US 20120171958A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2012/0171958 A1

(43) Pub. Date: Jul. 5, 2012

Cornett et al.

(54) METHOD AND APPARATUS FOR DISTRIBUTING DATA IN A SHORT-RANGE WIRELESS COMMUNICATION SYSTEM

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(21) Appl. No.: **13/036,123**

(22) Filed: **Feb. 28, 2011**

Related U.S. Application Data

(60) Provisional application No. 61/429,001, filed on Dec. 31, 2010.

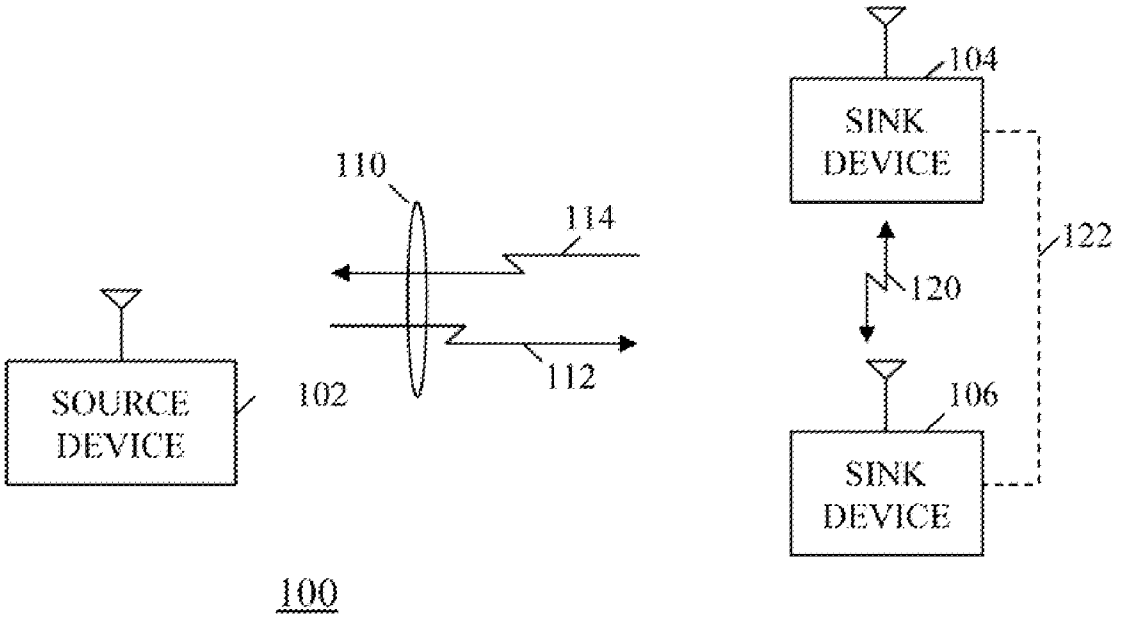
Publication Classification

(51) **Int. Cl.**
H04B 7/00 (2006.01)

(52) **U.S. Cl.** **455/41.2**

(57) **ABSTRACT**

A short-range communication system, such as a Bluetooth communication system, is provided that provides for a source communication device to multiplex data packets that are intended for different sink communication devices of multiple sink communication devices into a single stream that is broadcast to all of the multiple sink communication devices, and for each of the multiple sink communication devices to decode only the data packets intended for that sink communication device. Further, the communication system provides for a first sink communication device of the multiple sink communication devices to negotiate connection parameters associated the broadcast and to convey the negotiated connection parameters to a second sink communication device of the multiple sink communication devices, as opposed to each sink communication device setting up its own connection with the source communication device.



