivation to combine, claims may be rejected as obvious provided a POSITA would have had a reasonable expectation of success regarding the proposed combination. I have also been informed that common sense may be considered. Common sense teaches that familiar items may have obvious uses beyond their primary purposes. I have been informed that if the combination was obvious to try (regardless of whether it was actually tried) or leads to anticipated success, then it is likely the result of ordinary skill and common sense rather than non-obvious innovation.

29. I have been informed that the existence of an explicit teaching, suggestion, or motivation to combine known elements of the prior art is a sufficient, but not a necessary, condition to a finding of obviousness. In determining whether the subject matter of a patent claim is obvious, neither the particular motivation nor the avowed purpose described in the patent-in-suit controls. I have been further informed that the obviousness analysis may consider the effects of demands known to the technological community or present in the marketplace and the background knowledge possessed by a POSITA. These issues may be considered to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent.

30. I have been informed that it is improper to combine references where the references teach away from their combination. A reference may be said to teach away when a POSITA, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the patent applicant. I have also been informed that a reference does not teach away if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage investigation into the invention claimed.

31. I am informed that even if a case of obviousness is established, the final determination of obviousness must also consider “secondary considerations” if presented. Secondary considerations include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; and (h) teaching away from the invention in the prior art.

32. I have been further informed that secondary considerations evidence is only relevant if the offering party establishes a connection, or nexus, between the evidence and the claimed invention. The nexus cannot be based on prior art features.

The establishment of a nexus is a question of fact. While I understand that Patent Owner here has not offered any secondary considerations at this time, I will supplement my opinions should Patent Owner raise secondary considerations during the course of this proceeding.

C. Claim Construction

33. I understand that the claim terms in an IPR proceeding are construed according to their plain and ordinary meaning as understood in light of the claim language, the patent's description, and the prosecution history viewed from the perspective of a POSITA. I further understand that where a patent defines claim language, the definition of the patent controls, even if there are other definitions that might be understood by those working in the art.

34. I have been instructed to adopt the following constructions for purposes of this proceeding:

“Time of flight calculations” – “Determining the amount of time between when a signal is transmitted and when a reply signal is received”

“Signal delay” – “Difference in time between when a signal is received at two or more antennas”

IV. LEVEL OF A PERSON OF ORDINARY SKILL

35. Based on my review and analysis of the '246 Patent, the cited prior art, and the ordinary skill factors described in this section, a POSITA in the field of the '246 Patent at the time of the earliest possible priority date (February 26, 2010)

would have been knowledgeable regarding the field of mobile communication devices that send and/or receive wireless signals. In my experience working in this field, most workers of ordinary skill in the art as of the earliest possible priority date of February 26, 2010, would have had a bachelor's degree in computer science, computer engineering, electrical engineering, or a similar technical field and 2-4 years of experience with wireless ranging and positioning systems, wireless communication devices, and associated computer programming. *See, e.g., '246 Patent* at 2:61–3:25. Additional industry experience or technical training may offset less formal education, while advanced degrees or additional formal education may offset lesser levels of industry experience. When I refer to the understanding of a POSITA, I am referring to the understanding of such a person as of February 26, 2010.

36. As of February 26, 2010, I had more than ordinary skill in the art. I am, however, familiar with the skills and knowledge possessed by those I would have considered to be of ordinary skill in the art as of that date. For example, I worked with such people, and I worked in the field as a Member and then a Distinguished Member of Technical Staff at Bell Labs from 1996 to 2001. While at Bell Labs, I received the Bell Labs President's Silver award for outstanding research contributions, and the 1999 Best Paper Award for *Bell Labs Technical Journal*. Since leaving Bell Labs in 2001, I have been a professor at Virginia Polytechnic

Institute and State University, where I have taught numerous courses in the field of wireless communications, including short courses relating to position location. I also am an IEEE Fellow (so named “for contributions to wideband signal processing in communications and geolocation”). Further, as a consultant over the past 20+ years I have interacted with many professionals that would meet the definition of a POSITA.

37. My opinions provided in this declaration would not change in view of minor modifications to this level of ordinary skill.

V. OVERVIEW OF THE '246 PATENT

38. The '246 Patent generally describes a wireless device equipped with a graphical user interface (GUI) that can locate a remote device. '246 *Patent* at Abstract, 4:52-54 (“...a location system for use with a handheld wireless communication device 110”). The Challenged Claims are generally related to an embodiment where the device 110 is used to help a user locate a missing personal object coupled to another wireless device. *Id.* at 7:35-46, Claims 1, 11. Device 110 may be “a smart phone, digital book, netbook, personal computer with wireless data communication or other wireless communication device that includes a wireless transceiver for communicating over a long range wireless network ... and/or a short-range wireless network[.]” *Id.* at 4:55-64. Device 110 “includes one or more processing devices for executing other applications and a user interface that includes,

for example, buttons, a display screen such as a touch screen, a speaker, a microphone, a camera for capturing still and/or video images and/or other user interface devices.” *Id.* at 5:4-10.

39. “Adjunct device 100 includes a housing that is coupleable to the handheld wireless communication device 110 via a communication port of the handheld wireless communication device 110.” *Id.* at 5:31-34. “The adjunct device 100 includes a short-range wireless receiver” that communicates with a wireless device 120. *Id.* at 5:34-36. “The short-range wireless receiver of adjunct 100 can also be part of a transceiver that operates in conjunction with a communication standard such as 802.11, Bluetooth, ZigBee, ultra-wideband, Wimax or other standard short or medium range communication protocol[.]” *Id.* at 5:36-40.

40. To be able to communicate with each other, the devices are paired via a “pairing procedure.” *Id.* at 15:61-62. The ’246 Patent provides an example of the pairing procedure, stating: “a user interface, such as user interface 132 or 142 generates a pairing signal in response to an indication from a user to pair the devices. A short-range wireless transceiver, such as short-range wireless transceiver 130 or 140, communicates RF signals, such as pairing signals 116 to pair the devices 70 and 72.” *Id.* at 15:61-67. An exemplary wireless device 120 is depicted in Fig. 1 and the internal components used for the pairing procedure is depicted in Fig. 5.

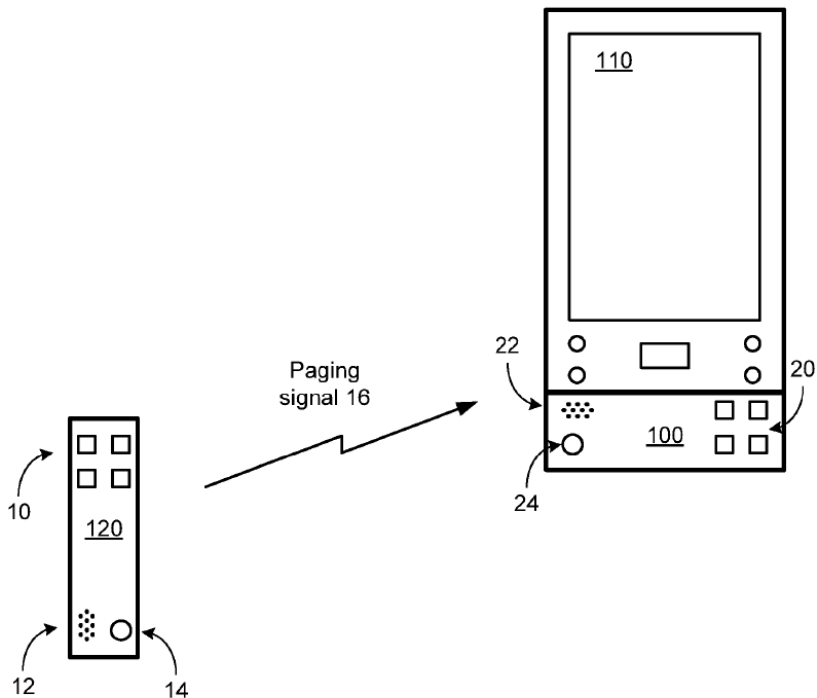


FIG. 1

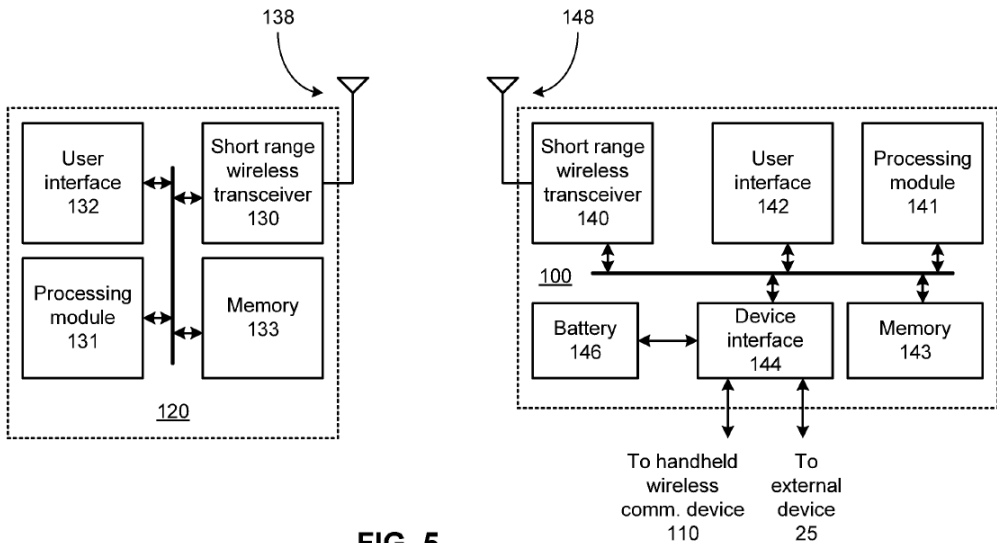


FIG. 5

Id. at Figs. 1 and 5, respectively.

41. “[A]djunct device 100 and wireless device 120 can operate in a reciprocal fashion to locate wireless device 120.” *Id.* at 7:38-40. “[W]ireless device 120 includes a housing that is attachable to or includes a ring, clip or other fastener that can be coupled to key 30 as shown or to another personal object such as a coat, a person, a pet or other thing.” *Id.* at 7:40-44. “[W]ireless device 120 includes its own short-range wireless receiver that receives a paging signal 112 transmitted by adjunct device 110” and “emits a detectable alert signal that helps the user locate the personal object.” *Id.* at 7:47-52. The detectable alert may be a light or a sound. *Id.*

42. To assist the user in choosing which paired device to page, the GUI can have a screen display where the display “includes a menu that indicates the plurality of personal objects, that each correspond to one of a plurality of remote device such as devices 70 or 72, or devices 80-85.” *Id.* at 17:64-67. The user may be prompted to name each device when pairing; the name is then associated with the particular device and stored so the devices listed are easily identifiable for the user. *Id.* at 18:1-12. The screen display can be seen in Fig. 18.

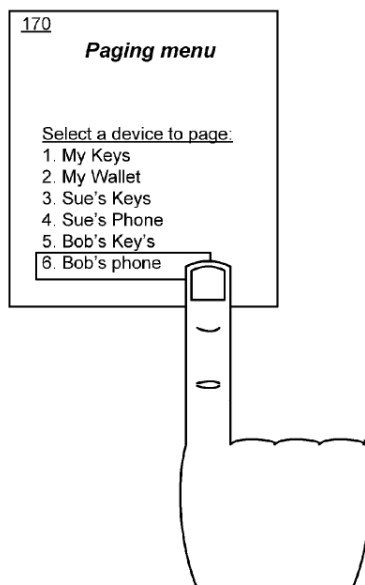
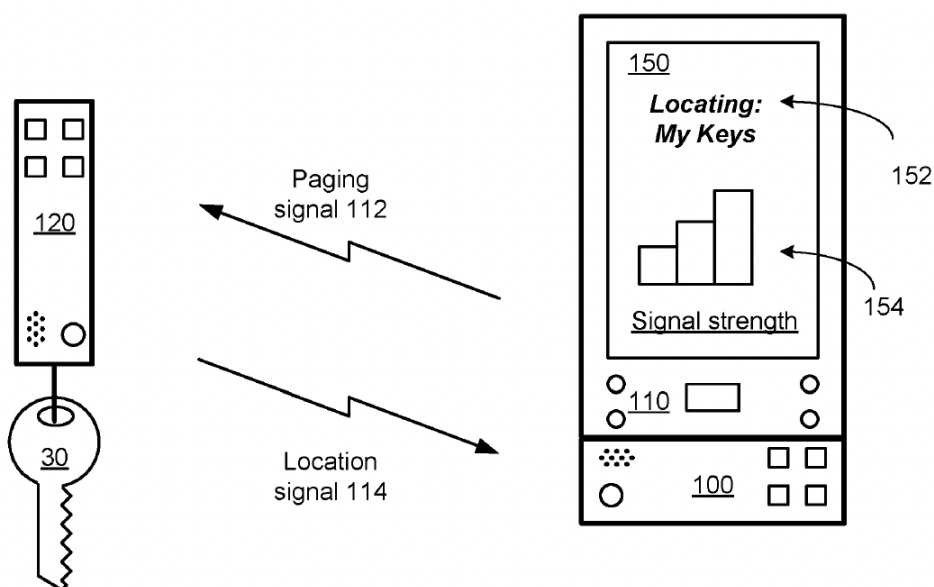


FIG. 18

Id. at Fig. 18.

43. The wireless device 120 also transmits “a location signal 114 via short-range wireless transceiver 130, such as a beacon signal or other location signal.” *Id.* at 10:42-44.



Id. at Fig. 6.

44. “The signal strength of the location signal 114 from short-range wireless transceiver 140 is converted to signal strength data by processor 141[.]” *Id.* at 10:53-56. “The signal strength is used to generate signal strength data that is communicated to the location application of handheld wireless communication device 110 via the communication port of the handheld wireless communication device.” *Id.* at 11:23-27. “While signal strength is described above as a measure of approximate distance to a remote device, the time of flight methodology ... or other distance approximations can likewise be employed.” *Id.* at 11:4-7.

45. “The use of a directional antenna in the implementation of antenna 148 can assist the location application in determining a direction to the wireless device 120.” *Id.* at 11:27-30. The signal strength 164 and an indication of direction 166 can be shown on the screen of the wireless communication device 110 as depicted in Fig. 8 or Fig. 15. In Fig. 8, the “indication of direction 166 is fixed” and when the “inverted signal strength indication 164 peaks” it is “pointing toward the wireless device 120.” *Id.* at 12:19-26. On the other hand, in Fig. 15, the “indication of direction 166’ moves based on the repeated directional sweeps by a steerable antenna such as antenna 148’.” *Id.* at 14:53-55. As such, the “indication of direction 166’ can be used ... to point the user in the direction of the wireless device 120.” *Id.* at 14:60-63.

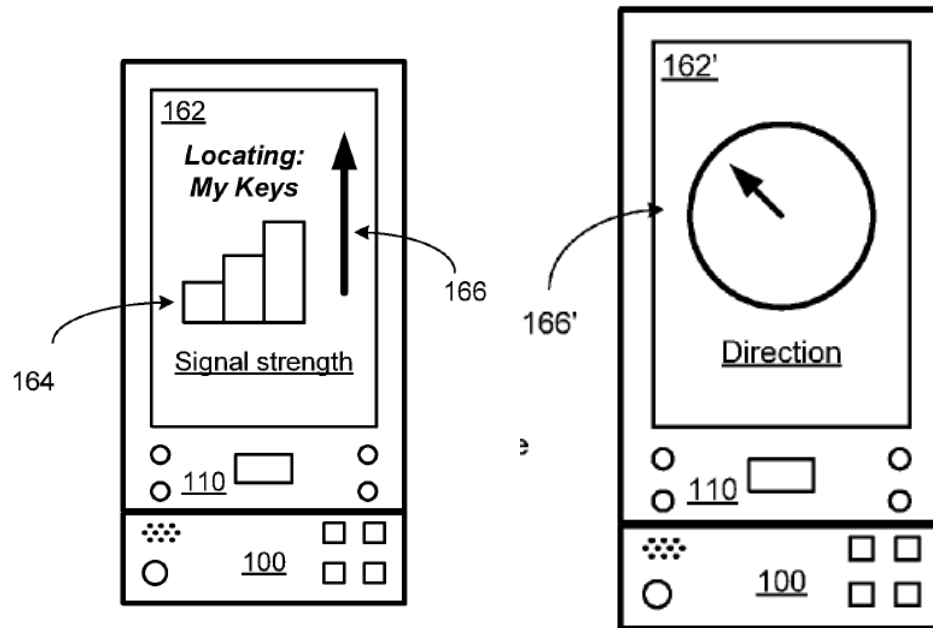


FIG. 8

FIG. 15

Id. at Figs. 8, 15.

A. Field of Endeavor

46. I have been informed that the field of endeavor of the claimed invention can be determined by reference to explanations of the invention's subject matter in the patent application, including the embodiments, function, and structure of the claimed invention.

47. The '246 Patent defines the "Technical Field of the Invention" as "wireless communication devices" and claims 1 and 11 are generally directed to "mobile communication devices." '246 Patent at 2:8-9, 37:54, 39:4. In the embodiments described in the '246 Patent's specification, the wireless/mobile

communication devices perform functions relating to transmitting signals in response to user interactions with the device and receiving signals from other wireless devices:

A wireless device includes a user interface that generates a pairing signal in response to an indication from a user to pair the wireless device to at least one remote device and generates a first location request signal in response to a second indication from a user to locate the at least one remote device. A short-range wireless transceiver communicates RF signals to pair the wireless device to the at least one remote device and that transmits a first RF paging signal to the at least one remote device in response to the location request signal.

Id. at Abstract.

In operation, a user can attach the adjunct device 100 to his or her handheld wireless communication device 110. If the handheld wireless communication device 110 is lost or mislaid, the user can locate the handheld wireless communication device by activating a paging button on the wireless device 120 that causes paging signal 16 to be broadcast.

Id. at 5:54-59.

In an embodiment of the present invention, the adjunct device 100 operates in a similar fashion to wireless device 120 to initiate the paging signal 112. In particular, the transmission of paging signal 112 can be initiated by pressing a button or otherwise interacting with the user interface of adjunct 100. In a further embodiment, handheld wireless communication device 100 includes an interactive application that generates application data that is passed to adjunct device 100 via the

communication port of the handheld wireless communication device 100. Adjunct device 100 responds to such application data by initiating the transmission of the paging signal 112. In either case, a user of handheld wireless communication device 110 that wishes to locate his or her key 30, or other object coupled to wireless device 120, initiates the paging signal 112.

Id. at 7:52-67.

FIG. 6 presents a pictorial representation of a location system for use with a handheld wireless communication device 110 in accordance with an embodiment of the present invention. In this embodiment, adjunct device 100 operates as previously described to transmit a paging signal 112. In this embodiment however, wireless device 120 transmits a location signal 114 via short-range wireless transceiver 130, such as a beacon signal or other location signal. Adjunct device 100 aids the user of handheld wireless communication device 110 in homing in on the location signal 114 based on the signal strength of the location signal 114 as received by short-range wireless transceiver 140.

In an embodiment of the present invention, the handheld wireless communication device 110 executes a location application that operates under user control to initiate the transmission of paging signal 112 to locate key or keys 30 or other object associated with wireless device 120. The signal strength of the location signal 114 from short-range wireless transceiver 140 is converted to signal strength data by processor 141 and sent to handheld wireless communication device 110 via device interface 144 and the communication port of the handheld wireless communication device 110.

Id. at 10:37-59.

FIG. 16 presents a schematic block diagram of wireless devices 70 and 72 in accordance with an embodiment of the present invention. In particular, the devices 70 and 72 can each be either a wireless device 120 or an adjunct device 100. The two devices can be sold as a set and are pre-paired to communicate with one another. In another embodiment of the present invention, the user can configure the devices 70 and 72 to be paired with one another.

In pairing, one or both devices 70 and 72 initiate the pairing procedure. For example, a user interface, such as user interface 132 or 142 generates a pairing signal in response to an indication from a user to pair the devices. A short-range wireless transceiver, such as short-range wireless transceiver 130 or 140, communicates RF signals, such as pairing signals 116 to pair the devices 70 and 72.

Id. at 15:53-67.

Further, while the present invention has been described in conjunction with a handheld wireless communication device 300 or 110, it should be noted that the functions and features of the present invention can be implemented in conjunction with an adjunct device coupled to another mobile or stationary computing device capable of executing one or more of the applications described herein in conjunction with handheld wireless communication device 110 or in an another integrated device that includes one or more functions and features of adjunct device 100, 100', 101 and 103 and handheld wireless communication device 110.

Id. at 31:18-28; *see also, id.* at Figs. 1, 4, 6, 16.

48. The wireless communication device performs these functions using wireless transceivers:

FIG. 1 presents a pictorial representation of a location system for use with a handheld wireless communication device 110 in accordance with an embodiment of the present invention. In particular, a handheld wireless communication device 110, such as a smart phone, digital book, netbook, personal computer with wireless data communication or other wireless communication device that includes a wireless transceiver for communicating over a long range wireless network such as a cellular, PCS, CDMA, GPRS, GSM, iDEN or other wireless communications network and/or a short-range wireless network such as an IEEE 802.11 compatible network, a Wimax network, another wireless local area network connection or other communications link. Handheld wireless communication device 110 is capable of engaging in wireless communications such as sending and receiving telephone calls and/or wireless data in conjunction with text messages such as emails, short message service (SMS) messages, pages and other data messages that may include multimedia attachments, such as documents, audio files, video files, images and other graphics.

Id. at 4:52-5:4; *see also, id.* at Fig. 1.

FIG. 5 presents a schematic block diagram of a wireless device 120 and adjunct device 100 in accordance with an embodiment of the present invention. In particular, wireless device 120 includes short-range wireless transceiver 130 coupled to antenna 138, processing module 131, user interface 132 and memory 133. While not expressly shown,

wireless device 120 can include a replaceable battery for powering the components of wireless device 120. In the alternative, wireless device 120 can include a battery that is rechargeable via an external charging port, for powering the components of wireless device 120. Adjunct device 100 includes short-range wireless transceiver 140 coupled to antenna 148, processing module 141, user interface 142 and memory 143, device interface 144, and battery 146. The processing modules 131 and 141 control the operation of the wireless device 120 and adjunct device 100, respectively and provide further functionality described in conjunction with, and as a supplement to, the functions provided by the other components of wireless device 120 and adjunct device 100.

As discussed in conjunction with FIGS. 1-4, the short-range wireless transceivers 130 and 140 each can be implemented via a transceiver that operates in conjunction with a communication standard such as 802.11, Bluetooth, ZigBee, ultra-wideband, Wimax or other standard short or medium range communication protocol, or other protocol

Id. at 8:2-28.

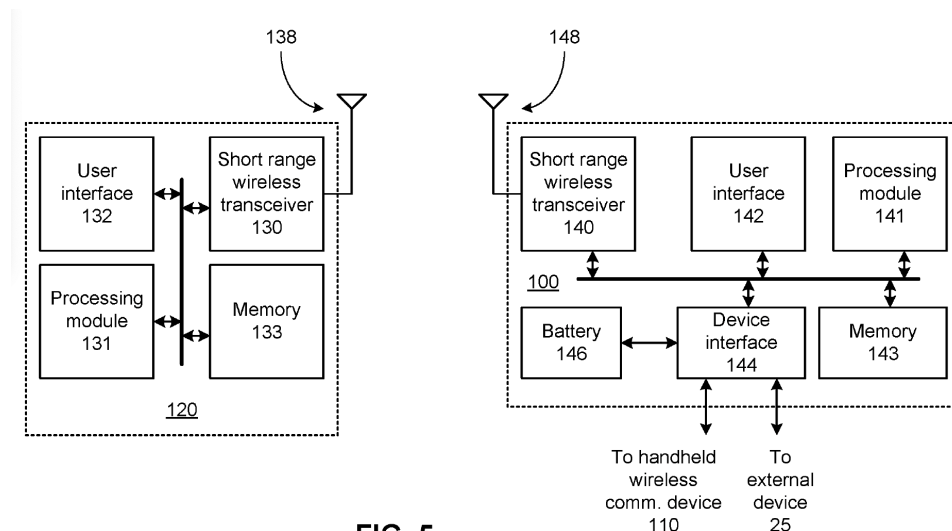


FIG. 5

Id. at Fig. 5.

49. For these reasons, a POSITA would understand that the field of endeavor of the '246 Patent includes wireless communication devices that send and/or receive wireless signals.

B. Problem Solved by the Inventors of the '246 Patent

50. I have been informed that a prior art reference is “reasonably pertinent” if a POSITA would have consulted it and applied its teachings when faced with the problem that the inventor was trying to solve. As such, I have been asked to analyze the '246 Patent and determine the problem that the inventors were trying to solve.

51. The '246 Patent recognizes that “the wireless telephone has, in some ways, become an important device for many aspects of the user’s life,” but “[m]isplacing a user’s wireless telephone can be an annoying experience.” '246 *Patent* at 2:35-38. To solve this problem, the “DETAILED DESCRIPTION OF THE INVENTION” describes a “location system for use with a handheld wireless communication device.” *Id.* at 4:52-55. Thus, a POSITA would understand that the '246 Patent is directed to solving the problem of employing a first wireless device, such as a mobile communication device, to locate a second wireless device.

VI. PROSECUTION HISTORY OF THE '246 PATENT

52. I have reviewed the prosecution history for the '246 Patent. The '246 Patent did not face any prior art rejection during prosecution. In the notice of

allowance, the examiner cited four references “pertinent to applicant’s disclosure,” but failed to identify which claim limitations are missing from the prior art. ’246 *Patent File History* at 278-280. U.S. Patent Publication No. 2004/0233872 to Karaoguz was found to teach “transmitting UWB pulses to a plurality of devices[,] [t]hen the devices transmits UWB pulses back[, and] ranging is then performing using a time during of a round trip of the UWB pulses thereby determining relative precise positions of the devices[.]” *Id.* at 278. U.S. Patent Publication No. 2008/0062120 to Wheeler et al. was found to teach an arrow “used on mom’s phone enabling mom to quickly locate at least one remote device associated with a child[.]” *Id.* U.S. Patent Publication No. 2009/0270093 to Lee was found to teach an orientation sensor “to detect orientation or acceleration of the wireless device” and “displaying distance and direction to the paired devices[.]” *Id.* at 279. Lee was also found to teach “a Range Setting for Ultra-Wideband pairing[.]” *Id.* Finally, U.S. Patent No. 5,379,447 to Bonta et al. was found to teach “determining distance between devices by using round-trip signal delays[.]” *Id.* As demonstrated below, all of the claimed features were well-known in the prior art.

VII. OVERVIEW OF THE TECHNOLOGY

53. I was asked to briefly summarize the background of the prior art from the standpoint of a person having ordinary skill in the art prior to February 26, 2010. As explained below, the lost item-finding techniques described by the ’246 Patent

were based on well-known ranging and direction-finding techniques and developed for handheld wireless devices in tandem with the increasing prevalence of small but important items that were easy to misplace (e.g., keys, wallets, wireless headsets, phones, etc.) and cell phones (which were nearly ubiquitous in 2010) becoming technologically advanced enough to perform the needed functions to locate items (a common problem). All the hardware components and functionalities encompassed by the Challenged Claims were thus well-known and conventional prior to the invention of the '246 Patent.

A. Real-Time Locating Systems

54. Real-time locating systems (RTLS) are “wireless systems with the ability to locate the position of an item anywhere in a defined space (local/campus, wide area/regional, global) at a point in time that is, or is close to, real time. Position is derived by measurements of the physical properties of the radio link.” *ISO/IEC 24730* at V. Different types of multilateration techniques can be used to determine the position of an item, including “Time of Flight Ranging Systems,” “Amplitude Triangulation,” “Time Difference of Arrival (TDOA),” and “Angle of Arrival.” *Id.* Different types of location information can be used to determine the position of an item, including “physical location, symbolic location, absolute location, and relative location.” *Liu* at 1067.

Physical location is expressed in the form of coordinates, which identify a point on 2-D/3-D map....Symbolic location expresses a location in a

natural-language way, such as in the office, in the third-floor bedroom, etc. Absolute location uses a shared reference grid for all located objects. A relative location depends on its own frame of reference. Relative location information is usually based on the proximity to known reference points or base stations.

Id.

55. RTLS emerged in the 1990s and “combined the automatic identification capabilities of active RFID tags and the ability to display the information on a computer screen” to locate items. *Moko Smart* at 3-4. Due to the initial high cost, the primary early adopters of RTLS were “government agencies and militaries;” however, RTLS began seeing commercial use beginning with hospitals in the 1990s. *Id.* RTLS was then adapted by other industries, such as for “detection of products stored in a warehouse...location detection of firemen in a building on fire...and finding tagged maintenance tools and equipment scattered all over a plant.” *Liu* at 1067.

56. Early location tracking systems involved the use of infrared (IR) sensors. For example, in 1992, Want et al. developed the *Active Badge* location system for the “location of people in an office environment.” *Want* at 91. The *Active Badge* is a badge worn by office workers that uses “[p]ulse-width modulated infrared (IR) signals...for signaling between the badge and sensor[s].” *Id.* at 93. The signals “are picked up by a network of sensors placed around the host building. A master

station...polls the sensors for badge ‘sightings,’ processes the data, and then makes it available to clients.” *Id.* The *Active Badge* is illustrated in the following figure:

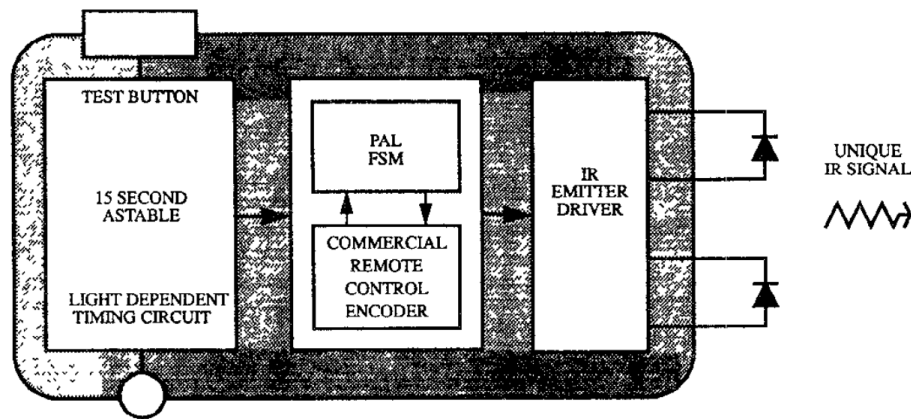


Fig. 1. The ORL Active Badge.

Want at 93.

57. As mobile devices became more ubiquitous it became desirable to track users using RF wireless networks to overcome the deficiencies of IR networks.

The proliferation of mobile computing devices and local-area wireless networks has fostered a growing interest in location-aware systems and services...The limited range of an IR network...is a handicap in providing ubiquitous coverage. Also, the IR network is often deployed for the sole purpose of locating people and does not provide traditional data networking services.

Bahl at 1. Working at Microsoft, Bahl et al. developed the RADAR system, “a radio-frequency (RF) based system for locating and tracking users inside buildings. RADAR operates by recording and processing signal strength information.” *Id.* The RADAR system included “three base stations” and “[a] mobile host, carried by the

user being tracked.” *Id.* at 2. Each base station and the mobile host is “equipped with a...network interface card (NIC)...[that] makes available the *signal strength* (SS) and *the signal-to-noise ratio* (SNR).” *Id.* (emphasis in original). RADAR used “the signal strength information gathered at multiple receiver locations to *triangulate* the user’s coordinates.” *Id.* at 1 (emphasis in original).

58. Ultrawideband (UWB) systems were also employed for RLTS and provided several advantages, including transmitting “a signal over multiple bands of frequencies simultaneously” and consuming “less power than conventional RF tags.” *Liu* at 1074. An early system that used UWB technology was called PulsON by Time Domain. *Moritz*. Larry Fullerton, the inventor who developed and filed numerous patents on ultra-wideband technology in 1987, founded Time Domain that same year. *Id.* By the mid-1990s Fullerton had developed prototypes for several commercial applications of UWB including ranging devices (which could be used for positioning) like the PulsON chips. *Id.* “The ultra low power PulsON chip harnesses information that is contained in a radio pulse that has no specific frequency. Huge amounts of data are transmitted without interfering with other radio frequencies, creating amazing new possibilities in low-cost voice and data communications, personal radar, and **precise positioning**.” *Paddock* at 12 (emphasis added).

59. IEEE released the 802.15.4a standard in 2007 that added two physical layers (PHYs) for “data communication devices with precision ranging, extended range, and enhanced robustness.” *802.15.4a Standard* at iv. One of the physical layers added was the UWB PHY. *Id.* The 802.15.4a standard standardized two-way ranging using UWB devices (referred to as “*ranging capable devices (RDEVs)*”), which allowed for “two-way time-of-flight computation of distance between two RDEVs”. *Id.* at 8 (emphasis in original). The two-way ranging exchange is shown in the figure below. Additionally, the 802.15.4a standard standardized “[p]osition awareness through one-way transmissions” for UWB devices. *Id.* at 12. The UWB PHY was “designed to provide enhanced robustness” for low-rate wireless personal area network (LR-WPAN) applications. *Id.* at 7. One PHY feature that provides for the “enhanced robustness” is the “[e]xtremely wide bandwidth characteristics (UWB) that can provide very robust performance under harsh multipath and interference conditions.” *Id.* The UWB PHY also includes a “[c]oncatenated forward error correction (FEC) system to provide flexible and robust performance under harsh multipath conditions.” *Id.* UWB, accordingly, provided an improvement over location finding systems that used narrowband transmissions (e.g., Bluetooth), which cannot “provide accurate estimate of distance in a heavy multipath environment.” *Phalavan* at 115. (“[I]t has been shown that the UWB signal does not

suffer multipath fading...which is desirable for accurate TOA estimation in indoor areas.” *Id.* at 116.

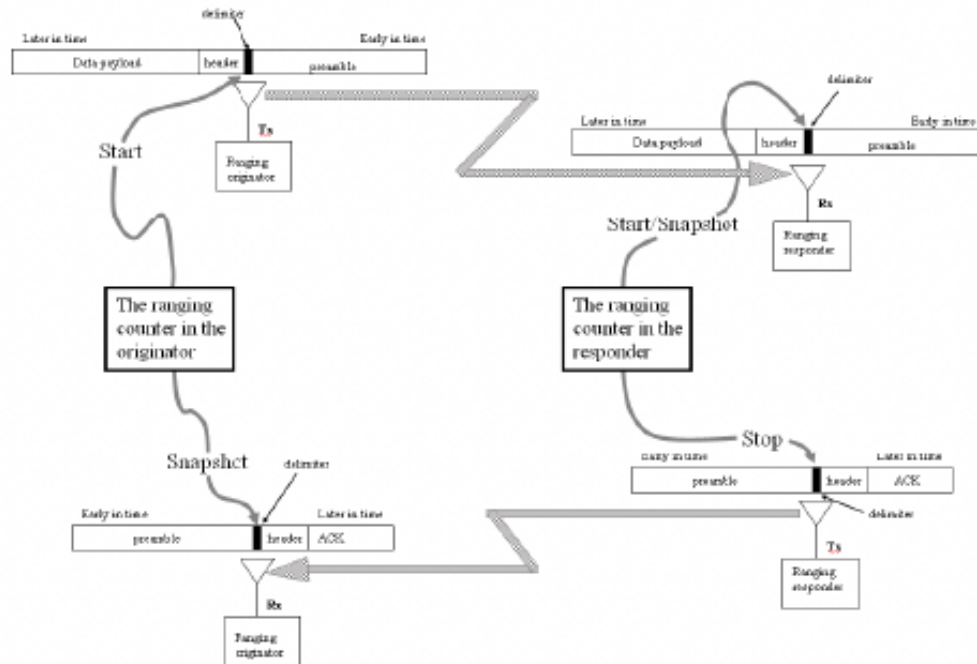


Figure 13a—The complete two-way ranging exchange

Id. at 9.

60. Bluetooth location systems were similarly developed. Bluetooth systems provide advantages in that Bluetooth is a “‘lighter’ standard, highly ubiquitous (embedded in most phones, personal digital assistants (PDAs), etc.) and supports several other networking services in addition to IP.” *Liu* at 1075. By 2007, Bluetooth-based location systems included systems that used Bluetooth tags, which are “small transceivers” with a “unique ID...for locating the Bluetooth tag.” *Id.* Another Bluetooth system was the Topaz local positioning system made up of:

“positioning server(s), wireless access points, and wireless tags” that was “suitable for tracking humans and assets.” *Id.* at 1076. Still another Bluetooth location system converted “received signal power levels to distance estimates.” *Id.*

B. Location Determining Techniques

61. The aforementioned RTLS typically used “traditional triangulation, [and] positioning algorithms using scene analysis or proximity” to locate items. *Liu* at 1068. Triangulation uses “the geometric properties of triangles to estimate the target locations” and “has two derivations: lateration and angulation. Lateration estimates the position of an object by measuring its distances from multiple reference points.” *Id.* The distance can be derived by measuring “time of arrival (TOA) or time difference of arrival (TDOA)” to compute distances “by multiplying the radio signal velocity and the travel time.” *Id.* Lateration can also employ “[r]oundtrip time of flight (RTOF) or received signal phase method.” *Id.*

62. TOA can enable 2-D positioning by making “TOA measurements with respect to signals from at least three reference points,” and “the one-way propagation time is measured, and the distance between measuring unit and signal transmitter is calculated.” *Id.* The position of the target can be computed by “minimizing the sum of squares of a nonlinear cost function, i.e., least-squares algorithm.” *Id.* Fig. 1 below illustrates positioning based on TOA measurements.

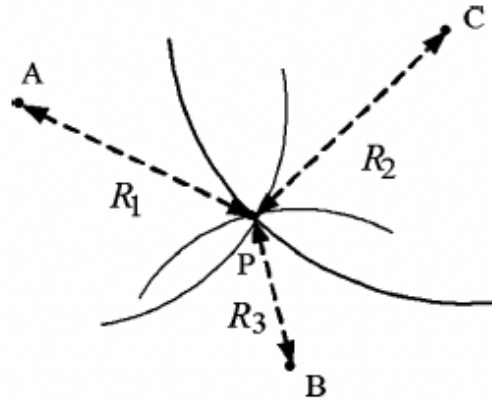


Fig. 1. Positioning based on TOA/RTOF measurements.

Id. TDOA, meanwhile, can be used to “determine the relative position of the mobile transmitter by examining the difference in time at which the signal arrives at multiple measuring units.” *Id.* at 1069. Using TDOA, the target can be located by forming “two hyperbolas...from TDOA measurements at three fixed measuring units (A, B, C) to provide an intersection point, which locates the target P.” *Id.* TDOA, for example, is used in GPS systems where four satellites are used with a GPS receiver to triangulate its 3-dimensional position using TOF methods. *Hightower* at 4 (“GPS satellites are precisely synchronized with each other and transmit their local time in the signal allowing receivers to compute the *difference* in time-of-flight.”) Fig. 2 below illustrates positioning based on TDOA measurements:

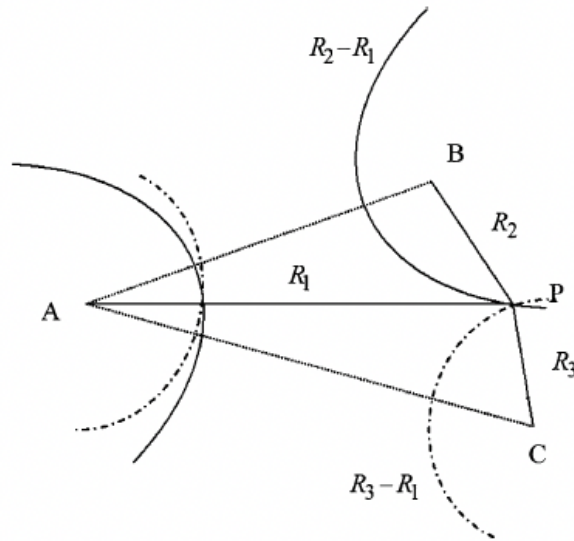


Fig. 2. Positioning based on TDOA measurements.

Liu at Fig. 2.

63. TOF calculations for locating an object involve “measuring the time it takes to travel between the object and [a] point *P* at a known velocity.” *Hightower* at 3. TOF can be used when the object is traveling at a known velocity or when, “as is far more typical, the object is approximately stationary and we are instead observing the difference in transmission and arrival time of an emitted signal.” *Id.*

64. Signal strength methods involve estimating “the distance of the mobile unit from some set of measuring units, using the attenuation of emitted signal strength.” *Liu* at 1069. These signal attenuation-based methods “attempt to calculate the signal path loss due to propagation. Theoretical and empirical models are used to translate the difference between the transmitted signal strength and the received

signal strength into a range estimate.” *Id.* Fig. 3 illustrates an example of positioning based on received signal strength (RSS).

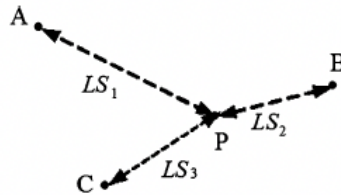


Fig. 3. Positioning based on RSS, where LS_1 , LS_2 , and LS_3 denote the measured path loss.

Id. at Fig. 3.

65. Angulation, like lateration, can also be used to determine object positioning. Angulation determines the location of the desired target “by the intersection of several pairs of angle direction lines, each formed by the circular radius from a base station...to the mobile target.” *Id.* at 1070. Estimation of AOA is also known as “direction finding” and can be accomplished “either with directional antennae or with an array of antennae.” *Id.* In three dimensions, “one length measurement, one azimuth measurement, and two angle measurements are needed to specify a precise position.” *Hightower* at 5. The advent of phased antenna arrays was “an excellent enabling technology for the angulation technique.” *Id.* An example of angulation is shown below:

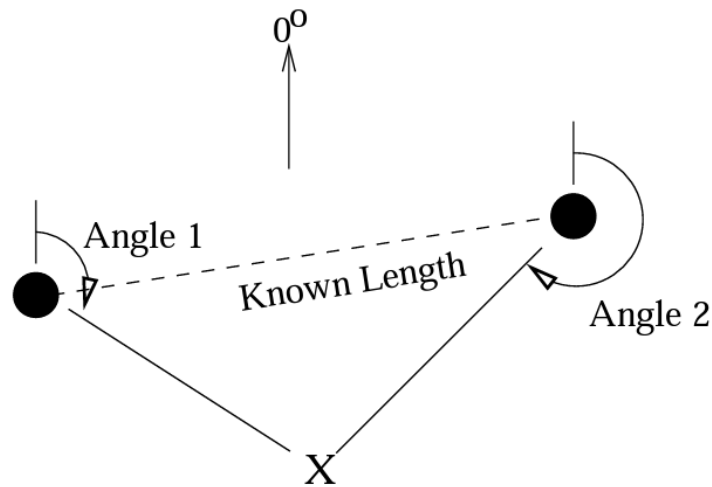


Figure 2: This example of 2D angulation illustrates locating object 'X' using angles relative to a 0° reference vector and the distance between two reference points. 2D angulation always requires at least two angle and one distance measurement to unambiguously locate an object.

Id.

66. Proximity detection, another commonly used technique in early-stage RTLS, determines “when an object is ‘near’ a known location.” *Id.* at 7. Proximity detection often uses two different methods for non-physical contact detection: (1) determining when a mobile device is within range of a wireless cellular access point, and (2) observing automatic ID systems. *Id.*

67. Proximity detection “relies upon a dense grid of antennas, each having a well-known position. When a mobile target is detected by a single antenna, it is considered to be collocated with it. When more than one antenna detects the mobile target, it is considered to be collocated with the one that receives the strongest signal.” *Liu* at 1072. The Active Badge system is one example system that operates

by monitoring wireless cellular access points. *Hightower* at 7. Another publicly demonstrated system that played an instrumental role in shaping ubiquitous computing systems was the Xerox ParcTAB, introduced around 1992. *PARC History* at 3. The ParcTAB system used diffused infrared cells which allowed the system to detect devices within range of access points. *Hightower* at 7. An illustrative example is shown below:

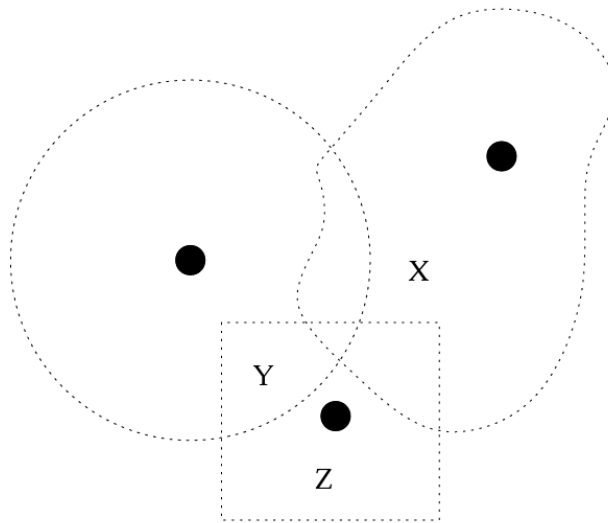


Figure 4: Objects 'X', 'Y', and 'Z' are located by monitoring their connectivity to one or more access point in a wireless cellular network. The cell geometry is an artifact of the wireless technology technology used in the implementation. For example, a radio cellular network cell may have the shape of the region containing object 'X' while diffuse infrared in a room is constrained by the walls resulting in a square shape.

Id.

C. Mobile Communication Devices

1. *Touch Screens and Graphical User Interface Development*

68. Mobile communication devices benefited from additional technological advances alongside the development of RTLS. In 1992, the IBM Simon, which some consider to be the “world’s first smartphone,” used a touch screen for its graphical user interface (“GUI”). *Guifx* at 4. The touch screen became a popular GUI with the Apple Newton MessagePad shortly following the IBM Simon in 1993. *Id.* The Apple Newton was also “one of the first-ever Personal Digital Assistants (PDAs)” and allowed the user to interact directly with the graphical user interface displayed on the touch screen (depicted below):



Id.

69. The original iPhone, released in 2007, further built on the concepts discussed and quickly became a widely popular smartphone. The iPhone included a touchscreen for user input and output which is shown below:

iPhone at a Glance



iPhone User's Guide at 10 (annotated). A user could perform many functions with the touch screen. For example, a user could “[t]ap any application to open it,” “[f]lick or drag up or down to scroll,” and even “zoom in and out” of pictures. *Id.* at 15-17.

70. After the release of the original iPhone, the use of touch screens in smart phones boomed in popularity, and by Q4 2009, “smart phones with touch screens account for more than half of all smart phone shipments globally.” *Canalys*

at 1. Indeed, by 2009 touch screens were “everywhere” including “phones, office equipment, speakers, digital photo frames, TV control buttons, remote controls, GPS systems, automotive keyless entry, and medical monitoring equipment[.]” *Kolokowsky* at 1.

71. Generally, a touch screen is composed of a clear touch sensor that is placed over a display, such as an LCD, such that the touch sensor completely covers the viewable area of the display as shown in the example below:

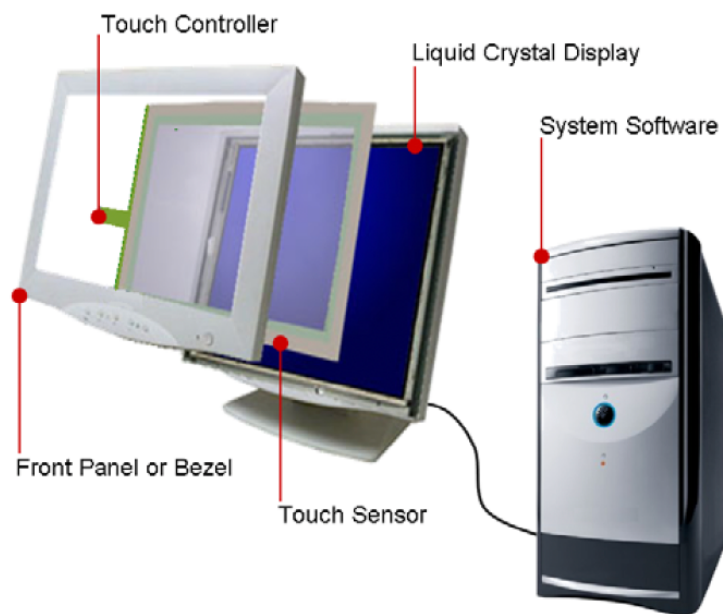


Figure 1. Touchscreen Contoller Autopsy

Id. at 1-2.

72. At the time, there were already “many different touch sensor technologies on the market, each using a different method to detect touch input.” *Id.* at 2. However, “these technologies all use an electrical current running through the

panel that, when touched, causes a voltage or signal change.” *Id.* “This voltage change is sensed by the touch controller to determine the location of the touch on the screen.” *Id.* This allows users to interact directly with the GUI on the display. *See e.g., Hotelling* at [0007] (“When using a touch screen, a user makes a selection on the display screen by pointing directly to GUI objects on the screen[.]”).

2. Bluetooth in Mobile Communication Devices

73. Bluetooth was developing around the same time as the IBM Simon and Apple Newton MessagePad were hitting the market. The origins of Bluetooth are traceable to 1994 when Ericsson “wanted to find a way to enrich the functionality of mobile phones” using “short-range radio connections.” *Auris* at 3. In 1996, members of the Bluetooth Special Interest Group (Intel, Ericsson, and Nokia) met to determine how Bluetooth could be “standardized between different products and industries.” *Id.* at 4. In 1999, the first consumer Bluetooth products hit the market, with the first consumer Bluetooth device being a hands-free mobile headset. *Id.* In that same year, the “first Bluetooth specification, 1.0, was launched...allowing for release of many other wireless devices.” *Id.*

74. The first Bluetooth enabled mobile phone was the Ericsson T39 that was released in 2001. *Ericsson T39 User Guide* at 4. The Ericsson T39 mobile phone “became an accessible way for consumers to start using wireless technology in their daily lives.” *Auris* at 5. The Ericsson T39 used Bluetooth to “make it possible for

you to connect your phone wirelessly to different *Bluetooth* devices such as a headset, PC, PDA or printer.” *Ericsson T39 User Guide* at 49 (emphasis in original). Once paired with another device, the Ericsson T39 could “exchange” and “synchronize” information with the paired device. *Id.* The Ericsson T39 also supported Bluetooth pairing with multiple devices. *Id.* at 50 (“Your phone can be paired with up to ten *Bluetooth* devices.”).

75. The pairing procedure involves transmitting pairing signals between Bluetooth devices:

Bluetooth technology uses the principles of device “inquiry” and “inquiry scan.” Scanning devices listen to known frequencies for devices that are actively inquiring. When an inquiry is received, the scanning device sends a response with the information needed for the inquiring device to determine and display the nature of the device that has recognized its signal.

Scientific American. Once in range of one another (the Ericsson T39 recommended 10 meters), “[y]ou can initiate the pairing between two *Bluetooth* devices from your own phone or you can accept a request for pairing from the other device.” *Ericsson T39 User Guide* at 50. The Ericsson T39 included a graphical user interface for performing the pairing process. *Id.* (“A list of device types that can be paired with your phone is shown...When the search is finished, the display shows available devices.”) Once an available device was chosen, the user would enter a passkey for both the phone and the other device. *Id.* A user could even edit the “name tag” for a

device after pairing was completed. *Id.* The Ericsson T39 also provided procedural steps for accepting pairing with a device. *Id.* (“**To accept pairing with a device...**Press YES to confirm the pairing...When the pairing has been completed, you may edit the name tag for the device and press **YES.**”).

76. As Bluetooth developed over time, standards were developed defining protocols for Bluetooth, including the IEEE 802.15.1-2005 standard that defined the “physical layer (PHY) and medium access control (MAC) specifications for wireless connectivity with fixed, portable, and moving devices within or entering a personal operating space (POS),” in which a POS was defined as the “space about a person or object that typically extends up to 10 m in all directions and envelops the person whether stationary or in motion.” *802.15.1-2005* at 1. The IEEE 802.15.1-2005 Standard defined Bluetooth as a “short-range communications system” with “a wireless communication link, operating in the unlicensed industrial, scientific, and medical (ISM) band at 2.4 GHz using a frequency hopping transceiver.” *Id.* at 5, 19. Additionally, the standard defined a “core system” for “the combination of a radio frequency (RF) transceiver, BB [Baseband], and protocol stack.” *Id.* at 19. Similarly, in 2003, version 1.2 of the Bluetooth Core Specification was being developed by the Bluetooth Special Interest Group, which likewise defined the Bluetooth core system as consisting of “an RF transceiver, baseband, a protocol stack.” *Bluetooth Specification*, Vol. 1 at 13.

77. Bluetooth was also incorporated into the original iPhone in 2007. The iPhone transmitted and received cell phone, Wi-Fi, and Bluetooth signals. *iPhone User's Guide* at 13. The iPhone had a specific way to pair devices to it, including entering a discoverable mode, choosing which device to connect with, and optionally entering a passkey. *Id.* at 39. The iPhone even included a Bluetooth status icon displayed on the GUI that indicated to the user if Bluetooth “is on and a device is connected,” “is on, but no device is connected,” or “is turned off.” *Id.* at 40.

3. *RTLS in Mobile Communication Devices*

78. As Bluetooth and RTLS developed alongside one another, there became interest in using Bluetooth in RTLS as discussed previously. *Almaulu* at 1 (“As Bluetooth enabled devices become a part of our wireless world, there is increased interest in locating and communicating with other Bluetooth devices within a local network.”). The potential usefulness of Bluetooth-enabled mobile devices for RTLS was quickly recognized. For example, one Bluetooth locator system used “USB Bluetooth dongles on PCs [*sic*] throughout a building” enabling “mobile devices...to get distance information” by scanning the USB Bluetooth dongles. *Id.* at 2. Additionally, the advantages of Bluetooth were recognized as “[p]ositioning systems are most common in mobile contexts where power is limited” and “Bluetooth is designed to consume little power and is suitable for mobile devices.” *Hallberg* at 2.

79. A Bluetooth device as early as 2003 could either take an “active role in the positioning task as it sends a position on request” or a “more passive role in a positioning task, where the unique address of the device is used by a connected device to look up [the] respective position in a database.” *Id.* at 1. Additionally, it was possible to “forward a position gained from the positioning platform using the peer to peer characteristics in Bluetooth.” *Id.* Any wireless Bluetooth device could now be “turned into a position source without having the need of any added software.” *Id.*

80. Early Bluetooth RTLS primarily used RSSI (received signal strength indicator) for determining position. For example, an early study discovered that “RSSI can be used to indicate distance” in a room with “well known” dimensions. *Id.* However, RSSI can be inaccurate because “RSSI measurements can fluctuate greatly for a given mobile device even when it is stationary.” *Almaulu* at 3. It was typically required to create a precise mapping of the geometry of each room to increase the potential accuracy from RSSI. *Id.* at 2 (“[I]t is clear that RSSI measurements are not perfect and many previous projects either mask these inaccuracies with redundancy and/or tailor a system to the specific environment in which it will be deployed.”).

81. Despite the limitations of RSSI, by 2006, real-time locating systems using Bluetooth used RSSI with trilateration to determine location. *Id.* at 1 (“The

Bluetooth Triangulator...allow[s] Bluetooth devices to communicate with each other and determine the position of other Bluetooth devices using signal strength readings”). An example of Bluetooth trilateration is shown in the figure below, where three master nodes take signal strength measurements from a target Bluetooth device:

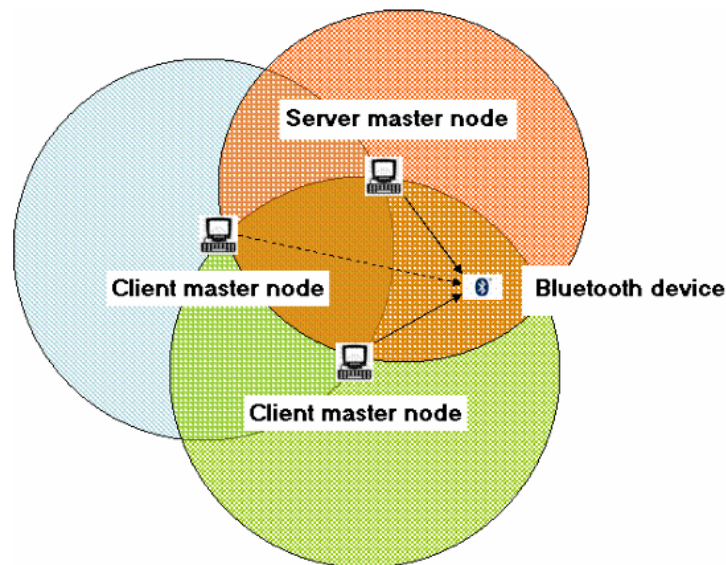


Figure 1: Diagram illustrating master node layout and mobile devices.

Id. at 4. As illustrated, the well-known method of trilateration was simply adapted to use Bluetooth signals for transmitting the position information of nodes nearby. *Id.* (“By placing the dongles in an ‘L’ shaped triangle, a simple trilateration scheme was used to predict the coordinates and distance from the origin.”).

82. RTLS were also evolving to assist users by emitting an audible or visual alert. For example, a research study conducted by the Georgia Institute of

Technology in 2006 that reviewed current lost and found devices and suggested a new style of such devices to allow “the visually impaired to track and locate objects they lose frequently but for which they do not have a specific strategy for tracking.” *Kientz* at 1. The system, named FETCH, “uses devices the user already owns, such as their cell phone and laptop” and “is completely mobile and uses Bluetooth-enabled tags similar to key fobs and a Bluetooth-enabled cell phone or laptop with screen readers[.] The tags emit an audible beep and work within a range of 30 meters, a range large enough to find an object anywhere within a house, apartment, or office.” *Id.* As shown, below, the FETCH system enabled users to locate devices such as television remotes and tags using a mobile phone. Comparable lost and find systems at the time included “Find One Find All,” “FindIT,” “KeyRinger,” and “The Locator.” *Id.* at 2.



Figure 1: Left: User locating television remote control with phone. Right: Front and back of tags with a U.S. quarter to show size

Id.

83. The Locator from the Gloucester Smart House was a system that used “an audio paging system for locating objects tagged around an environment.” *Id.* Further, The Locator used a “proprietary radio frequency” which required custom devices. *Id.* FETCH, on the other hand, used “the more standardized Bluetooth communication protocol” and thus worked “with existing Bluetooth enabled devices.” *Id.* The FETCH system allowed users to input the tagged object they wanted to locate, and in response the system “activates the beeping on the tag” until the tag is found. *Id.* An exemplary user interface on a mobile device that worked with the FETCH system is shown below:

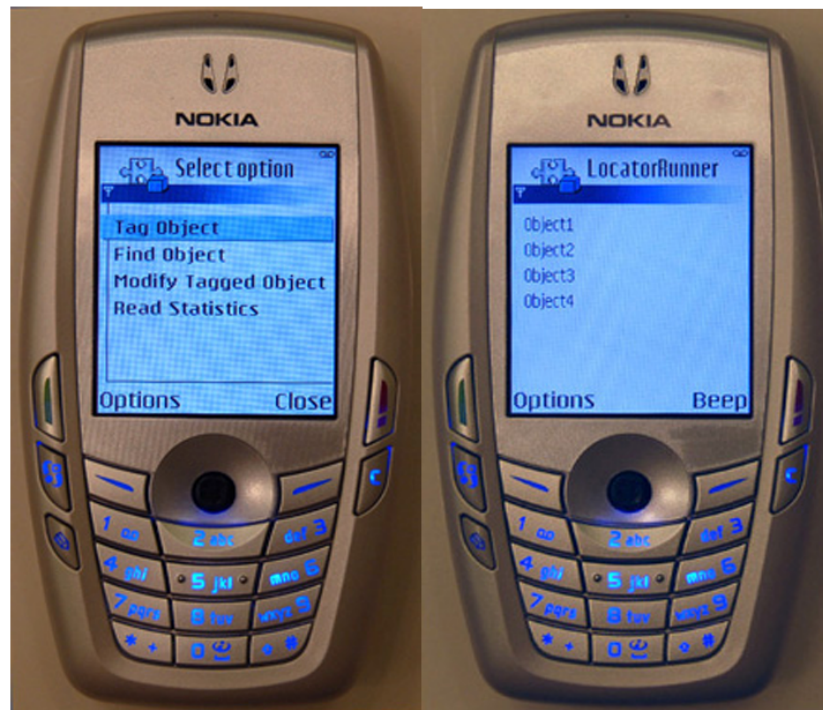


Figure 4: Sample screens from mobile phone object location interface. Left shows main menu, right shows list of objects

Id. If the selected tag was “not within Bluetooth range” the FETCH system would “keep prompting” the user to start the beeping, allowing the user to walk around until a beep was heard once in range of the tag. *Id.*

VIII. SUMMARY OF THE PRIOR ART REFERENCES

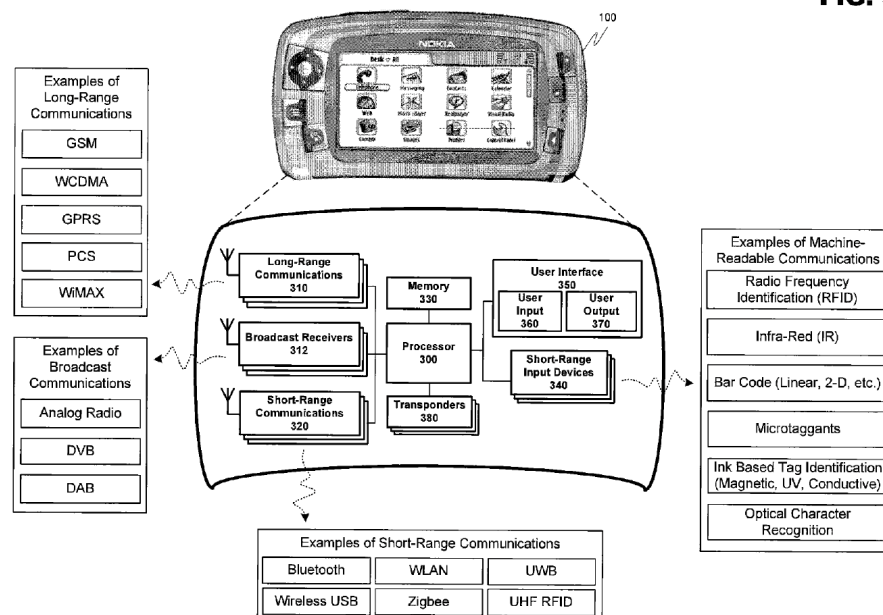
A. Kalliola

84. According to Kalliola, “wireless communication devices (WCDs) have become commonplace for both personal and business use, allowing users to transmit and receive voice, text and graphical data from a multitude of geographic locations.” *Kalliola* at [0004]. “Wireless communication devices employing the previously discussed characteristics may be used for a variety of applications other than basic voice communications.” *Id.* at [0008]. For example, location services allow the user to “determine [their] current location using their WCD,” and provide “route or direction finding from a current location to another mapped location.” *Id.* at [0009]. Kalliola also cites “handheld location-finding systems that operate using services such as the Global Positioning System (GPS)” and “provide bearings and directions to address locations or latitude/longitude positions.” *Id.* at [0010].

85. However, “[t]raditional GPS receivers will not assist a user who wishes to track an object tagged with a beacon (for example, an IR beacon on a keychain fob), or a destination that is currently unknown, such as access to public transportation or a hospital marked by an IR beacon.” *Id.* To solve this problem,

Kalliola proposes “a directional and/or location finding method and system that allows a user to track or locate a signal beacon using a direction of Arrival (DoA) estimation, while simultaneously managing the wireless communication device to optimize its performance.” *Id.* at [0011].

86. Kalliola’s WCD “may be anything from a basic cellular handset to a more complex device such as a wirelessly enabled palmtop or laptop computer.” *Id.* at [0034]. The “WCD may both transmit and receive information over a wide array of wireless communication networks, each with different advantages regarding speed, range, quality (error correction), security (encoding), etc.” *Id.* at [0033]. The WCD includes, among other things, a processor, memory, software stored by memory that is executed by the processor, a user interface, and short and long-range transceivers. *Id.* at [0043]-[0054].

FIG. 3

Id. at Fig. 3.

87. “Processor 300 controls overall device operation” and “is coupled to at least communications sections 310, 320 and 340.” *Id.* at [0043]. The processor 300 is “implemented with one or more microprocessors that are each capable of executing software instructions stored in memory 330.” *Id.* “Memory 330 may include random access memory (RAM), read only memory (ROM), and/or flash memory, and stores information in the form of data and software components (also referred to herein as modules).” *Id.* at [0044]. “The software components stored by memory 330 include instructions that can be executed by processor 300.” *Id.* at [0045]. “User interface 350 facilitates the exchange of information with a user” and “includes a user input 360 and a user output 370.” *Id.* at [0050]. User input 360 “include[s] one or more components that allow a user to input information,” such as “keypads, touch screens, and microphones.” *Id.* User output 370 “allows a user to receive information from the device, and “may include various components, such as a display, light emitting diodes (LED), tactile emitters and one or more audio speakers.” *Id.*

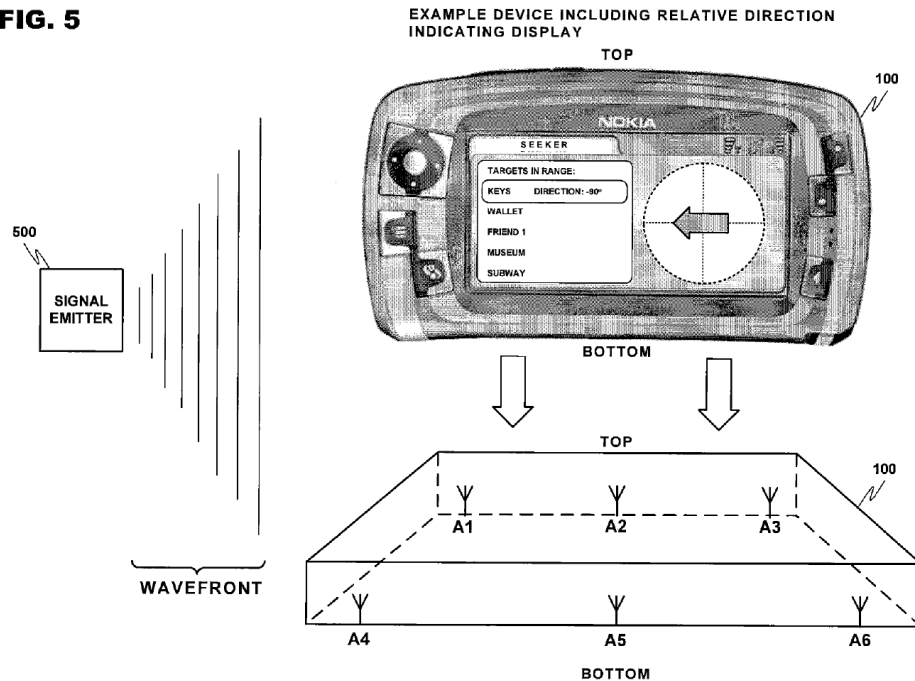
88. The WCD includes long-range communications 310 that “performs functions related to the exchange of information over large geographic areas (such as cellular networks) via an antenna.” *Id.* at [0046]. “These communication methods include technologies from the previously described 1G to 3G,” such as “basic voice

communications (e.g., via GSM)” and “data communications sessions, such as General Packet Radio Service (GPRS) sessions and/or Universal Mobile Telecommunications System (UMTS) sessions.” *Id.*

89. Short-range communications 320 “is responsible for functions involving the exchange of information across short-range wireless networks.” *Id.* at [0048]. Examples of short-range wireless networks include, but are not limited to “Bluetooth™, WLAN, UWB [Ultra-Wideband] and Wireless USB connections.” *Id.* “Accordingly, short-range communications 320 performs functions related to the establishment of short-range connections, as well as processing related to the transmission and reception of information via such connections.” *Id.*

90. The WCD communicates with “battery-operated transmitters in a keychain, in a wallet, embedded in an ID badge, mounted in a vehicle such as an automobile, motorcycle, scooter, bicycle or in a piece of clothing” that are “activated remotely by a user as needed.” *Id.* at [0075]. “For example, the device may operate in a lower power or power conservation mode until a message is received instructing a device to activate the position-indicating transmission signal.” *Id.* “This message may be received by any of the aforementioned wireless mediums such as via a Bluetooth™ message.” *Id.*

91. As shown in Fig. 5, signal emitter 500, which is associated with the user's keys in this example, transmits a "position-indicating transmission," which is received by the WCD's antenna array A1-A6:

FIG. 5

Id. at Fig. 5; *see also, id.* at [0067], Fig. 6.

92. "The direction of arrival of the incident signal (e.g., the position-indicating transmission) is resolved based on the phase and possibly amplitude differences of the signals received by the respective antennas A1-A6." *Id.* at [0070]. The WCD's graphical user interface "shows the directional arrow pointing in the direction of the keys, and gives a relative direction measurement towards the keys of -90° ." *Id.* at [0069].

93. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention or if it is reasonably pertinent to the particular problem that the inventor was trying to solve.

94. As discussed above, the field of endeavor of the claimed invention of the '246 Patent includes wireless communication devices that send and/or receive wireless signals. *See* ¶¶ 46-49. As demonstrated above, Kalliola’s WCD is a wireless communication device that sends and receives wireless signals. Thus, Kalliola is in the same field of endeavor as the claimed invention of the '246 Patent.

95. Kalliola is also reasonably pertinent to the problem solved by the inventors of the '246 Patent. As discussed above, the '246 Patent is directed to solving the problem of employing a first wireless device, such as a mobile communication device, to locate a second wireless device. *See* ¶¶ 50-51. As demonstrated above, Kalliola proposes using the WCD to help the user locate signal emitters associated with the user’s personal items, such as their keys or wallet. Thus, a POSITA would have consulted Kalliola and applied its teachings when faced with the problem of helping a user locate other wireless devices.

B. *Turunen*

96. Turunen teaches a “method of transmitting Internet data between a mobile host and a remote host coupled via the Internet and a GSM/GPRS cellular telephone network.” *Turunen* at Abstract. “With the increased use of mobile cellular telephones, there is a growing demand for so-called mobile Internet access, where access is made from a portable computer connected to a cellular telephone or from an integrated computer/cellular phone device.” *Id.* at 2:65-3:2. Turunen seeks to “facilitate the substantially seamless flow of Internet data across the Internet and digital cellular telephone networks.” *Id.* at 3:45-49.

97. Turunen further explains that “the telephone network is a GSM network, and said packet switched transmission mode is that known as GPRS” and the invention “is also applicable to other cellular telephone networks and to satellite telephone networks.” *Id.* at 4:43-48. Fig. 2 shows an illustrative view of the mobile cellular network communicating by, e.g., GSM/GPRS:

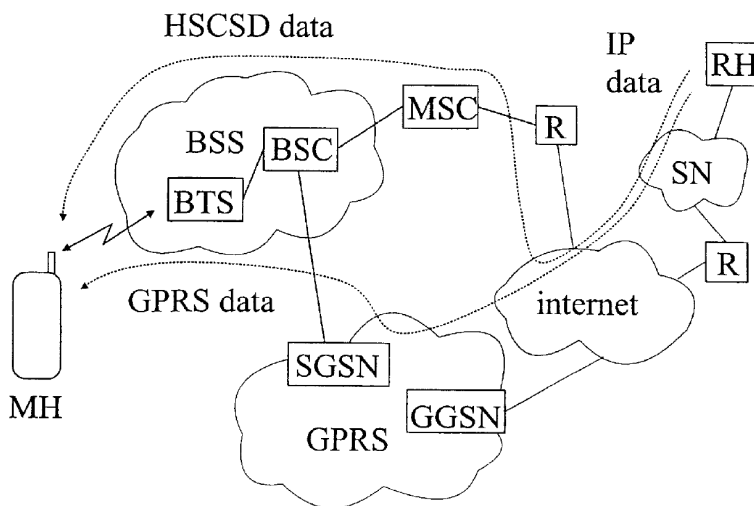


Figure 2

Id. at Fig. 2.

98. “FIG. 2 illustrates schematically the situation where a mobile host (MH) is connected to the Internet via a digital cellular telephone network. For the purpose of the present example, this network is a GSM phase 2 network which allows for the transmission of user data by either a High Speed Circuit Switched Data (HSCSD) transmission link or by a General Packet Radio Service (GPRS) link. As will be described below, Internet data may be transmitted between the MH and the Internet via either of these links.” *Id.* at 5:29-38. Additionally, “[i]f GPRS is the selected transmission mode, a Gateway GPRS Support Node (GGSN) (see below) acts as a Home Agent for the MH and maps a unique Internet address to the line ID number of the MH.” *Id.* at 6:11-15.

99. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention.

100. As discussed above, the field of endeavor of the claimed invention of the '246 Patent includes wireless communication devices that send and/or receive wireless signals. *See* ¶¶ 46-49. As demonstrated above, Turunen’s mobile host is a wireless communication device that sends and receives wireless signals. Thus, Turunen is in the same field of endeavor as the claimed invention of the '246 Patent.

C. **Oswald**

101. Oswald teaches an “apparatus for determining positional information relating to an object” that “finds particular application in the field[] of object tracking systems[.]” *Oswald* at [0001]-[0002]. The apparatus includes “means for receiving a signal transmitted” from a transmitter of the object. *Id.*, [0005]. The apparatus “may transmit UWB pulses” that are used to determine the angular position of the object. *Id.* at [0012]-[0013], [0245].

102. Oswald teaches an overview of the positioning system with respect to Fig. 1.

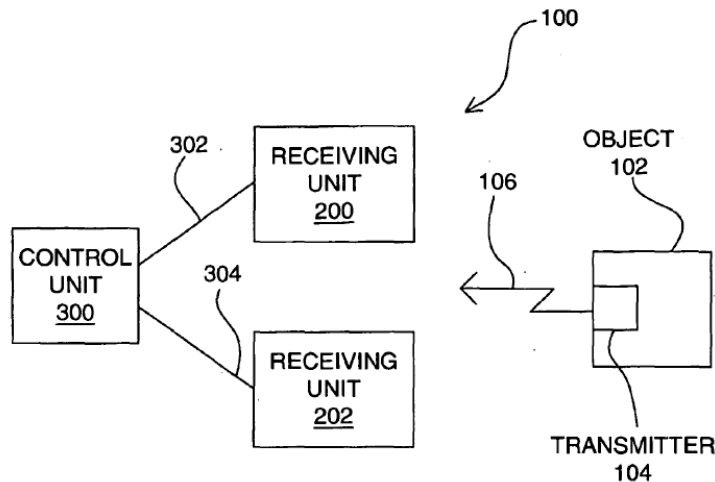
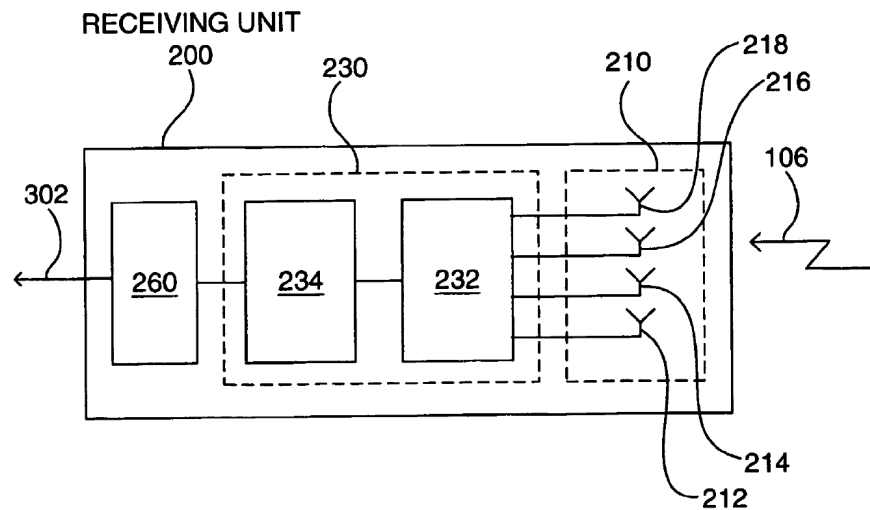


Figure 1

Id. at Fig. 1, [0244] (“[T]he positioning system 100 comprises an object to be located 102, a transmitter 104 associated with or contained in the object 102 and outputting a signal 106, a pair of receiving apparatuses 200, 202, and a control unit 300.”).

103. The receiving units 200, 202, pass data to the control unit and “[t]he control unit then processes the data received from the receiving units so as to determine the angular position of the object with respect to each receiving unit.” *Id.* at [0245]. Oswald teaches the transmitter transmits “Ultra Wide Band (UWB) signals.” *Id.* at [0099].

104. Additionally, Oswald teaches the receiving unit can include an antenna array. “The receiver component 210 in the receiving unit 200 comprises four antennas 212, 214, 216, 218 for receiving the transmitted signal 106 at carefully chosen spaced apart locations.” *Id.* at [0260].



Id. at Fig. 9.

105. Oswald uses signal delay techniques to determine the angular position of the object. “[D]ifferential timing techniques are used to compute the angular position of transmitting objects whose signals are received at the receiving unit, which requires the analysis of a plurality of received signals. Accordingly, the antennas 212, 214, 216, 218 are provided, each having its own separate channel in the detector component 230 such that separate outputs are provided by the detector component 230 for each antenna.” *Id.* at [0261].

106. Oswald teaches a “differential sensor array in FIG. 16.”

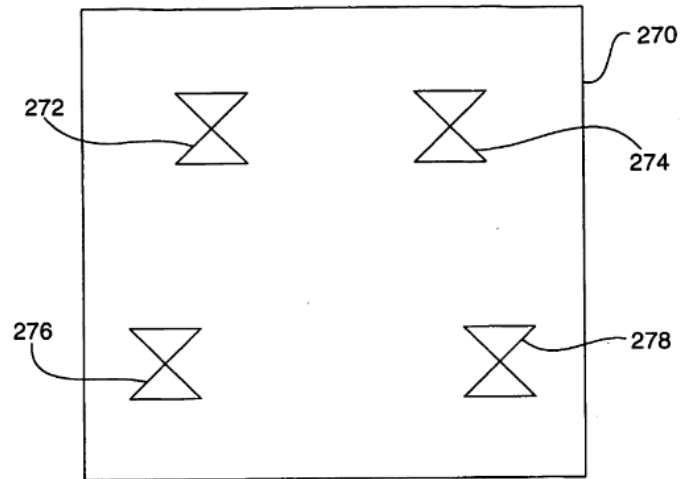


Figure 16

Id. at Fig. 16, [0345] (“FIG. 16 is a plan view of a sensor array in a receiving unit. In FIG. 16, the array substrate 270 contains four antennas 272, 274, 276, 278 formed on the substrate.”).

107. Additionally, the sensor array of Fig. 16 is used to locate “an object located at distances R1, R2, R3 and R4 from the receiving elements 272, 274, 276, 278 respectively.” *Id.* at [0347].

[I]f the object is located off-axis, for example at a location with azimuth ϕ and elevation θ , there will be a time difference of approximately $D_v \sin \theta / c$ between the signals arriving at vertically spaced receiving elements of the array 270 and a time difference of approximately $D_h \sin \phi / c$ between the signals arriving at horizontally spaced receiving elements of the array 270 where D_v and D_h are, respectively, the vertical and horizontal distance between receiving elements in the array 270. In the above, c is the speed of light.

Id. at [0349].

108. Oswald provides the below equations for determining “the times at which the reflected signals will be received by the receiving elements are times Tr1, Tr2, Tr3, Tr4.” *Id.* at [0350].

$$Tr1=(2R5+(-D14 \sin(\theta)+D12 \sin(\phi))/2)/c$$

$$Tr2=(2R5+(-D23 \sin(\theta)-D12 \sin(\phi))/2)/c$$

$$Tr3=(2R5+(D23 \sin(\theta)-D34 \sin(\phi))/2)/c$$

$$Tr4=(2R5+(D14 \sin(\theta)+D34 \sin(\phi))/2)/c$$

Id. (“The above equations can be solved...to obtain the angles θ and ϕ .”).

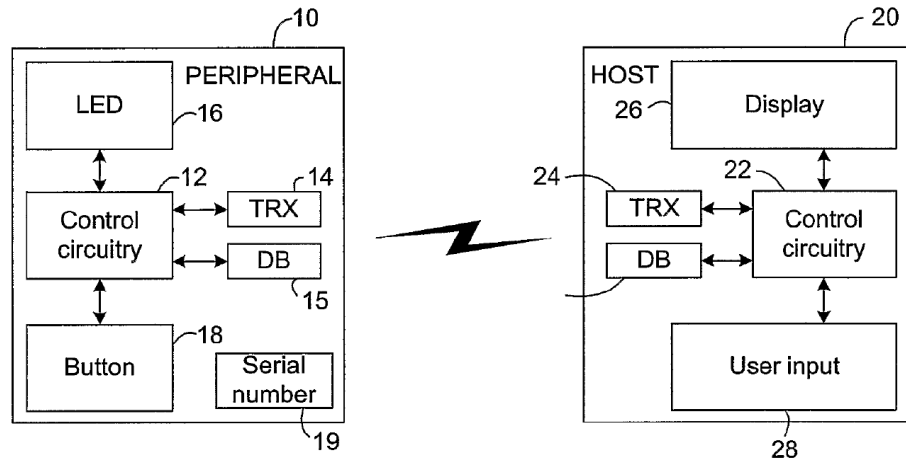
109. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention or if it is reasonably pertinent to the particular problem that the inventor was trying to solve.

110. As discussed above, the field of endeavor of the claimed invention of the '246 Patent includes wireless communication devices that send and/or receive wireless signals. *See* ¶¶ 46-49. As demonstrated above, Oswald’s receiving unit is a wireless communication device that receives wireless UWB signals. Thus, Oswald is in the same field of endeavor as the claimed invention of the '246 Patent.

111. Oswald is also reasonably pertinent to the problem solved by the inventors of the '246 Patent. As discussed above, the '246 Patent is directed to solving the problem of employing a first wireless device, such as a mobile communication device, to locate a second wireless device. *See* ¶¶50-51. As demonstrated above, Oswald proposes using the receiving unit to determine positional information relating to an object associated with a UWB transmitter. Thus, a POSITA would have consulted Oswald and applied its teachings when faced with the problem of helping a user locate other wireless devices.

D. *Vauclair*

112. Vauclair teaches a pairing procedure between wireless communication devices. “Pairing is achieved between a host communications device and a peripheral communications device, in order to establish an ad hoc wireless or wired network.” *Vauclair* at Abstract. As will be explained below, the pairing procedure involves a device identification that is displayed to and confirmed by the user. *Id.* The host device (or second device) 20 may be a “mobile telephone” while the peripheral device (or first device) 10 may be a “mobile telephone handsfree kit[.]” *Id.* at [0022]. The devices can “communicate according to any wireless or wired protocol, for example, such as ... Bluetooth [or] Zigbee[.]” *Id.* The hardware components of each device can be seen below in Fig. 1:



Id. at Fig. 1.

113. Importantly, Vauclair explains that the “second electronic device is also provided with user input 28” that the user interacts with “to send a signal to the control circuitry.” *Id.* at [0030]; *see also id.* at [0036] (“For example, to initiate the [pairing] process, the user may select a pairing option from a menu, using the user input 28.”). “[T]he host device 20 then seeks a nearby peripheral device ... by sending a beacon signal (S3 in FIG. 2) containing its identification.” *Id.* at [0037]. Shortly after the peripheral device 10 detects the beacon signal, the two devices perform an authentication procedure for ensuring the pairing procedure is secure. *Id.* at [0039]-[0046].

114. After the authentication procedure, the devices 10, 20 determine whether they are “in fact already paired with the respective other devices.” *Id.* at [0047]. If the two devices are not paired “the host device 20 requests the initiation of a pairing procedure with the peripheral device 10. Specifically, it sends a pairing

request signal (S8 in FIG. 2) to the peripheral device, and ... [t]he peripheral device 10 then returns a pairing started signal (S9 in FIG. 2) to the host device 20[.]” *Id.* at [0049]. The user is then required to confirm the first device 10 by comparing the device identification of the first device 10 to the device identification displayed on the display 26 of the second device 20. *Id.* at [0052]. If the identifications match, “the user accepts the presented device identification ... by pressing an ‘OK’ key on the user input 28 on the host device 20 (S13 in FIG. 2).” *Id.* Once authenticated, paired, and confirmed, the devices “are then able to perform secure wireless (or wired) communications[.]” *Id.* at [0047].

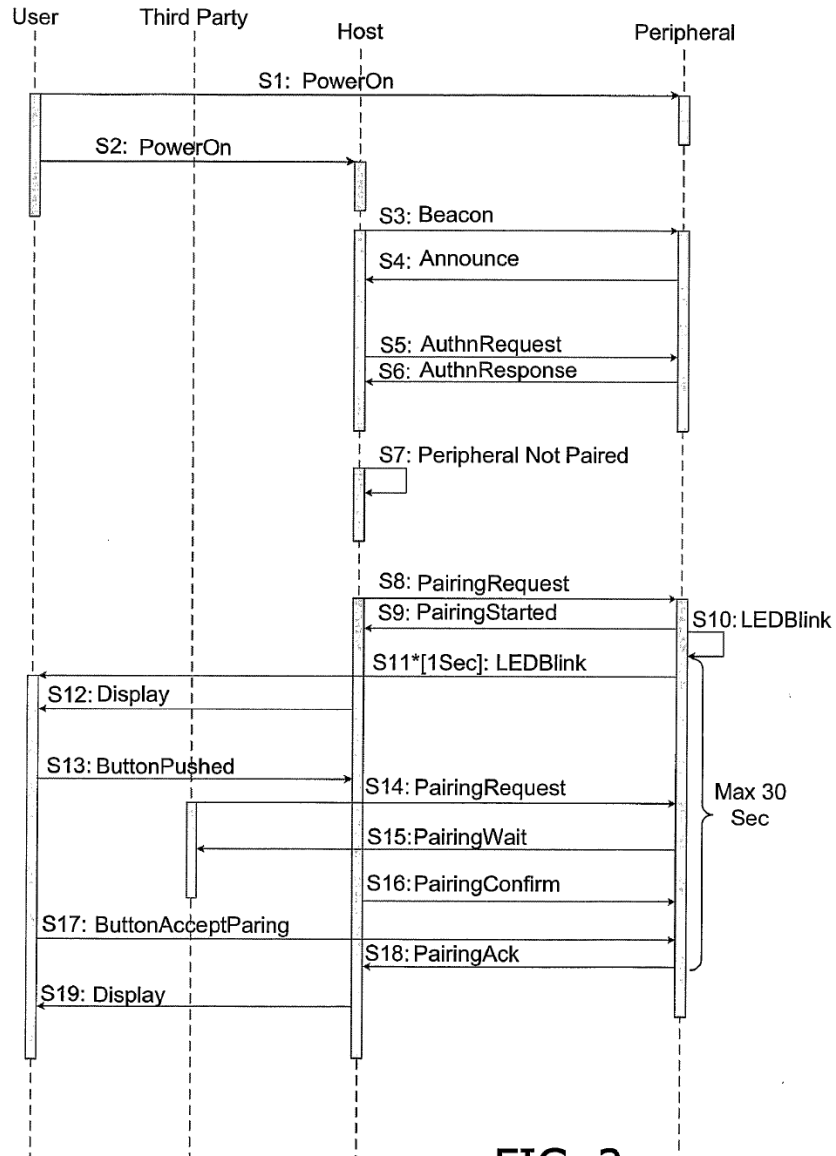


FIG. 2

Id. at Fig. 2.

115. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention.

116. As discussed above, the field of endeavor of the claimed invention of the '246 Patent includes wireless communication devices that send and/or receive wireless signals. *See* ¶¶ 46-49. As demonstrated above, Vauclair's host device is a wireless communication device that sends and receives wireless signals. Thus, Vauclair is in the same field of endeavor as the claimed invention of the '246 Patent.

E. **Kalayjian**

117. Kalayjian recognizes that “[s]mall items get lost” and that “[t]hese items, such as keys or remote controls, often are close by, but can be out of sight.” *Kalayjian* at [0002]. “The resulting search for such objects is tedious, annoying and sometimes unsuccessful if the objects are never found.” *Id.* Kalayjian describes previous devices “designed to aid users in locating lost objects” that “transmit a radio frequency signal to a transceiver which reacts by broadcasting an audio or visual alarm.” *Id.* However, these “[t]raditional location discovery systems have several drawbacks,” including “permanent base units, which broadcast a signal to the lost object” and “take up space and often offer no other functions.” *Id.* at [0003]. Additionally, “[t]he transmitted signal, which is essentially an alert to trigger an alarm, is typically the only type of signal being broadcast” and is often just “a one way signal to the lost device, which can emit a sound, flash a light, etc. to try and let the user know where the device is.” *Id.* Thus, Kalayjian seeks to “provide an improved way to aid people in locating misplaced objects.” *Id.* at [0005].

118. Kalayjian proposes an object-finding system using a “Bluetooth communications protocol” between a paired “first device ... referred to as the master device” and “one or more second devices ... referred to as the slave devices.” *Id.* at Abstract. The slave device can even assist the user in finding its location by “transmit[ting] a return signal to the master device or emit[ting] auditory or visual alerts[.]” *Id.* Fig. 3a shows an example of master device 310 as a “cell phone” and slave device 320 as a “Bluetooth enabled wireless phone headset.” *Id.* at [0033]-[0034].

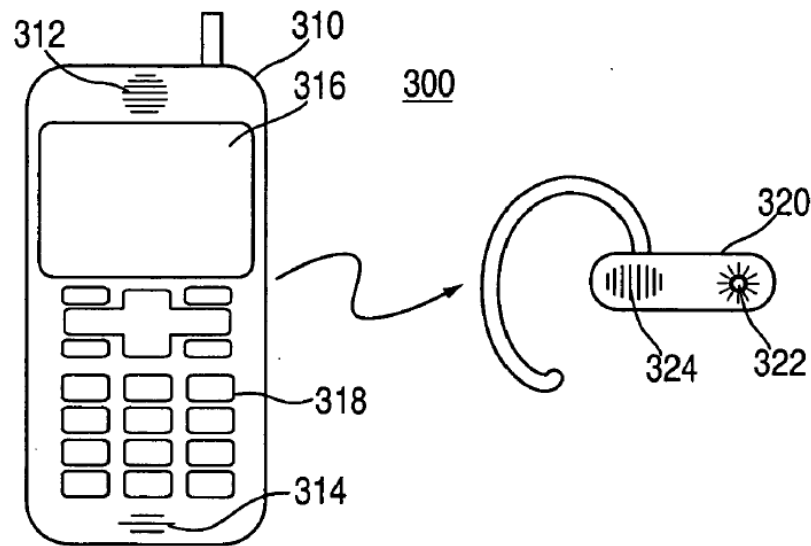


FIG. 3a

Id. at Fig. 3a.

119. “Cell phone 310 can include speaker 312, microphone 314, display screen 316 and keypad 318” while “[h]eadset 320 can include light 322, speaker 324, and microphone 326. Light 322 can be activated to attempt to guide a user to its

location. ... Headset 320 can have speaker 324 to emit sounds operable to guide a user to its location.” *Id.* at [0033]-[0034]. Along with the cell phone example, Kalayjian generally discusses that Bluetooth can be used to “create wireless links between mobile computers, mobile phones and other portable and handheld devices.” *Id.* at [0020].

120. Second device 320 may also be “an attachable device” that is “attached to objects (e.g. keys, etc.) to aid in locating ... [the] objects[.]” *Id.* at [0035]. The attachable device is shown in Fig. 4 as device 400 and “can have light 422 and speaker 424 which function similar to the corresponding features of device 320. ... [D]evice 400 can also be referred to as slave device 400. Once a master device has been paired to slave device 400, a user can create or edit an identifying name in the master device's user interface to correspond to the object that device 400 has been attached to.” *Id.*

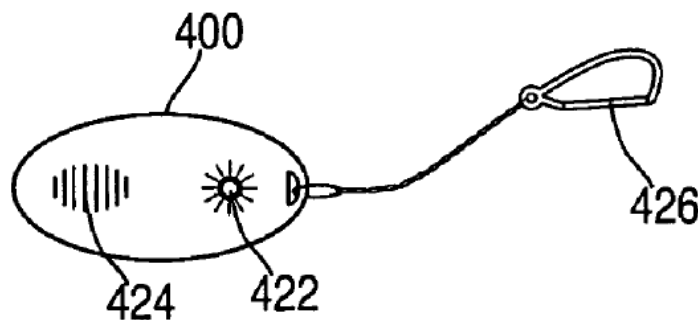


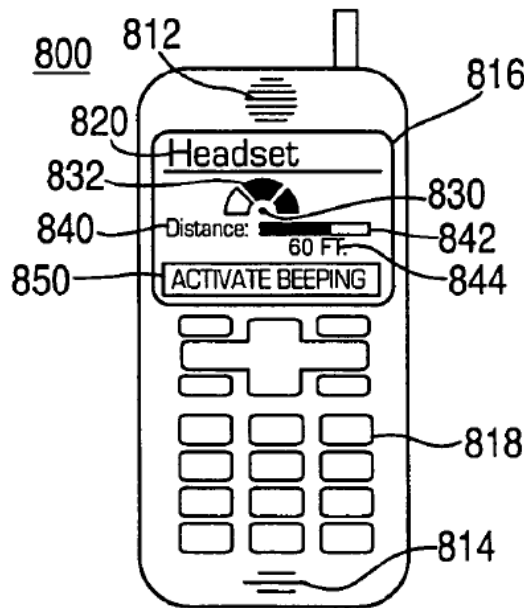
FIG. 4

Id. at Fig. 4.

121. A “user can initiate the location discovery process through master device 310” to “locate one of the slave devices 320 [or] 400[.]” *Id.* at [0038]. “Master device 310 can transmit a signal to a slave device. Upon receiving the signal, the slave device can guide a user to its location and/or notify a user of the distance from master device 310 to the slave device.” *Id.* The distance can be determined by “comparing the amount of time delay between the transmission of the signal sent from the master device to the slave device and the reception of the return signal from the slave device ... [or] by switching the amount of power used to transmit signals and measuring the comparative strength of the received signals.” *Id.* at [0041]. The slave device can additionally guide a user to its location “by emitting auditor or visual signals ... [which] allows a user to follow the sound or light to the misplaced object.” *Id.* at [0039].

122. Kalayjian teaches graphically displaying information to the user via the master device. “The results of [the distance] calculation can be presented to a user through a graphical display on screen 316.” *Id.* at [0040]; *see also id.* at [0042] (“Once this distance is calculated, it can be displayed to the user through graphics on the master device. This information can also affect an auditory or visual signal emitted by the slave device. For example, a beeping alarm might change in pitch, rate of beeping, or volume as a user approaches a second device. In that instance, the beeping could get faster as the user gets closer to the missing device, or the sound

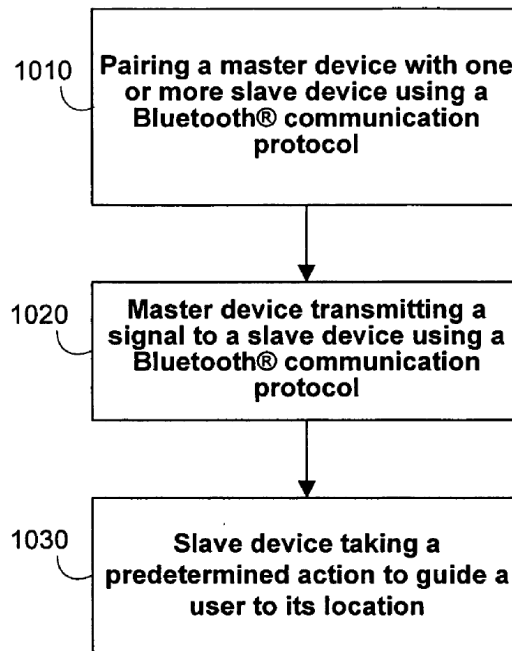
could get louder as the user gets closer.”). An example of the displayed results is shown in Figure 8 as a “screenshot of the user interface of master device 800 when the master device is attempting to locate a slave device.” *Id.* at [0049].



Id. at Fig. 8.

123. “Screen 816 can include title 820 to identify the selected slave device. Screen 816 can include directional graphic 830 to indicate to the user the direction where the slave device should be located. ... Screen 816 can include distance graphic 840 to identify the distance between the selected slave device and master device 800. Distance graphic 840 can include a symbolic representation 842 of distance, for example, a horizontal bar graphic or a numeric representation of distance 844. Screen 816 can include graphical button 850 to enable the user to prompt the slave device to beep, flash or perform a combination of both, or provide some other

indication.” *Id.* at [0049]. Fig. 10 teaches “a flowchart of method 1000 for locating an object.” *Id.* at [0054].



Id. at Fig. 10.

124. “At step 1010, a master device is paired with one or more slave devices using a Bluetooth communications protocol. ... At step 1020, the master device transmits a signal to a slave device using a Bluetooth communications protocol, step 1030, the slave device takes a predetermined action to guide a user to its location. The predetermined action could be, for example, turning on a light, emitting a sound, or transmitting a signal back to the master device with information about the slave device’s location.” *Id.* at [0054].

125. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed

invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention or if it is reasonably pertinent to the particular problem that the inventor was trying to solve.