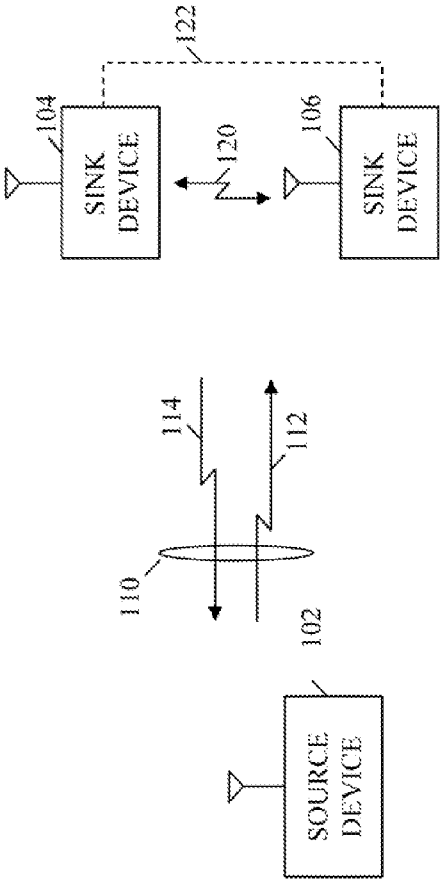


FIG. 1

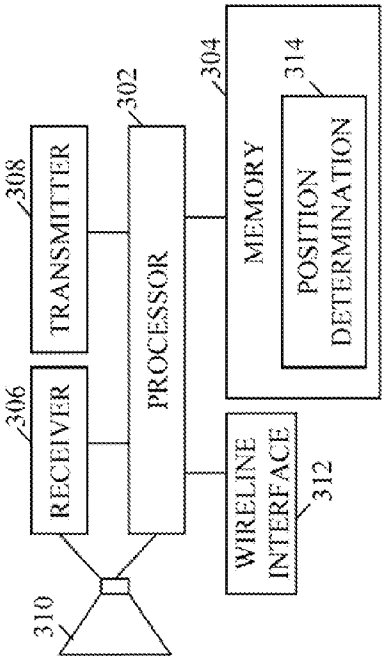