126. As discussed above, the field of endeavor of the claimed invention of the '246 Patent includes wireless communication devices that send and/or receive wireless signals. *See* ¶¶ 46-49. As demonstrated above, Kalayjian's master device is a wireless communication device (i.e., first/master device 310) that sends and receives wireless signals. Thus, Kalayjian is in the same field of endeavor as the claimed invention of the '246 Patent.

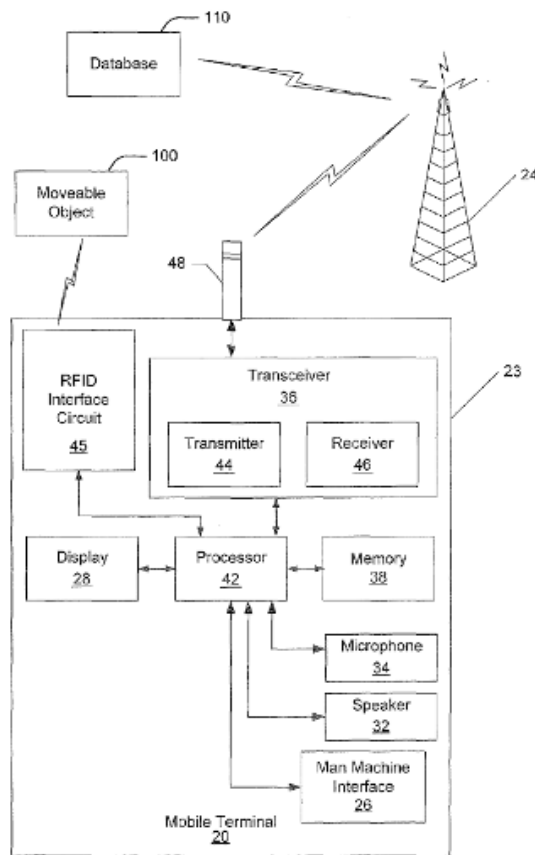
127. Kalayjian is also reasonably pertinent to the problem solved by the inventors of the '246 Patent. As discussed above, the '246 Patent is directed to solving the problem of employing a first wireless device, such as a mobile communication device, to locate a second wireless device. *See* ¶¶ 50-51. As demonstrated above, Kalayjian proposes using the master device to help the user locate a slave device, which may be a wireless accessory, such as a Bluetooth headset, or a wireless device attached to an object, such as the user's keys. Thus, a POSITA would have consulted Kalayjian and applied its teachings when faced with the problem of helping a user locate other wireless devices.

F. **Thorn**

128. Thorn teaches “methods, computer program products, terminals, and systems for providing location information associated with moveable objects.” *Thorn* at [0004]. An RFID tag is attached to the movable object, which “can be wallets, keys, mobile telephones, clothing, automobiles, and may even be included in printed inks on, for example, paper.” Thorn additionally discloses that Bluetooth tags can be used in place of the RFID tags. *Id.* at [0032]. Thorn teaches communication between mobile terminals such that the moveable object can be located when lost:

Embodiments of such systems may include a database that is configured to associate multiple terminals and respective ID information corresponding to moveable objects, a first terminal that is configured to receive identification (ID) information from a movable object via Radio Frequency Identification (RFID) signal and generate location information corresponding to the location of the first terminal, and a second terminal that is associated with the ID information corresponding to the movable object, the second terminal is configured to receive the ID information and location information corresponding to the first terminal.

Id. at [0014]. FIG. 1 shows a “schematic diagram[]” of a mobile terminal. *Id.* at [0033].



Id. at Fig. 1. Thorn teaches the mobile terminals can be “a cellular phone” and are capable of communication over a “cellular network.” *Id.* at [0035]-[0036].

129. The RFID tag stores identification (ID) information “that can uniquely identify the moveable object 100 associated with the tag.” *Id.* at [0042]. A first mobile terminal “periodically receives unique Identification (ID) Information from RFID tags coupled to moveable objects, such as a wallet, a briefcase, a set of keys, rental equipment, etc.” *Id.* at [0030]. Once received, “[t]he first terminal can then send the ID information to a database to determine if the moveable object is associated with the first terminal.” *Id.* If it is determined the moveable object is not

associated with the moveable object, “location information” that is “available through a network in which the first terminal communicates” can be determined. *Id.* This location information can then be transmitted to “a second terminal that is associated with the ID information” for a moveable object. *Id.* at [0031].

130. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention or if it is reasonably pertinent to the particular problem that the inventor was trying to solve.

131. As discussed above, the field of endeavor of the claimed invention of the '246 Patent includes wireless communication devices that send and/or receive wireless signals. *See* ¶¶ 46-49. As demonstrated above, Thorn’s mobile terminal is a wireless communication device that sends and receives wireless signals. Thus, Thorn is in the same field of endeavor as the claimed invention of the '246 Patent.

132. Thorn is also reasonably pertinent to the problem solved by the inventors of the '246 Patent. As discussed above, the '246 Patent is directed to solving the problem of employing a first wireless device, such as a mobile communication device, to locate a second wireless device. *See* ¶¶ 50-51. As demonstrated above, Thorn proposes using the mobile terminal to help the user

locate an RFID or Bluetooth tag associated with a moveable object. Thus, a POSITA would have consulted Thorn and applied its teachings when faced with the problem of helping a user locate other wireless devices.

G. **Sharp**

133. Sharp teaches “remotely communicating with a mobile device” to cause “the mobile device to perform a function through the transmission of one or more remote commands,” such as a “sound command [that] can cause a mobile device to output an auditory alert.” *Id.* at [0002], [0041]. Sharp recognizes the need for remotely communicating with mobile devices “[b]ecause mobile devices are sized for portability, they easily can be misplaced” and “because mobile devices often are carried to many different locations, they can be forgotten or lost.” *Id.* at [0004].

134. Sharp teaches an exemplary computing environment including a user station 110, which may be “a personal computing device, such as a desktop or workstation, or a portable computing device, such as a laptop or smart phone,” that communicates with an application server 115 via communication network 105. *Id.* at [0032]-[0035]. “Also, the user station 110 includes an interface application, such as a web browser or custom application, for communicating with a web-enabled application [e.g., a remote management application].” *Id.* at [0033]. “[T]he computing environment 100 can include one or more mobile devices, such as a mobile telephone 120, a digital media player 125, and a laptop computer 130,” which

are configured to establish a connection to the communication network 105.” *Id.* at [0039]. “The communication network 105 can be any type of network, including a local area network (‘LAN’), such as an intranet, and a wide area network (‘WAN’), such as the internet.” *Id.* at [0031].

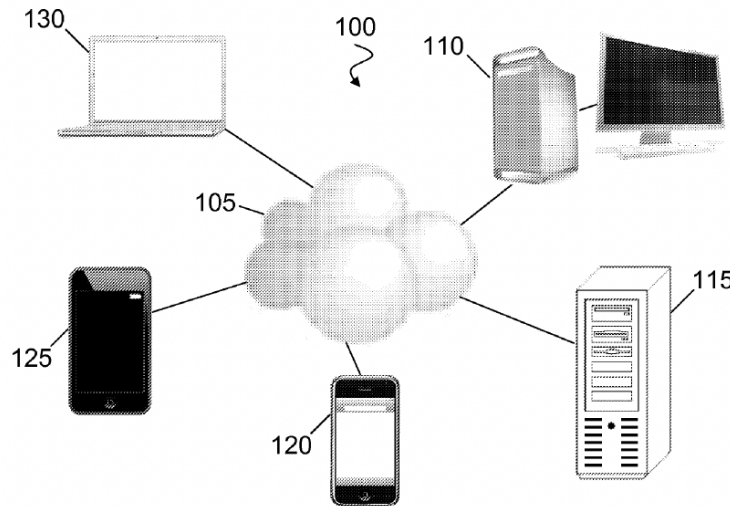


FIG. 1

Id. at Fig. 1.

135. “A remote management application can be configured to remotely command one or more linked mobile devices by publishing remote command messages to a notification service.” *Id.* at [0051]. “Once access to a remote management account has been granted, a list of mobile devices linked with the remote management account can be presented (310).” *Id.* at [0053]. “The list of mobile devices identifies each of the managed devices associated with the remote management account.” *Id.* “A mobile device can be selected from the list of managed

devices (315).” *Id.* at [0054]. “For example, the account owner can select a mobile device that has been misplaced.” *Id.*

136. “A remote command to be executed by the mobile device can be selected from the available remote commands (325).” *Id.* at [0055]. An exemplary remote command includes a “locate command” that causes the mobile device to “determine its present location (810)” and “publish a result message” including the location information. *Id.* at [0079], [0081]. Another exemplary remote command is a “sound command” that “cause[s] a mobile device to output an auditory alert.” *Id.* at [0041]. “The remote management application can generate and transmit the selected remote command to the notification service.” *Id.* at [0056]. “The notification service can publish the remote command and send a notification message to the mobile device subscribing to the command collection topic.” *Id.*

137. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be “analogous art” to the claimed invention. I have been informed that a prior art reference is analogous to the claimed invention if the reference is from the same field of endeavor as the claimed invention or if it is reasonably pertinent to the particular problem that the inventor was trying to solve.

138. As discussed above, the field of endeavor of the claimed invention of the ’246 Patent includes wireless communication devices that send and/or receive

wireless signals. *See* ¶¶ 46-49. As demonstrated above, Sharp's personal station 110 and mobile devices 120, 125, 130 are all wireless communication devices that send and receive wireless signals. Thus, Sharp is in the same field of endeavor as the claimed invention of the '246 Patent.

139. Sharp is also reasonably pertinent to the problem solved by the inventors of the '246 Patent. As discussed above, the '246 Patent is directed to solving the problem of employing a first wireless device, such as a mobile communication device, to locate a second wireless device. *See* ¶¶ 50-51. As demonstrated above, Sharp proposes using the personal station to help the user locate a mobile device that has been misplaced. Thus, a POSITA would have consulted Sharp and applied its teachings when faced with the problem of helping a user locate other wireless devices.

IX. SUMMARY OF UNPATENTABILITY

140. I have reproduced the Proposed Grounds of Unpatentability from the Petition for ease of reference:

Proposed Grounds of Unpatentability
<u>Ground 1:</u> Claims 1 and 11-14 are obvious under § 103 over Kalliola, Turunen, Oswald, Vauclair, and Kalayjian
<u>Ground 2:</u> Claims 2-5 and 15-18 are obvious under § 103 over Kalliola, Turunen, Oswald, Vauclair, Kalayjian, and Thorn
<u>Ground 3:</u> Claims 6-10 and 19 are obvious over Kalliola, Turunen, Oswald, Vauclair, Kalayjian, Thorn, and Sharp

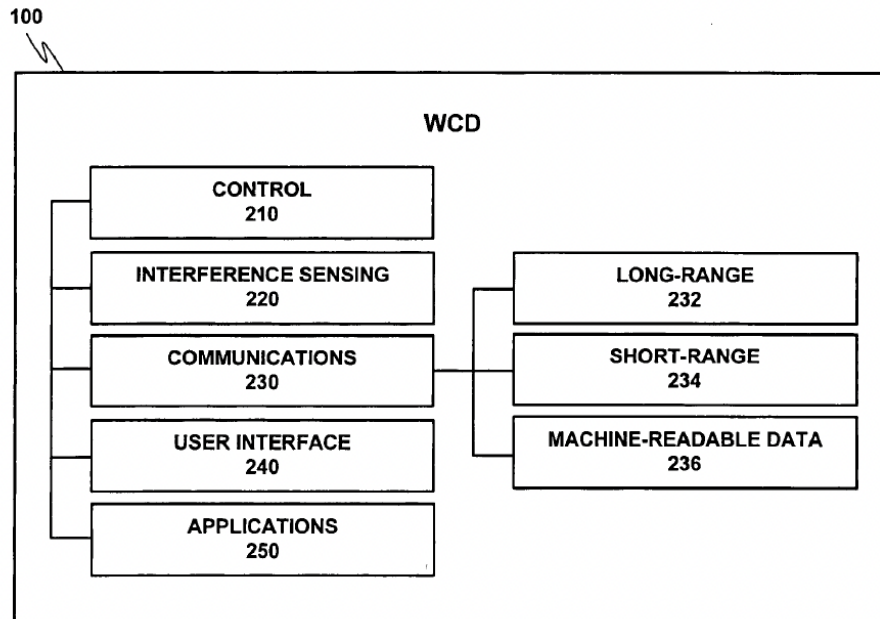
X. CLAIMED PROCESSOR OPERATES EXECUTING OPERATIONAL INSTRUCTIONS

141. The Challenged Claims include the limitation a “processor is configured to execute the operational instructions, which upon execution, cause the processor to” perform the various claimed steps. *See* Claim 1(d)(ii). As I discuss below, Kalliola is the primary reference for each of the grounds presented. Kalliola teaches a processor that executes operational instructions. *Kalliola* at [0043] (“Processor 300 may be implemented with one or more microprocessors that are each capable of executing software instructions stored in memory 330.”); [0045] (“The software components stored by memory 330 include instructions that can be executed by processor 300.”). Given Kalliola’s disclosures and functionality, a POSITA would have understood or found obvious that for each claimed step, Kalliola’s processor—alone or Kalliola’s processor as modified by another reference—“executes the operational instructions, which upon execution, cause the processor to” perform the claimed step.

142. For example, Kalliola’s processor 300 executes “software instructions” stored in memory. *Kalliola* at [0043], [0045]. Kalliola further teaches that “[p]rocessor 300 controls overall device operation,” and WCD 100 (which includes processor 300) “implements the functionality” of the disclosed system. *Id.* at [0043]. Kalliola’s WCD also includes memory 330 that stores various software instructions for WCD operation, including “software components that control the operation of

communication sections 310, 320 and 340,” a “user interface manager, and any communications utilities modules required to support WCD 100.” *Id.* at [0045].

143. Kalliola discloses software modules shown in Fig. 2 are implemented by the hardware of Fig. 3, including control module 210, user interface module 230, and applications module 250. *Id.* at [0043] (“FIG. 3 discloses an exemplary structural layout of WCD 100 according to an embodiment of the present invention that may be used to implement the functionality of the modular system previously described in FIG. 2.”). Kalliola notes that the software components are also referred to as “modules.” *Id.* at [0044] (“Memory 330 may include random access memory (RAM), read only memory (ROM), and/or flash memory, and stores information in the form of data and **software components (also referred to herein as modules).**”) (emphasis added). Further, Fig. 3 provides the structural description of the WCD’s modular/software components described in Fig. 2. *Id.* at [0018]-[0019], [0038] (disclosing Fig. 2 is the modular layout for the WCD with the functions performed by software and/or hardware components).



Id. at Fig. 2.

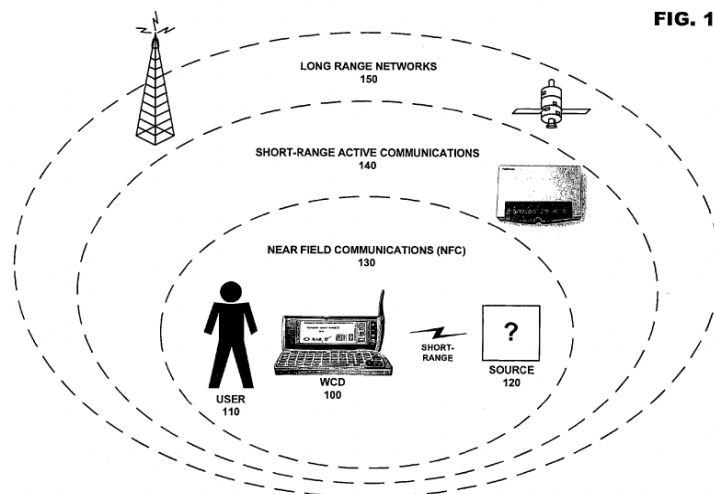
144. Kalliola further explains that “[c]ontrol module 210 regulates the operation of the device. Inputs may be received from various other modules included within WCD 100....Control module 210 interprets these data inputs, and in response, may issue control commands to the other modules in WCD.” *Id.* at [0039]. “User interface module 240...allow[s] the user 110 to receive data from, and enter data into, the device. The data entered by user 110 may be interpreted by control module 210 to affect the behavior of WCD 100.” *Id.* at [0041] [0051] (discussing user interface 350). User interface 350 “is also coupled to processor 300” and “may interact with a communication utilities software component, also contained in memory,” that allows for reception of services from remote devices. *Id.* at [0050], [0054].

145. Kalliola teaches applications module 250 “incorporates all other hardware and/or software applications on WCD 100,” which may include “data applications” “invoked by a control module 210” to read and supply information to other modules in WCD 100. *Id.* at [0042]. For example, Kalliola describes a tracking application 922 that “determine[s] the relative directions towards a target.” *Id.* at [0080]. Kalliola describes various steps performed by the tracking application as executed by the WCD. *Id.* at [0080]-[0082], Fig. 9. Because Kalliola expressly teaches the WCD’s memory stores software components for performing numerous actions “required to support WCD 100,” such actions include the tracking application, as the tracking application includes functionality related to, at the least, communication sections and user interface manager (e.g., managing interactions with the GUI). *Id.* at [0045]. Therefore, Kalliola’s processor that executes software instructions (e.g., tracking application 922), causes the processor to perform the claimed step because the processor “controls overall device operation.” *Id.* at [0043]. If the mapping requires modification of Kalliola’s system to perform the claimed step, a POSITA would have understood it would have been obvious for the Kalliola processor and stored software instructions to perform the claimed step per the motivations to combine provided in the mapping for the claimed step.

XI. OPINIONS REGARDING GROUND 1: CLAIMS 1 AND 11-14 ARE OBVIOUS OVER KALLIOLA, TURUNEN, OSWALD, VAUCLAIR, AND KALAYJIAN

A. 1[P]: “A mobile communication device comprising:”

146. Kalliola’s wireless communication device (WCD) is a *mobile communication device*.¹ Kalliola recognizes that “wireless **communication devices** (WCDs) have become commonplace for both personal and business use” and allow users to perform numerous functions. *Kalliola* at [0004] (emphasis added). The WCD “may be anything from a basic cellular handset to a more complex device such as a wirelessly enabled palmtop or laptop computer.” *Id.* at [0034]. As shown in Fig. 1 below, the wireless *communication device* communicates via long-range, short-range, and near-field wireless communication networks:



Id. at Fig. 1; *see also, id.* at [0034]-[0036], [0040], [0046]-[0049], Figs. 2-3, 5-7.

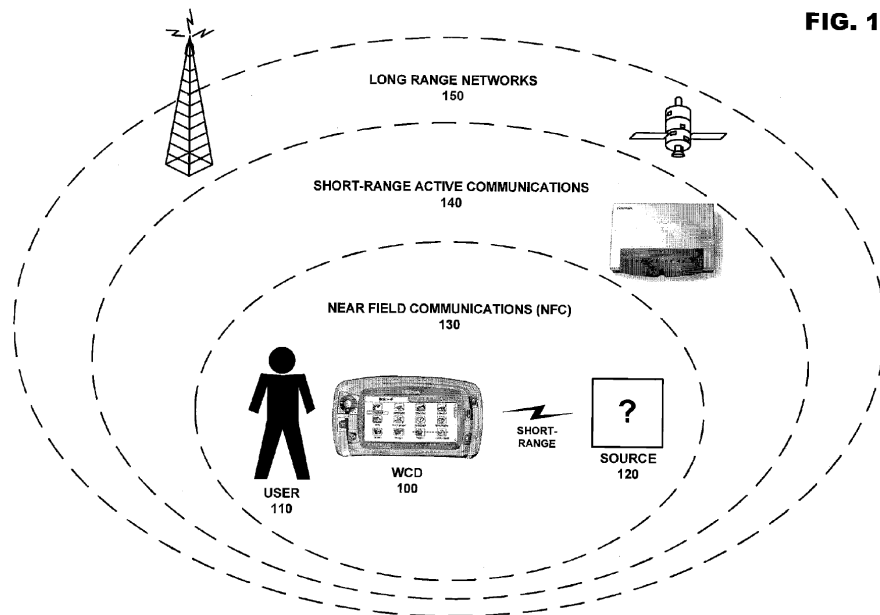
¹ I have emphasized the claim language throughout with italics and underline for clarity.

147. The WCD is also *mobile* at least because it is a “cellular telephone or other handheld wireless device[]” that the user moves around. *Id.* at [0037], [0014] (“When the WCD is **moved...**”) (emphasis added), [0069] (“As the **user moves** toward the selected target, WCD 100 will continuously measure the signal of the target device...”) (emphasis added), [0082] (“User 110 may be prompted by visual indicia appearing on the display to **move WCD 100...**”) (emphasis added); *see also*, *id.* at Figs. 1, 9A, 10, 13 (illustrating mobile communication devices).

B. 1(a): “a plurality of wireless transceivers including a Bluetooth transceiver, a long-range transceiver configured to send and receive telephone calls via a telephony network and to communicate Internet data, and one or more ultra-wideband transceivers coupled to two or more antennas;”

1. *Kalliola’s Teachings of “a plurality of wireless transceivers including a Bluetooth transceiver, a long-range transceiver configured to send and receive telephone calls via a telephony network... and one or more ultra-wideband transceivers”*

148. Kalliola’s WCD includes *a plurality of wireless transceivers*. As depicted in Fig. 1, Kalliola discloses that the “WCD may **both transmit and receive** information over a wide array of **wireless communication networks**, each with different advantages regarding speed, range, quality (error correction), security (encoding), etc.” *Id.* at [0033] (emphasis added).

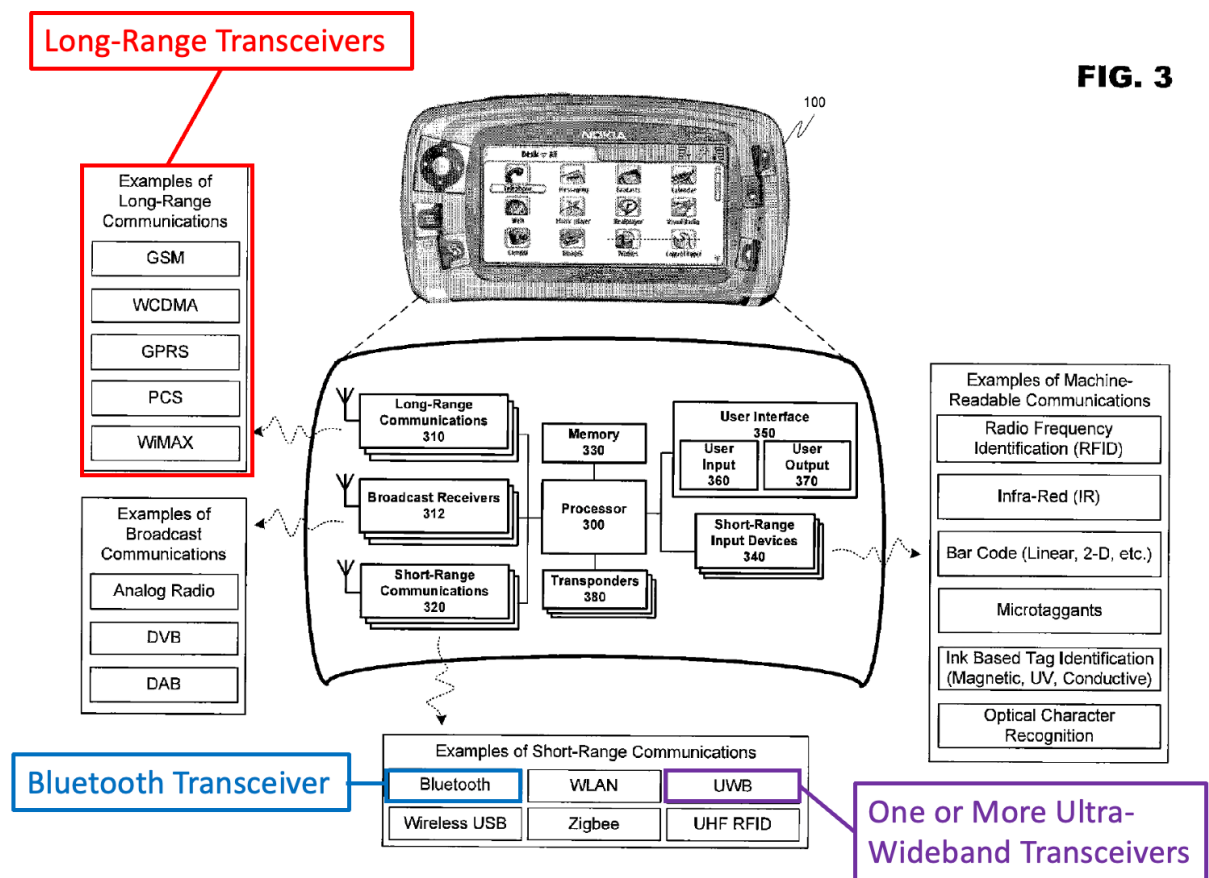


Id. at Fig. 1.

149. While Kalliola does not use the word “transceiver,” I note that it was well understood to POSITAs at the time of the ’246 Patent that any device that transmits and receives signals is a *transceiver*. See e.g., *Newton* at 846 (defining “Transceiver” as “Any device that transmits and receives.”). Indeed, the word “transceiver” is simply an amalgamation of the words “transmitter” and “receiver.” Thus, Kalliola’s disclosures of hardware components that transmit and receive information over wireless communication networks are express disclosures of *wireless transceivers*.

150. Kalliola’s WCD includes a communications module 230 having long-range communications module 232 and short-range communications module 234, which are used “to **receive** a multitude of different types of communication from

both local and long distance sources, and to **transmit** data to recipient devices within the transmission range of WCD 100.” *Id.* at [0040], [0041] (disclosing communications module may receive/transmit information), Fig. 2, [0038]. Kalliola explains that the structural layout of Fig. 3 is “used to implement the functionality of the modular system previously described in FIG. 2.” *Id.* at [0043]. Long-range communications 310 and short-range communications 320 are hardware components of the WCD performing the disclosed functionality of transmitting/receiving data. *Kalliola* at [0052], [0043].



Id. at Fig. 3 (annotated).

151. One such wireless transceiver component is the WCD's "[l]ong-range communications 310," which "performs functions related to the exchange of information over large geographic areas (such as cellular networks) via an antenna." *Kalliola* at [0046]. "[L]ong-range communications 310 may operate to **transmit and receive** messages" and provide "basic voice communications (e.g., via GSM)[.]" *Id.* (emphasis added). Long-range communications 310 is a wireless transceiver because it transmits and receives information in a wireless cellular network.

152. Cellular networks, including GSM networks, are telephony networks that "provide[] voice communication[.]" *Id.* at [0005]; *see also, id.* at [0004] ("These wireless communication devices (WCDs) have become commonplace for both personal and business use, allowing users to **transmit and receive voice...**") (emphasis added), [0005] ("[S]tarting in the late 1970s to early 1980s with first generation (1G) analog cellular telephones that provided baseline **voice communications...**") (emphasis added), [0008] ("Wireless communication devices employing the previously discussed characteristics may be used for a variety of applications other than basic **voice communications.**") (emphasis added).

153. This is consistent with the '246 Patent, which lists GSM as an example of a "wireless telephone network[]" providing "wireless telephony and messaging[.]" '246 Patent at 2:19-28. The '246 Patent also discloses that "long range wireless transceiver module 306" is "a wireless telephony receiver for

communicating voice and/or data signals in conjunction with a handheld wireless communication device network[.]” *Id.* at 30:15-19.

154. Because Kalliola’s long-range communications 310 transmits and receives voice communications via a GSM network, it qualifies as a long-range transceiver configured to send and receive telephone calls via a telephony network.

155. I have been informed that the express, implicit, and inherent disclosures of a prior art reference may be relied upon for an obviousness analysis. I understand that the fact that a claim limitation **may** be present in the prior art is not sufficient to establish the inherency. Rather, the limitation must be necessarily present in the reference.

156. In my opinion, Kalliola expressly or implicitly teaches the long-range communications 310 is a long-range transceiver because Kalliola teaches transmission and reception of voice/data performed wirelessly across cellular networks. As I discussed above, a transceiver was (and still is) well known to those skilled in the art as a device that transmits and receives signals. *See, e.g., Newton* at 846. Thus, Kalliola’s express teachings of the long-range communications 310 transmitting and receiving voice/data is an express teaching of a transceiver.

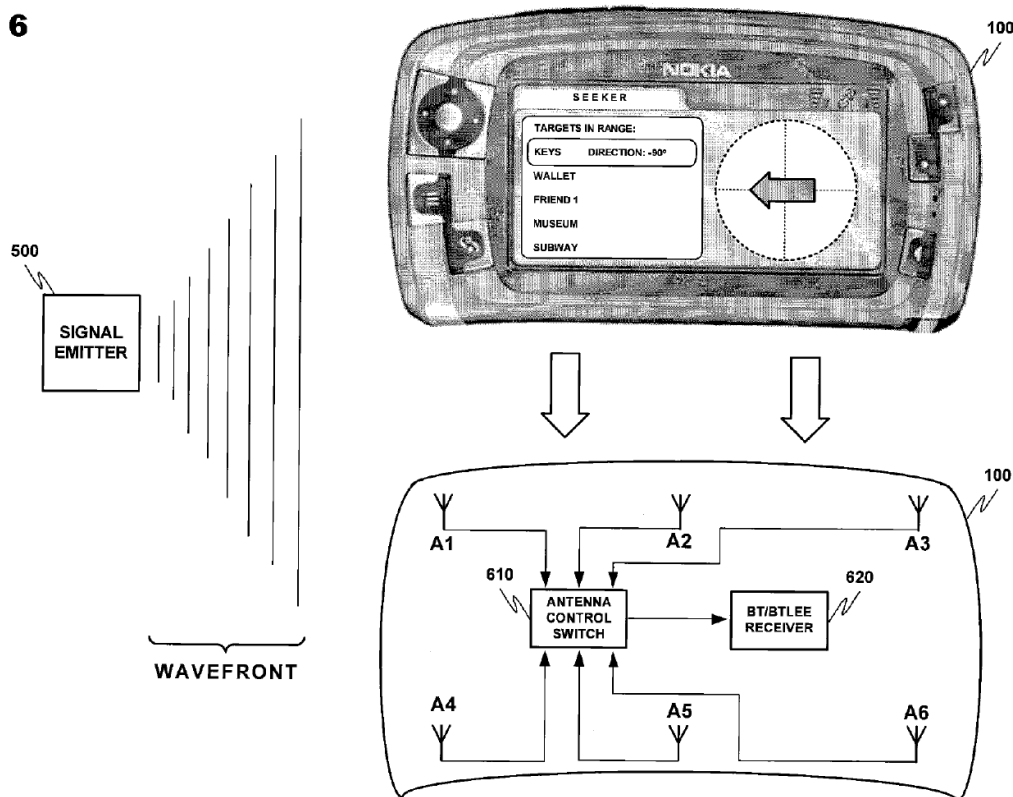
157. Kalliola also at least inherently teaches the long-range communications is a wireless long-range transceiver because a POSITA would have known that performing the disclosed wireless transmission/reception of data across cellular

networks such as GSM necessarily requires a long-range wireless transceiver. *See e.g., Orsatti* at 1869-1870 (describing “the specifications for the RF transceiver of a small mobile station (MS)” in a GSM network).

158. Finally, a POSITA would have found Kalliola renders obvious a long-range wireless transceiver, at least because (1) Kalliola expressly suggests the long-range communications 310 transmitting and receiving voice/data; (2) “the present invention may be implemented using a variety of wireless communication equipment”; and (3) wireless long-range transceivers were ubiquitous in mobile communication devices well prior to the ’246 Patent. *Kalliola* at [0004]-[0006] (describing cellular networks “starting in the late 1970s to early 1980s with first generation (1G) analog cellular telephones that provided baseline voice communications, to modern digital cellular telephones”), [0008], [0037]; *see also*, ¶ 77.

159. Another wireless transceiver component is the WCD’s “[s]hort-range communications 320,” which “performs functions related to the establishment of short-range connections, as well as processing related to the **transmission and reception** of information via such connections.” *Kalliola* at [0048] (emphasis added). Examples of short-range wireless networks include “**Bluetooth™**, WLAN, **UWB [Ultra-Wideband]**, and Wireless USB connections.” *Id.* (emphasis added).

160. “FIG. 6 includes a structural diagram of WCD 100” where “WCD 100 includes any and or all of the elements and features previously disclosed in FIG. 2 and 3.” *Id.* at [0070]. This diagram depicts “receiver 620” which “is a Bluetooth™ or Bluetooth Low End Extension (BTLEE) receiver, also known as BluLite.” *Id.* at [0071].

FIG. 6

Id. at Fig. 6; *see also, id.* at Fig. 7 (depicting “CONVENTIONAL BTLEE RECEIVER”).

161. Even though Figures 6 and 7 only depict the Bluetooth/BTLEE receiver 620/720, a POSITA would have understood that the Bluetooth standards required a

Bluetooth transceiver as part of the core system. *See e.g., Bluetooth Specification Vol. 1* at 13; *802.15.1-2005* at 19.

162. Because Kalliola's short-range communications 320 transmits and receives information over Bluetooth and UWB networks, it includes a Bluetooth transceiver and an ultra-wideband transceiver.

163. Kalliola expressly or implicitly teaches the short-range communications 320 includes a wireless transceiver because Kalliola teaches transmission and reception of data performed across short-range wireless networks, such as Bluetooth and UWB.

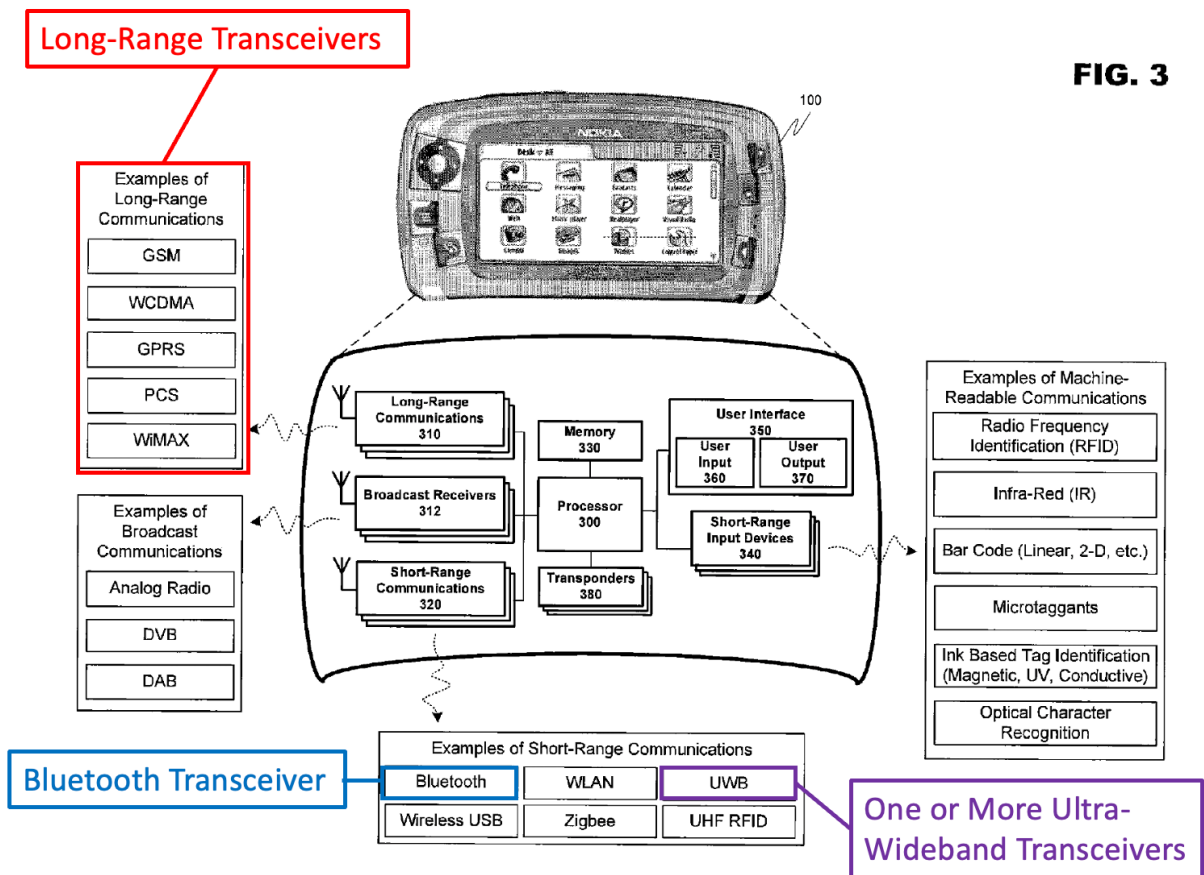
164. Kalliola also at least inherently teaches the short-range communications 320 includes a wireless transceiver because a POSITA would have known that to perform the disclosed wireless transmission/reception of data using a Bluetooth or UWB communications protocol necessarily requires a short-range wireless transceiver. For example, a POSITA would have understood that the Bluetooth standards required a Bluetooth device to include a transceiver as part of the core system. *See e.g., Bluetooth Specification Vol. 1* at 13; *802.15.1-2005* at 19. Likewise, the UWB standards required a UWB device to include a UWB transceiver. *See e.g., 802.15.4a Standard* at 4 ("The features of the PHY are activation and deactivation of the radio **transceiver**...") (emphasis added), 34 ("The new state in which to configure the **transceiver**...") (emphasis added), 178 ("*Transceiver and modulation*."

Transceiver can be simplex, full-duplex or semi-duplex.”) (emphasis in original).

Thus, Kalliola’s teachings of transmitting and receiving Bluetooth and UWB signals mean that a wireless transceiver is necessarily present.

165. Finally, a POSITA would have found Kalliola renders obvious a short-range wireless transceiver, at least because (1) Kalliola expressly teaches that short-range communications 320 transmits and receives wireless signals; (2) “the present invention may be implemented using a variety of wireless communication equipment”; and (3) wireless short-range transceivers were ubiquitous in mobile communication devices prior to the ’246 Patent. *Kalliola* at [0006] (describing popular prior short-range wireless networks including UWB and Bluetooth, which “is an example of a short-range wireless technology quickly gaining acceptance in the marketplace.”), [0008], [0037], [0048]; *see also*, ¶¶ 74-78.

166. For all these reasons, Kalliola’s WCD includes a plurality of wireless transceivers including a Bluetooth transceiver, a long-range transceiver configured to send and receive telephone calls via a telephony network... and one or more ultra-wideband transceivers as depicted in the annotated version of Fig. 3 below:



Kalliola at Fig. 3 (annotated).

167. To the extent it is determined that *Kalliola* does not expressly teach including a Bluetooth transceiver and a UWB transceiver, a POSITA would have found it obvious and been motivated to include both a Bluetooth transceiver and a UWB transceiver in the WCD's short-range communications module at least due to the express suggestions provided by *Kalliola*. As I have discussed, *Kalliola* teaches that short-range wireless networks, such as Bluetooth and UWB, "provide communication solutions that avoid some of the problems seen in large cellular networks." *Kalliola* at [0006]. Per *Kalliola*, "Bluetooth™ is an example of a short-

range wireless technology quickly gaining acceptance in the marketplace.” *Id.*

Indeed, a POSITA would have understood that cellular phones on the market at the time of the ’246 Patent commonly included Bluetooth transceivers. *See* ¶¶ 73-77.

Kalliola teaches that “[i]n addition to Bluetooth™ other popular short-range wireless networks include...UWB” and that “[a]ll of these wireless mediums have features and advantages that make them appropriate for various applications.” *Kalliola* at [0006].

168. Based on Kalliola’s express teaching, suggestion, and motivation, a POSITA would have been motivated to include both a Bluetooth transceiver **and** a UWB transceiver in Kalliola’s WCD to take advantage of the “features and advantages” of the Bluetooth and UWB wireless networks. Bluetooth had been in use for approximately a decade prior to the alleged invention of the ’246 Patent, and UWB communications were included in the IEEE 802.15.4a standard of 2007. *See* ¶59 (describing IEEE ultra-wideband standard), ¶¶73-74 (describing origins of Bluetooth). Further, it was common practice at the time of the ’246 Patent to include multiple wireless transceivers with different standards within a single wireless communications device for convenience and flexibility. For example, the iPhone included cellular, Wi-Fi, and Bluetooth transceivers. *iPhone User’s Guide* at 13. Because Bluetooth and UWB were both well-known, standardized wireless

protocols, there would have been a reasonable expectation of success incorporating Bluetooth and UWB transceivers in Kalliola's WCD.

2. *Kalliola and Turunen teach “a long-range transceiver configured ... to communicate Internet data”*

169. As I discussed above, Kalliola's long-range communication 310 qualifies as a long-range transceiver configured to send and receive telephone calls via a telephony network. Kalliola also teaches that long-range communications module 310 is configured to enable data communication sessions via GPRS and/or UMTS. *Kalliola* at [0046] (“[L]ong-range communications 310 may operate to establish **data communications sessions, such as General Packet Radio Service (GPRS) sessions and/or Universal Mobile Telecommunications System (UMTS) sessions.**”) (emphasis added). I note that Kalliola further recognizes that Internet access is available utilizing long-range networks. *Id.* at [0036]. While Kalliola discusses data communications, Kalliola does not specify what kind of data is communicated during the data communications sessions. A POSITA would have looked to references that describe GPRS and/or UMTS data communications to understand the specific types of data these protocols were designed to communicate.

170. One such reference is Turunen, which describes a “method of transmitting **Internet data** between a mobile host and a remote host coupled via the Internet and a GSM/GPRS cellular telephone network.” *Turunen* at Abstract. Turunen describes “the situation where a mobile host (MH) is connected to the

Internet via a digital cellular telephone network.” *Id.* at 5:30-32. Turunen teaches “this network is a GSM phase 2 network which allows for the transmission of user data by either a High Speed Circuit Switched Data (HSCSD) transmission link or by a General Packet Radio Service (GPRS) link” and “**Internet data** may be transmitted between the MH and the Internet via either of these links.” *Id.* at 5:33-38 (emphasis added). The mobile host is “a radio telephone wirelessly connected to the radio telephone device.” *Id.* at 4:36-40; *see also, id.* at 2:65–3:2 (“With the increased use of mobile cellular telephones, there is a growing demand for so-called **mobile Internet access, where access is made from a portable computer connected to a cellular telephone or from an integrated computer/cellular phone device.**”) (emphasis added). Thus, Turunen teaches utilizing a GPRS link to communicate Internet data via a GSM cellular network.

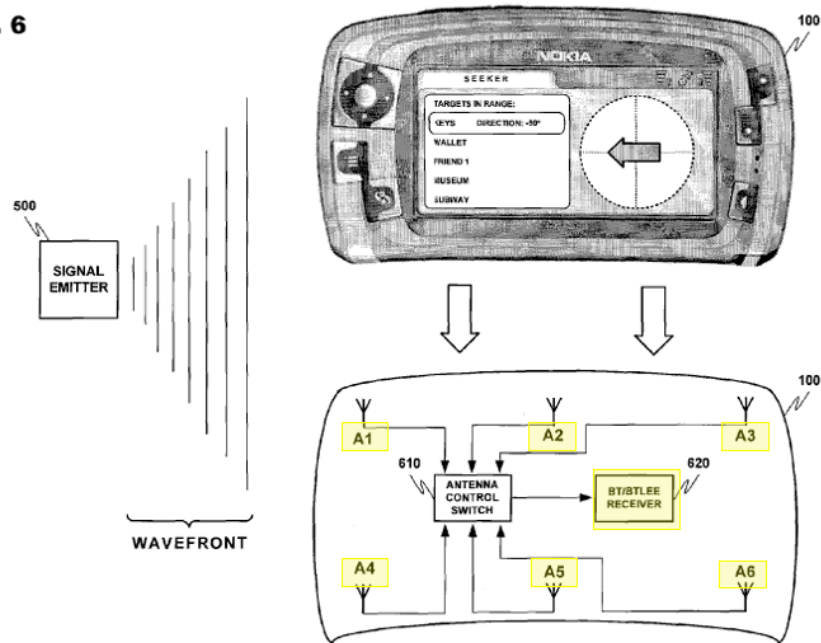
171. Based on the teachings of Turunen, it would have been obvious, and a POSITA would have been motivated to configure Kalliola’s GSM cellular transceiver to communicate Internet data using a GPRS link. At the time of the ’246 Patent, cellular devices that communicated Internet data were commonplace in the market. *See e.g., Beach* at 1036 (“Smartphones now allow millions of people to be connected to the Internet all the time and support mature development environments for third-party application developers. This has put personal computing power in the pockets of users and at the same time, given them ubiquitous access to rich online

social network information.”). Given the popularity of cellular devices providing Internet access, a POSITA would have been motivated to combine these prior art elements according to known methods to yield the predictable result of enabling Kalliola’s WCD to wirelessly communicate Internet data using GPRS data communication sessions on the GSM network. Because GPRS was specifically designed to handle Internet communications and had been in use for nearly a decade prior to the invention of the ’246 Patent, there would have been a reasonable expectation of success configuring Kalliola’s cellular transceiver to wirelessly communicate Internet data using GPRS data communication sessions. *See e.g., Bettstetter* at Abstract (1999 article describing GPRS as “a new bearer service for GSM that greatly improves and simplifies wireless access to packet data networks, e.g., to the Internet.”).

3. *Kalliola and Oswald teach one or more ultra-wideband transceivers coupled to two or more antennas*

172. Kalliola teaches an embodiment of the WCD in which the Bluetooth transceiver is coupled to an array of six antennas. *Kalliola* at [0071] (“In at least one embodiment of the present invention, receiver 620 is a Bluetooth™ or Bluetooth Low End Extension (BTLEE) receiver....BT/BTLEE receiver 620 receives signals multiplexed from Antennas A1-A6.”), [0070] (“**Antennas A1-A6** may be coupled to antenna control switch 610. Control switch 610 multiplexes the antennas so that one receiver 620 may monitor incoming transmissions from all of the antennas.”).

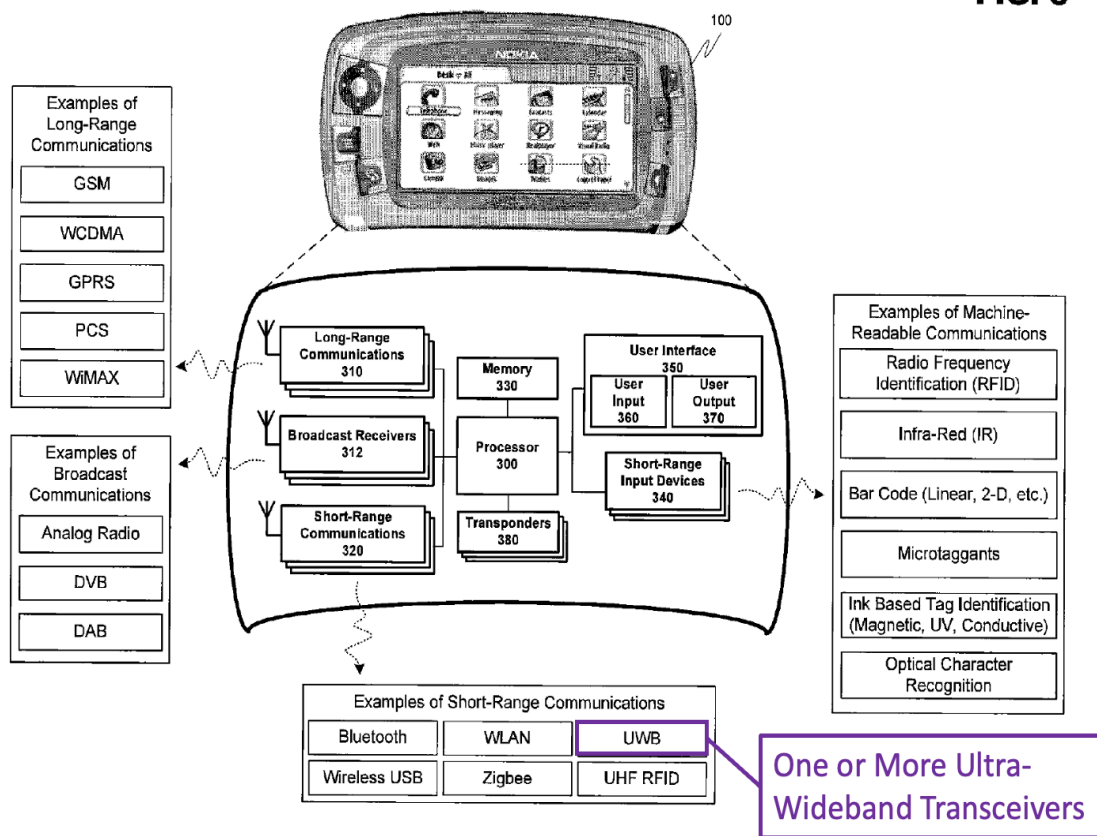
Fig. 6, which I have reproduced below, depicts the BT/BTLEE receiver 620 coupled to antennas A1-A6:

FIG. 6

Id. at Fig. 6 (emphasis added).

173. As I discussed above, Kalliola's WCD also includes a UWB transceiver, as shown in Fig. 3

FIG. 3



Id. at Fig. 3 (annotated).

174. As noted by Kalliola, the use of Bluetooth and UWB transceivers is desirable to “avoid some of the problems seen in large cellular networks” and because Bluetooth and UWB transceivers “have features and advantages that make them appropriate for various applications.” *Id.* at [0006]. A POSITA would have looked to other references describing UWB systems, such as Oswald, for more information regarding the antenna configuration of a UWB transceiver.

175. Like Kalliola, Oswald also teaches a positioning system for locating an object. Oswald at Abstract (“Apparatus for determining positional information

relating to an object...”), [0002] (“The invention finds particular application in the fields of object tracking systems...”). Oswald’s system includes an “object to be located 102, a transmitter 104 associated with or contained in the object 102 and outputting a signal 106, a pair of receiving apparatuses 200, 202, and a control unit 300.” *Id.* at [0244]; *see also, id.* at Fig. 1. “[T]he signals transmitted by the transmitter associated with the object are Ultra Wide Band (UWB) signals,” which are received by the receiving apparatuses 200, 202. *Id.* at [0099]; *see also, id.* at [0012] (“The apparatus may transmit UWB pulses.”), [0015] (“[T]he receiving means is adapted to receive an ultra-wide band (UWB) pulse.”), [0388] (disclosing a UWB transmitter and receiver).

176. The UWB transmitter is contained in a tag associated with the object. *Id.* at [0179] (“The transmitter may be associated with the object...The transmitter may be associated with a tag...”), [0185] (“[T]he transmitter comprises a tag associated with an object...”), [0239] (“A system for determining the position of an active object (that is, an object incorporating a transmitter, or ‘tag’)...”). The tag signals its “position using pulses whose relative bandwidth (that is, the size of the pulse bandwidth compared to the pulse frequency) is greater than, say, 10% and may be even greater (such as 20%, 30%, 40% or even higher).” *Id.* at [0278]. “The propagation characteristics of such pulses can be relatively favourable in indoor

applications, for example, where so-called narrowband pulses can propagate poorly and/or highly unpredictably.” *Id.*

177. Fig. 9 is “a schematic showing the receiving unit.” *Id.* at [0260]. “[T]he receiver component 210 in the receiving unit 200 comprises four antennas 212, 214, 216, 218 for receiving the transmitted signal 106 at carefully chosen spaced apart locations, and the detector component 230 in turn comprises a transceiver unit 232 coupled to the antennas 212, 214, 216, 218.” *Id.*

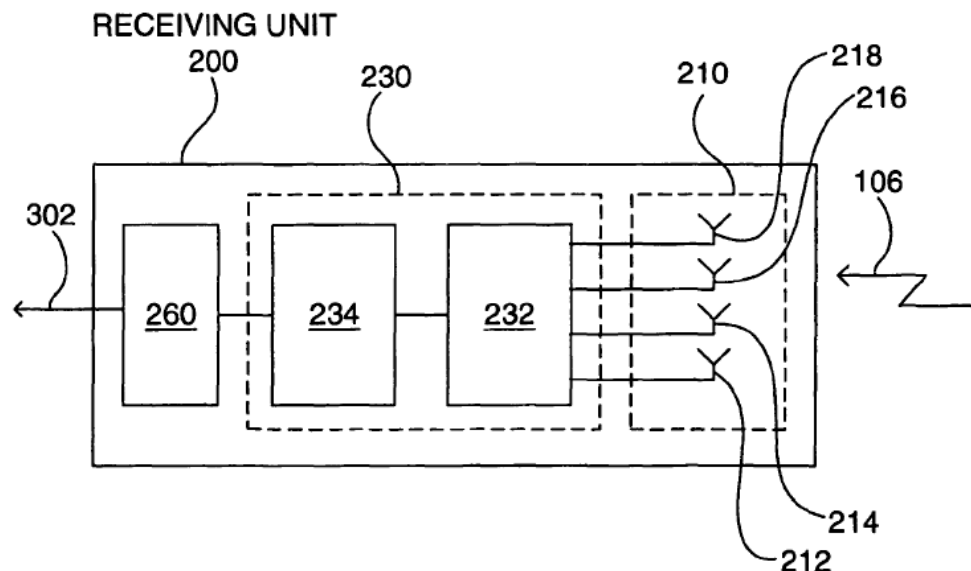
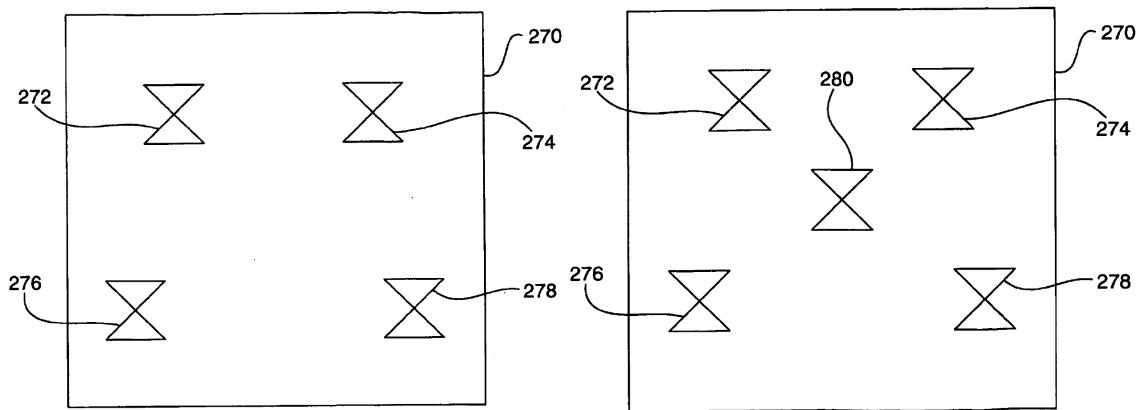


Figure 9

Id. at Fig. 9.

178. As depicted in Figures 16 and 17, Oswald’s UWB receiver includes an array of four or five antennas 272-280 (i.e., an array of two or more antennas):



Id. at Figs. 16-17; [0345] (“FIG. 16 is a plan view of a sensor array in a receiving unit. In FIG. 16, the array substrate 270 contains four antennas 272, 274, 276, 278 formed on the substrate.”), [0346] (“In FIG. 17, an array substrate 270 contains five antennas 272, 274, 276, 278, 280 formed on the substrate in a non-rectangular quadrilateral formation.”).

179. Based on the teachings of Oswald, it would have been obvious, and a POSITA would have been motivated to configure Kalliola’s UWB transceiver to be coupled to a UWB antenna array. As noted, Kalliola already teaches an antenna array (*see* Fig. 6), where the Bluetooth transceiver is coupled to the antenna array. The modification to Kalliola thus encompasses substituting Oswald’s UWB antenna array for Kalliola’s Bluetooth antenna array, such that the modified Kalliola WCD includes a UWB transceiver (as already taught in Kalliola) coupled to an antenna array (where an antenna array coupled to a transceiver is also already taught in Kalliola), where the antenna array is a UWB array (per Oswald).

180. Kalliola acknowledges that its “DoA estimation accuracy decreases in the presence of multipath propagation or noise” and that “[m]ultipath radio propagation causes fading that can lead to rapid changes of the DoA estimates and temporary mispointings.” *Kalliola* at [0064]-[0065].

181. Oswald recognizes that the propagation characteristics of UWB pulses are more favorable for indoor applications than narrowband transmissions. *Id.* at [0248] (“The propagation characteristics of such [UWB] pulses can be relatively favourable in indoor applications, for example, where so-called narrowband pulses can propagate poorly and/or highly unpredictably.”). A POSITA would have understood that Bluetooth utilizes narrowband transmissions. *See e.g., Haartsen* at 1652 (describing Bluetooth as utilizing a “low-cost **narrow-band** transceiver[.]”) (emphasis added), 1652 (“The channel makes use of several, equally spaced, 1-MHz hop channels.”), 1656 (“Since the channel capacity is only 1 MHz, as more and more users are added, throughput per user quickly drops to less than some 10 kb/s. The spectral bandwidth available is 79 MHz, but cannot be used effectively when every unit must share the same 1-MHz hop channel.”).

182. It was also generally well-known in the art that UWB pulses provided highly accurate location sensing for indoor applications. *See e.g., Liu* at 1074 (“UWB location exploits the characteristics of time synchronization of UWB communication **to achieve very high indoor location accuracy** (20 cm).”)

(emphasis added). Specifically, it was well-known that UWB was particularly effective at resolving multipath propagation typical of indoor environments. *See e.g., Quek* at 1863 (“The key motivations for using these systems are the ability of UWB signals to finely resolve multipath components, as well as the availability of technology to implement and generate UWB signals with relatively low complexity. Fine delay resolution properties make UWB radio a viable candidate for communications in dense multipath environments, such as short-range or indoor wireless communications[.]”). Further, a POSITA would have understood that UWB signals allow for measuring distance (i.e., ranging) with extremely high accuracy even in indoor environments where multipath is severe. *See e.g., Venkatesh* at 1 (“Ultra-wideband (UWB) is an excellent physical layer solution for location-aware sensor networks due to its robustness in harsh multipath environments, its ability to fuse accurate (on the order of tens of centimeters) ranging with low-data rate communication [10] and its covertness for tactical applications.”).

183. A POSITA would have appreciated that the user’s personal items, such as their keys and wallet, would often be indoors, such as in the user’s house or office, and that using UWB would be advantageous because of UWB’s known indoor location accuracy and ability to resolve multipath propagation present in indoor environments. Accordingly, a POSITA would have understood that utilizing UWB instead of Bluetooth would have been advantageous because UWB technology

provides high accuracy, even in harsh environments, due to its ability to resolve multipath and penetrate obstacles typical of indoor environments. *See e.g., Liu at 1075* (“UWB short duration pulses are easy to filter in order to determine which signals are correct and which are generated from multipath. At the same time, the signal passes easily through walls, equipment and clothing.”).

184. For these reasons, a POSITA would have been motivated to configure Kalliola’s UWB transceiver to be *coupled to an array of two or more antennas*, per Oswald, so that direction determination may be performed utilizing UWB instead of Bluetooth, thereby increasing the accuracy of Kalliola’s object-finding system and improving similar object-finding systems in the same way.

185. Additionally, a POSITA would have recognized that this modification to Kalliola’s WCD would have represented a simple substitution of one known element (i.e., Kalliola’s Bluetooth antenna array) for another (i.e., Oswald’s UWB antenna array) to yield the predictable result of allowing Kalliola’s WCD to perform the DoA estimation using UWB instead of Bluetooth. In other words, the modification is simply to couple Kalliola’s UWB transceiver to a UWB antenna array instead of coupling the Bluetooth transceiver to an antenna array, such as illustrated in Kalliola Figures 5 and 6. A person of ordinary creativity would have appreciated that using UWB for DoA instead of Bluetooth would have meant that Kalliola’s Bluetooth transceiver would not need to be coupled to multiple antennas.

Rather, the Bluetooth transceiver would simply need to be coupled to a single, 2.4 GHz antenna to enable the WCD to communicate with other Bluetooth devices per standard Bluetooth protocol. *See e.g., 802.15.1-2005* at 65-66.

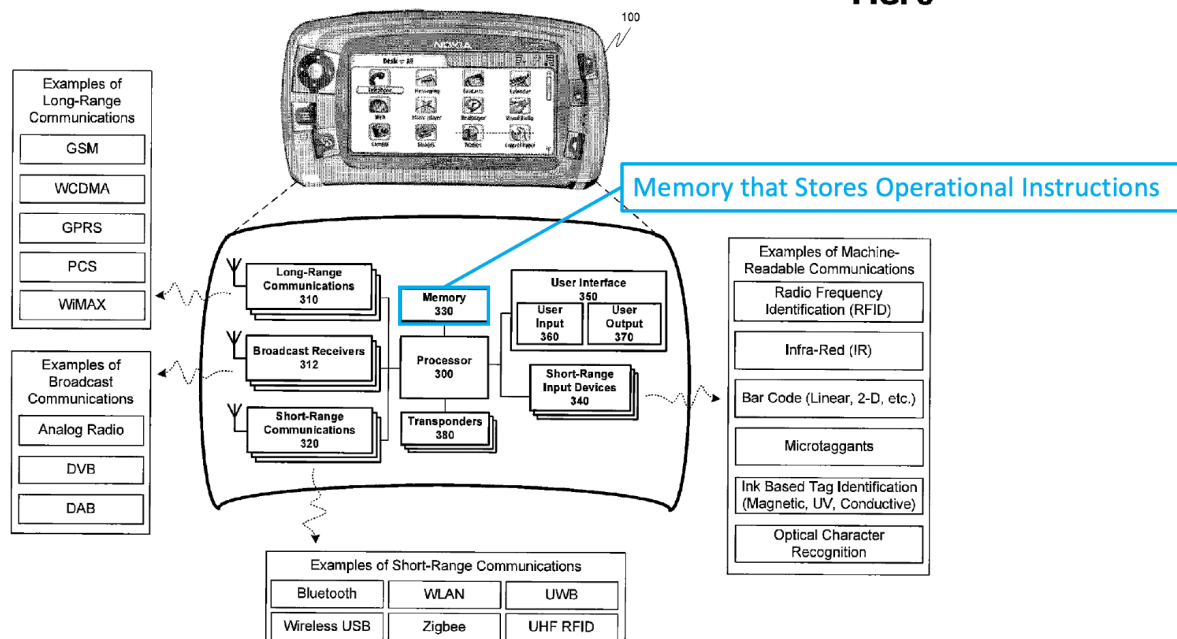
186. Given the well-known “availability of technology to implement and generate UWB signals with relatively low complexity” (*Quek* at 1863), there would have been a reasonable expectation of success configuring Kalliola’s WCD to include one or more ultra-wideband transceivers coupled to two or more antennas as taught by Oswald. Moreover, this modification would not have changed the principle of operation of Kalliola because the WCD would still be operable to determine the direction to the signal emitter – albeit with UWB instead of Bluetooth.

C. 1(b): “a memory that stores operational instructions;”

187. Kalliola’s WCD includes memory 330, which may be “random access memory (RAM), read only memory (ROM), and/or flash memory[.]” *Kalliola* at [0044]. Kalliola’s memory 330 stores operational instructions. Specifically, memory 330 “stores information in the form of data and **software components** (also referred to herein as modules).” *Id.* (emphasis added). The software components “stored by memory 330 include **instructions** that can be executed by processor 300.” *Id.* at [0045] (emphasis added); *see also, id.* at [0043] (“Processor 300 may be implemented with one or more microprocessors that are each capable of executing **software instructions stored in memory 330.**”) (emphasis added).

188. Kalliola also discloses a “tracking application 922” that is “an application in memory 330 executing on the main processor 300 of WCD 100[.]” *Id.* at [0080], FIG. 9B. In my opinion, Kalliola’s tracking application is embodied as operational instructions, i.e., software components that are executed by a processor.

189. Because (1) Kalliola’s processor controls overall device operation (per *Kalliola* at [0043]), (2) Kalliola’s WCD includes an applications module for performing functional data applications (*Kalliola* at [0042]), (3) memory 330 stores software components executed by processor and for performing WCD functionality (*Kalliola* at [0045]), and (4) one of the applications is the tracking application, Kalliola teaches or otherwise renders obvious a memory that stores operational instructions:

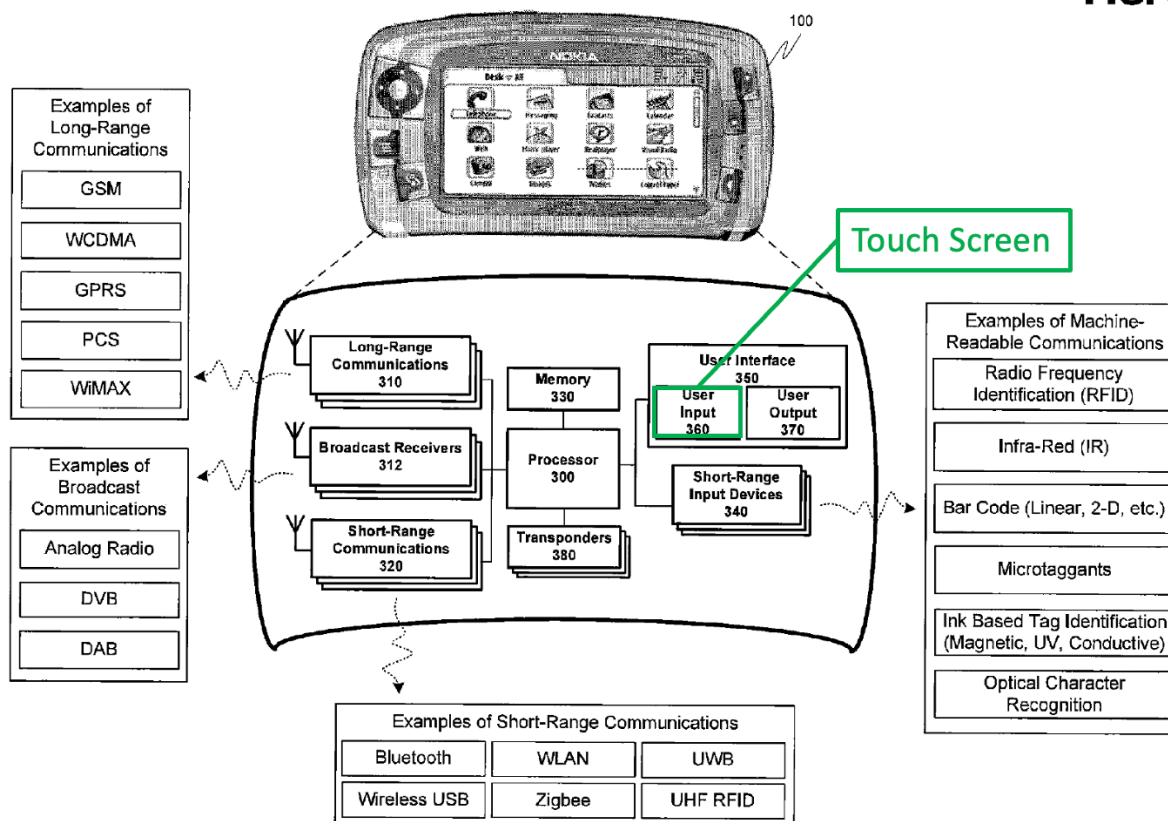
FIG. 3

Id. at Fig. 3 (annotated).

D. 1(c): “a touch screen; and”

190. Kalliola’s WCD includes “user interface 350 [that] facilitates the exchange of information with a user. ... [U]ser interface 350 includes a user input 360 and a user output 370.” *Kalliola* at [0050]. Kalliola teaches that user input 360 includes “one or more components that allow a user to input information,” including, for example, “keypads, **touch screens**, and microphones.” *Id.* (emphasis added). Thus, Kalliola’s user input 360 includes a touch screen:

FIG. 3



Id. at Fig. 3 (annotated).

191. While it is my opinion that Kalliola expressly discloses that user input 360 includes a touch screen, I have also been asked to consider whether it would

have been obvious to include a touch screen in Kalliola's WCD. As noted above, Kalliola expressly suggests implementing user input 360 as a touch screen. *Kalliola* at [0050]. As I discussed in the Overview of the Technology section, touchscreens for user input were widely adopted by electronic devices even before smartphones. *See* ¶¶ 68-69. In fact, I discussed several examples including the IBM Simon (released in 1992), the Apple Newton (released in 1993), and the original iPhone (released in 2007). *Id.* By the end of 2009, "smart phones with touch screens accounted for **more than half** of all smart phone shipments globally." *Canalys* at 1 (emphasis added). By the time of the alleged invention in 2010, a POSITA would have understood that touch screens were commonly used for user input. Furthermore, a POSITA would have recognized the advantage of using a touch screen as the touch screen allows the user to view data displayed by Kalliola's WCD and provide inputs to the WCD. This would reduce the size of the WCD, as the input and the display would no longer need to be separate components. Accordingly, a POSITA would have been motivated to include a touch screen as Kalliola's user input 360 based on Kalliola's express suggestion. Since touch screens were commonly included in wireless communication devices for decades prior to the '246 Patent, there would have been a reasonable expectation of success implementing Kalliola's user input 360 as a touch screen.

E. **1(d)(i): “a processor coupled to the plurality of wireless transceivers, the memory, and the touch screen,”**

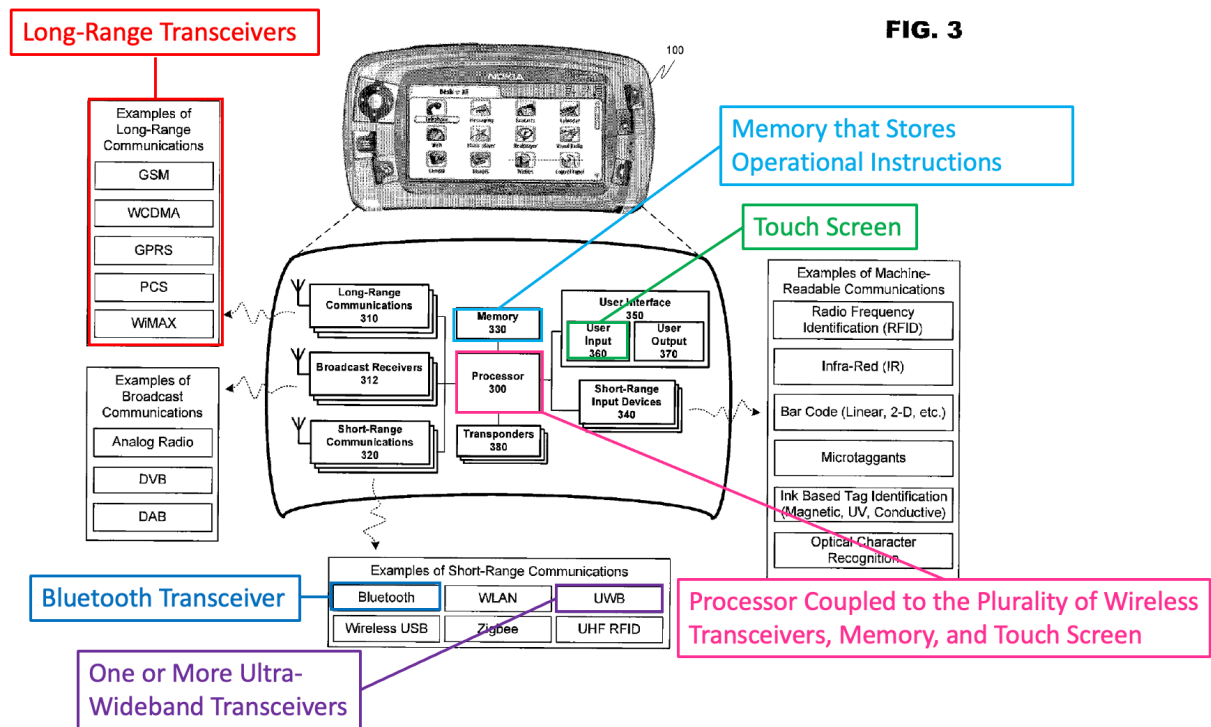
192. Kalliola’s WCD includes a *processor* 300 that “controls overall device operation” of the WCD. *Kalliola* at [0043]. The processor 300 is “**coupled** to communications sections 310, 320, and 340” (i.e., *the plurality of wireless transceivers*). *Id.* (emphasis added); *see also, id.* at [0053] (“One such technique involves **coupling separate hardware components corresponding to processor 300, communications sections 310, 312 and 320, ...** through one or more bus interfaces (which may be wired or wireless bus interfaces).”) (emphasis added); *see also*, Claim 1(a).

193. Processor 300 is also coupled to *the memory* 330. *Id.* at [0053] (“One such technique involves **coupling separate hardware components corresponding to processor 300... memory 330...** through one or more bus interfaces (which may be wired or wireless bus interfaces).”) (emphasis added). Specifically, Kalliola teaches that processor 300 is “implemented with one or more microprocessors that are each capable of executing software instructions **stored in memory 330.**” *Id.* at [0043] (emphasis added); *see also, id.* at [0045] (“The software components stored by memory 330 include instructions that can be executed by processor 300. Various types of software components may be stored in memory 330. For instance, memory 330 may store software components that control the operation of communication sections 310, 320 and 340.”). A POSITA would have understood that by teaching

that the processor 300 executes instructions stored in memory 330, Kalliola also teaches the processor 300 is coupled to the memory 330; otherwise, Kalliola's processor 300 would not be able to execute the instructions stored in memory 330. This is further evidenced by the block diagram of Fig. 3 that illustrates a line coupling processor 300 to memory 330. *Id.* at Fig. 3.

194. As discussed above, user interface 350 includes user input 360, which includes a touch screen. See Claim 1(c). “[U]ser interface 350 is also **coupled to processor 300**.” *Kalliola* at [0050] (emphasis added); see also *id.* at [0053] (“One such technique involves **coupling separate hardware components corresponding to processor 300, ...user interface 350...** through one or more bus interfaces (which may be wired or wireless bus interfaces).”) (emphasis added). Therefore, Kalliola teaches a processor coupled...to the touch screen.

195. Thus, Kalliola teaches a processor coupled to the plurality of wireless transceivers, the memory, and the touch screen:



Id. at Fig. 3 (annotated).

F. 1(d)(ii): “wherein the processor is configured to execute the operational instructions, which upon execution, cause the processor to:”

196. Kalliola teaches *the processor* 300 “controls overall device operation.”

Id. at [0043]. As I discussed previously, Kalliola teaches a “tracking application” that is “utilized to determine the relative direction towards a target” *Id.* at [0080]; *see also*, Claim 1(b). The tracking application is embodied as *the operational instructions* executed by processor 300. *Id.* Therefore, because Kalliola teaches the processor 300 *executes* software instructions (*operational instructions*), Kalliola expressly teaches *wherein the processor is configured to execute the operational instructions*. For the reasons explained below, the tracking application executing on

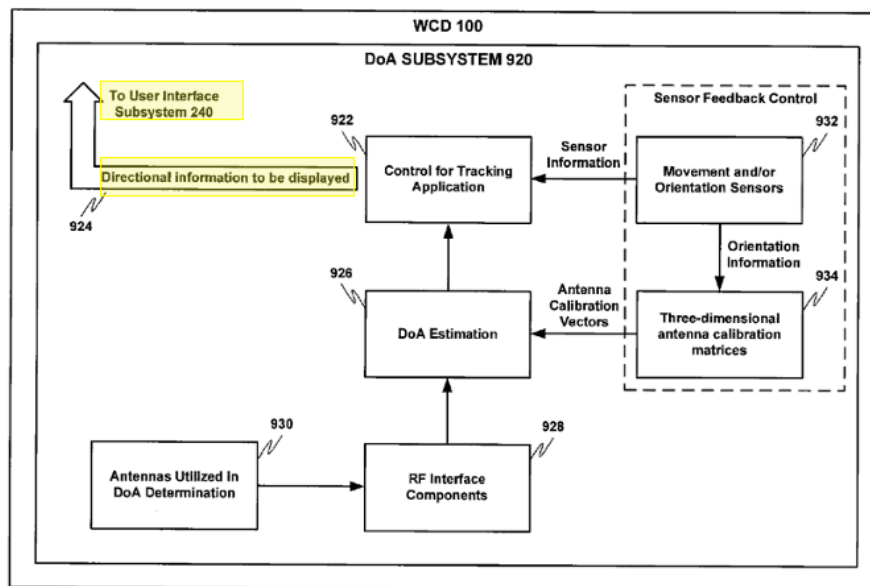
processor 300 causes processor 300 to perform steps 1(d)(iii)-1(d)(viii). *See also*, ¶¶ 141-145 (discussing Kalliola's processor executing operational instructions that cause the processor to perform the claimed steps).

G. 1(d)(iii): “present a graphical user interface via the touch screen;”

197. Kalliola's tracking application (i.e., *the operational instructions*) *causes the processor to present a graphical user interface via the touch screen.*

Kalliola teaches with respect to Fig. 9B that the tracking application 922 outputs “Directional Information to be displayed” to the “User Interface Subsystem 240.”

FIG. 9B



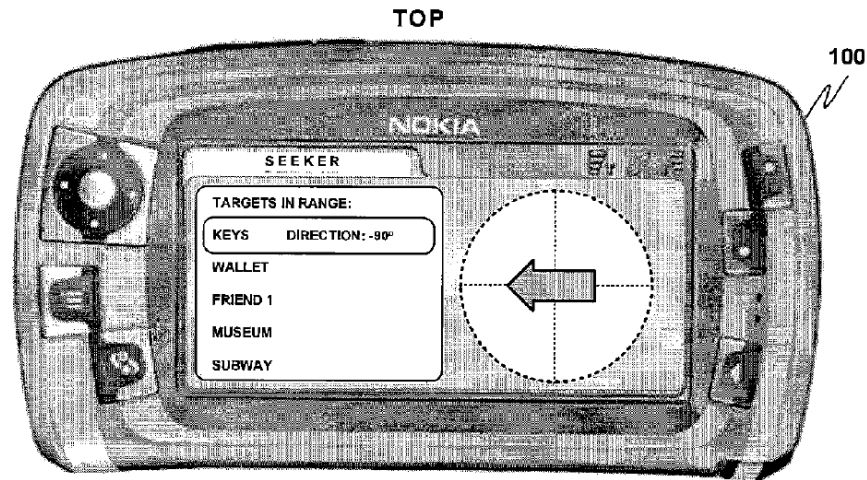
Id. at Fig. 9B (emphasis added); *see also, id.* at [0080] (“Control for a tracking application 922 may, for example, consist of an application in memory 330 executing on the main processor 300 of WCD 100...The local controller may utilize information provided by a DoA estimation module 926 to display direction

information 924 for a user. This information may be displayed through user interface module 240 as previously described.”).

198. “User interface module 240 [of Fig. 2] includes visual, audible and tactile elements which allow the user 110 to receive data from, and enter data into, the device.” *Id.* at [0041]. Fig. 3 “discloses an exemplary structural layout of WCD 100 ... used to implement the functionality of the modular system previously described in FIG. 2.” *Id.* at [0043]. Fig. 3 includes user interface 350, which “facilitates the exchange of information with a user” and includes user input 360. *Id.* at [0050]. As discussed above, user input 360 includes a touch screen. *See* Claim 1(c). Thus, Kalliola’s tracking application outputs directional information to be displayed on the WCD’s touch screen.

199. Fig. 5 of Kalliola illustrates an exemplary graphical user interface that depicts the directional information sent by tracking application 922 to user interface subsystem 240:

EXAMPLE DEVICE INCLUDING RELATIVE DIRECTION
INDICATING DISPLAY



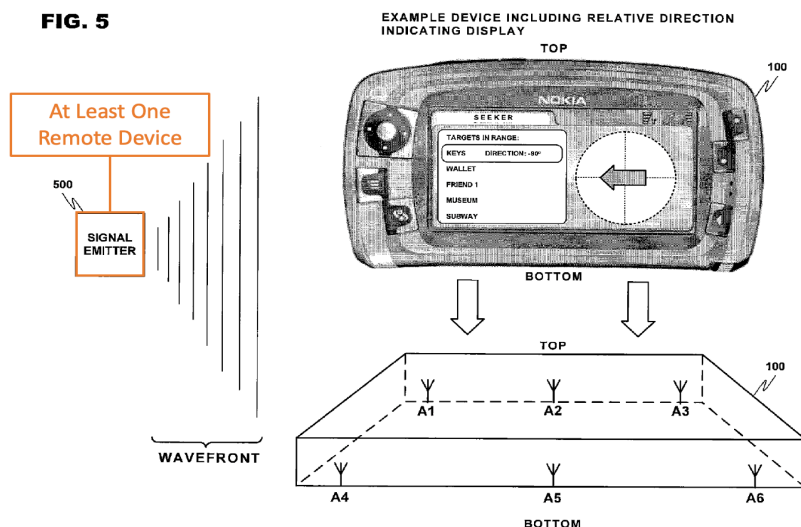
Id. at Fig. 5 (excerpt); *see also, id.* at Fig. 6, [0069] (“FIG. 5 also includes an example display shown on WCD 100 that is viewable by user 110.”).

200. A POSITA would have understood the touch screen to present a graphical user interface at least because such touch screens that presented graphical user interfaces were well-known before the '246 Patent as I discussed above. *See* ¶¶68-69. Because Kalliola teaches that (1) user input 360 is part of the structural layout for implementing the components of Fig. 2, including the user interface module 240, (2) the user input 360 is a touch screen, and (3) the tracking application output directional information to be displayed to the user interface module/subsystem 240, Kalliola teaches that the operational instructions, when executed by the processor, cause the processor to present a graphical user interface via the touch screen.

H. 1(d)(iv): “in response to a pair request from a user received at the graphical user interface, pair the mobile communication device with at least one remote device;”

1. *Kalliola’s Teachings of “at least one remote device”*

201. Kalliola teaches at least one remote device. Specifically, Kalliola teaches remotely activated signal emitters 500 attached to “target objects” such as keys or a wallet. *Kalliola* at [0069], [0075], Figs. 5, 8 (describing “Remote Activated Location transmissioning [sic] Examples” 802). The remotely activated signal emitter operates “in a lower power or power conservation mode until a message is received instructing [it] to activate the position-indicating transmission signal.” *Id.* at [0075]. “This message may be received by any of the aforementioned wireless mediums such as via a Bluetooth™ message.” *Id.* In the example depicted in Fig. 5, the signal emitter 500 is attached to the user’s keys, thereby disclosing the claimed at least one remote device:



Id. at Fig. 5 (annotated).

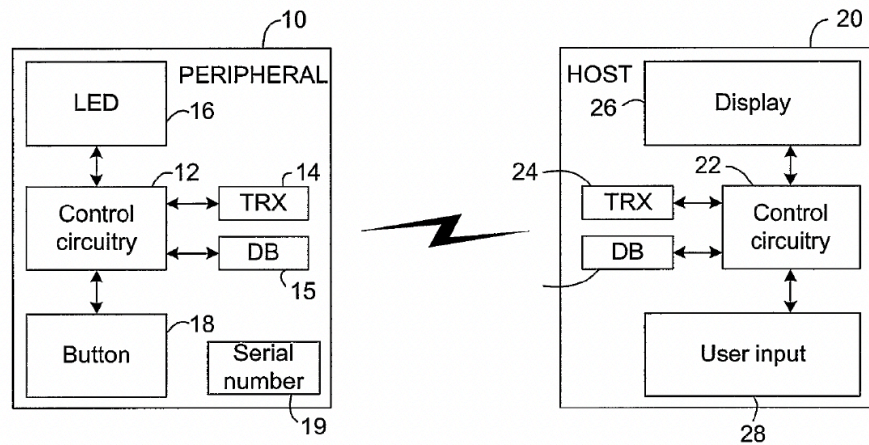
202. While Kalliola teaches Bluetooth communications between the WCD 100 and the signal emitter 500, Kalliola does not describe the initial pairing between the WCD 100 and the signal emitter 500. A POSITA would have looked to other references, such as Vauclair, describing wireless pairing procedures when implementing Kalliola's object-finding system.

2. *Vauclair's Disclosure Regarding Paring*

203. Vauclair teaches "secure pairing of...wireless communications devices" that use "wireless communication standards, such as Bluetooth" that "contain[] a mechanism for device pairing." *Vauclair* at [0001]-[0004]. "A first electronic device 10 is regarded as a peripheral device, while the second electronic device 20 is regarded as a host device." *Id.* at [0022]. The first/peripheral device 10 may be, for example, "a mobile telephone handsfree kit" and the second/host device 20 may be a "mobile telephone." *Id.* The host and peripheral devices communicate via "any wireless or wired protocol," including Bluetooth. *Id.* Thus, Vauclair's first/peripheral device 10 is similar to Kalliola's signal emitter 500, and Vauclair's second/host device 20 is similar to Kalliola's WCD.

204. The host device has a control circuitry 22, a display 26 that "display[s] detailed messages, or menu options, to the user" and user input 28 that "allow[s] the user to select from available menu options, to send a signal to the control circuitry 22." *Id.* at [0030]. The host device's control circuitry 22 is "a suitably programmed

processor” that “is connected to transceiver (TRX) circuitry 24, which handles radio frequency communications with other electronic devices able to use the same wireless protocol.” *Id.* at [0028].



Id. at Fig. 1.

205. To establish an ad hoc wireless network between the host and peripheral devices, “the user may **select a pairing option from a menu**, using the user input 28.” *Id.* at [0036] (emphasis added). Since the menu is presented via display 26, a POSITA would have understood that the user’s selection of a pairing option from a menu is a pair request from a user received at the graphical user interface. *Id.* at [0030] (Explaining that display 26 “display[s] ... menu options, to the user.”).

206. In response to the user selection of the pairing option (i.e., a pair request), the host and peripheral devices exchange a series of signals depicted in Fig. 2 to complete the pairing process:

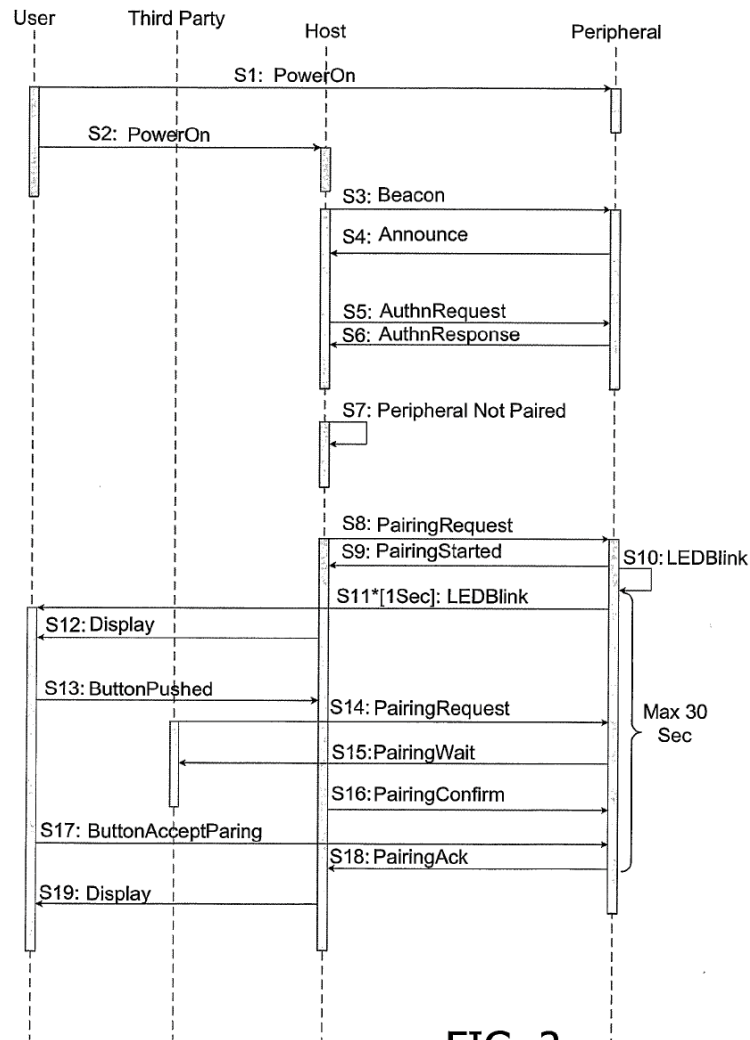


FIG. 2

Id. at Fig. 2.

207. Specifically, “the host device 20 then seeks a nearby peripheral device....by sending a beacon signal (S3 in FIG. 2).” *Id.* at [0037]. That is, the host device sends the beacon signal in response to the user selecting a pairing option from a menu. The host device and the peripheral device undergo an authentication procedure once the host device and the peripheral devices have detected one another and established communication. *Id.* at [0038]-[0048].

208. “Once the authentication procedure has been performed, the first and second devices 10, 20 check in their respective paired device databases 15, 25 whether they are in fact already paired with the respective other device.” *Id.* at [0047]. “If...the first and second devices determined that they are not already paired with the respective other device (S7 in FIG. 2), the first and second devices 10, 20 enter their respective Ready to Pair states 116, 210.” *Id.* at [0048]. Once in the “Ready to Pair” state, “the host device 20 requests the initiation of a pairing procedure with the peripheral device 10” by sending “a pairing request signal (S8 in FIG. 2) to the peripheral device, and the first and second devices enter their respective Pairing states 118, 212.” *Id.* at [0049]. “The peripheral device 10 then returns a pairing started signal (S9 in FIG. 2) to the host device 20, and the first and second devices 10, 20 enter their respective Pairing Started states 120, 214.” *Id.*

209. Vauclair’s pairing process continues with the host device displaying the identification of the peripheral device to the user such that “all that is then required is for the user to compare the device identification 19 physically written on the first device 10 and the device identification displayed on the display 26 of the second device, in order to confirm (step P7 in FIG. 3) that the two identifications match.” *Id.* at [0052]. Once the user confirms the two identifications match, “the host device 20 then sends a pairing confirm signal (S16 in FIG. 2) to the peripheral device 10, and presents on its display 26 a message to the user indicating that he can accept the

pairing....The peripheral device 10 then sends a pairing acknowledge signal (S18 in FIG. 2) to the host 20, which enters its Pairing Acknowledged state 218.” *Id.* at [0054]-[0055].

210. Thus, Vauclair teaches in response to a pair request from a user received at the graphical user interface, pair the mobile communication device with at least one remote device.

3. *The Combination of Kalliola and Vauclair Teaches Claim 1(d)(iv)*

211. It would have been obvious to configure Kalliola’s tracking application executing on processor 300 to pair Kalliola’s WCD and signal emitter 500 in response to a pair request from a user received at the graphical user interface, as taught by Vauclair. Specifically, it would have been obvious to a POSITA to configure Kalliola’s WCD to display Vauclair’s pairing menu on the WCD’s touch screen. As discussed above, Kalliola teaches a WCD having a touch screen that receives user inputs, while Vauclair teaches a display that displays a pairing menu with selectable devices to pair the host device with. Accordingly, Kalliola modified by Vauclair teaches a mobile communication device (i.e., WCD) with a touch screen that displays a menu from which a user selects at least one remote device (i.e., signal emitter 500) to pair with. It would have also been obvious to configure the tracking application executing on Kalliola’s processor to receive the user’s pairing selection via the graphical user interface and cause the Bluetooth transceiver to pair the WCD

with the signal emitter by communicating a series of pairing signals as taught by Vauclair.

4. *Motivation to Combine*

212. A POSITA would have found it obvious and been motivated to modify Kalliola's tracking application and Bluetooth transceiver to include a Bluetooth pairing menu to enable a user to initiate a Bluetooth pairing process between the WCD and the signal emitter by selecting a pairing option from the menu, as taught by Vauclair. A POSITA would have understood that Bluetooth pairing allows two Bluetooth devices to recognize each other on subsequent connections. *See e.g., Newton* at 614 (defining "pairing" as "[a] Bluetooth term" that involves "The creation and exchange of a link key between two devices" where the devices "use the link key for **future** authentication when exchanging information.") (emphasis added); *Gehrmann* at 29 ("[T]he pairing of two devices is a procedure by which two devices establish a shared secret that they can use when they **meet again**.") (emphasis added). A POSITA would have understood that Kalliola's WCD would need to be paired with the signal emitters associated with the user's personal items to recognize the signal emitters during subsequent connections. *Id.* This is particularly true since Kalliola's WCD included a Bluetooth transceiver, and a POSITA would have known that Bluetooth-based pairing was a typical method for establishing communications between Bluetooth-enabled devices. *See, e.g.,*

Ericsson T39 User's Guide at 49-50; *iPhone User's Guide* at 39 (discussing pairing with other devices).

213. The proposed modification of Kalliola with Vauclair would have been obvious at least for combining prior art elements according to known methods to yield predictable results. The claim requires the well-known element of pairing two devices in response to a user's pairing request. As I discussed above, Kalliola describes a WCD that communicates with a remote signal emitter via a Bluetooth transceiver but does not expressly describe the initial Bluetooth pairing process between the WCD and signal emitter. Vauclair describes allowing the user to select a pairing option from a menu on a host device, which causes the host device's transceiver to communicate a series of pairing signals to the peripheral device to complete a pairing process. The only difference between the claim and the prior art is the combination of the known prior art elements into a single device by incorporating Vauclair's pairing process into Kalliola's system. Because there is no change to the respective functions of either Kalliola's WCD or Vauclair's pairing process, this combination would have predictably resulted in a WCD that allows the user to pair with a remote signal emitter.

214. As I discussed above, it was well known for years prior to the '246 Patent to pair Bluetooth-enabled devices responsive to a user providing an indication/request via a graphical user interface to pair two Bluetooth-enabled

devices. *See* ¶¶ 74-75. For example, the Ericsson T39 was a Bluetooth-enabled phone that allowed a user to initiate pairing by selection of a menu item presented in a graphical user interface. *Ericsson T39 User Guide* at 50. As such, GUIs allowing users to initiate Bluetooth pairing and the signaling between a Bluetooth host device and a peripheral device during the pairing process were well understood toPOSITAs at the time of the '246 Patent. Therefore, there would have been a reasonable expectation of success configuring Kalliola's tracking application to present a pairing menu to the user on the touchscreen and configuring the Bluetooth transceiver to initiate the Bluetooth pairing RF signaling in response to the user's request to pair the WCD to the signal emitter.

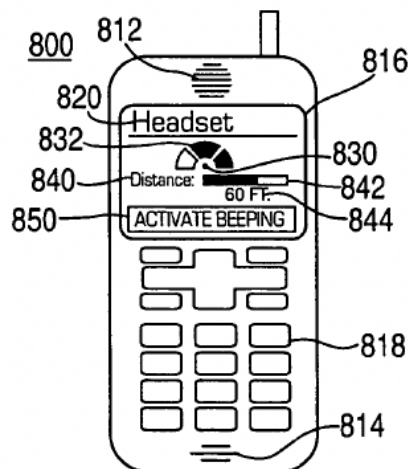
I. **1(d)(v): “in response to an audio alert request from the user received at the graphical user interface, transmit an audio alert request signal to the at least one remote device via the Bluetooth transceiver;”**

1. *Kalayjian's Teachings*

215. As I discussed above, Kalayjian teaches a system for locating a wireless object that includes a first or master device 310 and a second or slave device 320. *See* ¶¶ 117-124. Kalayjian teaches the master and slave devices “can be any devices capable of communicating a Bluetooth protocol but in this instance are cellular phone 310 and headset 320.” *Kalayjian* at [0032], [0033]-[0034]. The slave device, such as headset 320, includes “speaker 324 to emit sounds operable to guide a user to its location.” *Id.* at [0034]; *see also, id.* at [0035]-[0036], Figs. 3a-b (depicting

speaker 324), Fig. 4 (depicting speaker 424), Fig. 5a (depicting speaker 524), [0039] (“[S]lave devices 320, 400 and 500 can guide a user to their location by emitting auditory or visual signals. This embodiment allows a user to follow the sound or light to the misplaced object.”).

216. “When prompted by a user, the master device can transmit a signal to one of the slave devices,” which takes “a predetermined action to attempt to guide a user to its location,” such as “emit[ting] auditory or visual alerts itself.” *Id.* at [0007]. “FIG. 8 includes a screenshot of the user interface of master device 800 when the master device is attempting to locate a slave device.” *Id.* at [0049]. As shown in Fig. 8 below, the graphical user interface (i.e., screen 816) includes “graphical button 850 to enable the user to prompt the slave device to beep, flash or perform a combination of both, or provide some other indication.” *Id.*



Id. at Fig. 8.

217. Thus, Kalayjian's teaching of the user selecting the "ACTIVATE BEEPING" graphical button 850 via the graphical user interface 816 qualifies as the claimed audio alert request from the user received at the graphical user interface.

218. In response to the user selecting the "ACTIVATE BEEPING" graphical button 850, "the master device transmits a signal to a slave device using a Bluetooth communications protocol," and "the slave device takes a predetermined action to guide a user to its location," such as, "emitting a sound." *Id.* at [0054]; *see also, id.* at Fig. 10 (steps 1020, 1030). Thus, Kalayjian's teaching of the master device transmitting a signal to the slave device via Bluetooth that causes the slave device to beep teaches the claimed transmit[ting] an audio alert request signal to the at least one remote device via the Bluetooth transceiver.