FIG. 3

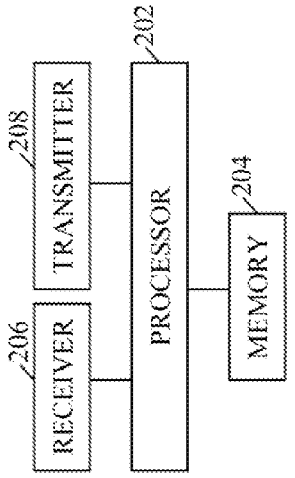
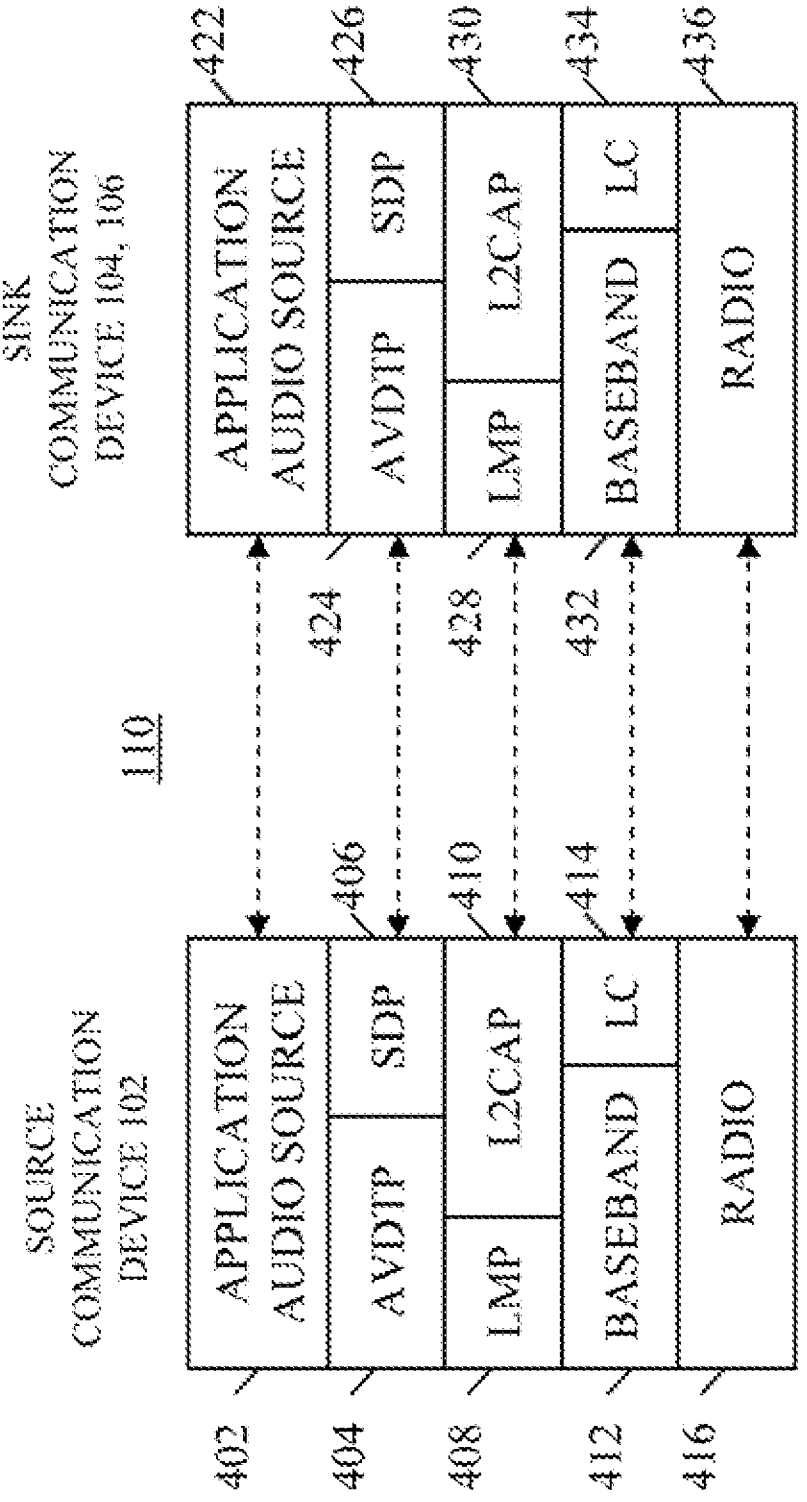