2. Motivation to Combine

219. A POSITA would have been motivated and found it obvious to combine Kalayjian's teachings of transmitting an audio alert request signal to a slave device in response to an audio alert request from a user with Kalliola's object-finding system. Specifically, a POSITA would have been motivated to modify Kalliola's signal emitter 500 to include a speaker, as taught by Kalayjian. A POSITA would have also been motivated to configure Kalliola's tracking application running on the WCD to provide a graphical user interface allowing the user to input an audio alert request. For example, it would have been obvious to include a graphical button, such

as Kalayjian's "ACTIVATE BEEPING" button, that when pressed by the user, causes the WCD to transmit an audio alert request signal to the signal emitter 500 via the WCD's Bluetooth transceiver.

220. Kalayjian teaches that "[s]mall items get lost" and that "[t]hese items, such as keys or remote controls, often are close by, but can be out of sight." *Kalayjian* at [0002]. Kalayjian also teaches that causing the slave device to emit a sound "allows a user to follow the sound....to the misplaced object." *Id.* at [0039]. Thus, Kalayjian expressly teaches a motivation that would have prompted a POSITA to modify Kalliola's object-finding system to incorporate Kalayjian's audio alert feature.

221. Moreover, a POSITA would have recognized that including Kalayjian's teachings of the slave device emitting auditory alerts to aid the user in locating the slave device would enhance Kalliola's object-finding system, which is directed to solving the same problem as Kalayjian, i.e., locating a small lost item, such as keys or a wallet. *Kalliola* at [0069] (describing locating a "KEYS" target object), Fig. 5, [0075] (describing remotely activated signal emitters, "such as battery-operated transmitters in a keychain, in a wallet, embedded in an ID badge..."). A POSITA would have recognized that while Kalliola's WCD would provide the direction to the signal emitter, the user would still have difficulty locating the signal emitter if it is hidden from view. Therefore, a POSITA would

have been motivated to configure Kalliola's signal emitter to include a speaker and emit audio alerts in response to receiving a signal from the WCD as taught by Kalayjian to further aid the user in locating the signal emitter and improve similar object-finding systems in the same way.

222. As discussed above, Kalliola teaches that the WCD transmits Bluetooth messages to the signal emitter 500. *Kalliola* at [0075] ("This message may be received by any of the aforementioned wireless mediums such as via a Bluetooth™ message."). Thus, a POSITA would have also been motivated to combine the prior art elements of Kalliola's WCD transmitting Bluetooth messages to signal emitter 500 and Kalayjian's Bluetooth audio alert request signal to reliably and predictably communicate the audio alert request to the signal emitter so that it can generate an audible alert when requested by the user.

223. A POSITA would have recognized the usefulness of Kalliola's signal emitter generating an auditory alert if the signal emitter, attached to the user's keys, for example, had been misplaced somewhere out of sight of the user (e.g., left in a coat pocket or buried under mail on a table). Additionally, modifying Kalliola in such a way would not have change the operation of Kalliola's system, which would still function as an object-finding system. Rather, Kalliola's system would be enhanced to enable the user of the WCD to locate those items/signal emitters that are not visible despite the user's proximity to the device.

224. Modifying Kalliola's WCD and signal emitter based on Kalayjian's teachings for the signal emitter to emit an audio alert in response to a user-inputted request via Kalliola's touch screen, would have involved minimal hardware and software changes. The hardware changes would have involved including a speaker in the signal emitter 500 to emit the audio alert, and the software changes would have involved (1) programming Kalliola's WCD to transmit a Bluetooth signal to the signal emitter in response to an audio alert request signal (as taught by Kalayjian) received via Kalliola's touch screen and (2) programming the signal emitter to emit the alert in response to receiving the audio alert request signal. As discussed above, it would have been obvious to modify Kalliola's graphical user interface to display an option that allowed a user to input an audio alert request, such as an "ACTIVATE BEEPING" button similar to the one taught by Kalayjian. Such systems were well-known in the art well before the alleged invention of the '246 Patent, such as Kientz's FETCH system that included a button that activated beeping of a remote tag device. *Kientz* at 105. Thus, a POSITA would have had a reasonable expectation of success incorporating Kalayjian's well-known audio alert feature into Kalliola's object-finding system.

225. Additionally, with respect to the changes for the signal emitter, because Kalliola already teaches that the signal emitter responds to the activation message with the position-indicating transmission, in my opinion, it would have been a minor

modification to the software of the signal emitter to also emit an audio alert in response to the audio alert request signal. Furthermore, such signal emitters capable of emitting audio alerts were well-known prior to the '246 Patent such that a POSITA would have had a reasonable expectation of success in modifying Kalliola's signal emitter to emit a detectable alert signal based on the teachings of Kalayjian. For example, the FETCH system included "Bluetooth enabled tags" attached to an object that could be activated to begin "beeping" such that a visually impaired user could locate the object based on the beeping. *See* ¶¶82-83.

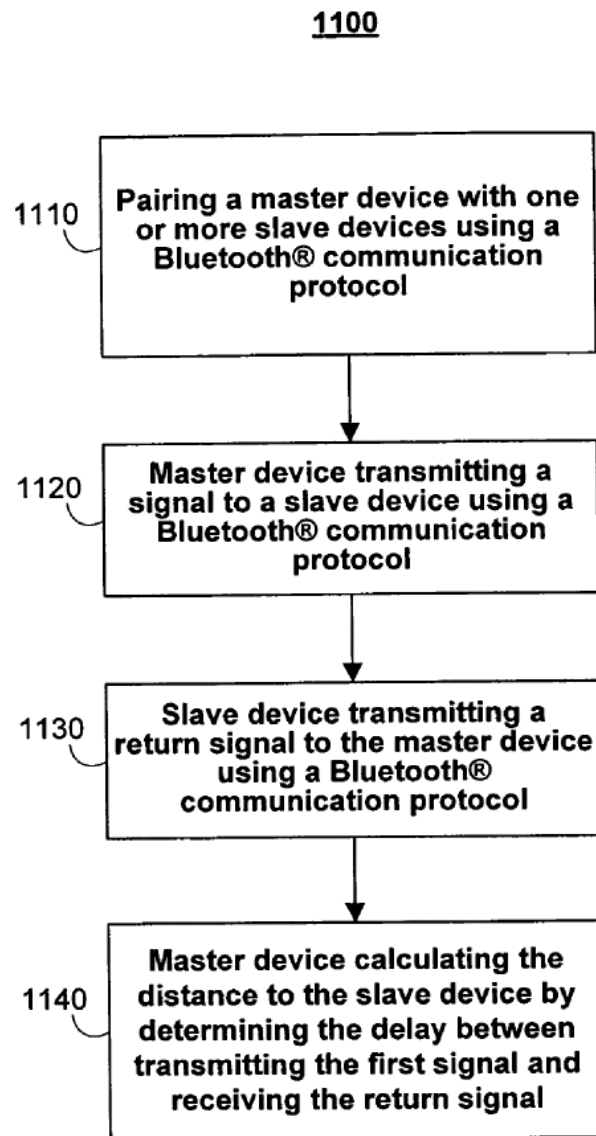
- J. 1(d)(vi): "estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations;"

1. *Kalayjian's Teachings of Distance Estimations*

226. I have been instructed to interpret the term *time of flight calculations* as "determining the amount of time between when a signal is transmitted and when a reply signal is received." I apply this interpretation below.

227. Kalayjian teaches the slave device 320 "can notify a user of the distance between the slave device and master device 310" by "transmitting a return signal to master device 310." *Kalayjian* at [0040]. "Master device 310 can then **calculate the distance** to the slave devices," and the "results of this calculation can be presented to a user through a graphical display on screen 316." *Id.* (emphasis added). "At step

1140, the master device calculates the distance to the slave device by **determining the amount of time delay between transmitting its signal to the slave device and when it receives a return signal from the slave device.**” *Id.* at [0055] (emphasis added). “The master device can use the known speed of radio waves and the known response time of the slave device when calculating the distance.” *Id.*



Id. at Fig. 11.

228. Kalayjian additionally teaches:

The distance between the devices can be calculated by comparing the **amount of time delay** between the transmission of the signal sent from the master device to the slave device and the reception of the return signal from the slave device. With a precise timing system, the master device can be capable of performing such measurements. Since the speed of the radio waves is known, the distance can be calculated using the time information. The average time it takes the slave device to respond after receiving a signal can also be used to compensate the time delay.

Id. at [0041].

229. Thus, Kalayjian teaches estimat[ing] a distance between the master device and the slave device by determining the amount of time between when a signal is transmitted and when a reply signal is received (i.e., time of flight calculations).

2. Motivation to Combine

230. As I discussed above, Kalliola teaches a UWB transceiver, and a POSITA would have been motivated to include both a Bluetooth transceiver and a UWB transceiver (coupled to an antenna array, per Oswald) in Kalliola's WCD. *See* Claim 1(a). Based on the teachings of Kalayjian, it would have also been obvious, and a POSITA would have been motivated to configure the WCD modified in view of Oswald to estimate a distance between the WCD (i.e., the mobile communication device) and the signal emitter (i.e., the at least one remote device) based on ultra-

wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations.

231. Like Kalayjian, Oswald teaches that “the delay between transmission and reception of a pulse” is “proportional to the range between transmitter and receiver[.]” *Oswald* at [0286]; *see also, id.* at [0288] (“The (now unambiguous) computed range delay 432 is multiplied by the speed of light to obtain a measure of the distance between the relevant receiving unit and the transmitter.”). Oswald refers to the distance between two objects as the “range.” *Id.* at [0012] (“Range may be short, typically less than 50 metres, typically less than 10 metres.”), [0247] (“The receiving units 200, 202, 204, 206 have an effective range of 10 metres.”), [0277] (“The system is designed to have a maximum detection range of the active object (or ‘tag’) of 10 m.”). As I discussed above, Oswald also teaches the advantages of UWB transmissions for indoor positioning applications relative to narrowband transmissions. *See* Claim 1(a); *Oswald* at [0278] (discussing the poor and unpredictable propagation characteristics of narrowband pulses in indoor applications).

232. One of the purposes of Kalliola’s invention is to provide “a directional and/or location finding method and system that allows a user to track or locate a signal beacon.” *Kalliola* at [0011]. However, Kalliola only describes providing directional information to the user. A POSITA would have understood that also

providing the user with the estimated distance from the WCD to the signal emitter, as taught by Kalayjian, would have enhanced the user's ability to quickly and easily locate the object associated with the signal emitter. For example, Kalliola's Fig. 5 shows that the user's keys are located 90° to the left. *Kalliola* at Fig. 5; *see also, id.* at [0069] ("The display shows the directional arrow pointing in the direction of the keys, and gives a relative direction measurement towards the keys of -90°."). A POSITA would have understood that providing the estimated distance to the signal emitter in addition to the direction (e.g., 10 feet at 90° to the left) would provide additional data to further assist the user in locating the object. If no distance information is provided, then the user would have to search in the direction provided by the WCD for up to the maximum range of the WCD. Assuming the WCD's maximum range is 30 feet, for example, the signal emitter may be in an entirely different room than the user (and WCD) is located. If the distance is provided in addition to the direction, then the user would be able to determine the location of the signal emitter more effectively. For these reasons, a POSITA would have been motivated to configure Kalliola's WCD to estimate the distance to the signal emitter based on round trip time of flight calculations as taught by Kalayjian to improve similar object-finding systems in the same way. Further, a POSITA would understand that having multiple modalities (e.g., distance and direction information)

provides additional reliability. Having distance information in addition to angle information allows for improved location capability in the presence of errors.

233. As I described above, Oswald recognizes that UWB transmissions are more favorable for indoor applications than narrowband transmissions, such as Bluetooth transmissions, because “narrowband pulses can propagate poorly and/or highly unpredictably.” *Oswald* at [0278]; *see also, Haartsen* at 1652 (describing Bluetooth as utilizing a “low-cost **narrow-band** transceiver[.]”) (emphasis added), 1652 (“The channel makes use of several, equally spaced, 1-MHz hop channels.”), 1656 (“Since the channel capacity is only 1 MHz, as more and more users are added, throughput per user quickly drops to less than some 10 kb/s. The spectral bandwidth available is 79 MHz, but cannot be used effectively when every unit must share the same 1-MHz hop channel.”). A POSITA would have also understood that the user’s personal items, such as their keys and wallet, would often be indoors, such as in the user’s house or office. A POSITA would have understood that utilizing UWB instead of Bluetooth would have been advantageous because UWB technology provides high accuracy, even in harsh environments, due to its ability to resolve multipath typical of indoor environments and its resulting resistance to fading. *See e.g., Quek* at 1863 (“The key motivations for using these systems are the ability of UWB signals to finely resolve multipath components, as well as the availability of technology to implement and generate UWB signals with relatively low complexity.

Fine delay resolution properties make UWB radio a viable candidate for communications in dense multipath environments, such as short-range or indoor wireless communications[.]”). More specifically, a POSITA would understand that UWB signals allow for measuring distance (i.e., ranging) with extremely high accuracy even in indoor environments where multipath is severe. *See e.g., Venkatesh at 1* (“Ultra-wideband (UWB) is an excellent physical layer solution for location-aware sensor networks due to its robustness in harsh multipath environments, its ability to fuse accurate (on the order of tens of centimeters) ranging with low-data rate communication [10] and its covertness for tactical applications.”). A POSITA would have understood that this improved distance measurement would allow a user to locate their devices faster. Therefore, a POSITA would have been motivated to implement Kalayjian’s two-way time-of-flight technique using UWB instead of Bluetooth to predictably improve the accuracy of the distance estimate.

234. Additionally, estimating distance using two-way time of flight calculations was incorporated into the IEEE 802.15.4a UWB standard in 2007. *See 802.15.4a Standard at 8* (“This standard is primarily structured to support the two-way time-of-flight computation of distance between two RDEVs. The overview of two-way ranging is shown in Figure D1.4 (in Annex D1).”), 124-125 (describing two-way ranging sequence on time-of-flight computations). As such, there would have been a reasonable expectation of success in modifying Kalliola’s WCD to

estimate a distance using time-of-flight calculations per Kalayjian, where the time-of-flight calculations were based on UWB communication between the WCD's UWB transceiver and a remote device, per Oswald. Therefore, Kalliola-Oswald-Kalayjian renders obvious estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations.

K. 1(d)(vii): “determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device; and”

235. I have been instructed to interpret the term signal delay as “the difference in time between when a signal is received at two or more antennas.” I apply this interpretation below. Kalliola and Oswald both teach direction determination based on signal delay, while Oswald expressly teaches determin[ing] direction based on signal delay of UWB communications between two or more antennas and the at least one remote device.

1. *Kalliola’s Teachings of Direction Determination Based on Signal Delay*

236. I have been informed that the Patent Owner contends that “signal delay...can be measured as phase delay.” In my opinion, Kalliola’s WCD determine[s] a direction...based on signal delay under Patent Owner’s interpretation of the claim. Kalliola teaches that “the present invention employs signals received

on multiple antennas in a Direction of Arrival ('DoA') signal processing scheme in order to determine a relative direction to a target from WCD 100." *Kalliola* at [0060]. "The direction of arrival of the incident signal (e.g., the position-indicating transmission) is resolved based on the **phase** and possibly amplitude **differences of signals** received by the elements of an antenna array." *Id.* (emphasis added), *see also, id.* at [0070] ("The direction of arrival of the incident signal (e.g., the position-indicating transmission) is resolved based on the **phase** and possibly amplitude differences of the signals received by the respective antennas A1-A6. Control switch 610 sequentially feeds the signal from each antenna to the receiver 620, where the Direction of Arrival ('DoA') signal processing operates on the **signal phase** and possibly amplitude information to **determine a relative direction to a target from WCD 100.**") (emphasis added).

237. I have been informed that Patent Owner has contended that signal delay can be measured as a time delay or a phase delay of the signal. Thus, *Kalliola* teaches the claimed signal delay under Patent Owner's interpretation of the claim because *Kalliola* teaches determining a direction based on the "phase differences of signals." Because *Kalliola* teaches determining a direction to a target based on a phase of signals received at the antenna array, *Kalliola* teaches determin[ing] a direction to the at least one remote device based on a signal delay...between the two or more antennas and the at least one remote device. A POSITA would have looked to

related art, such as Oswald, for the express teaching of the signal delay being based on UWB communications or the UWB transceiver coupled with the antenna array.

2. *Oswald's Teachings of Direction Determination Based on UWB Signal Delay*

238. Oswald teaches determining a direction to a remote transmitter based on the difference in time between when a UWB pulse is received at two or more antennas. Specifically, Oswald teaches a UWB receiver that includes an antenna array having four antennas. *Oswald* at [0345] (“In FIG. 16, the array substrate 270 contains four antennas 272, 274, 276, 278 formed on the substrate.”), Fig. 16, [0012] (“The apparatus may transmit UWB pulses...”), [0099] (“[T]he signals transmitted by the transmitter associated with the object are Ultra Wide Band (UWB) signals.”). “FIG. 18 is a side-view of the sensor array in operation” where “the antennas 272, 276 are again mounted on the substrate 270, and receive a signal from an object as indicated.” *Id.* at [0351]. “It can be seen that **the signal arrives at the antennas 272, 274, 276, 278 at different times** dependent upon the transmitting object’s three-dimensional location with respect to the receiving unit.” *Id.* (emphasis added). “The elevation angle θ and the signal path length difference 284 (which is proportional to **the time delay between reception of the signal at both antennas 272, 276**) are shown.” *Id.* (emphasis added).

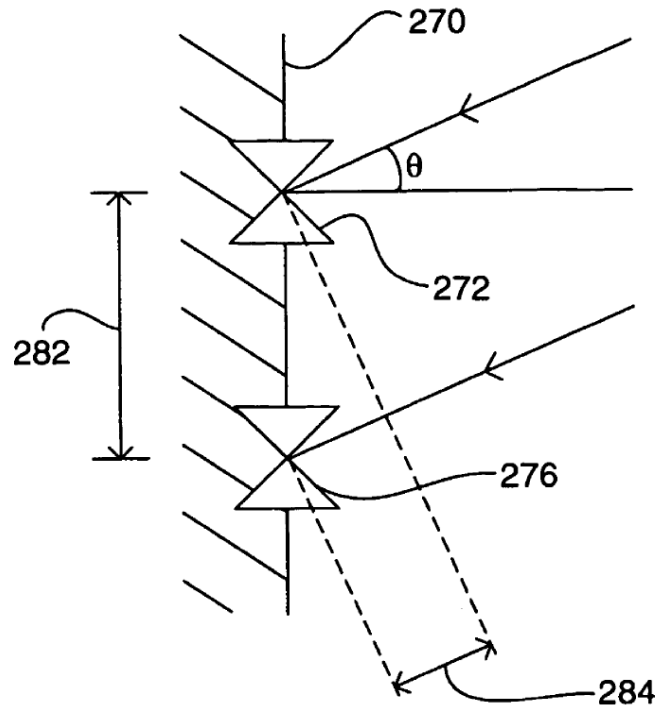


Figure 18

Id. at Fig. 18.

239. Oswald teaches using the times that the UWB signal is received at each antenna to determine the azimuth ϕ and elevation θ directions to the remote transmitter. “More specifically, the times at which the reflected signals will be received by the receiving elements are times Tr_1 , Tr_2 , Tr_3 , Tr_4 , respectively[.]” *Id.* at [0350]. Based on the signal receipt times for each of the antenna elements Tr_1 , Tr_2 , Tr_3 , Tr_4 , the following set of equations are solved for the azimuth ϕ and elevation θ angles:

$$Tr1 = (2R5 + (-D14 \sin(\theta) + D12 \sin(\phi))/2)/c$$

$$Tr2 = (2R5 + (-D23 \sin(\theta) - D12 \sin(\phi))/2)/c$$

$$Tr3 = (2R5 + (D23 \sin(\theta) - D34 \sin(\phi))/2)/c$$

$$Tr4 = (2R5 + (D14 \sin(\theta) + D34 \sin(\phi))/2)/c$$

Id. (“The above equations can be solved (without knowledge of R5, which cannot easily be determined due to the asynchronicity of the transmitter and receiving unit) to obtain the angles θ and ϕ .”)

240. For these reasons, Oswald teaches determin[ing] a direction to the at least one remote device based on signal delay [i.e., the difference in time between when a signal is received at two or more antennas] of ultra-wideband communications between the two or more antennas and the at least one remote device.

3. *Motivation to Combine*

241. As discussed above, the combination relies on either (1) Kalliola’s teaching of determining signal delay (i.e., phase-based DoA estimation) that is modified to use UWB signals instead of Bluetooth signals for the DoA calculation or (2) alternatively modifying Kalliola’s object finding system to use Oswald’s UWB direction-finding technique. I note that in the modified Kalliola WCD, Kalliola’s Bluetooth antenna array is substituted with Oswald’s UWB antenna array,

such that Kalliola's UWB transceiver is coupled to Oswald's antenna array. See Claim 1(a).

242. Regarding (1), it would have been obvious to a POSITA to modify Kalliola's object-finding system to use UWB signals instead of Bluetooth signals for the DoA calculation. Regarding (2) and to the extent that it is determined that phase delay does not meet the signal delay limitation, it would have been obvious to a POSITA to configure Kalliola's object-finding system to use Oswald's UWB direction-finding technique instead of Kalliola's DoA calculation.

243. Kalliola recognizes that "DoA estimation accuracy decreases in the presence of multipath propagation or noise." *Kalliola* at [0064]; *see also, id.* at [0065] ("Multipath radio propagation causes fading that can lead to rapid changes of the DoA estimates and temporary mispointings."). To address multipath propagation errors, Kalliola proposes a tracking algorithm that keeps "a register of several DoA estimates and choos[es] the one with highest average power to be selected as the actual output." *Id.* at [0065]. Specifically, Kalliola's "DoA estimation algorithm calculates an Azimuth Power Spectrum (APS), e.g., the signal power received from azimuth directions." *Id.* at [0066]. "The tracking algorithm extracts the maxima from the azimuth power spectrum" and "keeps track of e.g. the 5 strongest directions." *Id.* "If one of the newly extracted maxima is close (e.g. within 10 degrees) to one of these directions, then the signal power and the direction is

added to the tracked direction.” *Id.* “If not, the new direction is tracked.” *Id.* “All the signal power values of the tracked directions are filtered using a forgetting curve and the DoA of each tracked direction is calculated using a weighted average of the extracted directions for this tracker.” *Id.* “After each tracker update, tracked directions that are closer than e.g. 10 degrees are merged and the number of tracked directions is reduced to the five strongest directions.” *Id.*

244. A POSITA would have understood that using UWB instead of Bluetooth would have removed the need for Kalliola’s tracking algorithm because of UWB’s ability to finely resolve multipath components. *See e.g., Quek* at 1863 (“The key motivations for using these systems are the ability of UWB signals to finely resolve multipath components, as well as the availability of technology to implement and generate UWB signals with relatively low complexity. Fine delay resolution properties make UWB radio a viable candidate for communications in dense multipath environments, such as short-range or indoor wireless communications[.]”). Moreover, it was well-recognized that one of the key motivations for using UWB in multipath environments was “the availability of technology to implement and generate UWB signals with relatively **low complexity**.” *Id.* (emphasis added).

245. Oswald also teaches the advantages of UWB transmissions relative to narrowband transmissions, such as Bluetooth:

For efficiency and performance reasons, the tags signal their position using pulses whose relative bandwidth (that is, the size of the pulse bandwidth compared to the pulse frequency) is greater than, say, 10% and may be even greater (such as 20%, 30%, 40% or even higher). The propagation characteristics of such pulses can be relatively favourable in indoor applications, for example, where so-called narrowband pulses can propagate poorly and/or highly unpredictably.

Oswald at [0278]; *see also*, *Haartsen* at 1652 (describing Bluetooth as utilizing a “low-cost **narrow-band** transceiver[.]”) (emphasis added), 1652 (“The channel makes use of several, equally spaced, 1-MHz hop channels.”), 1656 (“Since the channel capacity is only 1 MHz, as more and more users are added, throughput per user quickly drops to less than some 10 kb/s. The spectral bandwidth available is 79 MHz, but cannot be used effectively when every unit must share the same 1-MHz hop channel.”).

246. As such, a POSITA would have understood that (1) implementing Kalliola’s DoA calculation using UWB signals instead of Bluetooth; or (2) implementing Oswald’s UWB direction-finding technique instead of Kalliola’s DoA calculation would have resulted in a simpler system for addressing multipath propagation. For the reasons discussed above, it would have been obvious to couple the WCD’s antenna array to the UWB transceiver as taught by Oswald. *See* Claim 1(a). By further incorporating a UWB transmitter in the signal emitter 500 to send UWB position indicating transmissions that are received by the WCD’s UWB

antenna array and modifying Kalliola's DoA processing to determine the phase difference of UWB signals instead of Bluetooth signals or modifying the WCD to use Oswald's UWB direction calculation, the additional processing required by Kalliola's tracking algorithm would have been eliminated.

247. In my opinion, the addition of Oswald's hardware (i.e., a UWB transmitter in the signal emitter) for less processing (removal of the tracking algorithm) would have been a design choice that would have resulted in a more accurate system for delay (distance) and direction determination. By using the higher bandwidth UWB signal that (a) is more robust to multipath and (b) has finer delay/distance estimation capability, the combined system would provide improved target location performance. A POSITA would also know that adding UWB functionality (e.g., adding 802.15.4a) involved a straightforward trade between space, weight and power and functionality. As digital components have shrunk over the past 30 years, adding functionality to wireless devices (e.g., Wi-Fi, Bluetooth, UWB, etc.) became more attractive since the cost (in terms of size/weight/power) decreased while the benefits (in terms of increased functionality) increased.

248. I have been informed that any need or problem known in the field of endeavor can provide a motivation to combine prior art references. Thus, the known problem (multipath propagation in indoor environments) provides a motivation to combine Oswald's UWB teachings that address the problem of multipath

propagation in indoor environments with Kalliola's DoA calculation, which suffers from this problem. Accordingly, a POSITA would have been motivated to configure Kalliola's system to either (1) perform DoA processing using UWB instead of Bluetooth; or (2) use Oswald's UWB direction-finding method based on the signal delay of UWB pulses received at the antenna elements to overcome known multipath propagation issues.

249. Additionally, as I discussed with respect to Claim 1(d)(v), a POSITA would have recognized that Kalliola's WCD would often be used to find objects in indoor environments (e.g., a user's keys or wallet). A POSITA would have recognized the advantages of using UWB to locate these items because of UWB's known advantages in indoor environments. *See e.g., Liu* at 1074 ("UWB short duration pulses are easy to filter in order to determine which signals are correct and which are generated from multipath. At the same time, the signal passes easily through walls, equipment and clothing.") As such, the proposed combination of Oswald with Kalliola represents use of a known technique (signal delay estimation for direction determination, per either Kalliola or Oswald, using UWB communications, per Oswald) to a known device (Kalliola's UWB transceiver modified to be coupled to an antenna array) to improve similar devices (Kalliola's WCD) in the same way (Oswald's express advantages of UWB communications). The results of such a combination would have been predictable at least because (1)

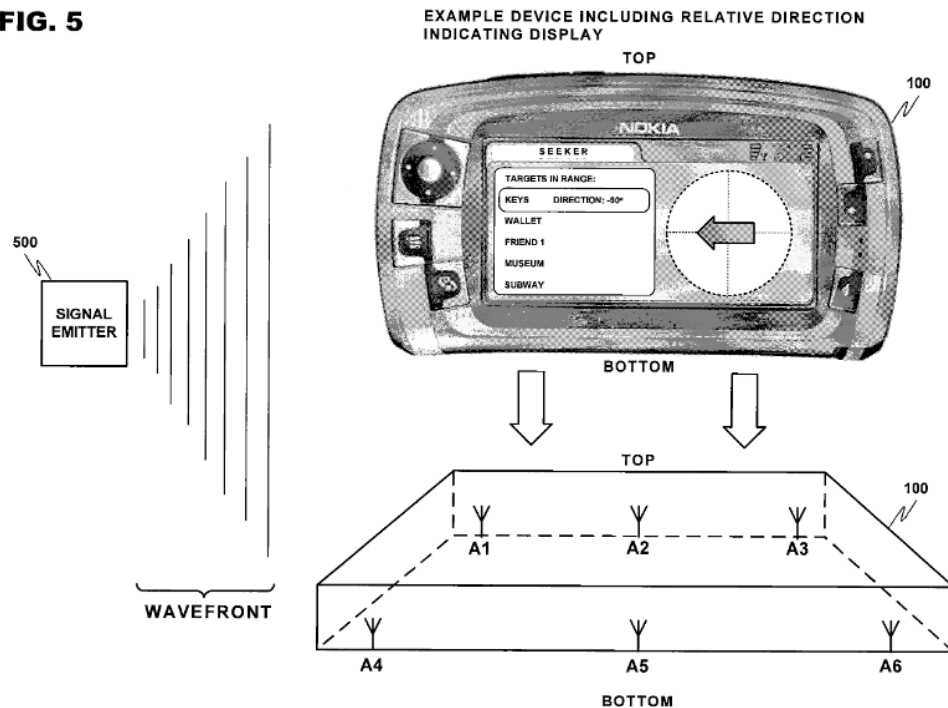
the use of UWB in positioning applications was well-known in the art (per Oswald and Liu), and (2) Kalliola's WCD already includes a UWB transceiver. *Kalliola* at [0048], FIG. 3. Thus, a POSITA would have had a reasonable expectation of success in configuring Kalliola's system to either (1) perform DoA processing using UWB instead of Bluetooth or (2) use Oswald's UWB direction-finding technique in lieu of Kalliola's DoA calculation. Furthermore, a POSITA would have recognized that modifying Oswald with Kalliola in such a way would not have changed the principle of operation of Kalliola's WCD, as the relative direction to the signal transmitter would still be determined.

L. **1(d)(viii): "output to the graphical user interface the estimated distance to the at least one remote device and an arrow pointing in the direction of the at least one remote device."**

1. ***Kalliola's Teachings of Displaying Directional Arrow Pointing to the Signal Emitter***

250. Kalliola's tracking application executing on the processor output[s] to the graphical user interface...an arrow pointing in the direction of the at least one remote device (i.e., signal emitter 500). As I discussed above, Fig. 5 is a screenshot of an exemplary graphical user interface output by the tracking application. See Claim 1(d)(iii). As shown below, the graphical user interface output by the tracking application "shows both a list of possible target objects and an **arrow pointer**." *Kalliola* at [0069] (emphasis added).

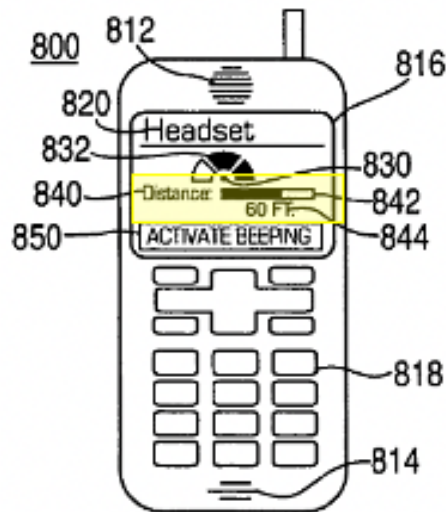
FIG. 5



Id. at Fig. 5; *see also, id.* at Fig. 6, [0069] (“The display shows the **directional arrow pointing in the direction of the keys**, and gives a relative direction measurement towards the keys of -90° .”) (emphasis added).

2. *Kalayjian’s Teachings Regarding Displaying Distance*

251. Kalayjian teaches output[ting] to the graphical user interface the estimated distance to the at least one remote device. As I discussed above, Kalayjian teaches distance estimation from the master device to the slave device (i.e., a remote device). *See* Claim 1(d)(vi). After the master device calculates the distance estimate, “results of this calculation can be presented to a user through a graphical display on screen 316.” *Kalayjian* at [0040]. Fig. 8 is an exemplary graphical user interface that includes the distance estimation:



Id. at Fig. 8 (emphasis added); *see also, id.* at [0049] (The user interface “can include **distance graphic 840 to identify the distance between the selected slave device and master device 800**. Distance graphic 840 can include a symbolic representation 842 of distance, for example, a horizontal bar graphic or a numeric representation of distance 844.”) (emphasis added).

3. *Motivation to Combine*

252. In my opinion, it would have been obvious, and a POSITA would have been motivated to modify Kalliola’s GUI to also display an estimated distance in addition to the arrow directional arrow. As I previously discussed, providing the user distance information in addition to directional information would have improved Kalliola’s WCD because it would have made it easier for the user to locate the signal emitter. *See* Claim 1(d)(iv). For example, when the signal emitter is hidden from sight, the distance information would make it easier for the user to locate the signal

emitter because the user would be able to ascertain how far away the signal emitter is from the user's current location. *Id.* Thus, a POSITA would have understood that displaying the estimated distance to the signal emitter in addition to the direction would have predictably enhanced the user's ability to quickly locate the target object, thereby enhancing user satisfaction.

253. Kalayjian expressly teaches the desire for the slave device to “guide a user to its location.” *Kalayjian* at Abstract; *see also, id.* at [0038] (“[T]he slave device can guide a user to its location and/or notify a user of the distance from master device 310 to the slave device.”). For these reasons, a POSITA would have been motivated to use Kalayjian's known technique of providing a graphical user interface that includes an estimated distance to the signal emitter to improve similar object-finding systems in the same way.

254. A POSITA would have understood that including a distance estimate on the tracking application's graphical user interface would have only required minor software changes. Given the predictability of programming at the time of the '246 Patent, there would have been a reasonable expectation of success configuring Kalliola's WCD to output to the tracking application's graphical user interface the estimated distance to the signal emitter as taught by Kalayjian. There would also be no change to the principle of operation of Kalliola's WCD since it would still output directional information to the user.

M. 11[P]: “A mobile communication device comprising:”

255. *See* Claim 1[P].

N. 11(a): “a plurality of wireless transceivers including a Bluetooth transceiver, a long-range transceiver configured to send and receive telephone calls via a telephony network and to communicate Internet data, and one or more ultra-wideband transceivers coupled to two or more antennas;”

256. *See* Claim 1(a).

O. 11(b): “a memory that stores operational instructions;”

257. *See* Claim 1(b).

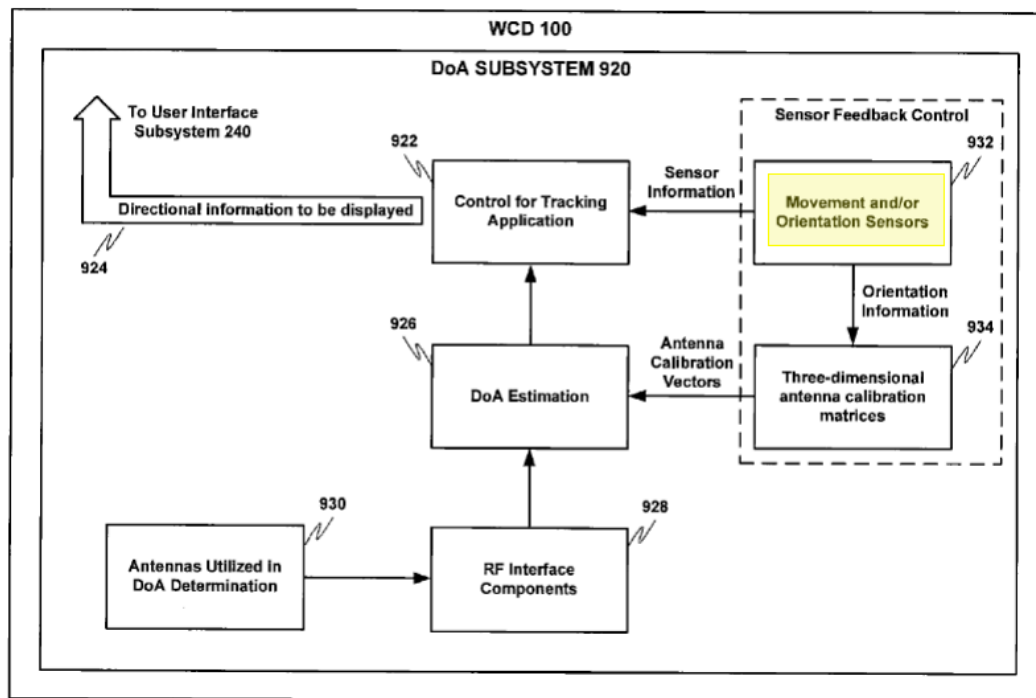
P. 11[c]: “a touch screen;”

258. *See* Claim 1(c).

Q. 11(d): “an orientation sensor to detect rotation of the mobile communication device; and”

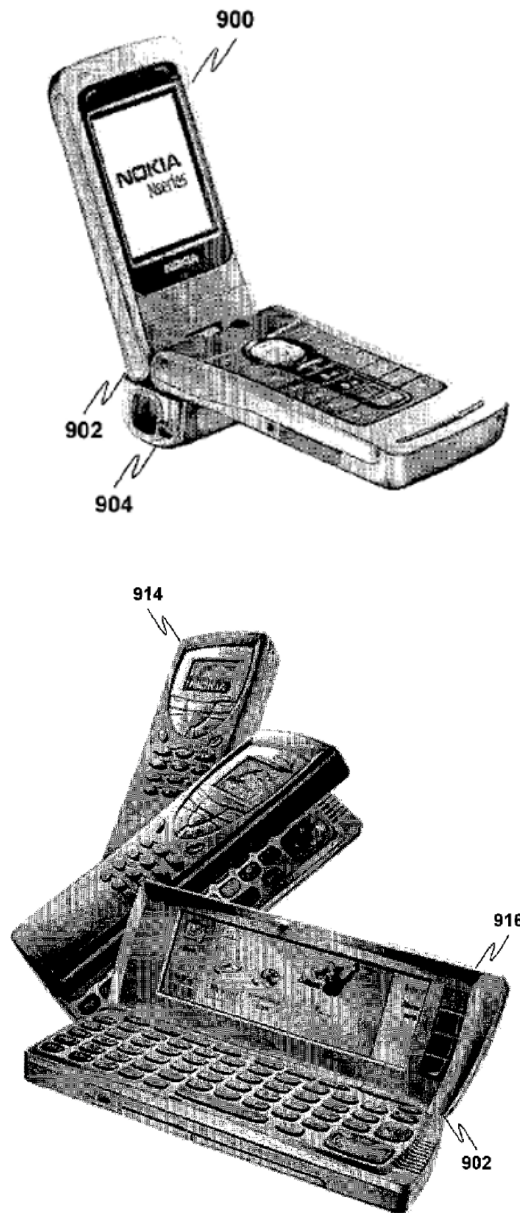
259. Kalliola’s WCD includes an orientation sensor to detect rotation of the mobile communication device. Specifically, Kalliola teaches sensors that “provide information on the relative **orientation** of two sections of WCD 100” where the orientation information is “provided to a controller in WCD 100.” *Kalliola* at [0078] (emphasis added). Kalliola teaches, “[t]his sensor may provide information to a controller in WCD 100 regarding the orientation of the device, such as shown at 900, as to whether a flip cover of the device is open or closed.” *Id.* Fig. 9B depicts “[m]ovement and/or orientation sensors module 932” that “collect information from sensors integrated into WCD 100.” *Id.* at [0081] (emphasis added).

FIG. 9B



Id. at Fig. 9B (emphasis added).

260. The orientation sensor also detects when the cover of the WCD is rotated into an open/closed position:



Id. at Fig. 9A (excerpt).

261. A POSITA would understand that when the orientation sensor is determining whether the flip cover of a flip phone is open/closed, the orientation sensor is detect[ing] rotation of the mobile communication device and specifically, rotation of the cover relative to the body. *Id.* at [0078] (“[A]n exemplary WCD 100

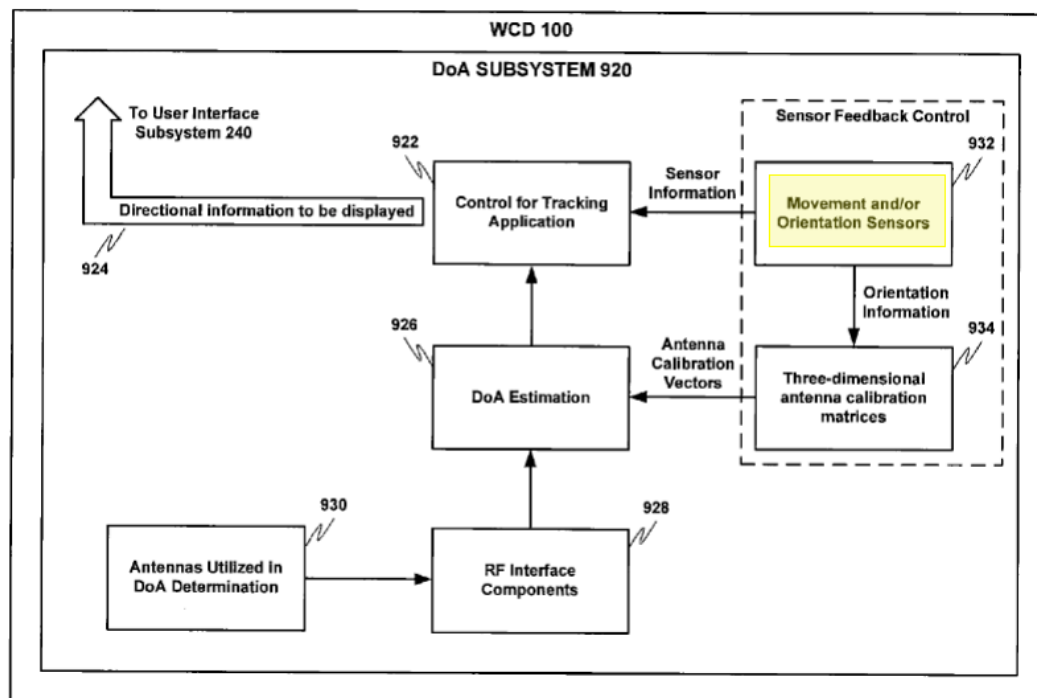
is pictured at 900, wherein a sensor may be integrated into hinge 902. This sensor may provide information to a controller in WCD 100 regarding **the orientation of the device**, such as shown at 900, as to whether a flip cover of the device is open or closed.”) (emphasis added); [0079] (“In this second orientation, the controller of the device may implement alternate functionality or enable resources not available in the ‘closed’ mode. In the example at 916, a cellular telephone mode may be implemented at 914 when a hinge sensor 902 (**similar to sensor 902** previously discussed with respect to 900) provides that the device is in **a closed orientation.**”) (emphasis added).

262. Additionally, Kalliola teaches that an orientation sensor is implemented via a “semiconductor gyroscope chip” to “detect when WCD 100 is being moved.” *Id.* at [0084]. I have been informed that Patent Owner contends that a gyroscope meets the orientation sensor limitation. Thus, Kalliola’s gyroscope is an orientation sensor to detect rotation of the mobile communication device under Patent Owner’s interpretation of the claim.

R. 11(e)(i): “a processor coupled to the plurality of wireless transceivers, the memory, the touch screen and the orientation sensor,”

263. As I discussed above, Kalliola’s WCD includes a processor coupled to the plurality of wireless transceivers, the memory, and the touch screen. See Claim 1(d)(i). Kalliola additionally teaches the processor is coupled to the orientation

sensor. As I discussed above with respect to Claim 11(d), Kalliola’s WCD includes an “**orientation sensors module 932** [that] may collect information from sensors integrated into WCD 100 (e.g., the sensors described in FIG. 9A), and may convey this information to at least the **control** for the tracking application 922[.]” *Kalliola* at [0081] (emphasis added); *see also*, Claim 11(d). The “control for a tracking application 922 may, for example, consist of an application in memory 330 executing on the main processor 300 of WCD 100[.]” *Id.* at [0080].

FIG. 9B

Id. at Fig. 9B (emphasis added).

264. Additionally, Kalliola’s sensor in the flip phone is coupled to the processor, at least because Kalliola shows in Fig. 9B that sensor information output

by the sensors 932 is provided to the “Control for Tracking Application” 922, which is “an application in memory 330 executing on the main processor 300 of WCD 100[.]” *Id.* at Fig. 9B, [0080]. Because the sensor provides information to the processor, the sensor is “coupled” to the processor within the context of the ’246 Patent. Similarly, Kalliola’s gyroscope is *coupled to the processor*, at least because movement information as sensed by the gyroscope is used to direct DoA acquisition, thereby indicating the gyroscope information is provided to the processor. *Id.* at [0084]. I note the ’246 Patent, 37:3-14 states the term “coupled” as used in the ’246 Patent Specification includes both direct and indirect coupling. In Kalliola, for either the orientation sensor for the cover or the gyroscope to provide information to the processor, the sensor is “coupled” to the processor because a communication path exists between the sensor and processor.

265. A POSITA would have understood that because Kalliola teaches that (1) the control for the tracking application is an application executing on the main processor, and (2) the orientation sensors module conveys orientation information to the tracking application, Kalliola teaches *a processor coupled to...the orientation sensor*.

S. **Claim 11(e)(ii): “wherein the processor is configured to execute the operational instructions, which upon execution, cause the processor to:”**

266. *See* Claim 1(d)(ii).

T. **Claim 11(e)(iii): “present a graphical user interface via the touch screen;”**

267. *See* Claim 1(d)(iii).

U. **Claim 11(e)(iv): “in response to a pair request from a user received at the graphical user interface, pair the mobile communication device with at least one remote device;”**

268. *See* Claim 1(d)(iv).

V. **Claim 11(e)(v): “in response to an audio alert request from the user received at the graphical user interface, transmit an audio alert request signal to the at least one remote device via the Bluetooth transceiver;”**

269. *See* Claim 1(d)(v).

W. **Claim 11(e)(vi): “estimate a distance between the mobile communication device and the at least one remote device based on ultra-wideband communication between the one or more ultra-wideband transceivers and the at least one remote device and time of flight calculations;”**

270. *See* Claim 1(d)(vi).

X. **Claim 11(e)(vii): “determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device and on rotation of the mobile communication device detected by the orientation sensor; and”**

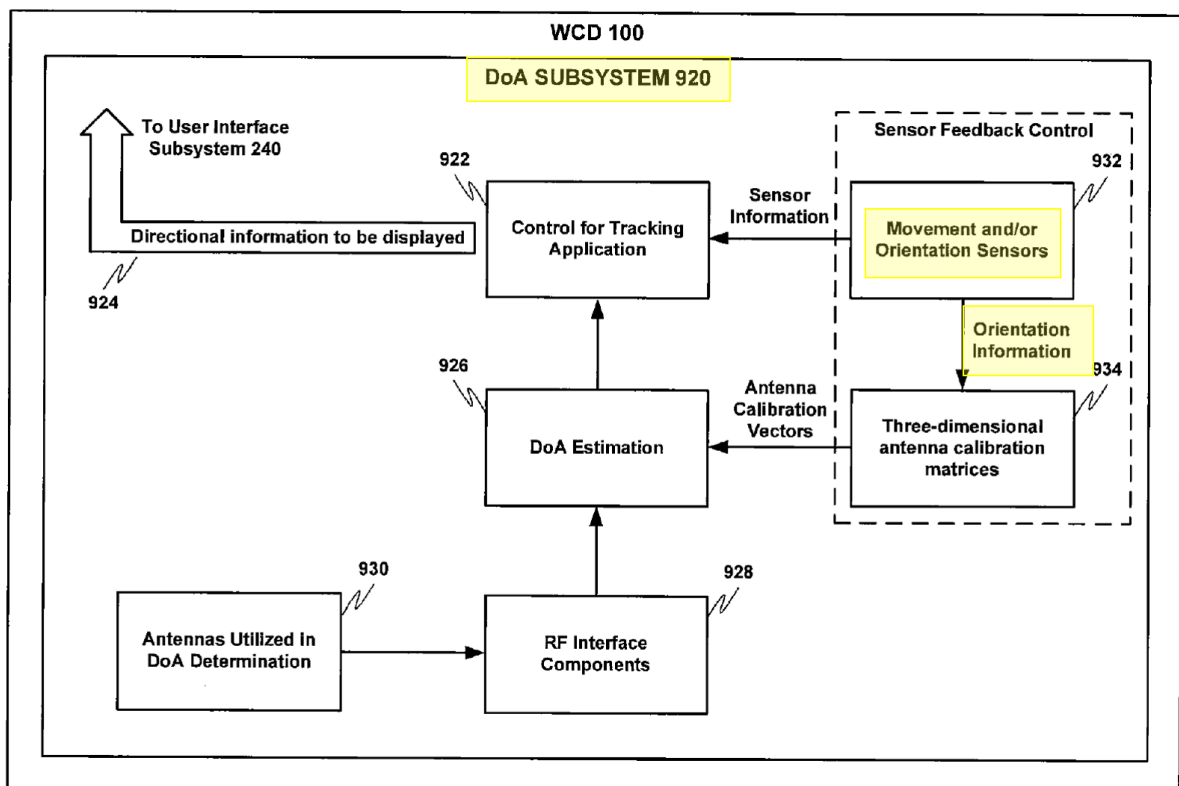
271. As I discussed above, Kalliola and Oswald render obvious determine a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device. *See* Claim 1(d)(vii). Additionally, Kalliola teaches at least two embodiments in which the rotation of the WCD, which is detected by an orientation sensor as

discussed above with respect to Claim 11(d), is used to determine a direction of the WCD to the at least one remote device (i.e., a target).

1. *Kalliola's First Mapped Embodiment*

272. Kalliola teaches a first embodiment in which the WCD includes DoA subsystem 920. The DoA subsystem 920 includes modules that “work together in order to provide a relative direction towards a target beacon.” *Kalliola* at [0080].

FIG. 9B



Id. at Fig. 9B (emphasis added); *see also, id.* at [0013] (“The DoA estimation may operate in a multitude of modes depending on the **physical orientation** of the device. For example, a closed device with an external display screen may execute a DoA

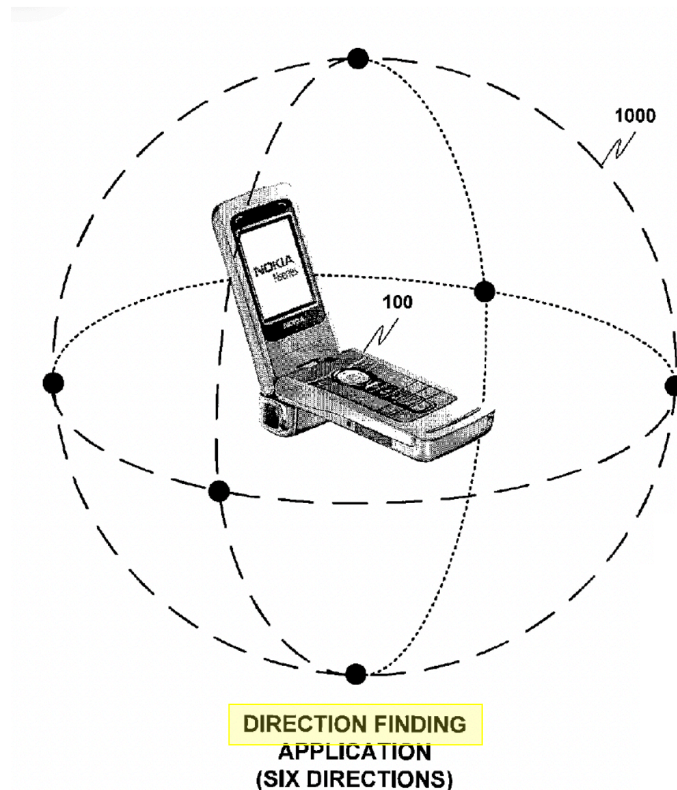
application that displays a directional pointer in a compass-like fashion in order to indicate the direction towards a target.”) (emphasis added).

273. As discussed previously, the DoA subsystem 920 includes a movement and/or orientations sensors module 932. *See* Claim 11(d). The movement and/or orientation sensors module 932 “collect[s] information from sensors integrated into WCD 100 (e.g., the sensors described in FIG. 9A), and may convey this information to at least the control for the tracking application 922 and/or a three-dimensional (3-D) antenna calibration matrices module 934.” *Kalliola* at [0081].²

274. As can be seen in FIG. 9B above, the orientation information collected by module 932 is passed to a three-dimensional (3-D) antenna calibration matrices module 934. “3-D antenna module 934 may use the collected sensor information to determine the appropriate antenna calibration vectors to provide to DoA Estimation module 926. These calibration vectors allow DoA Estimation module 926 to configure the antenna array.” *Id.* at [0081]. The antenna configuration can include “how the measurements from the active antennas will be interpreted in order to determine direction.” *Id.*

275. Fig. 10 includes “examples of applications wherein different antenna calibration vectors may be employed.” *Id.* at [0082].

² The sensors described in FIG. 9A includes the orientation sensor mapped for Claim 11(d). *See* Claim 11(d).



Id. at Fig. 10 (excerpt, emphasis added).

276. Specifically, in the example application 1000 shown above:

WCD 100 may be configured in a mode allowing a user to seek a target including a locating beacon. The orientation of WCD 100 in a “flip-phone open” mode may trigger 3-D antenna module 934 to set a specific antenna configuration, such as an antenna calibration vector utilizing six directional antennas sensing in a spherical-pattern matrix as shown at 1000, for use in DoA estimation.

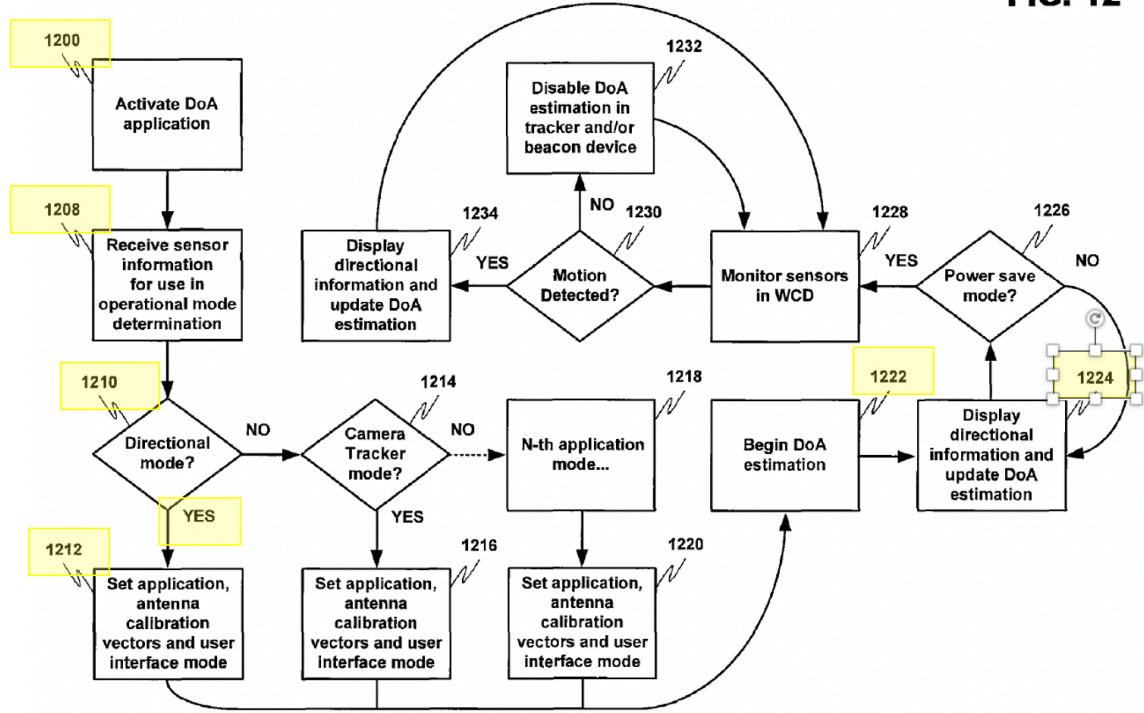
Id. at [0082].

277. Kalliola additionally teaches reading “sensor information” to “determine whether a compass directional mode should be set” as shown in Fig. 10 above. *Id.* at [0085]. Upon setting the compass directional mode, “the DoA

application, antenna calibration vectors and a user interface mode may be set in WCD 100.” *Id.* Once setting the DoA application, antenna calibration vectors, and user interface mode, a “DoA determination may initiate” and the “directional information” is then displayed via the WCD. *Id.* at [0087].

278. Specifically, Fig. 12 is an “exemplary process flow” that begins with initiation of “[a]n application employing DoA estimation” (Step 1200). *Id.* at [0085]. Subsequently, at a step 1208, “[p]art of the initiation of the DoA application will be to retrieve orientation information from various sensors within WCD 100.” *Id.* This orientation information is used at step 1210 to “determine whether a compass directional mode should be set.” *Id.* Upon determining the compass directional mode should be set at step 1212, the antenna calibration vectors and user interface are set as I discussed above. *Id.* Thereafter, the DoA estimation begins (step 1222), and then directional information is then displayed (step 1224). *Id.* at [0087].

FIG. 12



Id. at Fig. 12 (emphasis added).

279. As I discussed previously, Kalliola teaches that sensor information (e.g., orientation sensors) are used to control the WCD. “Controller 922 may use this sensor information to configure and/or implement functionality to enhance the performance of WCD 100” where the “sensor information” includes “information from sensors integrated into WCD” that is collected by movement and/or orientation sensors module 932. *Id.* at [0081]; *see also, id.* at [0082] (“The orientation of WCD 100 in a ‘flip-phone open’ mode may trigger 3-D antenna module 934 to set a specific antenna configuration...for use in DoA estimation.”). Because Kalliola (1) expressly teaches the use of orientation sensor information (e.g., to determine

whether a flip phone cover is opened or closed), and (2) this information is used to set “antenna calibration vectors” that “allow DoA estimation module 926 to configure the antenna array,” Kalliola as modified by Oswald (*see* Claim 1(d)(vii)) also teaches determin[ing] a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device and on rotation of the mobile communication device detected by the orientation sensor. That is, because Kalliola teaches the orientation information is used to configure the antenna array, and the antenna array is used to determine direction to the signal emitter, the Kalliola-Oswald combination also satisfies claim 11(e)(vii). *Id.* at [0082] (“WCD 100 may be configured in a mode allowing a user to seek a target including a locating beacon. The orientation of WCD 100 in a “flip-phone open” mode may trigger 3-D antenna module 934 to set a specific antenna configuration, such as an antenna calibration vector utilizing six directional antennas sensing in a spherical-pattern matrix.”), [0087] (“A DoA determination may initiate in step 1222. The beacon signal may be received by one or more antennas in an antenna array within (or attached to) WCD 100, and a DoA estimation may be converted into directional information for display on the device.”)

280. I note that modifying Kalliola DoA method to use UWB signals as taught by Oswald or substituting Oswald’s signal delay method using UWB pulses (as required by Claim 11(e)(vii)) would not change the principle of operation of

determining direction to the signal emitter based on rotation of the WCD determined by orientation sensors as taught by Kalliola. That is, whether or not UWB is employed, Kalliola would still function to determine orientation using an orientation sensor and to determine a preferred antenna configuration based on the rotation of the WCD (e.g., whether the WCD is open or closed). To state another way, the preferred antenna configuration determined based on rotation of the WCD is agnostic to the type of signal being transmitted.

2. *Kalliola's Second Mapped Embodiment*

281. Kalliola teaches a second embodiment that likewise teaches Claim 11(e)(vii). As discussed, Kalliola teaches collecting sensor information (e.g., orientation information) “during the execution of a DoA estimation in order to enhance the performance of the WCD.” *Kalliola* at [0014]. Furthermore, “[a] DoA-based application tracking a stationary target may conserve power by pausing a DoA estimation until the motion of the WCD is detected by the motion sensors. When the WCD is moved, the updating of the DoA estimation may be resumed.” *Id.* at [0084] “[M]otion sensors integrated in WCD 100 (e.g., in the form of a **semiconductor gyroscope chip**, micro motion sensor, etc.) may further be used to detect when WCD 100 is being moved.” *Id.* (emphasis added). “If WCD 100 is motionless, and the target is also not moving, then updated directional information would not be necessary until the position of WCD 100 changes.” *Id.* When motion resumes, “the

DoA application control 902 may resume the DoA estimation in order to provide updated directional information through a display on WCD 100.” *Id.* Thus, Kalliola teaches that the DoA estimation is paused when the sensors on the WCD do not detect movement (including rotations) and resumed when the sensors detect movement.

282. As discussed with respect to the first mapped embodiment, the sensors include orientation sensors to detect motion of the WCD (e.g., whether the flip cover is open or closed). Kalliola additionally teaches employing a “correction or compensation mode...when user 110 moves WCD 100 too quickly for an accurate DoA estimation.” *Id.* at [0086]. An increase in motion (i.e., rotation) can also be used to adjust the speed at which the DoA estimation is performed. “Increased activity detected by motion sensors in WCD 100 may trigger a configuration that increases the speed of the DoA estimation.” *Id.* Determining the user is rotating the WCD too quickly and increasing the speed of the directional estimation would be equally applicable when performing the direction estimation using UWB.

283. Because Kalliola teaches that pausing, resuming, and adjusting the processing of the DoA estimation is (1) based on detected motions of the WCD, and (2) orientation sensors module 932 detects rotation (i.e., a rotational motion) of the WCD, Kalliola also teaches determin[ing] a direction to the at least one remote

device based...on rotation of the mobile communication device detected by the orientation sensor.

284. As with the first mapped embodiment, modifying Kalliola's WCD with Oswald's teachings and performing the power saving measures by enabling/disabling direction estimation based on detected motion would still be applicable to the modified WCD. Irrespective of whether Bluetooth or UWB signals are used, the benefits of power saving by not performing directional estimation when the WCD is stationary would remain. Likewise, increasing the processing of directional estimations in response to an uptick in activity would be equally applicable when incorporating Oswald's UWB teachings into Kalliola's WCD.

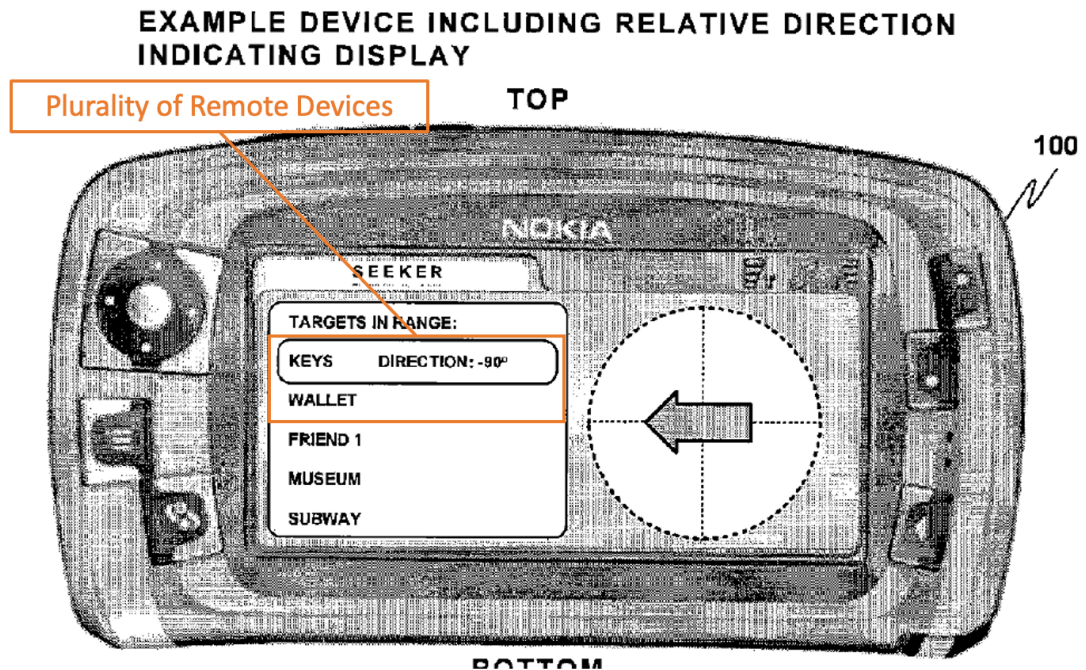
Y. Claim 11(e)(viii): "output to the graphical user interface the estimated distance to the at least one remote device and an arrow pointing in the direction of the at least one remote device."

285. See Claim 1(d)(viii).

Z. Claim 12(a) "The mobile communication device of claim 11, wherein the at least one remote device includes a plurality of remote devices and wherein the operational instructions further cause the processor to"

286. As I discussed above, Kalliola's signal emitter satisfies the claimed at least one remote device. See Claims 1(d)(iv) and 11(e)(iv). Kalliola further teaches that "[t]here can be one or **multiple active signal emitters 500** within one area at the same time." *Kalliola* at [0069] (emphasis added). The use of multiple active signal emitters (plurality of remote devices) is also shown in Fig. 5, where the

graphical user interface of the touch screen displays multiple signal emitters, including signal emitters associated with the user's keys and wallet:



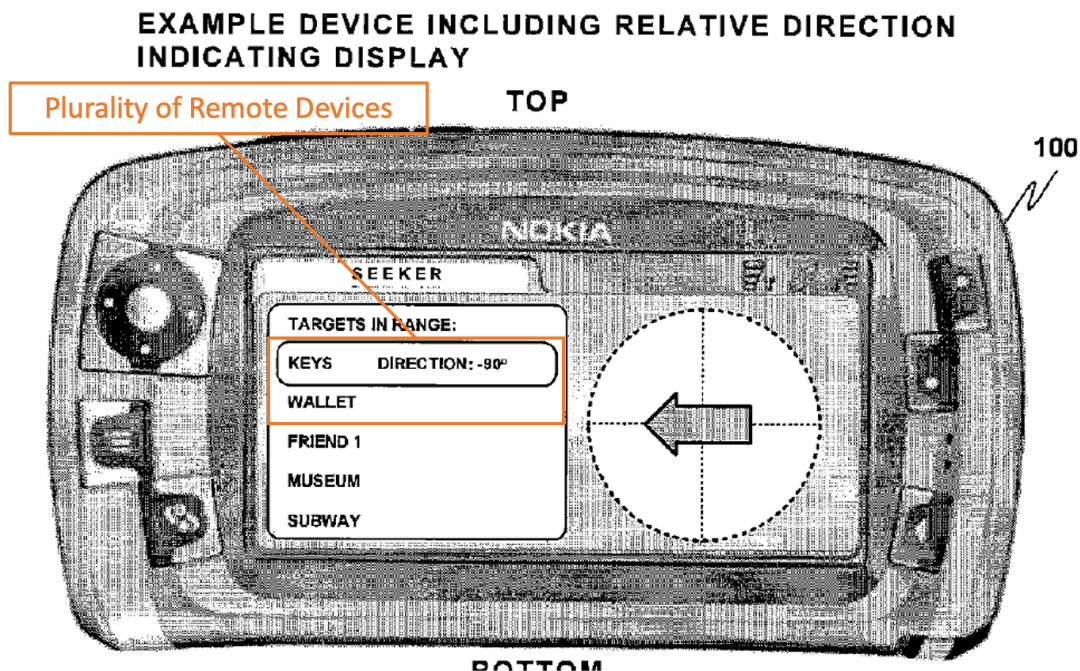
Id. at Fig. 5 (annotated, excerpt); *see also, id.* at [0075] (“These devices, such as battery-operated transmitters in a keychain, in a wallet, embedded in an ID badge, mounted in a vehicle such as an automobile, motorcycle, scooter, bicycle or in a piece of clothing, may be activated remotely by a user as needed.”)

287. Thus, Kalliola’s teachings of multiple signal emitters satisfies wherein the at least one remote device includes a plurality of remote devices.

AA. Claim 12(b) “(i) output to the touch screen a representation of the plurality of remote devices”

288. Kalliola’s tracking application executing on the WCD’s processor output[s] to the touch screen a representation of the plurality of remote devices.

Regarding Fig. 5, Kalliola teaches that “the display shows both **a list of possible target objects** and an arrow pointer.” *Kalliola* at [0069] (emphasis added). As shown in Fig. 5, the “list of possible target objects” is a representation (i.e., a textual representation) of the plurality of remote devices, including the user’s keys and wallet:

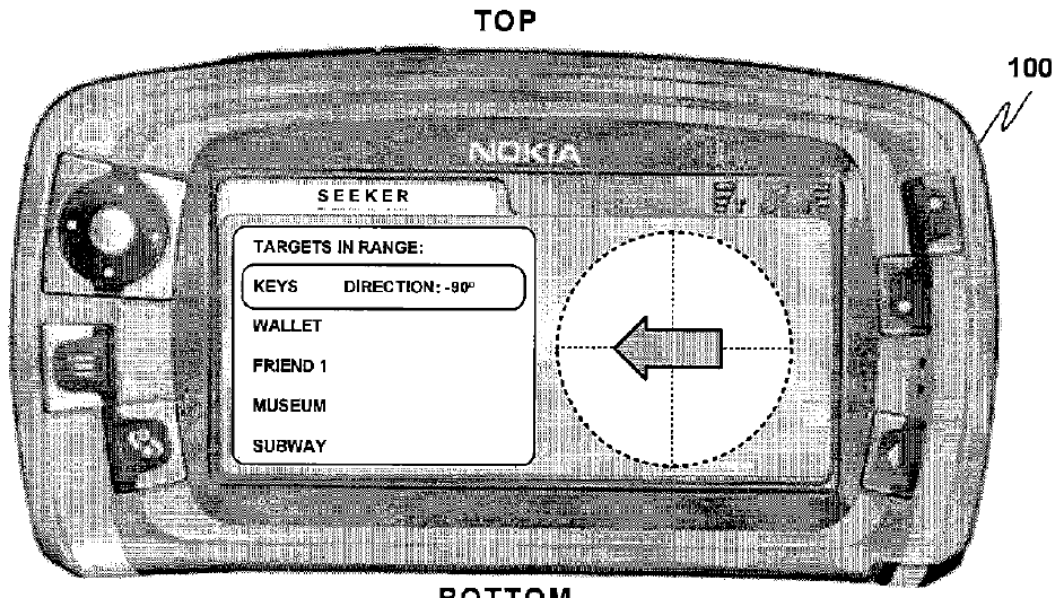


Id. at Fig. 5 (annotated, excerpt).

289. The display showing the list of target objects is a touch screen as I discussed with respect to Claim 1(c) and Claim 1(d)(iii). *See* Claim 1(c) and Claim 1(d)(iii).

BB. Claim 12(c) “(ii) receive user input from the touch screen selecting one of the plurality of remote devices, and”

290. Fig. 5 depicts a screenshot of the tracking application graphical user interface displayed on the touchscreen where “[t]he “KEYS” target object is currently selected.” *Kalliola* at [0069].



Id. at Fig. 5 (excerpt); *see also, id.* at Fig. 6.

291. *Kalliola* teaches that user input 360 includes a touchscreen. *See* Claims 1(c), 11(c). Because the WCD’s user input device is a touchscreen, and because *Kalliola* teaches the KEYS target is selected in Fig. 5, a POSITA would have understood or found obvious that *Kalliola* teaches the processor receives user input at the touchscreen via selection of the KEYS signal emitter.

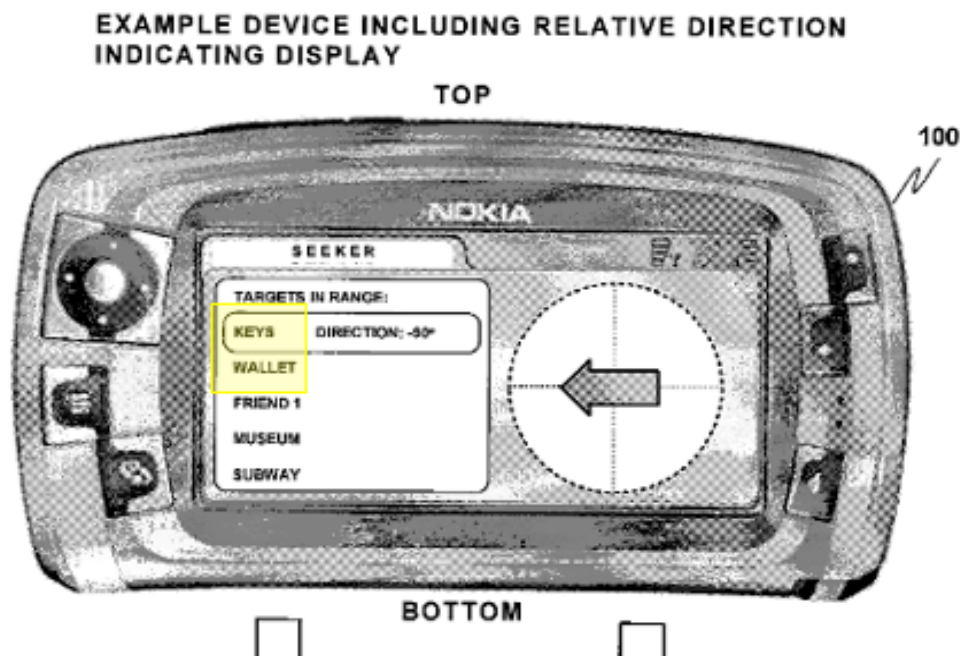
CC. **Claim 12(d) “(iii) output to the touch screen the estimated distance to the selected one of the plurality of remote devices and the direction to the selected one of the plurality of remote devices.”**

292. *See* Claims 1(d)(viii), 11(e)(viii).

DD. Claim 13 “The mobile communication device of claim 12, wherein the operational instructions, upon execution, further cause the processor to receive input from the touch screen defining names for one or more of the plurality of remote devices.”

1. Kalliola’s Teachings

293. As shown in FIG. 5, Kalliola teaches that the signal emitters are associated with names of target objects. For example, the signal emitter associated with the user’s keys is named “KEYS,” and the signal emitter associated with the user’s wallet is named “WALLET.”



Kalliola at Fig. 5 (emphasis added).

294. Kalliola does not describe how the signal emitters are named. However, a POSITA would have been motivated to look to similar object-finding systems for more information on how such names are defined.

2. Kalayjian’s Teachings of Defining Names

295. Kalayjian teaches that the user defines names for each of the slave devices after they are paired with the master device. Specifically, Kalayjian teaches that the master device 310 keeps “a record of the various slave devices to which the master device is paired” and that “[a] user can be given the ability to **create unique names...for the slave devices through the master device’s user interface.**” *Kalayjian* at [0037] (emphasis added). Thus, Kalayjian expressly teaches receiv[ing] input...defining names for one or more of the plurality of remote devices.

3. *Motivation to Combine*

296. It would have been obvious and a POSITA would have been motivated to combine Kalayjian’s teachings of assigning names to remote devices with Kalliola’s touch screen that displays a list of names of target objects. As shown in Kalliola’s Fig. 5 above, Kalliola already discloses that signal emitters are named based on the object a signal emitter is attached to. Thus, a POSITA would have understood that Kalliola implicitly provides for naming of the signal emitters. Based on Kalayjian’s teachings, it would have been obvious to configure Kalliola’s tracking application to allow the user to name each signal emitter by receiving input from the WCD’s touch screen thereby rendering obvious receiv[ing] input from the touch screen defining names for one or more of the plurality of remote devices.

297. Additionally, a POSITA would have understood that the signal emitter’s manufacturer’s device identifier (e.g., a Bluetooth Device Address), would

be a random identifier that would not inform the user to which object the signal emitter would be attached. *See e.g., 802.15.1-2005* at 54-55 (defining the Bluetooth Device Address as a 48-bit address), 258 (discussing a “user-friendly” name that can be assigned to distinguish one device from another). Thus, a POSITA would have been motivated to modify Kalliola’s tracker application (*operational instructions*) to further cause the processor to receive input from the touch screen (the touch screen on Kalliola’s WCD) defining names for one or more of the plurality of remote devices (per Kalayjian’s teachings of defining names for slave devices) to improve similar object-finding systems in the same way.

298. A POSITA would have had a reasonable expectation of success in combining Kalayjian’s teachings with Kalliola as discussed above at least because assigning names to paired wireless devices was well-known well before the alleged invention of the ’246 Patent. For example, the Ericsson T39 phone allowed user’s to assign a name to a paired Bluetooth device. *Ericsson T39 User’s Guide* at 50 (“When the pairing has been completed, **you may edit the name tag for the device[.]**”) (emphasis added).

299. Modifying Kalliola with Kalayjian’s teachings would have involved minimal software changes to Kalliola’s tracker application. The software changes would have involved enabling a name to be defined for the signal emitter. Per Kalayjian and the Ericsson T39 User’s Guide, defining names for remote devices

(e.g., Bluetooth devices/tags) was well-known such that there would have been a reasonable expectation of success in modifying Kalliola's tracker application in this way. Additionally, modifying Kalliola's tracker application to allow defining names for signal emitters would not have changed the principle of operation of Kalliola's tracker application, which still would have functioned to aid a user in locating a selected target object. Rather, this modification would have enhanced the tracker application's functionality by making the selection of a signal emitter to locate a target object easier because the user could name the signal emitter in accordance with the object to which the signal emitter was attached.

EE. **Claim 14 “The mobile communication device of claim 13, wherein the operational instructions, upon execution, further cause the processor to determine the direction to one or more of the plurality of remote devices based on a strength of a signal received from the one or more of the plurality of remote devices at one or more of the plurality of wireless transceivers.”**

1. Kalliola's Teachings

300. Kalliola teaches an alternative signal-strength method for determining the direction to a target. Specifically, “an omnidirectional antenna is used to find any targets in the vicinity by receiving their signals, in order to indicate their presence and possibly the location of the tracking device.” *Kalliola* at [0058]. “To improve the accuracy, a unidirectional antenna on tracking device 420 may be used to **measure the strength of each received signal[.]**” *Id.* (emphasis added). “The user physically moves the device in a sweeping pattern and monitors the signal strength

indicator” and “[t]he **direction of strongest signal reception** is deemed to be the direction towards the target.” *Id.* (emphasis added). Thus, Kalliola teaches determin[ing] the direction to one or more of the plurality of remote devices based on a signal strength received from one or more of the plurality or remote devices received at one or more of the plurality of wireless transceivers.

2. *Motivation to Combine*

301. In my opinion, it would have been obvious, and a POSITA would have been motivated to modify Kalliola’s tracking application to also perform the signal strength measurements for direction finding in addition to the UWB direction measurements taught by the modified Kalliola system as discussed with respect to Claims 1 and 11. *See* Claims 1(d)(vii) and 11(e)(vii). A POSITA would have understood that measuring the signal strength in addition to the aforementioned UWB signal delay method would provide an additional data point that the tracking application would use to confirm the accuracy of the direction measurement. Moreover, a POSITA would have understood that in the event the UWB signal delay direction measurement returns ambiguous results, the signal strength measurement would be used as a backup to assist the tracking application resolve the ambiguous measurement. As noted by Kalliola, signal strength is an “economical way to provide directional location of a target.” *Kalliola* at Fig. 4; *see also, id.* at [0059] (“While this type of system is **very economical** to operate...” (emphasis added)). Thus,

configuring the WCD to also perform a signal strength directional measurement would not significantly add to the cost of the WCD. Based on this express teaching, a POSITA would have been motivated to use signal strength in addition to the UWB signal delay technique described above to economically obtain more data points to increase the accuracy of the tracking application's direction measurement.

302. I have been informed that it is improper to combine references where the references teach away from their combination. A reference may be said to teach away when a POSITA, upon reading the reference, would be discouraged from following the path set out in the reference or would be led in a direction divergent from the path that was taken by the patent applicant. I have also been informed that a reference does not teach away if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage investigation into the invention claimed. I have been asked to consider whether Kalliola's description of the disadvantages associated with determining direction only based on signal strength teaches away from the claimed invention.

303. Fig. 4, which is reproduced below, describes disadvantages of prior "radio directional location based **only** on signal strength":

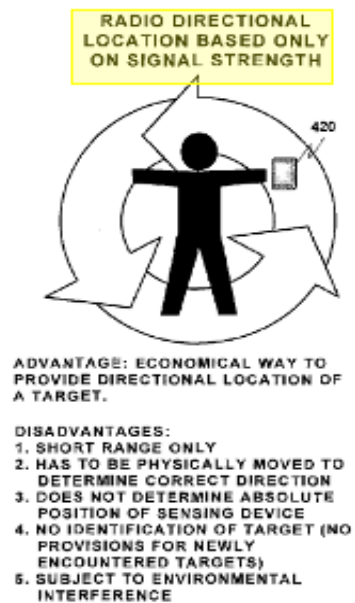


FIG. 4

Id. at Fig. 4 (emphasis added); *see also, id.* at [0058]-[0059] (describing advantages and disadvantages associated with determining direction only based on signal strength).

304. I have been informed that a dependent claim includes all the limitations of the claim(s) from which it depends. Claim 14 ultimately depends on Claim 11, which requires determin[ing] a direction to the at least one remote device based on signal delay of ultra-wideband communications between the two or more antennas and the at least one remote device and on rotation of the mobile communication device detected by the orientation sensor.³ See Claim 11(e)(vii). Thus, the claimed

³ Claim 14 depends on Claim 13, which depends on Claim 12, which depends on Claim 11.

invention does **not** require determining the direction to one or more of the plurality of remote devices **only** based on a signal strength.

305. Because Kalliola discusses the disadvantages that arise when *only* signal strength is employed, Kalliola's teachings would not have led a POSITA away from the claimed invention, which requires determining direction based on signal strength *and* signal delay of UWB communications. Thus, the combination relies on Oswald's UWB teachings in addition to Kalliola's signal strength teaching. Further, Kalliola's teachings do not criticize, discredit, or discourage the use of signal strength in addition to another method for direction determination. As such, nothing in Kalliola would discourage a POSITA from further modifying Kalliola's WCD to determine the direction to the signal emitter based on signal strength in addition to the UWB signal delay method discussed above.

306. Furthermore, a POSITA would have had a reasonable expectation of success in modifying Kalliola's object-finding system to additionally determine direction based on signal strength. Kalliola recognizes the simplicity of using signal strength to determine direction. *Kalliola* at [0058] (describing "the simplest implementation"), [0059] ("While this type of system is very economical to operate..."). Additionally, a POSITA would have recognized that this direction determination would have been performed alongside the UWB signal delay measurement using, for example, a different short-range transceiver than the UWB

transceiver. As one example, Kalliola's Bluetooth transceiver could have been used to determine direction based on signal strength, while the UWB transceivers determine direction as discussed with respect to Claim 11(e)(vii). Because the WCD would still provide directional information to the user, this modification would not have changed the principle of operation of Kalliola's object-finding system.

XII. OPINIONS REGARDING GROUND 2: CLAIMS 2-5 AND 15-18 ARE OBVIOUS OVER KALLIOLA, TURUNEN, OSWALD, VAUCLAIR, KALAYJIAN, AND THORN

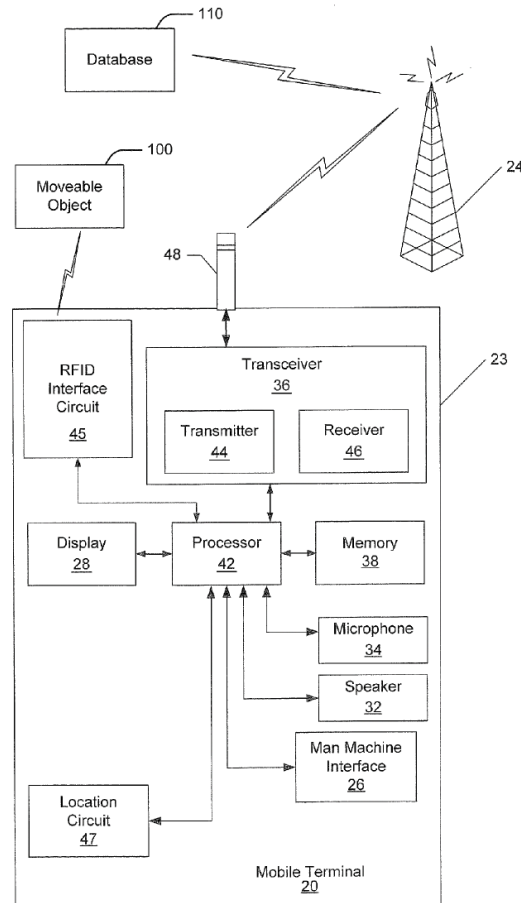
- A. **Claim 2: "The mobile communication device of claim 1, wherein the operational instructions, upon execution, further cause the processor to output to the touch screen an estimated position of the at least one remote device based on information received at one of the plurality of wireless transceivers via a wireless network."**

1. Thorn's Teachings

307. Thorn describes methods and systems "for providing location information associated with movable objects." *Thorn* at [0014]; *see also, id.* at Abstract ("A method of providing location information associated with moveable objects can include periodically receiving identification (ID) information at a first terminal from a moveable object via a Radio Frequency Identification (RFID) signal."). The system includes mobile terminals that communicate with a base station transceiver 24 in a wireless communication network. *Id.* at [0034] ("FIGS. 1 and 2 include a mobile terminal 20 and a base station transceiver 24 in a wireless communications network."), [0036] (disclosing types of mobile terminals).

308. Each mobile terminal 20 includes a transceiver 36 for wireless communication. *Id.* at [0034] (“The mobile terminal 20 includes ... a transceiver 36...”), [0035] (“The transceiver 36 typically includes a transmitter circuit 44 and a receiver circuit 46, which respectively transmit outgoing radio frequency signals to the base station transceiver 24 and receive incoming radio frequency signals, such as voice signals and/or data signals, from the base station transceiver 24 via an antenna 48.”).

309. The wireless communication network may be “any type of wireless communications network,” including a cellular network. *Id.* at [0029]; *see also, id.* at [0037] (“The base station transceiver 24 comprises the radio transceiver(s) that defines an individual cell in a cellular network and communicates with a mobile terminal 20 in other terminals in the cell using a radio-link protocol.”). Each mobile terminal 20 also wirelessly communicates via Bluetooth or RFID with a moveable object 100, which may be “a wallet, a briefcase, a set of keys, rental equipment, etc.” *Id.* at [0030]; *see also, id.* at [0041] (“The mobile terminal 20 includes a Radio Frequency Identification (RFID) interface circuit 45 that can transmit RFID signals to the RFID tags and can periodically receive identification (ID) information that uniquely identifies the RFID tags coupled to moveable objects 100.”), [0032] (disclosing Bluetooth communication with the movable object).



Id. at Fig. 2; *see also, id.* at Fig. 1.

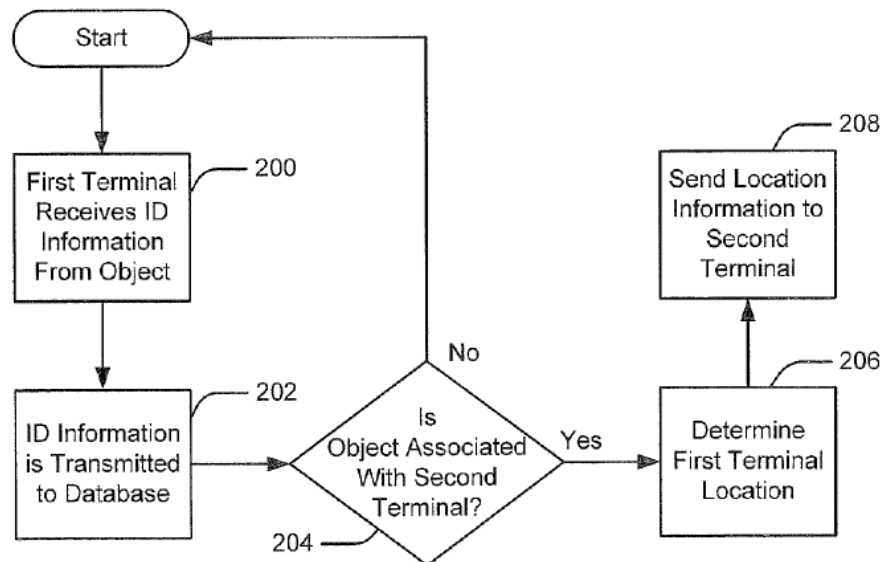
310. Thorn teaches a method of providing location information for a movable object employing first and second terminals (e.g., mobile communication devices) communicating via the wireless communication network. In the method, a first user of a first terminal happens upon a lost movable object, such that the first terminal is proximate the movable object. *Id.* at [0053]; *see also, id.* at Fig. 3. Because the first terminal is proximate the movable object, the location of the first terminal “correspond[s] to the location of the movable object.” *Id.* The first terminal determines whether the moveable object is “associated” with it. If there is no

association between the two, the first terminal sends location information corresponding to the movable object via a database connected to a wireless network to a second terminal, which is associated with the moveable object. *Id.* at [0053], [0064]-[0065], [0047]-[0048] and [0011]-[0012] (disclosing location information is determined using GPS or “a network location circuit that uses location information provided by the network, such as a base station ID, that has location information associated therewith”). In more detail:

As illustrated, the first terminal 150 does not have an association with the movable object 100. The first terminal 150 communicates with a location information source 180. The location information source 180 provides location information to the first terminal 150 that may correspond to the location of the movable object 100. In some embodiments, the first terminal 150 may transmit location information to the database 160, which may transmit ID information and location information corresponding to the movable object 100 to the second terminal 170. In this manner, the second terminal 170 may be notified of the location of the movable object 100 by virtue of proximity between the movable object 100 and the first terminal 150. Although, as illustrated, the second terminal 170 receives location information from the database 160, in some embodiments, the database 160 may be used primarily for data storage and/or lookup functions. For example, location and ID information may be sent to the second terminal 170 via another network device and/or from the first terminal 150 via the communications network.

Id. at [0053].

311. Thorn, at [0055]-[0056] and Fig. 4 disclose a similar functionality as discussed at [0053] that includes periodic updating of the movable object's location:



Id. at Fig. 4; *see also, id.* at [0055]-[0056], [0059]-[0060].

312. Thus, Thorn teaches a first terminal determining its location (from location information source 180), where the first terminal is proximate the movable object. The first terminal then sends the location (for the first terminal and movable object) to the second terminal via the wireless communications network.

313. Regarding the claimed output to the touch screen an estimated position of the at least one remote device, Thorn teaches that the movable object's location information sent from the first terminal to the second terminal is displayed on the second terminal's display on a map: "the location information message includes a map including the location information on a display of the associated terminal." *Id.*

at [0013]; *see also, id.* at [0062] (same). As discussed in the below motivation to combine section, it would have been obvious to display Thorn's map with location information for the signal emitter on Kalliola's touch screen.

314. Regarding the claimed based on information received at one of the plurality of wireless transceivers via a wireless network, Thorn teaches each of the terminals includes transceiver 36 for performing wireless communication across a communications network, such as a cellular network, as discussed above. *Id.* at [0034]-[0035], [0029]. Thorn also teaches the location information is transmitted from the first terminal and to the second terminal "via the communications network." *Id.* at [0053]. A POSITA would have understood or found obvious the transmission of the location information via the communications network is performed by receiving information at the second terminal's transceiver (i.e., the transceiver of the mobile communication device of Claim 1).

315. Thorn, therefore, teaches output[ting] an estimated position of the at least one remote device (the location of the movable object) based on information received (the location information) at one of the plurality of wireless transceivers via a wireless network (location information received by the transceiver of the second terminal).

2. *Motivation to Combine*

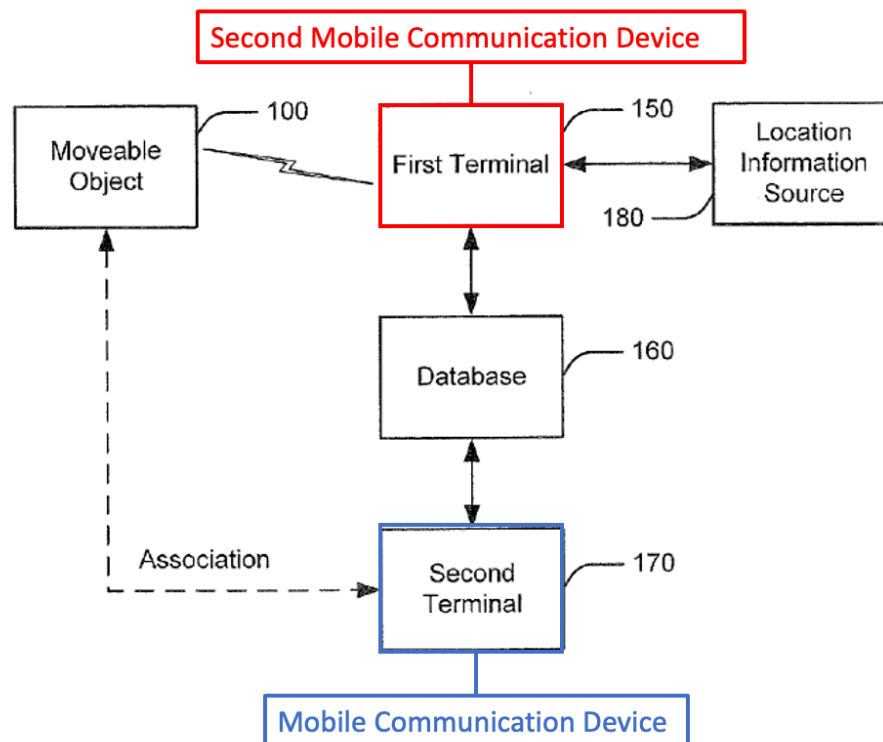
316. It would have been obvious to a POSITA to configure Kalliola's object-finding system to locate signal emitters outside the range of WCD's short-range transceivers using Thorn's long-range location-finding method. A POSITA would have understood that the user may have left a personal item at a location far away from their current location and out of range of the WCD's short-range wireless transceivers. For example, a POSITA would have understood that the user may drop a personal item, such as their keys or wallet while traversing a path from one location to another, as taught by Thorn. In this instance, a POSITA would have readily understood the inherent limitation of reliance on short-range communication only, i.e., that objects outside the range of Kalliola's WCD would not be locatable via the Kalliola's short-range transceivers. Further, a POSITA would recognize that it would have been advantageous to utilize Thorn's long-range location-finding method to send the location of the signal emitter to the WCD via the cellular network and display a map depicting the estimated position on the WCD's touch screen. Thus, a POSITA would have been motivated to configure Kalliola's tracking application (i.e., the operational instructions) executing on the WCD's processor to display the estimated position of the signal emitter based on information received at the WCD's long-range transceiver and from another user's mobile device, as taught by Thorn.

317. A POSITA would have recognized that Kalliola's object-finding system would only be able to find objects located within range of the WCD's short-range transceivers. Configuring Kalliola's system to also utilize Thorn's long-range method would have predictably enabled Kalliola's system to locate the signal emitter over a wide geographical area, thereby eliminating the need for the user to be within Bluetooth/UWB range of the signal emitter. This modification would have predictably improved the system's flexibility and robustness, thereby increasing user satisfaction. For these reasons, a POSITA would have been motivated to configure Kalliola's tracking application to improve similar object-finding systems in the same way.

318. Kalliola's WCD includes the long-range cellular transceiver hardware required to configure Kalliola's WCD to implement Thorn's long-range location-finding method. *See* Claim 1(a). Therefore, this modification would not have required any hardware changes to Kalliola's WCD or changed its principle of operation. Thus, there would have been a reasonable expectation of success configuring Kalliola's WCD to implement Thorn's long-range location-finding method.

- B. **Claim 3: “The mobile communication device of claim 2, wherein, the operational instructions, upon execution, further cause the processor to output on the touch screen the estimated position of the at least one remote device based on information received from a second mobile communication device.”**

319. As I explained with regard to Claim 2, Thorn teaches that the estimated position of the moveable object is *based on information received from a second mobile communication device*. See Claim 2. Specifically, in the embodiment described in [0053] and depicted in Fig. 3, a first terminal sends the estimated position of the moveable object to the second terminal. *Thorn* at Fig. 3, [0053]. Thus, the first terminal of *Thorn* qualifies as the claimed *second mobile communication device* because *Thorn*’s second terminal (the claimed *mobile communication device*) receives the estimated position of the movable object from the first terminal:



Id. at Fig. 3 (annotated).

320. Thus, the combination of Kalliola and Thorn also teaches the limitation of Claim 3 for all the same reasons as discussed with regard to Claim 2. *See* Claim 2 (including motivations to combine).

C. **Claim 4: “The mobile communication device of claim 3, wherein the second mobile communication device is paired with the at least one remote device.”**

1. ***Thorn’s Teachings***

321. Thorn teaches a scenario where “multiple traveling companions shar[e] a common resource, such as, for example a travel book.” *Thorn* at [0057]. “In the case when one of the travelers wishes to use the resource, the location may be determined relative to which of the travelers is in possession of the resource.” *Id.* In this scenario, it would have been obvious for each traveler’s terminal to be paired with the moveable object (i.e., the travel book) based on the teachings of Kalayjian.

2. ***Kalayjian’s Teachings***

322. Kalayjian teaches “determining a slave device’s relative location...using **more than one master device** and determining the distance of the slave device to each master device.” *Kalayjian* at [0046] (emphasis added). Thus, Kalayjian teaches more than one master device, which would include at least a first and a second mobile communication device. Kalayjian teaches that each master device must be paired with the slave device to communicate with it. *Id.* at [0054] (“At step 1010, a master device is paired with one or more slave devices using a

Bluetooth communications protocol.”), [0055] (“At step 1110, a master device is paired with one or more slave devices using a Bluetooth communications protocol.”), Figs. 10-11. Thus, Kalayjian teaches pairing a slave device (i.e., at least one remote device) with multiple master devices (i.e., a first and second mobile communication device).