FIG. 2


SOURCE COMMUNICATION DEVICE 102
SINK COMMUNICATION DEVICE 104, 106
110
APPLICATION AUDIO SOURCE
AVDTP
SDP
L2CAP
LMP
BASEBAND
LC
RADIO
402
404
406
408
410
412
414
416
422
424
426
428
430
432
434
436

100

FIG. 4

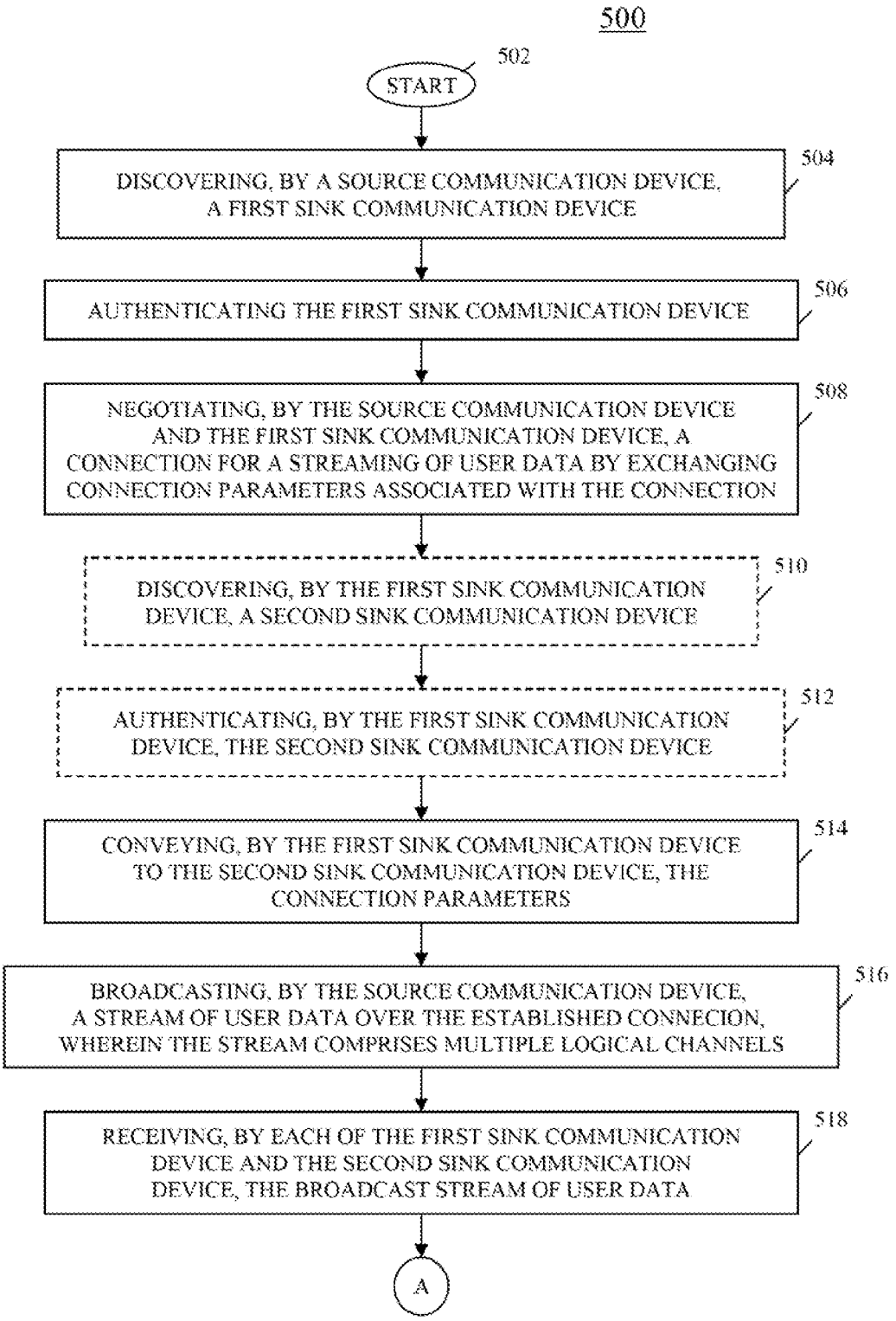

500
502
START
DISCOVERING, BY A SOURCE COMMUNICATION DEVICE, A FIRST SINK COMMUNICATION DEVICE
504
AUTHENTICATING THE FIRST SINK COMMUNICATION DEVICE
506
NEGOTIATING, BY THE SOURCE COMMUNICATION DEVICE AND THE FIRST SINK COMMUNICATION DEVICE, A CONNECTION FOR A STREAMING OF USER DATA BY EXCHANGING CONNECTION PARAMETERS ASSOCIATED WITH THE CONNECTION
508
DISCOVERING, BY THE FIRST SINK COMMUNICATION DEVICE, A SECOND SINK COMMUNICATION DEVICE
510
AUTHENTICATING, BY THE FIRST SINK COMMUNICATION DEVICE, THE SECOND SINK COMMUNICATION DEVICE
512
CONVEYING, BY THE FIRST SINK COMMUNICATION DEVICE TO THE SECOND SINK COMMUNICATION DEVICE, THE CONNECTION PARAMETERS
514
BROADCASTING, BY THE SOURCE COMMUNICATION DEVICE, A STREAM OF USER DATA OVER THE ESTABLISHED CONNECION, WHEREIN THE STREAM COMPRISES MULTIPLE LOGICAL CHANNELS
516
RECEIVING, BY EACH OF THE FIRST SINK COMMUNICATION DEVICE AND THE SECOND SINK COMMUNICATION DEVICE, THE BROADCAST STREAM OF USER DATA
518
A