3. *Motivation to Combine*

323. For the reasons discussed above, it would have been obvious to a POSITA to configure Kalliola’s WCD (mobile communication device) to receive an estimated position of the signal emitter from a second WCD (second mobile communication device). See Claims 2-3. Based on the teachings of Thorn and Kalayjian, it would have been obvious to allow Kalliola’s signal emitter to be paired with more than one WCD so that users of both WCDs may share access to and track the location of the object associated with the signal emitter. If the user of the second WCD is in possession of the shared resource when the user of the first WCD attempts to locate it, then the first WCD, as modified by Thorn and Kalayjian, would receive the estimated position of the resource/signal emitter from the second WCD, which is paired with the signal emitter (per Kalayjian). Thus, the combination of Kalliola, Kalayjian, and Thorn teaches wherein the second mobile communication device is paired with the selected remote device.

324. Based on the teachings of Thorn and Kalayjian, it would have been obvious, and a POSITA would have been motivated to configure Kalliola-Thorn's second WCD to be paired with the signal emitter. As noted by Thorn, multiple users may share a common resource (e.g., multiple travelers sharing a travel book). In this scenario, it would have been obvious for each user's WCD to be paired with the signal source associated with the shared resource so that each of the users can track the resource's location. Thus, a POSITA would have been motivated to combine the prior art elements of Kalliola's object-finding system with Thorn's teaching of multiple users sharing a common resource and determining the location of the resource relative to which of the users is in possession of it and Kalayjian's teaching of pairing multiple mobile communication devices to the same remote device to yield the predictable result of an object finding system where multiple users are able to track the location of a shared object. A POSITA would have understood that this modification would have only required minor software changes and would not have changed the principle of operation of Kalliola's object-finding system. Given the predictability of Bluetooth pairing at the time of the '246 Patent, there would have been a reasonable expectation of success configuring Kalliola-Thorn's second WCD to be paired with the signal emitter. *See ¶¶ 74-75.*

D. Claim 5: “The mobile communication device of claim 3, wherein the second mobile communication device is not paired with the at least one remote device.”

325. As provided in Thorn’s example scenario discussed at [0053], “the first terminal 150 does **not** have an association with the movable object 100.”

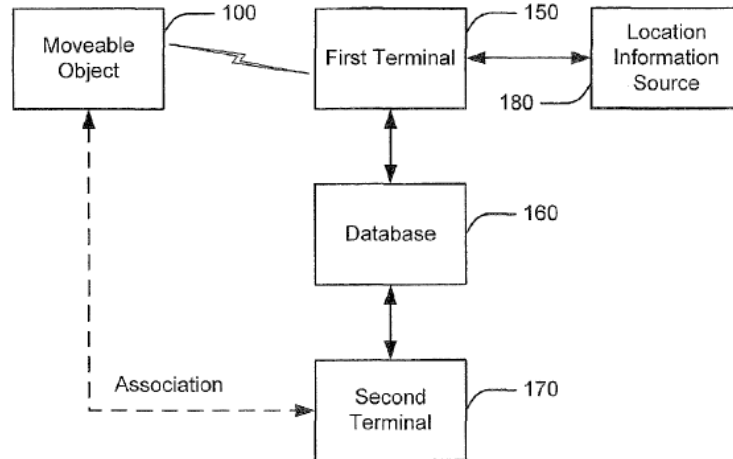


FIG. 3

Id. at Fig. 3; *see also, id.* at [0030] (“If **the moveable object is not associated with the first terminal**, the first terminal can determine location information, using for example...location information that is available through a network in which the first terminal communicates.”) (emphasis added).

326. Thorn teaches that the associations between the movable object and the terminals are stored in database 110. *Id.* at [0039] (“The database 110 may include multiple fields corresponding to uniquely identified movable objects 100. For example, fields may include ... terminal information associated with the movable object 100...”). As I discussed above, pairing creates an association between two

Bluetooth devices that allows them to recognize each other on subsequent connections. *See e.g., Newton* at 614 (defining “pairing” as “[a] Bluetooth term” that involves “The creation and exchange of a link key between two devices” where the devices “use the link key for **future** authentication when exchanging information.”) (emphasis added); *Gehrmann* at 29 (“[T]he pairing of two devices is a procedure by which two devices establish a shared secret that they can use when they **meet again.**”) (emphasis added). Thus, a POSITA would understand that Thorn’s teaching that the first terminal (i.e., *the second mobile communication device*) is not associated with the movable object means that the first terminal is not paired with the moveable object.

327. A POSITA reading Thorn would understand based on Thorn’s teaching of the use of a Bluetooth transceiver for short range communication between a terminal and a moveable object that an association between the two devices would include the devices being paired. As pairing was (and still is) a well-known aspect of the Bluetooth protocol, a POSITA would naturally understand that Thorn’s association would necessarily include pairing in the context of Bluetooth. Thus, the lack of an association between a moveable object and terminal would also teach a lack of pairing between the two devices. Again, I note that for the scenario discussed at [0053], Thorn’s second terminal corresponds to the claimed *mobile communication device*, and Thorn’s first terminal corresponds to the claimed *second*

mobile communication device. See Claim 3. Therefore, the combination of Kalliola and Thorn teaches wherein the second mobile communication device is not paired with (i.e., is not associated with) the at least one remote device for the same reasons as discussed with regard to Claims 2 and 3. See Claims 2 and 3 (including motivations to combine).

- E. **Claim 15: “The mobile communication device of claim 14, wherein the operational instructions, upon execution, further cause the processor to output to the touch screen an estimated position of the one or more of the plurality of remote devices based on information received at one of the plurality of wireless transceivers from a wireless network.”**

328. See Claim 2.

- F. **Claim 16: “The mobile communication device of claim 15, wherein the operational instructions, upon execution, further cause the processor to output on the touch screen an estimated position of the one or more of the plurality of remote devices based on information received from a second mobile communication device.”**

329. See Claim 3.

- G. **Claim 17: “The mobile communication device of claim 16, wherein the second mobile communication device is paired with the at least one remote device.”**

330. See Claim 4.

- H. **Claim 18 “The mobile communication device of claim 16, wherein the second mobile communication device is not paired with the at least one remote device.”**

331. See Claim 5.

XIII. OPINIONS REGARDING GROUND 3: CLAIMS 6-10 AND 19 ARE OBVIOUS OVER KALLIOLA, TURUNEN, OSWALD, VAUCLAIR, KALAYJIAN, THORN, AND SHARP

- A. **Claim 6: “The mobile communication device of claim 3, wherein the operational instructions, upon execution, further cause the processor to transmit an audio alert request signal to the at least one remote device via the wireless network.”**

1. Sharp’s Teachings

332. Sharp teaches “[b]ecause mobile devices are sized for portability, they easily can be misplaced” and “are often carried to many different locations,” which means that “they can be forgotten or lost.” *Sharp* at [0004]. To solve this problem, Sharp recognizes “a need to allow a mobile device owner to remotely issue one or more remote commands to the mobile device, including commands used to present a message or **sound** on the mobile device.” *Id.* at [0009] (emphasis added). “[A] **sound command** can be sent to provide an **audible alert** so that the mobile device may be noticed.” *Id.* at [0057] (emphasis added).

333. Sharp’s system includes a user station 110, which can be “a portable computing device, such as a laptop or smart phone,” communicating with an application server 115 via communication network 105. *Id.* at [0031]-[0033]. The communication network 105 is “implemented using any type or types of physical media, including...**wireless** communication paths associated with multiple service providers.” *Id.* at [0031] (emphasis added). Sharp’s system additionally includes “one or more mobile devices, such as a mobile telephone 120, a digital media player

125, and a laptop computer 130” that “can establish an IEEE 802.11 (i.e., Wi-Fi or WLAN) network connection to the communication network 105.” *Id.* at [0039], [0059]. To preserve battery life, the “mobile device can be configured to establish a network connection at a predetermined interval, such as every thirty minutes, to receive remote management commands.” *Id.* at [0059].

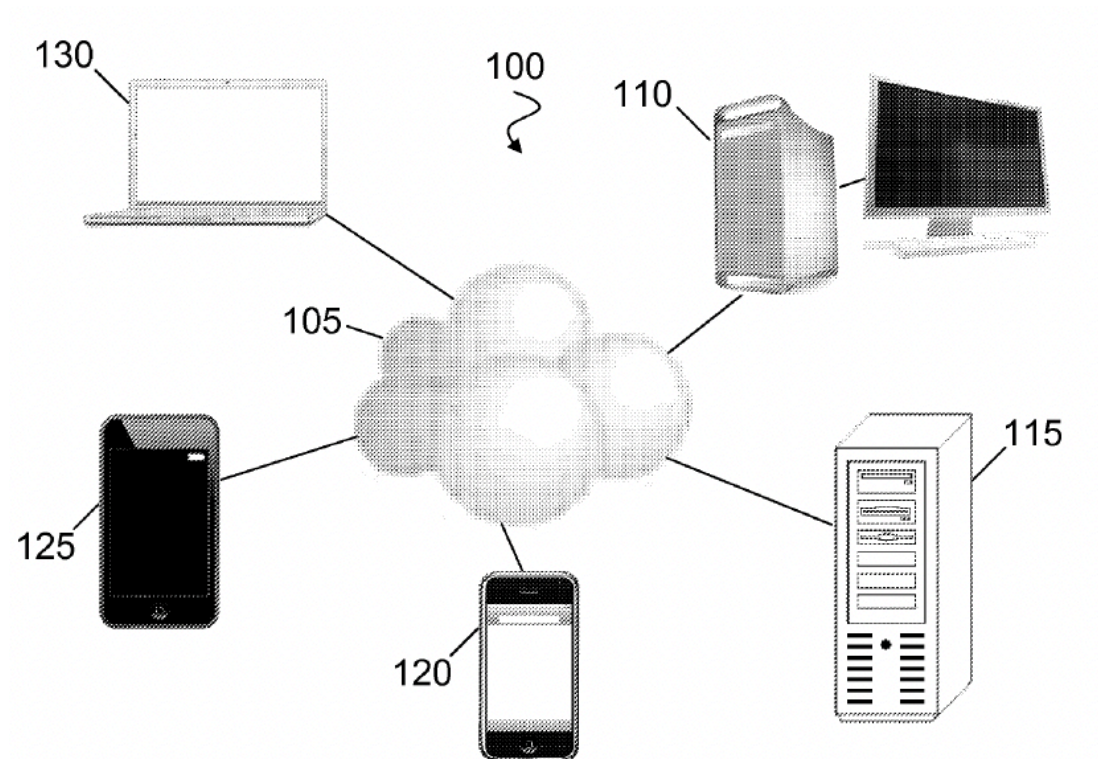


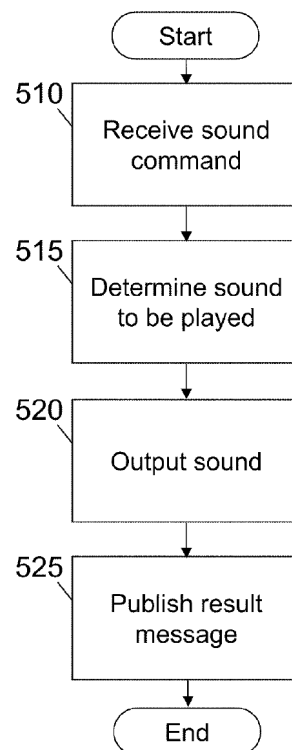
FIG. 1

Id. at Fig. 1.

334. The application server 115 is configured “to host a remote management application that facilitates communication with one or more mobile devices associated with an account.” *Id.* at [0035]. Using the user station, the user can access

the remote management application to “select a mobile device that has been misplaced” from a list of mobile devices linked with the user’s remote management account. *Id.* at [0053]-[0054]. “A remote command to be executed by the mobile device can be selected from the available remote commands (325).” *Id.* at [0055]; *see also, id.* at Fig. 3. A notification message is sent to the misplaced mobile device. *Id.* at [0056].

335. As shown in Fig. 5, the misplaced mobile device receives “a **sound command** indicating that an **audible alert** is to be output (510)” and “[t]he one or more **sounds** representing the **audible alert** can then be output by the mobile device (520).” *Id.* at [0068], [0070] (emphasis added).



Id. at Fig. 5.

336. Thus, Sharp teaches a mobile communication device (i.e., user station) that transmits an audio alert request signal (i.e., sound command) to the at least one remote device (i.e., the selected mobile device) via the wireless network (i.e., communication network 105).

2. Motivation to Combine

337. A POSITA would have been motivated and found it obvious to configure Kalliola's tracking application to transmit an audio alert request signal to the signal emitter via the long-range cellular network per Sharp's teachings. A POSITA would have understood that Kalliola (modified in view of Kalayjian per Claims 1(d)(iv)-1(d)(v)) would have only enabled the signal emitter to receive an audio alert request when the signal emitter is within range of the WCD's Bluetooth receiver. *See* Claims 1(d)(iv)-1(d)(v).

338. As I discussed with respect to Claim 2, a POSITA would have recognized that the signal emitter could be mistakenly left in a location outside the range of Kalliola's short-range transceivers. *See* Claim 2. As taught by Sharp, it would have been advantageous to allow the user to remotely activate the signal emitter's audio alert via the cellular network to increase the chances of the signal emitter being noticed. *Sharp* at [0057]. For example, it would have been advantageous to allow the audio alert to be accessed via the cellular network to alert nearby persons of the signal emitter's location. For these reasons, a POSITA would

have been motivated to improve similar object-finding systems in the same way by configuring Kalliola's tracking application to transmit an audio alert request signal to the signal via the wireless cellular network when the signal emitter is out of range of the WCD's short-range transceivers.

339. As I discussed previously, object-finding systems using wireless signals to trigger auditory alerts were well-known prior to the invention of the '246 Patent. *See* ¶ 83. By the end of 2009, most smartphones had Wi-Fi capabilities. *See e.g., Canalys* at 4 ("Canalys estimates that the proportion of smart phones with Wi-Fi rose to 84% in Q4..."). Because Wi-Fi transceivers were conventional components of wireless devices well before the alleged invention of the '246 Patent, a POSITA would have had a reasonable expectation of successfully modifying the signal emitter to include a Wi-Fi transceiver.

340. A POSITA would have understood that periodically turning on the signal emitter's Wi-Fi transceiver (as taught by Sharp) when the signal emitter is out of range of the WCD's Bluetooth transceiver would have preserved the signal emitter's battery life. Moreover, a POSITA would have understood that modifying Kalliola's tracker application such that it transmits an audio alert signal via the wireless cellular network would have only required minor software changes. That is, because Kalliola (as modified by Kalayjian) already teaches generating an audio alert in response to a signal sent via a short-range transceiver, it would have been a

minor change to additionally configure Kalliola's modified signal emitter to respond to a similar signal sent over a long-range wireless network. A POSITA would have further recognized that the addition of this feature would not have changed the principle of operation of Kalliola's tracking application because Kalliola's tracking application would still function to locate the signal emitter. Thus, there would have been a reasonable expectation of success modifying Kalliola's tracking application to transmit an audio alert signal via the wireless cellular network as taught by Sharp.

- B. Claim 7(a): “The mobile communication device of claim 6, wherein the at least one remote device includes a plurality of remote devices and wherein the operational instructions further cause the processor to”**

341. *See* claim 12(a).

- C. Claim 7(b): “(i) output to the touch screen a representation of the plurality of remote devices,”**

342. *See* claim 12(b).

- D. Claim 7(c): “(ii) receive user input from the touch screen selecting one of the plurality of remote devices, and”**

343. *See* claim 12(c).

- E. Claim 7(d): “(iii) output to the touch screen the estimated distance to the selected one of the plurality of remote devices and the direction to the selected one of the plurality of remote devices.”**

344. *See* claim 12(d).

- F. **Claim 8 “The mobile communication device of claim 7, wherein the operational instructions, upon execution, further cause the processor to receive input from the touch screen defining names for one or more of the plurality of remote devices.”**

345. *See* Claim 13.

- G. **Claim 9 “The mobile communication device of claim 7, additionally comprising an orientation sensor coupled to the processor and wherein the operational instructions further cause the processor to determine a direction to one or more of the plurality of remote devices based on a manual rotation of the mobile communication device.”**

346. Claim 11 recites limitations that are similar to an orientation sensor coupled to the processor and wherein the operational instructions further cause the processor to determine a direction to one or more of the plurality of remote devices based on a manual rotation of the mobile communication device and my analysis for these limitations is incorporated here by reference. See Claims 11(d) (reciting an orientation sensor), 11(e)(i) (reciting a processor coupled to ... the orientation sensor), and 11(e)(vii) (reciting determine a direction to the at least one remote device based ... on rotation of the mobile communication device detected by the orientation sensor). For claim 11, I provide two mappings for the orientation sensor – one for Kalliola’s sensor to detect manual rotation of the flip phone cover to an open/closed position, and a second for Kalliola’s gyroscope to detect movement/motion of the phone.

347. In Kalliola's first mapped embodiment regarding the flip phone cover, Kalliola teaches a sensor employed to determine the "orientation of the device," i.e., the rotation, as to whether a cover of the flip phone is open/closed. *Kalliola* at [0078]; *see also*, Claim 11(e)(vii). A POSITA would have understood or found obvious that a user manually flips the cover between open/closed positions. Such flip phones were well-known well before the time of the alleged invention of the '246 Patent, including the Ericsson T39 mobile phone, for example, which included a flip cover and sensors for detecting when the flip cover was open responsive to a user's manual rotation of the cover. *Ericsson T39 User Guide* at 6, 29 (discussing automatically answering an incoming call when the user opens the flip). Therefore, Kalliola's first mapped embodiment teaches determin[ing] a direction to one or more of the plurality of remote devices based on a manual rotation of the mobile communication device.

348. As I discussed with respect to Kalliola's second mapped embodiment (*see* Claim 11(e)(vii)), Kalliola teaches that tracker application 922 halts/starts the direction estimation based on the received sensor information. *Kalliola* at [0084]. A POSITA also would have understood the sensor is detecting manual rotation of the WCD, at least because the sensor is detecting movement of the WCD, and the WCD is carried by a user. Thus, direction estimation is adjusted based on the speed of the user's manual rotations of the WCD and the second mapped embodiment of Kalliola

also teaches determin[ing] a direction to one or more of the plurality of remote devices based on a manual rotation of the mobile communication device.

- H. Claim 10 “The mobile communication device of claim 9, wherein the operational instructions, upon execution, further cause the processor to determine a direction to one or more of the plurality of remote devices based on a strength of a signal received from the one or more of the plurality of remote devices at one or more of the plurality of wireless transceivers.”

349. See Claim 14.

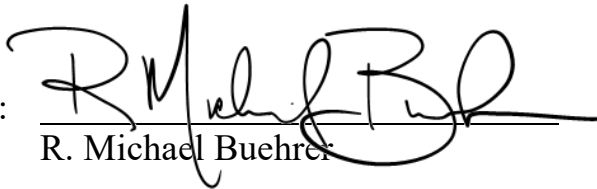
- I. Claim 19 “The mobile communication device of claim 16, wherein the operational instructions, upon execution, further cause the processor to transmit an audio alert request signal to the at least one remote device via the wireless network.”

See Claim 6.

XIV. CONCLUSION

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements 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: 1/19/24

By: 
R. Michael Buehrer

Appendix A

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May 1994 – Aug. 1994	Senior Engineer, Stanford Telecommunications, Advanced Programs.
Sep. 1991 – Aug. 1993	Graduate Research Assistant, The University of Toledo, Department of Electrical Engineering and Computer Science, Communications Research Group.

Honors and Recognitions

- Fellow of the IEEE (So named “for contributions to wideband signal processing in communications and geolocation”)
- 2023 MILCOM Lifetime Award for Technical Achievement
 - For Outstanding, Sustained Technical Contributions to Military Communications
- NSC Vanu Bose Best Paper Award *IEEE Military Communications Conference (MILCOM)* 2023.
- 2023 Fred W. Ellersick Award for the Best Paper in the Unclassified Technical Program, *IEEE Military Communications Conference (MILCOM)*, 2023
- NSC Vanu Bose Best Paper Award *IEEE Military Communications Conference (MILCOM)* 2021.
- Dean’s Award for Teaching Excellence - April 2014.
- 2010 Fred W. Ellersick Award for the Best Paper in the Unclassified Technical Program, *IEEE Military Communications Conference (MILCOM)* 2010.
- SDR Forum Best Paper Award, 2007.
- Outstanding Paper Award, SDR Forum, 2008.
- Dean’s Award for Outstanding New Assistant Professor, College of Engineering, 2003.
- Dean’s List for Teaching Effectiveness (teaching evaluation greater than 3.6) 16 out of 18 semesters list was published.
- Nominated for Certificate of Teaching Excellence (CTE), College of Engineering, Spring 2004 and Spring 2005.
 - Served as a member of the College of Engineering CTE committee from 2006 through 2021.
- Bell Labs President’s Silver Award for outstanding research contributions.
- 1999 Best Paper Award for *Bell Labs Technical Journal*.

Patents

- S. D. Gordon, R.M. Vaghefi, and R.M. Buehrer, “Estimating the Location of a Wireless Terminal Based on Cooperative Measurements,” *US Patent No. 10,527,708*, January 7, 2020.
- S. D. Gordon, R.M. Vaghefi, and R.M. Buehrer, “Estimating the Location of a Wireless Terminal Based on Radio-Frequency Pattern Matching and Cooperative Measurements,” *US Patent No. 9,989,620 B1*, June 5, 2018.
- S. D. Gordon, R.M. Vaghefi, and R.M. Buehrer, “Estimating the Location of a Wireless Terminal Based on Radio-Frequency Pattern Matching and Cooperative Measurements,” *US Patent No. 9,596,571 B1*, March 14, 2017.
- R.M. Buehrer, R.A. Soni, and J.A. Tsai, “Methods and Apparatus for Downlink Diversity in CDMA Using Walsh Codes,” *U.S. Patent No. 7,400,614 B2*, July 15, 2008.
- R. D. Benning, R. M. Buehrer, Mark H Kramlm, and P. A. Polakos, “Space-Time Spreading and Phase Sweep Transmit Diversity”, *US Patent No. 7,042,955 B2*, May 9, 2006.
- R.D. Benning, R.M. Buehrer, and R.A. Soni, “Biased Phase Sweep Transmit Diversity”, *US Patent No. 7,035,599 B2*, April 25, 2006.

- R. D. Benning, R. M. Buehrer, P. A. Polakos, and R. A. Soni, “Split Shift Phase Sweep Transmit Diversity, ” *US Patent No. 6,980,778 B2*, December 27, 2005.
- R.D. Benning, R.M. Buehrer, and R.A. Soni, “ Symmetric Sweep Phase Sweep Transmit Diversity”, *US Patent No. 6,920,314*, July 19, 2005.
- R.M. Buehrer, S.P. Nicoloso, R.A. Soni, and D. Uptegrove, “Cellular Communications System And Related Methods”, *US Patent No. 6,801,791*, October 5, 2004.
- R.M. Buehrer, S.-C. Liu, S.P. Nicoloso, and D. Uptegrove, “Method of channel estimation and compensation based thereon,” *U.S. Patent No. 6,542,560*, April 1, 2003.
- R.M. Buehrer and S.-C. Liu, “Code division multiple access system and method of operation with improved signal acquisition and processing,” *U.S. Patent No. 6,549,565*, April 15, 2003.
- R.D. Benning, R.M. Buehrer, and R.A. Soni, “Apparatus and method of enhancing transmit diversity,” *U.S. Patent No. 6,594,226*, July 15, 2003.
- R.M. Buehrer, S.-C. Liu, S.P. Nicoloso, and D. Uptegrove, “Iterative channel estimation and compensation based thereon,” *U.S. Patent No. 6,614,857*, September 2, 2003.
- R.M. Buehrer and R.A. Soni, “Methods And Apparatus For Downlink Diversity In CDMA Using Walsh Codes”, *U.S. Patent No. 6,515,978*, February 4, 2003.
- R.M. Buehrer, S. Gollamudi, and S.P. Nicoloso, “Multistage interference cancellation for CDMA applications using M-ary orthogonal modulation,” *US Patent No. 6,363,103*, March 26, 2002.
- S.A. Allpress, R.M. Buehrer, and R.A. Soni, “Receiver Architecture Employing Space Time Spreading and Orthogonal Transmit Diversity Techniques,” *US Patent No. 6,317,410 B1*, November 13, 2001.
- S.A. Allpress, R.M. Buehrer, Quinn Li, Ramesh Nallepilli, and R.A. Soni, “Transmitter Architecture Employing Space Time Spreading and Orthogonal Transmit Diversity Techniques,” *US Patent No. 6,392,988*, May 21, 2001.
- R.M. Buehrer, M.D. Hahm, S.C. Liu, and S.P. Nicoloso, “Base Station System Including Parallel Interference Cancellation Processor,” *US Patent No. 6,157,847*, December 5, 2000.

Teaching

Undergraduate Courses

- Engineering Exploration (ECE 1024)
- Electric Circuits (ECE 2004)
- Signals and Systems (ECE 2704, ECE 2714)
- Introduction to Communications (ECE 3614)
- Digital Communications (ECE 4634)
- Analog and Digital Communication Laboratory (ECE 4664)– *developed this course with \$70k grant from the State of Virginia.*

Graduate Courses

- Spread Spectrum Communications (ECE 5660)– *developed this course for the ECE department. It is has been a permanent offering since 2003.*
- Advanced Digital Communications (ECE 5654)
- Multi-Channel Communications (Course covers the fundamentals of OFDM and MIMO techniques the underlying technologies for 4G cellular communications) – *Developed this course for the ECE dept. It is has been a permanent offering since 2008.*
- Information Theory (ECE 5634)
- Machine Learning for Communication Systems (ECE 5984)

Teaching Evaluations (Fall 2001 through Spring 2011)

- Average student evaluation – 3.8/4.0 (17 courses, 450 students)
- Dean’s List (student evaluation > 3.6) in 16 of 18 semesters of teaching

Teaching Evaluations (Fall 2011 through Spring 2023)

- Average student evaluation – 5.5/6.0 (25 courses, > 700 students)

Short Courses Given

- Position Location
- Position Location using Ultra-Wideband Signals
- Radio Resource Management in CDMA Systems
- WiFi – An introduction to WLANs
- OFDM – Multicarrier transmission for high data rate systems; Application to 4G (LTE) cellular and Wi-Fi
- Ultra Wideband Communications
- Multi-Input Multi-Output (MIMO) Communication Systems; Application to 4G (LTE/LTE-Advanced) cellular and Wi-Fi

Advising

Current

- Don-Roberts Emenonye, ” Machine Learning Approaches to Remote Rehabilitation,” Ph.D. candidate, expected graduation December 2023.
- Sam Shebert, ”Automatically Classifying Modern Communication Waveforms,” Ph.D. candidate, expected graduation May 2024.
- Megan Moore, “Geolocation via LEO Networks,” Ph.D. candidate, expected graduation May 2025.

- Haozhou Hu, “Geolocation via Landmarks,” Ph.D. candidate, expected graduation May 2025.
- Gaurav Duggal, “Combined Radar and Communications Signals for Geolocation,” Ph.D. candidate, expected graduation May 2025.
- Harish Dureppagari, “Emergency Localization using UAVs and Collaborative Localization,” Ph.D. candidate, expected graduation May 2026.
- Kumar Sai Bondada, “Synchronization for Distributed MIMO,” Ph.D. candidate, expected graduation May 2026.
- Xinrui Li, “Interference Mitigation in Radio Astronomy,” Ph.D. candidate, expected graduation May 2026.
- Tom Anders, “Resource Allocation in Multi-static and Mono-static Radar Networks,” M.S. candidate, expected graduation December 2024.
- Zach Schutz, “Machine Learning-based Signal Jamming,” M.S. candidate, expected graduation May 2024.

Former

1. William H. Howard, “Distributed Learning for Cognitive Radar Networks,” Ph.D. Novemer 2023.
2. Charlie Thornton, “ On the Value of Online Learning for Cognitive Radar Waveform Selection,” Ph.D., May 2023.
3. Jianyuan Yu, “Wireless Sensing and Fusion using Deep Neural Networks,” Ph.D., August 2022.
4. Yue Xu, “ Deep Recurrent Q Networks for Dynamic Spectrum Access in Dynamic Heterogeneous Environments with Partial Observations,” Ph.D. , August 2022.
5. Chris O’Lone, “Statistical Analysis of Geolocation Fundamentals Using Stochastic Geometry,” Ph.D. December 2020.
6. Jeff Poston, “ILoViT: Indoor Localization via Vibration Tracking,” Ph.D. March 2018.
7. Mahi Abdelbar, “Applications of Sensor Fusion in Classification, Localization and Mapping,” Ph.D. February 2018.
8. Mico Woolward, “SUPPLEMENTING LOCALIZATION ALGORITHMS FOR INDOOR FOOTSTEPS,” Ph.D., July 2017.
9. Daniel Jakubisin, “Advances in Iterative Probabilistic Processing for Communication Receivers,” Ph.D., April, 2016, *currently employed by The Hume Center*.
10. Jeannette Nounagnon “Using Kullback-Leibler Divergence to Analyze the Performance of Collaborative Positioning,” Ph.D., April, 2016, *currently employed by ComSat*.
11. SaiDhiraj Amuru, “Intelligent Approaches for Communication Denial,” Ph.D., September, 2015, *currently employed by Samsung*.
12. Javier Schloemann, “Fundamental Analyses of Collaborative and Noncollaborative Positioning,” Ph.D., August, 2015, *currently employed by Northrup-Grumman*.
13. Reza Vaghefi, “Cooperative Positioning in Wireless Sensor Networks Using Semidefinite Programming,” Ph.D., December 2014, *currently employed by Blue Danube Labs*.
14. Jeong-heon Lee, “Physical Layer Security for Wireless Position Location in the Presence of Location Spoofing,” Ph.D., March 2011, *currently employed by Samsung*.

15. Haris I. Volos, "Cognitive Radio Engine Design For Link Adaptation," Ph.D., September 2010, *currently employed by the University of Arizona.*
16. Tao Jia, "Collaborative Position Location for Wireless Networks in Harsh Environments," Ph.D., March 2010, *currently employed by Qualcomm, Inc.*
17. Heba Shaban, "A Novel Highly Accurate Wireless Wearable Human Locomotion," Ph.D., April 2010, *currently employed by Arab Academy of Science and Technology.*
18. Haesoo Kim, "Cooperative Communications," Ph.D., August 2008, *currently employed by LG Electronics.*
19. Rekha Menon, - "Interference Avoidance based Underlay Techniques for Dynamic Spectrum Sharing," Ph.D., April 2007, *currently employed by Tyco Electronics.*
20. Swaroop Ventkatesh, "The Design and Modeling of Ultra-Wideband Position-Location Networks," Ph.D., February 2007, *currently employed by Marvel Semiconductor.*
21. Jihad Ibrahim, "Algorithms and Architectures for UWB Receiver Design," Ph.D. January 2007, *currently employed by MathWorks.*
22. Chris Anderson, "A Software Defined Ultra Wideband Transceiver Testbed for Communications, Ranging, or Imaging," Ph.D., September 2006, *currently an Associate Professor at the US Naval Academy.*
23. Samir Al-Ghadhban - "Multi-layered Space Frequency Time Codes," Ph.D. October, 2005, *currently an associate professor at King Fahd University.*
24. Jing Jiang – "Increasing the Capacity of Wireless Data Systems - A Cross Layer Perspective," Ph.D., July 2004, *currently employed by Texas Instruments.*
25. Jiann-An Tsai – "Overloaded Array Processing Using Interference Cancellation," Ph.D., May 2002. *Currently employed by Samsung.*
26. Sebastian Rodriguez, "Value of Machine Learning and Cognition on Target Tracking," M.S., June 2022.
27. C. Tanner Fredieu, "Spectrum Awareness: Deep Learning and Isolation Forest Approaches for Open-set Identification of Signals," M.S. May 2022.
28. Dhwan Wanjara, "A Python Software Library to Improve the Accessibility of the Apple Watch as a Research Tool," M.S. May 2022.
29. Daniel Tait, "Electromagnetic Vector-Sensor Direction-of-Arrival Estimation in the Presence of Interference," M.S. August 2020.
30. Don-Roberts Emenonye, "Application of Machine Learning to Multi-Antenna Transmission and Machine Type Resource Allocation," M.S. July 2020.
31. Charlie Thornton, "Learning Schemes for Adaptive Spectrum Sharing Radar," M.S. May 2020.
32. Mark Kozy, "Creation of a Cognitive Radar with Machine Learning: Simulation and Implementation," M.S., May 2019.
33. Bryse Flowers, "Adversarial RFML: Evading Deep Learning Enabled Signal Classification," M.S., June 2019.
34. Parker White, "Constrained Clustering for Frequency Hopping Spread Spectrum Signal Separation," M.S., August 2019.
35. Ersin Selvi, "Cognitive Radar Applied To Target Tracking Using Markov Decision Processes," M.S. December 2017, *currently employed by Raytheon.*
36. Ali Gaber Mohamed, "Navigating via Discrete Astronomical Radio Sources: Geolocation Using Fringe Rates," M.S. April 2017, *currently employed by Alexandria University.*

37. Eric Sollenberger, "Iterative Leakage-Based Precoding for Multiuser-MIMO Systems," M.S., May, 2016, *currently employed by Qualcomm, Inc.*
38. Kevin McDermott, "On the Improvement of Positioning in LTE with Collaboration and Pressure Sensors," M.S., May, 2015, *currently employed by Northrup Grumman*
39. Tori Jewell, "Use of GIS in Radio Frequency and Positioning Applications," M.S. June 2014.
40. Jacob Overfield, "The Impact of MIMO on Signal Localization," MS, May 2013, *currently employed by n-ask, inc.*
41. Zachary Biskaduros, "Collaborative GPS," MS, June 2013, *currently employed by n-ask, inc.*
42. Hunter DeJarnette, "Measuring Noise in the VHF Band and Its Effect On Low SNR Signal Detection," MS Thesis, September 26, 2012, *currently employed by Johns Hopkins Applied Physics Lab.*
43. Benton Thompson, "Characterization and Improvement of the Collaborative and Non-Collaborative Position Location Problems," MS, August 2011, *currently employed by G3, Inc.*
44. Corey Cooke, "Attenuation Field Estimation using Radio Tomography," MS, August 2011, *currently a Ph.D. student at Georgia Tech.*
45. Harpreet Dhillon, "The Optimal Sum-Rate of Multi-Band MIMO Interference Channel," MS, July 2010, *currently an Assistant Professor at Virginia Tech.*
46. Justin Kelly, "The Value of Collaboration in Dynamic Spectrum Access," MS, July 2009, *currently employed by the Department of Energy.*
47. Matthew Roney, "Dual-Channel Direction Finding in Multipath Channels," M.S. candidate, *currently employed by DRS Signal Solutions.*
48. Jesse Reed, "Approaches to Multiple-source Localization and Signal Classification," MS, May, 2009, *currently employed by Arinc, Inc.*
49. Chang Li, "Non-contact Estimation of Respiration and Heartbeat Rate using Ultra Wideband," MS, August 20, 2008, *currently employed by Qualcomm, Inc.*
50. Arjun Bhupathi Raju, "Characterization of Uplink Transmit Power and Talk-Time in WCDMA Networks", MS, July 15, 2008, *currently employed by Qualcomm, Inc.*
51. Rajaraman Parameswaran – "Effects of user and spatial diversity on high data rate wireless systems," M.S., August 2005, *currently employed by Qualcomm Inc.*
52. Nathan Harter, "Single Channel Direction Finding in Multipath Channels," M.S., April 2007, *currently employed by IO-Max.*
53. John Keaveny – "The Implementation of Single-Channel Direction Finding," M.S., February 2005. *Currently employed by Boeing.*
54. Brian Donlan, "Ultra-wideband Narrowband Interference Cancellation and Channel Modeling for Communications," M.S., January 2005, *currently employed by IOMAX USA.*
55. Vivek Baradwaj, "Ultra-Wideband for Communications: Spatial Characteristics and Interference Suppression," M.S., April 2005. *Currently employed by Qualcomm, Inc.*
56. Liu Yang, "On the Applicability of the Tap-delay Line Model to UWB Channel Modeling," M.S., August 2004, *currently employed by Microsoft.*
57. Dan Hibbard, "The Impact of Bandwidth on Indoor Communication System Performance," M.S., May 2004. *Currently employed by Raytheon.*

58. Nishant Kumar – “MAC and Physical Layer Design for Ultra-Wideband Communications,” M.S., May 2004. *Currently employed by Staccato Communicaitons.*
59. Samir Ginde – “A Game-theoretic Analysis of Link Adaptation in Cellular Radio Networks,” M.S., May 2003. *Currently employed by Qualcomm, Inc.*
60. Rahul Mahajan – “Cross Layer Optimization: System Design and Simulation Methodologies,” M.S., December, 2003. *Currently employed by Qualcomm, Inc.*
61. Aaron Orndorf, “Transceiver Design for Ultra Wideband Communications,” M.S., completed May 2004.
62. David McKinstry – “Channel Models and Receivers for Ultra Wideband Communications,” M.S., May 2003. *Currently employed by Johns Hopkins Applied Physics Lab.*
63. Venkatasubramanian Ramasamy – “MC-CDMA/OFDM and Adaptive Antennas,” M.S., June 2002. *Currently employed by Apple.*
64. Ray Chan – “Link Adaptation for Public Safety Wireless Information Networks,” M.S., June 2003. *Currently employed by Northrup Grummond Corp.*
65. Payal Jain – “Software Radio Implementation of Adjustable High Data Rate Receivers,” M.S., November 2002. *Currently employed by Digital Receiver Technology, Germantown, MD.*

Funded Research

1. Title: “Design and Control of Multi-modal Sensors and Sensor Networks,”
Sponsor: Army Research Lab,
Funding: \$200,000 (\$910,962 max)
Period of Performance: , Septemper 1, 2023 - August 31, 2024
Percent: 100
2. Title: “Multi-Target Detection and Tracking with Multi-Mode Radar Networks,”
Sponsor: Lockheed Martin,
Funding: \$150,000,
Period of Performance: August 1, 2023 - July 31, 2024
Percent: 50
3. Title: “Mobile Distributed MIMO: Learning Meets Spreading in Networking,”
Sponsor: Advanced Technology International,
Funding: \$358,531 (max \$8,741,427),
Period of Performance: September 19, 2023 - July 17, 2026
Percent: 10
4. Title: “Development of Machine Learning Methodologies for Radar Signal Classification,”
Sponsor: Alion,
Fudning: \$118,000,
Period of Performance: January 26, 2023 – December 31, 2024
Percent: 100
5. Title: “Prototyping 5G-enabled Indoor Geolocation System for Fire Fighters using UAVs,”
Sponsor: National Institutes of Standards and Technology (through George Mason University),
Fudning: \$849,994,
Period of Performance: June 1, 2022 – May 31, 2025
Percent: 34

6. Title: “ SWIFT: Electronically-Reconfigurable Surfaces for Improved Coexistence Between Radio Astronomy and Satellite Communications Systems,”
Sponsor: National Science Foundation,
Funding: \$748,463,
Period of Performance: September 1, 2021 - August 31, 2024.
Percent: 50%.
7. Title: “ Collaborative Research: CNS Core: Medium: Localization in Millimeter Wave Cellular Networks: Fundamentals, Algorithms, and Measurement-inspired Simulator,”
Sponsor: National Science Foundation,
Funding: \$635,000,
Period of Performance October 2021 – September 2025.
Percent: 50%.
8. Title: “ SWIFT: SMALL: Interference Canceling for Improved Coexistence for Passive and Active Radio Systems,”
Sponsor: National Science Foundation,
Funding: \$499,999,
Period of Performance January 2021– January 2024.
Percent: 50%.
9. Title: “SCH:INT: Collaborative Research: Semi-Automated Rehabilitation in the Home,”
Sponsor: National Science Foundation,
Funding: \$1.1M
Period of Performance: August 2020 – July 2024,
Percent: 10%
10. Title: “Vector Sensor Processing in the Presence of Multipath”
Sponsor: Applied Signals Intelligence
Funding: \$170,000
Period of Performance: April 2020 - April 2021.
Percent: 90%
11. Title: “Machine Learning Approaches to Optimize Army Radar, Communication and EW Systems”
Sponsor: Army Research Lab
Funding: \$975,000
Period of Performance: May 11, 2020 - May 10, 2024.
Percent: 100%
12. Title: “Vector Sensor Processing in the Presence of Interference”
Sponsor: Applied Signals Intelligence
Funding: \$232,193
Period of Performance: December 20, 2018 - April 30, 2019.
Percent: 60%
13. Title: “Digital Beamforming and Interference Mitigation for MIMO Systems ”
Sponsor: GIRD Systems
Funding: \$1,575,398
Period of Performance: October 17, 2018 - October 16, 2021.
Percent: 50%
14. Title: “Cognitive Radar for C-SCoRE: Enhancing Radar Functionality through Interference Analysis and Avoidance,”
Sponsor: Georgia Tech Research Institute (AFRL)
Funding: \$285,000
Period of Performance: December 15, 2018 – May 30, 2022
Percent: 100%

15. Title: "Collaborative Learning for Harmonious Coexistence of Heterogeneous Wireless Networks"
Sponsor: Defense Advanced Research Projects Agency
Funding: \$1,999,994
Period of Performance: January 1, 2017 - December 30, 2019.
Percent: 25%
16. Title: "MU-MIMO Channel Characterization"
Sponsor: GIRD Systems
Funding: \$117,712
Period of Performance: April 1, 2017 - March 31, 2019.
Percent: 100%
17. Title: "Cognitive Radio Approaches to Optimize Army Radar Systems"
Sponsor: Army Research Lab
Funding: \$250,000
Period of Performance: January 1, 2018 - December 30, 2020.
Percent: 100%
18. Title: "Cognitive Radio Approaches to Optimize Army Radar and Communication Systems"
Sponsor: Army Research Lab
Funding: \$190,282
Period of Performance: January 1, 2017 - December 30, 2017.
Percent: 50%
19. Title: "Hyper-wideband Communications"
Sponsor: Defense Advanced Research Projects Agency
Funding: \$182,451
Period of Performance: May 1, 2015 - April 30, 2016.
Percent: 50%
20. Title: "IUSE: Gamification of Wireless Communication Testbeds for Authentic STEM Learning"
Sponsor: National Science Foundation
Funding: \$626,665
Period of Performance: Sept. 1, 2014 - Aug. 31, 2017.
Percent: 20%
21. Title: "Advanced Cognitive Radio Design using SDRs"
Sponsor: Lockheed Martin Advanced Technologies
Funding: \$494,600
Period of Performance: April 1, 2014 – Sept. 30, 2015
Percent: 100%
22. Title: "SDR Technology Development Support"
Sponsor: DoD
Funding: \$375,000
Period of Performance: 5/1/14 – 4/30/14
P.I.: J.H. Reed
Percent: 30%
23. Title: "Improving Cellular Positioning through Collaboration"
Sponsor: Polaris Wireless
Funding: \$82,813
Period of Performance: 11/01/2013 - 10/31/2014
Percent: 100%
24. Title: "Advanced Wireless Systems and Technologies"
Sponsor: DoD

- Funding: \$3,883,320
Period of Performance: 07/01/2012 - 06/30/2014
P.I. R.W. McGwier
Percent: 10%
25. Title: "Cognitive Radio Development"
Sponsor: Lockheed Martin – Advanced Technologies Lab
Funding: \$325,000
Period of Performance: 7/1/2012 – 12/31/2013
P.I. R.M. Buehrer
Percent: 50%
26. Title: "Next Generation Secure, Scalable Communication Network for the Smart Grid"
Sponsor: Oak Ridge National Labs
Funding: \$626,671
Period of Performance: 1/1/2011-10/31/2012
PI – R.M. Buehrer
Co-PI: J.H. Reed
Percent: 50%
27. Title: "Software Defined Radio Waveform and Device Development And Component Deployment Using Ossie"
Sponsor – DoD (Maryland Procurement Office)
PI – RM Buehrer
Period of Performance: Aug. 1, 2010 – July 31, 2013
Funding: \$299,227
Percent: 100%
28. Title: "SDR Technology Development Support"
Sponsor – DoD (Maryland Procurement Office)
PI – R.M. Buehrer and J.H. Reed
Funding: \$638,653
Period of Performance: 9/30/2010 – 4/30/2014
Percent: 75%
29. Title: "Signal Processing Research"
Sponsor: Aerospace Corp.
PI: T.C. Clancy
Co-PI: R.M. Buehrer
Period of Performance: 1/1/2011 – 10/31/2011
Funding: \$130k
Percent: 50%
30. Title: "IHCS: Proactive Cross-Layer Adversary Localization for Hostile or Harsh Wireless Environments"
Sponsor: National Science Foundation
Funding: \$494,788
Period of Performance: 5/1/08 – 4/30/11
PI: Y. Yang
Co-PI's: R.M. Buehrer and J.M. Park
Percent: 33%
31. Title: "A Fundamental Analysis of Spectrum Sharing"
Sponsor: Qualcomm, Inc.
Funding: \$120,000
Period of Performance: 5/1/08 – 4/30/10
PI: Buehrer
Co-PI's: Y. Yang
Percent: 85%

32. Title: "Reasoning and Learning in Adaptive Wireless Networks"
Sponsor: BBN/DARPA
Funding: \$605,000
Period of Performance: 10/1/07 – 3/31/10
PI: L. DaSilva
Co-PI's: R.M. Buehrer, C. Bostian, A. MacKenzie, and J.H. Reed
Percent: 25%
33. Title: DRS Graduate Fellowship
Sponsor: DRS Signal Solutions
Funding: \$76,000
Period of Performance: 9/01/07 – 8/30/09
PI: R.M. Buehrer
Percent: 100%
34. Title: U-PoLo Nets – Position Location in Harsh Environments
Sponsor: National Science Foundation
Funding: \$175k
Period of Performance: 8/1/05 – 7/30/08
PI: R.M. Buehrer
Percent: 100%
35. Title: NeTS ProWiN: An Open Systems Approach for Rapid Prototyping Waveforms for Software Defined Radio
Sponsor: National Science Foundation
Funding: \$1M
Period of Performance: 8/1/05 – 7/30/09
PI: J.H. Reed (lead), R.M. Buehrer, and W.H. Tranter
Percent: 33%
36. Title: Node and Network Benefits of Improved RF Characteristics in CDMA Cellular Networks
Sponsor: ParkerVision
Funding: \$131,474
Period of Performance: 11/1/07 – 10/31/08
PI: R. M. Buehrer
Percent: 100%
37. Title: UWB Propagation in Office Environments
Sponsor: Freescale Semiconductor
Funding: \$35,000
Period of Performance: 5/1/05 – 4/30/06
PI: R. M. Buehrer
Percent: 100%
38. Title: Networking Issues for Peer-to-Peer VoIP Link for Radio Interoperability, Fire Management and Security
Sponsor: Catalyst Communications
Funding: \$67,500
Period of Performance: 1/1/05 – 5/15/05
PI: S.M. Midkiff (lead) and R.M. Buehrer
Percent: 33%
39. Title: AWINN: Advanced Wireless Networking for the Navy
Sponsor: ONR
Funding: \$3M
Period of Performance: 12/20/04 – 6/19/06
PI: Warren Stutzman
Co-PI's: J.H. Reed, Scott Midkiff, R. M. Buehrer, W.H. Tranter, Peter Athanas, Tom Hou, Binoy Ravindran,

Rick Habayeb
Percent: 10%

40. Title: Ultra Wideband Communications Systems
Sponsor: ASPIRES
Funding: \$118,360
Period of Performance: 7/1/03 – 6/30/04
PI: R. M. Buehrer
Percent: 100%
41. Title: UWB Communications
Sponsor: Motorola
Period of Performance: 12/15/03 – 12/14/04
Funding: \$35,000
PI: Buehrer
Percentage: 100%
42. Title: Simulation of Ultra Wideband Communications
Sponsor: ITRI
Funding: \$10,000
Period of Performance: 9/1/03 – 12/31/03
PI: R.M. Buehrer
Percent: 100%
43. Title: Receiver Design for Ultra Wideband Communications
Sponsor: ITRI
Funding: \$15,000
Period of Performance: 9/1/03 – 12/31/03
PI: R.M. Buehrer
Percent: 100%
44. Title: Indoor Propagation
Sponsor: Qualcomm, Inc.
Funding: \$14,000
Period of Performance: 12/1/03 – 5/15/04
PI: R.M. Buehrer
Percent: 100%
45. Title: Single Channel Direction Finding
Sponsor: DRS Technologies
Funding: \$91,000
Period of Performance: 10/18/02 – 10/17/05
PI: R. M. Buehrer
Percent: 100%
46. Title: Flexible High Data Rate Transmission for Wireless Data Applications
Sponsor: BAE Systems
Funding: \$29,000
Period of Performance: 10/18/01 – 10/17/02
PI: R. M. Buehrer
Percent: 100%
47. Title: UWB Propagation Measurements, Modeling, and Communication System Enhancements
Sponsor: Defense Advanced Research Projects Agency
Funding: \$688,620
Period of Performance: 5/13/02-5/12/03
PI: R.M. Buehrer

Co-PI: A.S. Safaai-Jazi, W. Davis, D. Sweeney
Percentage: 35%

48. Title: Modeling and Simulation for the FCS Development Environment

Sponsor: Boeing

Funding: \$127,022

Period of Performance: 5/1/02 - 4/1/03

PI: W. H. Tranter

Co-PI: R. M. Buehrer, A. Annamalai

Percentage: 33%

49. Title: The Benefits of Multiple Antennas at the Handset for Cellular CDMA

Sponsor: e-Tenna Corporation

Funding: \$15,000

Period of Performance: 5/15/02 – 8/14/02

PI: R. M. Buehrer

Percent: 100%

50. Title: MPRG Affiliates Program

Sponsor: Analog Devices, ARO, Cingular, DRS Technologies, General Motors, General Dynamics, Huawei Technologies, Hughes, Lucent Technologies, Motorola, Qualcomm, Raytheon, Samsung, SW Bell, Texas Instruments, et. al.

Funding: \$2M

Period of Performance: 8/25/01 – 5/15/11

PI: J.H. Reed

Co-PI's: R.M. Buehrer, W.H. Tranter, S.W. Ellingson, others

Percent: 20%

Book Publications

1. S. Zekavat and R.M. Buehrer, editors, Position Location - Theory, Practice and Advances, Second Ed., Wiley-IEEE, 2019.
2. S. Zekavat and R.M. Buehrer, editors, Position Location - Theory, Practice and Advances, Wiley-IEEE, 2011.
3. J.H. Lee and R.M. Buehrer, "Security Issues in Position Location," Chapter 3 in Position Location - Theory, Practice and Advances, Wiley-IEEE, 2011.
4. R. M. Buehrer and S. Venkatesh, "Fundamentals of Time-of-Arrival-based Position Location," Chapter 6 in Position Location - Theory, Practice and Advances, Wiley-IEEE, 2011.
5. J.H. Lee and R.M. Buehrer, "Fundamentals of Received Signal Strength Based Position Location," Chapter 11 in Position Location - Theory, Practice and Advances, Wiley-IEEE, 2011.
6. T. Jia and R.M. Buehrer, "Collaborative Position Location," Chapter 23 in Position Location - Theory, Practice and Advances, Wiley-IEEE, 2011.
7. R.M. Buehrer, An Introduction to Code Division Multiple Access (CDMA), Morgan-Claypool Publishers, 2007.
8. R.A. Soni and R.M. Buehrer, "Multiple Antenna Techniques in 3G Wireless Systems," Chapter 25 in Space-Time Wireless Systems: From Array Processing to MIMO Communications, H. Bolecskei, D. Gesbert, C. Papadias, and A.J. vander Veen, editors, Cambridge University Press, 2005.
9. R.M. Buehrer, "Channel Modeling," Chapter 3 in An Introduction to Ultra Wideband Communication Systems, Jeff Reed, editor, pp. 73-158, Prentice-Hall, 2005.

10. A.F. Molisch, J. Kunisch, R. Qiu, D. Cassioli, M. Buehrer, M. Pendergrass, I.Z. Kvac, G.F. Pedersen, P.C.F. Eggers, S. Roy and I. Ramachandran, "UWB Propagation Channels," Chapter 2 in UWB Communication Systems – A Comprehensive Overview, M.-G. Di Benedetto, T. Kaiser, A.F. Molisch, I. Oppermann, C. Politano, and D. Porcino, editors, pp.21-142, Hindawi Publishing Company, 2006.
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12. S. Venkatesh, R.M. Buehrer, J. Liu, and M. Dohler, "Small-Scale Ultra-wideband Propagation Modelling," Chapter 15 in Ultra-wideband Antennas and Propagation for Communications, Radar and Imaging, B. Allen, et. al., editors, pp. 309-330, John Wiley and Sons, 2006.
13. R. Muhamed, R.M. Buehrer, A. Doradla, and T.S. Rappaport, "Mobile and Portable Radio Communications," Chapter 139 in The Engineering Handbook, Second Ed., R.C. Dorf, Editor, pp. 139-1 - 139-19, CRC Press, 2004.
14. T.S. Rappaport, R. Muhamed, M. Buehrer, and A. Doradla, "Mobile and Cellular Radio Systems," The Engineering Handbook, R. C. Dorf Editor, CRC Press, 1996.
15. R.M. Buehrer and B.D. Woerner, "Spread Spectrum for Wireless Communications," Wireless Personal Communications: Research Developments, B.D. Woerner, T.S. Rappaport, and J.H. Reed editors, Kluwer Academic Press, 1995.
16. H. Shaban, M. A. El-Nasr, and R. M. Buehrer, "A Full-Body Wireless Wearable UWB-Based Human Motion Capture and Gait Analysis System," Chapter 20 in E-Healthcare Systems and Wireless Communications: Current and Future Challenges, pp. 434-459, Prof. Mohamed K. Watfa, Editor.

Journal Publications

1. J. Budhu, S. Ellingson, S. Hum, and R.M. Buehrer, "Design of Rim-Located Reconfigurable Reflectarrays for Interference Mitigation in Reflector Antennas," *accepted for publication in IEEE Transactions on Antennas and Propagation*," Jan. 2024.
2. J. Yu, W. Howard, Y. Xu, and R.M. Buehrer, "Model Order Estimation in the Presence of multipath Interference using Residual Convolutional Neural Networks," *accepted for publication in IEEE Transactions on Wireless Communications*," Nov. 2023, DOI: 10.1109/TWC.2023.3339803.
3. D.-R. Emenonye, H. S. Dhillon, and R.M. Buehrer, "On the Limits of Single Anchor Localization: Near-Field vs. Far-Field," *accepted for publication in IEEE Wireless Communications Letters*, Nov. 2023, 10.1109/LWC.2023.3335611.
4. C.E. Thornton and R.M. Buehrer, "On the Value of Online Learning for Radar Waveform Selection," *IEEE Transactions on Radar Systems*, vol. 1, pp. 505-519, DOI: 10.1109/TRS.2023.3313624.
5. W.H. Howard and R.M. Buehrer, "Hybrid Cognition for Target Tracking in Cognitive Radar Networks," *IEEE Transactions on Radar Systems*, vol. 1, pp. 118-131, DOI: 10.1109/TRS.2023.3282846.
6. C. E. Thornton, R. M. Buehrer, and A. F. Martone, "Online Bayesian Meta-Learning for Cognitive Tracking Radar," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 59, No. 5, pp. 6485-6500, Oct. 2023, doi: 10.1109/TAES.2023.3275552.
7. D.-R. Emenonye, H. S. Dhillon and R. Michael Buehrer, "RIS-Aided Localization under Position and Orientation Offsets in the Near and Far Field," *IEEE Transactions on Wireless Communications*, vol. 22, no. 12, pp. 9327-9345, doi: 10.1109/TWC.2023.3270029.
8. D. -R. Emenonye, H. S. Dhillon and R. M. Buehrer, "Fundamentals of RIS-Aided Localization in the Far-Field," in *IEEE Transactions on Wireless Communications*, doi: 10.1109/TWC.2023.3307818.

9. D. -R. Emenonye, A. Sarker, A. T. Asbeck, H. S. Dhillon and R. M. Buehrer, "RIS-Aided Kinematic Analysis for Remote Rehabilitation," in *IEEE Sensors Journal*, doi: 10.1109/JSEN.2023.3308920.
10. S.W. Ellingson and R.M. Buehrer,"Coherent Time-Domain Canceling of Interference for Radio Astronomy," *Publications of the Astronomical Society of the Pacific*, 134, no. 1041 (2022): 114505, doi:10.1088/1538-3873/ac9b92
11. W.W. Howard, A.F. Martone, and R.M. Buehrer, "Distributed Online Learning for Coexistence in Cognitive Radar Networks," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 59, no. 2, pp. 1202-1261, April 2023, doi: 10.1109/TAES.2022.3198038.
12. J. Yu, P. Wang, T. Koike-Akino, Y. Wang, P. V. Orlik and R. M. Buehrer, "Multi-Band Wi-Fi Sensing with Matched Feature Granularity," *IEEE Internet of Things Journal*, vol. 9, no. 23, pp. 23810-23825, 2022, doi: 10.1109/JIOT.2022.3190826
13. M. O. Moore, R. M. Buehrer and W. C. Headley, "Decoupling RNN Training and Testing Observation Intervals for Spectrum Sensing Applications," *Sensors* 2022, 22(13), *Special Issue on Radio Frequency Machine Learning (RFML) Applications* 4706; doi: 10.3390/s22134706.
14. C.E. Thornton, R.M. Buehrer, H.S. Dhillon, and A.F. Martone, "Universal Learning Waveform Selection Strategies for Adaptive Target Tracking," *IEEE Transactions on Aerospace and Electronic Systems*, vol. 58, no. 6, pp. 5798-5814, Dec. 2022. doi: 10.1109/TAES.2022.3181554
15. A. Sarker, D.R. Emenonye, A. Kelliher, T. Rikakis, R. M. Buehrer, A. Asbeck, "Capturing Upper Body Kinematics and Localization with Low-cost Sensors for Rehabilitation Applications," *Sensors* 2022 , 22 , 2300. <https://doi.org/10.3390/s22062300>.
16. D.R. Emenonye, C. Dietrich, and R.M. Buehrer, "Differential Modulation in Massive MIMO With Low-Resolution ADCs," *IEEE Transactions on Wireless Communications*, vol. 21, No. 6, pp. 4482-4496, June 2022, DOI: 10.1109/TWC.2021.3130499
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18. L.J. Wong, W. H. Clark IV, B. Flowers, R. M. Buehrer, A. J. Michaels, and W. C. Headley, "An RFML Ecosystem: Considerations for the Application of Deep Learning to Spectrum Situational Awareness," *IEEE Open Journal of the Communications Society*, vol. 2, pp. 2243-2264, 2021, doi: 10.1109/OJCOMS.2021.3112939.
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22. C.E. Thornton, M. Kozy, A. F. Martone, K. Sherbondy, and R.M. Buehrer, "Deep Reinforcement Learning Control for Radar Detection and Tracking in Congested Spectral Environments," *IEEE Transactions on Cognitive Communications and Networking*, Vol. 6, No. 4, pp. 1335-1349, December 2020, Digital Object Identifier: 10.1109/TCCN.2020.3019605.
23. E. Selvi, R.M. Buehrer, A. Martone, and K. Sherbondy, "Reinforcement Learning For Adaptable Bandwidth Tracking Radars," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 56, No. 5, pp. 3904-3921, October 2020. Digital Object Identifier: 10.1109/TAES.2020.2987443.

24. Y. Xu, J. Yu, and R.M. Buehrer, "The Application of Deep Reinforcement Learning to Distributed Spectrum Access in Dynamic Heterogeneous Environments with Partial Observations," *IEEE Transactions on Wireless Communications*, vol. 19, no. 7, pp. 4494-4506, July 2020.
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29. C.E. O'Lone, H.S. Dhillon, and R.M. Buehrer, "A Statistical Characterization of Localization Performance in Wireless Networks," *IEEE Transactions on Wireless Communications*, vol. 17, no. 9, pp. 5841-5856, Sept. 2018.
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Conference Publications

1. Z. Schutz, C.E. Thornton, D.J. Jakubisin, and R.M. Buehrer, "Linear Jamming Bandits: Learning to Jam OFDM-Modulated Signals," *accepted for presentation/publication at the 2024 IEEE International Communications Conference (ICC'24)*, 9–13 June 2024, Denver, CO, USA.
2. J. Budhu, S. V. Hum, S. W. Ellingson, and R. M. Buehrer, "Loading Rims of Radio Telescopes with Reconfigurable Reflectarrays for Adaptive Null-Steering," *accepted for presentation at 2024 USNC-URSI National Radio Science Meeting (NRSM)*, Jan. 9 - 13, 2024, Boulder, CO.
3. S. W. Ellingson, R. M. Buehrer, T. Anders, and X. Li, "New Results on Mitigation of Satellite Interference by Coherent Time-Domain Canceling," *accepted for presentation at 2024 USNC-URSI National Radio Science Meeting (NRSM)*, Jan. 9 - 13, 2024, Boulder, CO.
4. M.O. Moore, R. M. Buehrer, and W. C. Headley, "Time-Diverse Doppler-only LEO PNT," *2023 Military Communications Conference (MILCOM'23)*, Oct. 30 - Nov. 3, 2023, Boston, MA. Winner of **NSC Vanu Bose Best Paper Award**, and **Fred W. Ellersick Award for the Best Paper in the Unclassified Technical Program**.
5. H. Hu, H.S. Dhillon and R.M. Buehrer, "Landmark-based Localization using Pairwise Constraints: A Stochastic Geometry Perspective," *Proceedings of SpaSWiN 2023*.
6. H. Hu, H.S. Dhillon and R.M. Buehrer, "Stochastic Geometry Analysis of Localizability in Vision-Based Geolocation Systems," *Proceedings of the 57th Asilomar Conference on Signals, Systems, and Computers*, 2023.
7. D.-R. Emenonye, H.S. Dhillon, and R.M. Buehrer, "Limitations of RIS-Aided Localization: Inspecting the Relationships between Channel Parameters," *accepted for presentation at the IEEE 2023 International Conference on Communications (ICC'23) SynComm6G Workshop*, June 2023, Rome, Italy.
8. H. K. Dureppagari, D.-R. Emenonye, H. S. Dhillon, and R. M. Buehrer, "UAV-Aided Indoor Localization of Emergency Response Personnel," *IEEE/ION Position Location and Navigation Symposium*, April 24-27, 2023, Monterey, CA.

9. D.-R. Emenonye, A. Pradhan, H.S. Dhillon, and R.M. Buehrer, "OTFS Enabled RIS-Aided Localization: Fundamental Limits and Potential Drawbacks," *IEEE/ION Position Location and Navigation Symposium*, April 24-27, 2023, Monterey, CA.
10. S.V. Hum, S.W. Ellingson, and R.M. Buehrer, "Toward Electronically Reconfigurable Rims for Reflectors in Radio Astronomy," accepted for presentation at *URSI General Assembly and Scientific Symposium 2023*.
11. S.V. Hum, S.W. Ellingson, and R.M. Buehrer, "Reflectarray Concept for Interference Mitigation in Radio Astronomy," accepted for presentation at *2023 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, 23-28 July, 2023, Portland, OR.
12. W.H. Howard and R.M. Buehrer, "Timely Target Tracking in Cognitive Radar Networks," accepted for presentation at *2023 IEEE Radar Conference*, San Antonio, Texas, May 1-5, 2023.
13. C.E. Thornton and R.M. Buehrer, "When Is Cognitive Radar Beneficial?" accepted for presentation at *2023 IEEE Radar Conference*, San Antonio, Texas, May 1-5, 2023.
14. D.-R. Emenonye, H.S. Dhillon, and R.M. Buehrer, "Estimation of RIS Misorientation in both Near and Far Field Regimes," accepted for presentation at *IEEE 2023 IEEE International Conference on Communications (ICC'23)*, 28 May – 01 June 2023, Rome, Italy.
15. G. Duggal, R.M. Buehrer, J. Reed, and N. Tripathi, "Line-of-Sight Probability for Outdoor-to-Indoor UAV-Assisted Emergency Networks," accepted for presentation at *IEEE 2023 IEEE International Conference on Communications (ICC'23)*, 28 May – 01 June 2023, Rome, Italy.
16. R.M. Buehrer and S.W. Ellingson, "Weight Selection for Pattern Control of Paraboloidal Reflector Antennas with Reconfigurable Rim Scattering," *Proceedings of the 2023 IEEE Aerospace Conference*, March 5-9, 2023, Big Sky, Montana.
17. S.W. Ellingson and R.M. Buehrer, "Techniques for Observing through Satellite Interference," *2023 USNC-URSI National Radio Science Meeting (NRSM)*, accepted for presentation. Boulder, CO, January 10-14, 2023,
18. S. Shebert, M.G. Amin, B.H. Kirk, and R.M. Buehrer, "Multi-Signal Classification Using Deep Learning and Sparse Arrays," *2022 IEEE Military Communications Conference (MILCOM '22)*, Rockville, MD, November 2022.
19. C.E. Thornton and R.M. Buehrer, "Linear Jamming Bandits: Sample-Efficient Learning for Non-Coherent Digital Jamming," *2022 IEEE Military Communications Conference (MILCOM '22)*, Rockville, MD, November 2022.
20. W.H. Howard and R.M. Buehrer, "Decentralized Bandits With Feedback for Cognitive Radar Networks," *2022 IEEE Military Communications Conference (MILCOM '22)*, Rockville, MD, November 2022.
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22. W.H. Howard , A.F. Martone, and R.M. Buehrer, "Adversarial Multi-Player Bandits for Cognitive Radar Networks", *2022 IEEE Radar Conference*, New York, NY, March 21-25, 2022.
23. C.E. Thornton, R.M. Buehrer, and A.F. Martone, "Online Meta-Learning for Scene-Diverse Waveform-Agile Radar Target Tracking," *2022 IEEE Radar Conference*, New York, NY, March 21-25, 2022.
24. B. K. Chalise, D. Wong, M. G. Amin, R. M. Buehrer, A. Martone, B. Kirk, K. Sherbondy, "Sparsity-Based Distributed DoA Estimation for Radar Networks", *2022 IEEE Radar Conference*, New York, NY, March 21-25, 2022.
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26. C.T. Fredieu, R.M. Buehrer and A. F. Martone, "Open-set Classification of Common Waveforms Using A Deep Feed-forward Network and Binary Isolation Forest Models," *accepted for presentation at the 2022 IEEE Wireless Communications and Networking Conference (WCNC 2022)*, December 2021.
27. W.H. Howard and R.M. Buehrer, "Multi-Target Localization Using Polarization Sensitive Arrays," *2021 IEEE Military Communications Conference (MILCOM2021)*, October 2, 2021.
28. C.E. Thornton, R.M. Buehrer, and A.F. Martone, "Waveform Selection for Radar Tracking in Target Channels With Memory via Universal Learning," *2021 IEEE Military Communications Conference (MILCOM2021)*, October 2, 2021. **(Received Vanu Bose Best Paper Award)**
29. S. Shebert, A.F. Martone, and R.M. Buehrer, "Open Set Wireless Standard Classification Using Convolutional Neural Networks," *2021 IEEE Military Communications Conference (MILCOM2021)*, October 2, 2021.
30. J. Yu, Y. Xu, H. Saad, and R.M. Buehrer, "Predicting Bit Error Rate from Meta Information Using Random Forests and Partial Data Augmentation," *SoutheastCon 2021*, Feb. 2021.
31. J. Yu, W. Howard, D. Tait, and R.M. Buehrer, "Direction-of-Arrival Estimation With A Vector Sensor Using Deep Neural Networks," *2021 IEEE Spring Vehicular Technology Conference*, Spring, 2021.
32. C.E. Thornton, R.M. Buehrer and A.F. Martone, "Constrained Online Learning to Mitigate Distortion Effects in Pulse-Agile Cognitive Radar", *2021 IEEE Radar Conference*, May 10-14, 2021.
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34. M. Moore, W.H. Clark IV, R.M. Buehrer, and W.C. Headley, "When is Enough Enough? "Just Enough" Decision Making with Recurrent Neural Networks for Radio Frequency Machine Learning," *39th IEEE – International Performance Computing and Communications Conference (IPCCC 2020)*, November 6th - 8th 2020.
35. C.E. Thornton, R.M. Buehrer and A.F. Martone, "Efficient Online Learning for Cognitive Radar-Cellular Coexistence via Contextual Thompson Sampling," *IEEE 2020 Global Communications Conference, GlobeCom2020*, Taipei, Taiwan, 7-11 December 2020.
36. J. Yu, M. S. Alhassoun, and R.M. Buehrer, "Interference Classification Using Deep Neural Networks," *IEEE Vehicular Technology Conference – Fall*, Victoria, British Columbia, July 2020.
37. A. Martone, K. Sherbondy, J. Kovarskiy, B. Kirk, J. Owen, B. Ravenscroft, A. Egbert, A. Dockendorf, A. Goad, C.E. Thornton, S. Blunt, R.M. Buehrer, C. Baylis, and R.M. Narayanan, "Practical Aspects of Cognitive Radar", *IEEE RadarConf2020*, June 2020.
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39. A. Shahanaghi, Y. Yang, and R. M. Buehrer, "Link Stability Analysis of Wireless Sensor Networks Over the Ocean Surface," *Proceedings of the 17th Annual IEEE International Conference on Sensing, Communication and Networking (IEEE SECON 2020)*, June 22-25, 2020, Como, Italy.
40. J. Yu, H. Saad, and R. M. Buehrer, "Indoor Localization from Channel State Information with Recurrent Neural Networks," *Proceedings of NAVIGATIONPORTLANDIEEE/ION Position Location and Navigation Symposium (PLANS)*, Portland, OR, April 20–23, 2020.
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43. C.E. O’Lone, H.S. Dillon, and R.M. Buehrer, “A Mathematical Justification for Exponentially Distributed NLOS Bias”, *Proceedings of the IEEE Global Communications Conference (GLOBECOM 2019)*, Waikoloa, Hawaii, December 9 – 13, 2019.
44. A. Shahanaghi, Y. Yang, and R. M. Buehrer, “On the Stochastic Link Modeling of Static Wireless Sensor Networks in Ocean Environments,” *IEEE Conference on Computer Communications (IEEE INFOCOM 2019)*, Paris, France, April 29 - May 2, 2019.
45. M. Kozy, J. Yu, R. M. Buehrer, A. Martone, and K. Sherbondy, “Applying Deep-Q Networks to Target Tracking to Improve Cognitive Radar,” *Proceedings of 2019 IEEE Radar Conference*, Boston, MA, April 22-26, 2019.
46. B. Kirk, M. Kozy, K. Gallagher, R. Narayanan, R. Buehrer, A. Martone, K. Sherbondy, “Cognitive Software Defined Radar: Evaluation of Target Detection with RFI Avoidance”, *Proceedings of 2019 IEEE Radar Conference*, Boston, MA, April 22-26, 2019. [FINALIST FOR BEST STUDENT PAPER]
47. J. A. Kovarskiy, M. Kozy, C. Thornton, A. F. Martone, R. M. Narayanan, R. M. Buehrer, and K. D. Sherbondy, “Comparing stochastic and Markov decision process approaches for predicting radio frequency interference,” *Proc. SPIE Conference on Commercial and Defense Sensing*, April 14-18, 2019, doi: 10.1117/12.2519675.
48. Y. Xu, J. Yu, and R.M. Buehrer, “Dealing with Partial Observations in Dynamic Spectrum Access: Deep Recurrent Q-Networks,” *IEEE 2018 Military Communications Conference (MILCOM’18)*, Los Angeles, CA, October 29 - 31, 2018.
49. Y. Xu, J. Yu, W.C. Headley, and R.M. Buehrer, “Deep Reinforcement Learning for Dynamic Spectrum Access in Wireless Networks,” *IEEE 2018 Military Communications Conference (MILCOM’18)*, Los Angeles, CA, October 29 - 31, 2018.
50. S. Dhiraj and R.M. Buehrer, “On Jammer Power Allocation Against OFDM Signals in Fading Channels,” *IEEE 2018 Military Communications Conference (MILCOM’18)*, Los Angeles, CA, October 29 - 31, 2018.
51. M. Abdelbar and R.M. Buehrer, “Pedestrian GraphSLAM using Smartphone-based PDR in Indoor Environments,” accepted for publication/presentation in IEEE ICC 2018 Workshop - 6th IEEE Workshop on Advances in Network Localization and Navigation (ANLN), Kansas City, MO, May 24, 2018.
52. E. Selvi, A. Martone, K. Sherbondy, R.M. Buehrer, “On the Use of Markov Decision Processes in Cognitive Radar: an Application to Target Tracking,” *2018 IEEE Radar Conference*, Oklahoma City, USA, April 23-27, 2018.
53. M. Abdelbar and R. M. Buehrer, “Indoor Localization Through Trajectory Tracking Using Neural Networks,” *Proceedings of the 2017 IEEE Military Communications Conference (MILCOM’17)*, Oct. 23-25, 2017, Baltimore, MD.
54. C.B. Dietrich, R. Goff, N. Polys, V. Marojevic, R. M. Buehrer, X. Gomez, S. Kim, A. Gaber Mohamed Ali and J. Garcia-Sheridan, “Remote laboratory exercises and tutorials for spectrum-agile radio frequency systems,” *Proceedings of 2017 IEEE Frontiers in Education Conference (FIE)*, Oct. 18-21, 2017, Indianapolis, IN.
55. J. A. García-Sheridan, R. M. Goff, C.B Dietrich, V. Marojevic, N.F Polys, and R. M. Buehrer, “A Pretest-Posttest Quasi-Experimental Study for a Game Intervention in an Undergraduate Wireless Communications Course,” *2017 ASEE Annual Conference & Exposition*, June 25 - 28, 2017, Columbus, OH.
56. V. Marojevic, R. M. Goff, C. B Dietrich, T. Yang, C. W. Hearn, N. F Polys, and R.M. Buehrer, “Wireless Communication Testbed and Tools for Authentic STEM Learning,” *Innovations in Communications and Wireless Systems Education Collection, 2015 ASEE Annual Conference & Exposition*, June 14 – 17, 2015, Seattle, WA.
57. C.E. O’Lone and R.M. Buehrer, “Towards a Characterization of Localization Performance in Networks with Random Geometries,” *IEEE ICC Workshop on Advances in Network Localization and Navigation (ANLN)*, May 25, 2017, Paris, France.

58. S. Amuru, M. van der Schaar, and R.M. Buehrer, "Bandit Strategies for Blindly Attacking Networks," *Proceedings of the 2017 IEEE International Conference on Communications (ICC'17)*, May 21-25, 2017, Paris, France.
59. A. A. Gaber, H. Tillman, R.M. Buehrer, and S.W. Ellingson, "Sensitivity Analysis of Localization Using Discrete Astronomical Radio Sources," *Proceedings of the 2017 IEEE Wireless Communications and Networking Conference*, March 2017, San Francisco, CA.
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61. T. Bhandari, H. Dhillon, and R.M. Buehrer, "The Impact of Proximate Base Station Measurements on Localizability in Cellular Systems," *Proceedings of 2016 IEEE 17th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, July 3-6, 2016 in Edinburgh, UK.
62. D.J. Jakubisin and R.M. Buehrer, "BP, MF, and EP for Joint Channel Estimation and Detection of MIMO-OFDM Signals," *Proceedings of the 2016 IEEE Global Communications Conference (GLOBECOM'16)*, December 5-7, 2016.
63. M. Abdelbar and R.M. Buehrer, "A Novel Approach for Indoor Localization Through Motion Trajectories Similarities in Smart Buildings," in *Proceedings of IEEE/ION PLANS 2016 Conference*, Savannah, Georgia, April 11-14, 2016.
64. A. A. Gaber, H. Tillman, R.M. Buehrer, and S.W. Ellingson, "Navigating via Celestial Bodies: Geolocalization Using Fringe Rates," in *Proceedings of IEEE/ION PLANS 2016 Conference*, Savannah, Georgia, April 11-14, 2016.
65. C. E. O'Lone and R.M. Buehrer, "An Analysis of the Convex Hull's Impact on Localization Performance," in *Proceedings of IEEE/ION PLANS 2016 Conference*, Savannah, Georgia, April 11-14, 2016.
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67. R. M. Vaghefi, D. Jakubisin, and R.M. Buehrer, "MIMO-Radar-Based Indoor Passive Localization and Tracking," *Proceedings of IEEE/ION PLANS 2016 Conference*, Savannah, Georgia, April 11-14, 2016.
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70. N. El Gamel, J. Schloemann, F. Jondral, and R.M. Buehrer, "Improved Indoor Positioning Using the Baum-Welch Algorithm," in *Proceedings of the 2015 IEEE Global Communications Conference Workshop on Localization and Tracking: Indoors, Outdoors and Emerging Networks (GC - LION '15)*, San Diego, CA, December 6, 2015.
71. J. Schloemann, H. Dhillon, and R.M. Buehrer, "Effect of Collaboration on Localizability in Range-Based Localization Systems," in *Proceedings of the 2015 IEEE Global Communications Conference Workshop on Localization and Tracking: Indoors, Outdoors and Emerging Networks (GC - LION '15)*, San Diego, CA, December 6, 2015.
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74. S. Amuru and R.M. Buehrer, "To Send or Not to Send - Learning MAC Contention," in *Proceedings of the 2015 IEEE Global Communications Conference (GLOBECOM '15)*, San Diego, CA, December 6-10, 2015.
75. J.D. Poston, J. Schloemann, R.M. Buehrer, V.V. N. S. Malladi, A. Woolard, P. Tarazaga, "Vibration Sensing in Smart Buildings for Indoor Positioning of Pedestrians," in *Proceedings of the 2015 Indoor Positioning and Indoor Navigation Conference*, Oct. 13-16, 2015, Banff, Alberta, Canada.
76. J. D. Poston, J. Schloemann, R. M. Buehrer, V. S. Malladi, A. G. Woolard, and P. A. Tarazaga, "Towards Indoor Localization of Pedestrians via Smart Building Vibration Sensing," in *Proceedings of the International Conference on Localization and GNSS*, June 22-24, 2015, Gothenburg, Sweden.
77. S. Yousefi, R.M. Vaghefi, X.-W Chang, B. Champagne, and R.M. Buehrer, "Sensor Localization in NLOS Environments with Anchor Uncertainty and Unknown Clock Parameters," in *Proceedings of the 2015 ICC Workshop on Advances in Network Localization and Navigation*, June 8-12, 2015.
78. J. Schloemann, H.S. Dhillon, and R.M. Buehrer, "Localization Performance in Cellular Networks," in *Proceedings of the 2015 ICC Workshop on Advances in Network Localization and Navigation*, June 8-12, 2015.
79. S. Amuru and R.M. Buehrer "A Systematic Learning Method for Optimal Jamming", to appear in *Proceedings of the 2015 IEEE International Conference on Communications (ICC'15)*, June 8-12, 2015.
80. R.M. Vaghefi and R.M. Buehrer, "Improving Mobile Node Tracking Performance in NLOS Environments Using Cooperation", to appear in *Proceedings of the 2015 IEEE International Conference on Communications (ICC'15)*, June 8-12, 2015.
81. J. Schloemann, S. Malladi, P. Tarazaga, and R.M. Buehrer, "Vibration event localization in an instrumented building", *Proceedings of IMAC XXXIII - A Conference and Exposition on Structural Dynamics*, February 2-5 2015.
82. S. Amuru and R.M. Buehrer "Optimal Jamming Strategies in Digital Communications-Impact of Modulation", *Proceedings of the 2014 IEEE Global Communications Conference (GlobeCom'14)*, Austin, TX, December 2014.
83. R. Vaghefi and R.M. Buehrer, "A Linear Estimator for Joint Synchronization and Localization in Wireless Sensor Networks," *Proceedings of the 2014 IEEE Global Communications Conference (GlobeCom'14)*, Austin, TX, December 2014.
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88. D.J. Jakubisin and R.M. Buehrer, "On the Complexity-Performance Trade-off in Code-Aided Frame Synchronization," *The 15th IEEE International Workshop on Signal Processing Advances in Wireless Communications*, Toronto, Canada, 22-25 June 2014.
89. A. Amini, R. M. Vaghefi, J.M. da la Garza and R.M. Buehrer, "Improving GPS-Based Vehicle Positioning for Intelligent Transportation Systems," *Proceedings of 2014 IEEE Intelligent Vehicles Symposium*, Dearborn, Michigan, June 8 - 11, 2014.

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93. R. Tandon, S. Amuru, R.M. Buehrer, and T.C. Clancy, "On Secure Distributed Storage Systems with Exact Repair," *Proceedings of the 2014 IEEE International Conference on Communications (ICC'14)*, Sydney, Australia, June 6-10, 2014.
94. S. Amuru, R. Tandon, R.M. Buehrer, and T.C. Clancy, "Jamming Countermeasures for Multi-User MISO Broadcast Channels - a DoF perspective," *Proceedings of the 2013 IEEE Global Communications Conference (GlobeCom'13)*, December 2013.
95. R. Vaghefi and R.M. Buehrer, "Asynchronous Time-of-Arrival-Based Source Localization," *Proceedings of the 2013 International Conference on Acoustics, Speech, and Signal Processing (ICASSP'13)*, May 26-31, 2013, Vancouver, Canada.
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212. M. Keaton, R.M. Buehrer, S.C. Kwatra, and J. Kim, "A Wideband Communications Satellite for the National Research and Education Network," *1993 IEEE Global Communications Conference*, Houston, TX, vol. 3, 1644-1648, December 1993.
213. M. Keaton, R.M. Buehrer, S.C. Kwatra, and J. Kim, "Network Requirements for a Satellite Based National Research and Education Network," *1993 IEEE Military Communications Conference*, Boston, MA, vol. 3, pp. 993-997, November 1993.

Technical Reports

National Research Council. 2009. "Toward a Universal Radio Frequency System for Special Operations Forces", Washington, D.C.: The National Academies Press.

R. M. Buehrer, W.A. Davis, A. Saffai-Jazi, and D. Sweeney, "Ultra-wideband Propagation Measurements and Modeling - Final Report," submitted to DARPA as part of the NETEX Program.

R. M. Buehrer, A. Saffai-Jazi, W. A. Davis, D. Sweeney, "Path Loss Calculations for Ultra-wideband Signals in Indoor Environments," invited contribution to the International Telecommunications Union, Document Number USWP 3K-1, October 26, 2003.

15 technical memoranda in the areas of multiuser detection, intelligent antennas, and OFDM for Bell Labs – Lucent Technologies. Titles and abstracts are proprietary information.

Professional Affiliations

- *Fellow*, Institute of Electrical and Electronics Engineers (IEEE)
- Member, IEEE Communications Society
- Member, IEEE Vehicular Technologies Society
- Member, IEEE Signal Processing Society
- Member, Eta Kappa Nu
- Member, Tau Beta Pi
- Member, Pi Mu Epsilon

Selected Professional Activities

- Organizer, “International Workshop on Signal Reuse for Spectrum Efficiency,” *IEEE DySPAN 2024 Conference*.
- Area Editor, *IEEE Transactions on Wireless Communications*, 2017 - 2022.
- Guest Lead Editor, *IEEE Journal on Special Topics in Signal Processing*, special issue on non-cooperative position location networks.
- Guest Editor, *Proceedings of the IEEE*, special issue on cooperative localization.
- Associate Editor, *IEEE Wireless Communications Letters*, 2010 - 2014
- Associate Editor, *IEEE Transactions on Communications*, 2009 - 2014
- Associate Editor, *IEEE Transactions on Wireless Communications*, 2005 - 2012, 2015 - 2017
- Associate Editor, *IEEE Transactions on Vehicular Technologies*, 2005 - 2009
- Associate Editor, *IEEE Transactions on Signal Processing*, 2006-2007
- Associate Editor, *IEEE Transactions on Education*, 1997-2000
- Organizer and Technical Co-Chair, 2015 IEEE Global Communications Conference Workshop on Localization and Tracking: Indoors, Outdoors and Emerging Networks (GC - LION ‘15), December 6, 2015.
- “Signal Processing for Communications” symposium co-chair for IEEE ICC 2017
- Symposium co-chair for IEEE ICC 2017 Signal Processing for Communications Symposium
- Technical Program Co-Chair, WPNC 2013.
- Technical Program Chair for UWBST2003.
- Technical Program Committee, 2008-2016 IEEE Global Communications Conference
- Technical Program Committee, 2007-2016 IEEE International Conference on Communications
- Technical Program Committee, IEEE RWS 2006
- Technical Program Committee, IEEE 2006 International Conference on Ultra Wideband
- Technical Program Committee, IEEE Vehicular Technology Conference 2006 - Fall
- Technical Program Committee, 2004 IEEE International Workshop on Ultra Wideband Systems / Ultra Wideband Systems and Technologies.

- Technical Program Committee, 2004 IEEE Radio and Wireless Conference (RAWCON), September 2004.
- Technical Program Committee, 2005 Wireless Communications and Networking Conference.
- Reviewer for *IEEE Journal on Selected Areas in Communications*, *IEEE Transactions on Communications*, *IEEE Transactions on Vehicular Technology*, *IEEE Communications Letters*, *IEEE Transactions on Signal Processing*, *ETRI Research Journal*, *Army Research Office*, *State of Tennessee*
- Session Chair, IEEE Vehicular Technology Conference – Fall 2002

Selected Consulting

- Lutron Electronics
 - Provided recommendations on the design and testing of indoor wireless networks, August - Sept. 2019.
 - Evaluated RF coexistence plan, March 2020.
 - Evaluated RF coverage and planning techniques for 2.4GHz indoor networks, September - October 2021.
- Polaris Wireless - Provided an evaluation of Z-axis estimation algorithm, Sept-Oct 2018.
- ENSCO, Inc. – Provided an evaluation of spread spectrum ranging system. March 2011.
- FCC – Delivered short courses on various topics in wireless communications including WiFi, spread spectrum, and 3G technologies. Summer 2004, Summer 2005.

Selected Expert Witness Experience

- Cisco, Inc. vs. Netsocket
 - Law firm: Haynes and Boone
 - Represented: Cisco (Petitioner)
 - Served as expert in Inter Partes Review proceedings. Wrote declaration supporting petitioner. **Was deposed.**
 - IPR2023-00606
 - Technology: Quality of Service in wireless/wireline networks
 - Dates: Sept. 2022 - December 2023
- Intel
 - Law firm: Wilmer and Hale
 - Represented: Intel
 - Examined technical aspects of various patents to aid validity/invalidity analysis for potential IPR filings.
 - Technology: Multi-user MIMO in WiFi (802.11ac, 802.11ax)
 - Dates: September 2023 - December 2023
- Geoscope vs. Apple
 - Law firm: Gibson, Crutcher and Dunn
 - Represented: Apple
 - Analyzed technical aspects of various patents to aid validity/invalidity and infringement/non-infringement analysis with respect to ITC case. **Was deposed**

- Technology: Geolocation in 3GPP-based cellular systems.
- Dates: April 2023 - August 2023
- Ericsson vs. Apple
 - Law firm: Fish and Richardson
 - Represented: Apple
 - Analyzed technical aspects of various patents to aid validity/invalidity and infringement/non-infringement analysis. Included both Inter Partes Review proceedings and ITC case. **Was deposed multiple times. Testified at trial.**
 - Dates: September 2021 - December 2022
- Godo Kaisha IP Bridge vs. Nokia
 - Law firm: Alston & Bird
 - Represented: Nokia (defendant)
 - Served as expert witness for non-infringement and invalidity.
 - Case No. 2:21-CV-215-JRG
 - Technology: Sounding Reference Signal, RACH, ACK/NACK and CQI reporting in cellular networks. **Was deposed.**
 - Dates: September 2021 - November 2022
- Honeywell, Int'l., Inc., et. al. vs. Sisvel International
 - Law firm: K&L Gates
 - Represented: Honeywell (Petitioner)
 - Served as expert in Inter Partes Review proceedings. Wrote declaration supporting petitioner. **Was deposed.**
 - IPR2021-00640
 - Technology: Cell selection and reselection in Radio Resource Control
 - Dates: December 2021 - Jan. 2022
- Thales, et. al. vs. Sisvel International
 - Law firm: AddyHart
 - Represented: Thales (Petitioner)
 - Served as expert in Inter Partes Review proceedings. Wrote declarations supporting petitioner. **Was deposed.**
 - IPR2021-00639
 - Technology: Data connection management.
 - Dates: December 2021 - Jan. 2022
- ZTE, et. al. vs. Sisvel International
 - Law firm: Banner-Witcoff
 - Represented: ZTE (Petitioner)
 - Served as expert in Inter Partes Review proceedings. Wrote declarations supporting petitioner.
 - IPR2021-00639, IPR2021-00640
 - Technology: Cell selection and reselection in Radio Resource Control; Data connection management.
 - Dates: January 2021 - April 2021

- HP, Inc. vs. Ozmo
 - Law firm: DLA-Piper
 - Represented: HP
 - Served as testifying expert
 - 6:21-cv-00383-ADA
 - Technology: Wireless local area and personal area networks (WLANs and WPANs)
 - Dates: August 2021 - October 2021
- Samsung vs. Ericsson
 - Law firm: Fish & Richardson
 - Represented: Samsung
 - Wrote declarations for IPR filings.
 - IPR2021-00615, IPR2021-00685
 - Technology: Cellular communications
 - Dates: January 2021 - April 2021
- Tesla, Inc. vs. Optis
 - Law firm: Munger, Tolles, & Olson
 - Represented: Tesla (defendant)
 - Case 2:20-cv-00310
 - Served as testifying expert witness
 - Technology: Control channels/information in cellular systems
 - Dates: November 2020 - March 2021
- Apple, Inc.
 - Law firm: Wilmer-Hale
 - Wrote declaration in support of request for ex parte reexamination
 - Reexam Control Number 90/014,653
 - Technology: Control information in cellular systems
 - Dates: November 2020 - January 2021
- Phillips vs. Garmin
 - Law firm: Alston-Bird
 - Represented: Garmin (defendant)
 - Served as testifying expert witness for Federal Trade Commission proceedings
 - Technology: Local and Cellular Wireless Connections in Personal Emergency Response Systems
 - District: FTC
 - Dates: June - July 2020
- ZTE vs. Sisvel International
 - Law firm: Banner-Witcoff
 - Represented: ZTE (Petitioner)
 - Served as expert in Inter Partes Review proceedings. Wrote declarations supporting petitioner. **Was deposed.**

- IPR2020-01070, IPR2020-01071
- Technology: Radio Resource Control
- Dates: March 2020 - May 2021
- Apple, Inc. vs. Optis
 - Law firm: Wilmer-Hale
 - Represented: Apple (Plaintiff)
 - Served as testifying expert witness for litigation. **Was deposed. Testified at trial.**
 - Case 2:19-cv-66 (E.D. Tex.)
 - Technology: Control information in cellular systems
 - District: Eastern District of Texas
 - Dates: July 2019 - August 2020.
- Apple, Inc. vs. Wi-LAN
 - Law firm: DLA Piper
 - Represented: Apple (Plaintiff)
 - Served as testifying expert witness for litigation. **Was deposed. Testified at trial.**
 - Technology: Resource Allocation in Wireless Systems
 - District: Southern District of California
 - Dates: January '19 - January '20
- TELUS Communications, Bell Mobility, and Rogers Communications vs. WiLAN, Inc.
 - Law firm: Torys, LLP.
 - Represented: TELUS Communications, Bell Mobility, and Rogers Communications
 - Served as testifying expert. Analyzed certain patents (and the prior art) and provided technical reports on sufficiency, validity and potential double-patenting.
 - Technology: Resource allocation in wireless networks
 - Dates: January 2019 - November 2019
- Samsung vs. Sharp
 - Law firm: Fish and Richardson
 - Represented: Samsung
 - Analyzed technical aspects of patent to aid validity/invalidity analysis.
 - Technology: Feedback in MIMO-OFDM systems
 - Dates: April 2019 - July 2019
- American Patents, LLC vs. HP, Inc.
 - Law firm: DLA Piper
 - Represented: HP, Inc.
 - Analyzed technical aspects of two patents to aid validity/invalidity analysis.
 - Case 18-cv-700 (E.D. Tex.)
 - Technology: MIMO/OFDM synchronization in cellular systems
 - Dates: June 2019
- Blackberry vs. Uniloc, LLC.

- Law firm: Oblon
- Represented: Blackberry (Petitioner)
- Wrote declaration to the USPTO concerning the disclosure of certain features of two patents in previous references.
- Technology: Traffic mapping between logical channels and transport channels in wireless systems
- Dates: June 2019.
- Apple, Inc. vs. Wi-LAN
 - Law firm: DLA Piper
 - Represented: Apple (Plaintiff)
 - Served as testifying expert witness for litigation (non-infringing alternatives). **Was deposed. Testified at trial.**
 - Case 3:14-cv-2235-DMS-BLM
 - Technology: Resource Allocation in Wireless Systems
 - District: Southern District of California
 - Dates: November '17 - July '18
- Apple, Inc., LG Electronics Inc., Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. vs. Uniloc, LLC.
 - Law firm: Fish and Richardson
 - Represented: Apple, Inc., LG Electronics Inc., Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. (Petitioner)
 - Wrote declarations to the USPTO concerning the disclosure of certain features of two patents in previous references.
 - IPR2019-00219, IPR2019-00222
 - Technology: Traffic mapping between logical channels and transport channels in Wireless Systems; Multi-mode transceivers
 - Dates: September 2018 - November 2019.
- CCE vs. Apple, Inc.
 - Law firm: DLA Piper
 - Represented: Apple (Defendant)
 - Served as testifying expert witness for litigation (infringement analysis). **Was deposed.**
 - 2:15-cv-00576-RWS-RSP
 - Technology: Power Headroom Reporting in Cellular Systems
 - District: Eastern District of Texas
 - Dates: January 2017 - July 2017
- Nokia Technologies vs. Apple, Inc.
 - Law firm: Wilmer-Hale
 - Represented: Apple (Defendant)
 - Served as testifying expert witness for litigation (infringement analysis)
 - Technology: antennas for handheld mobile devices
 - District: Eastern District of Texas
 - Dates: January 2017 - June 2017

- Core Wireless vs. Apple, Inc.
 - Law Firm: Wilmer-Hale
 - Represented: Apple (Defendant)
 - Role: Served as testifying expert witness for litigation (infringement and validity analysis). **Was deposed. Testified at trial.**
 - Case 5:15-cv-5008
 - Technology: Control Channels and Frame Stealing in 2G (GSM) cellular networks.
 - District: The US District Court for the Northern District of California
 - Dates: May 2015 - December 2016.
- AMERICAN SYSTEMS vs. US Navy
 - Law Firm: Miles and Stockbridge
 - Represented: AMERICAN SYSTEMS (Plaintiff)
 - Role: Served as testifying expert witness for litigation (case settled prior to expert reports being filed).
 - Technology: Wireless mesh networks.
 - Dates: Nov. 2014 - June 2015.
- TruPosition, Inc. vs. LM Ericsson Telephone Company, et. al.
 - Law Firm: Constantine-Cannon LLP
 - Represented: TruePosition (Plaintiff)
 - Role: Served as testifying expert witness for litigation. Case settled prior to depositions being taken.
 - Case 2:11-cv-04574-RK
 - Technology: Cellular-based geolocation for 4G (LTE) cellular networks.
 - District: The US District Court for the Eastern District of Pennsylvania
 - Dates: March 2013 - July 2014.
- Andrew, LLC vs TruPosition, Inc.
 - Law Firm: Patterson Belknap Webb & Tyler LLP
 - Represented: Andrew, LLC (Plaintiff)
 - Role: Served as testifying expert witness for patent litigation. **Was deposed.**
 - Civil Action 09-669
 - Technology: Cellular-based (2G, 3G) geolocation.
 - District: The US District Court for the District of Delaware
 - Dates: Nov. 2009 - March 2010.
- TCL vs. Ericsson
 - Law Firm: Sheppard Mullin
 - Provided Services for: TCL (Plaintiff)
 - Role: Served as consulting expert witness for essentiality analysis.
 - Technology: digital communications in 2G, 3G, and 4G cellular systems.
 - District: The US District Court for the Central District of California
 - Dates: March 2015 - December 2015.
- Univ. of Minnesota vs. Sprint

- Law Firm: McGuire-Woods
- Provided Services for: Sprint (Defendant)
- Role: Served as consulting expert for validity analysis.
- Technology: 4G cellular networks.
- Dates: October 2015 - January 2016.
- Eon Corp, IP Holdings, LLC vs Research In Motion Corporation, et. al.
 - Law Firm: Sidley-Austin
 - Provided Services for: Research in Motion Corporation (Defendant)
 - Served as consulting expert for patent litigation
 - Technology: Cellular technologies
 - Dates: March 2012
- InterDigital vs. Nokia
 - Law Firm: Alston-Bird LLP
 - Provided Services for: Nokia
 - Served as a consulting expert
 - Technology: Cellular CDMA and power control
 - Date: Oct. 2011 - Dec. 2011.
- SPH America, LLC vs Acer, Inc.
 - Law Firm: Spotts Fain PC
 - Provided Services for: UT Starcomm
 - Role: Served as a consulting expert for patent litigation
 - Technology: CDMA (spread spectrum) and 3G cellular technologies.
 - Dates: Jan. 2011 - March 2011

References

Available upon request.