FIG. 5A

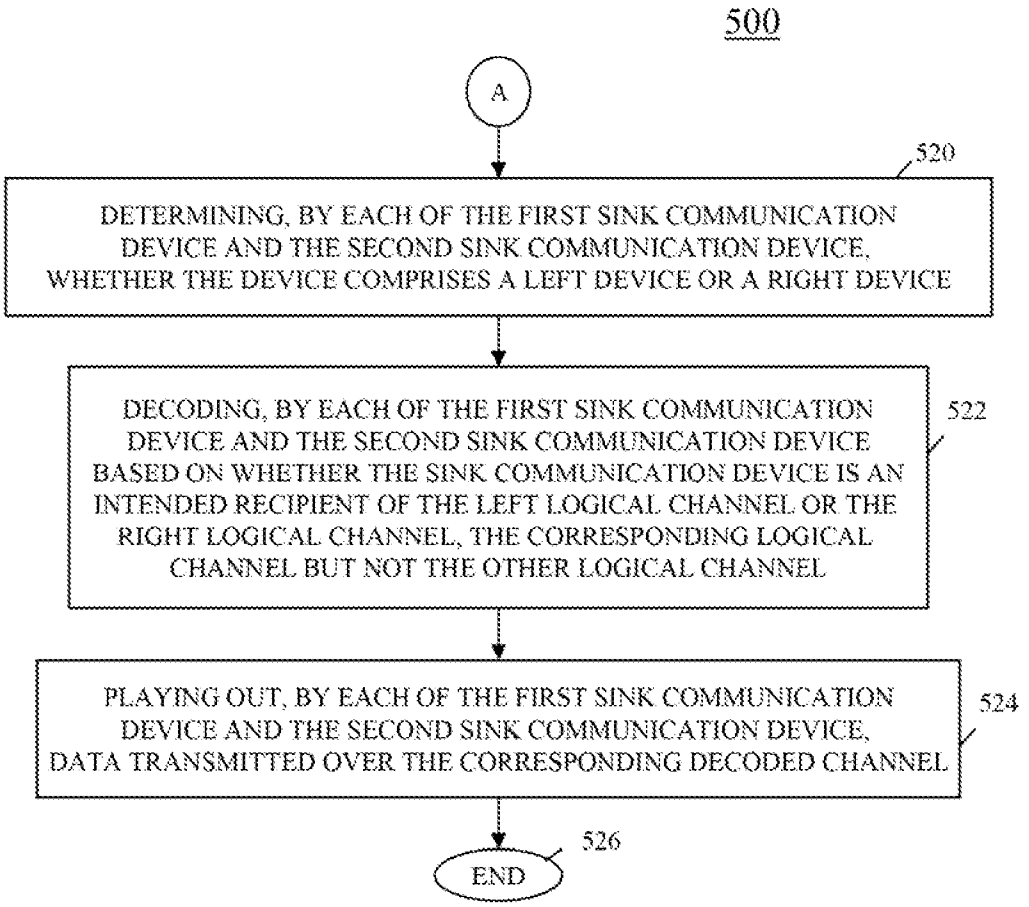

500
A
520
DETERMINING, BY EACH OF THE FIRST SINK COMMUNICATION DEVICE AND THE SECOND SINK COMMUNICATION DEVICE, WHETHER THE DEVICE COMPRISES A LEFT DEVICE OR A RIGHT DEVICE
DECODING, BY EACH OF THE FIRST SINK COMMUNICATION DEVICE AND THE SECOND SINK COMMUNICATION DEVICE BASED ON WHETHER THE SINK COMMUNICATION DEVICE IS AN INTENDED RECIPIENT OF THE LEFT LOGICAL CHANNEL OR THE RIGHT LOGICAL CHANNEL, THE CORRESPONDING LOGICAL CHANNEL BUT NOT THE OTHER LOGICAL CHANNEL
522
PLAYING OUT, BY EACH OF THE FIRST SINK COMMUNICATION DEVICE AND THE SECOND SINK COMMUNICATION DEVICE, DATA TRANSMITTED OVER THE CORRESPONDING DECODED CHANNEL
524
526
END

FIG. 5B

METHOD AND APPARATUS FOR DISTRIBUTING DATA IN A SHORT-RANGE WIRELESS COMMUNICATION SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates generally to short-range wireless communication systems, such as Bluetooth and Wireless Local Area Network communication systems, and in particular to wireless distribution of data to multiple sink communication devices in a short-range wireless communication system

BACKGROUND OF THE INVENTION

[0002] With the advent of wireless communications, short range wireless systems have been developed that allow an audio source, such as a Bluetooth-enabled cellular telephone or music player, to wirelessly transmit music to multiple audio sinks, such as desktop speakers or speakers of a Bluetooth headset. However, such speakers typically require a wired connection between the left and right speakers, which limits the industrial design of a system and limits the comfort of a headset. In addition, in surround sound systems that may employ up to five or more speakers, speaker wires must be run from the audio source to each speaker, which can be inconvenient and unsightly.

[0003] One proposed solution to eliminate such speaker wiring is to use a daisy chain architecture, wherein an audio source, or transmitter, conveys media content to a single speaker of multiple speakers. This speaker, also known as a 'master speaker,' then wireless conveys the signal to a second speaker, that is, a 'slave speaker,' which in turn then may convey the signal to a third speaker, that is, a second 'slave speaker,' and so on. However, this daisy chain solution introduces a latency issue between speakers that requires tuning during system design and set up. In addition, the daisy chain solution creates synchronization problems when media is being watched on the audio source, for example, a cell phone, while the audio is wirelessly transferred to the speakers. Another proposed solution is to include multiple radios in the audio source, that is, one for each speaker, so that the audio content intended for the speakers may be transmitted simultaneously to each speaker. However, this is a cumbersome and expensive solution to the problem.

[0004] Therefore a need exists for a method and an apparatus for wirelessly transmitting a same stereo content to multiple speakers and separating the content at the speakers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a block diagram of a Bluetooth communication system in accordance with an embodiment of the present invention.

[0006] FIG. **2** is a block diagram of a transmitting communication system of the communication system of FIG. **1** in accordance with an embodiment of the present invention.

[0007] FIG. **3** is a block diagram of a receiving communication system of the communication system of FIG. **1** communication system in accordance with an embodiment of the present invention.

[0008] FIG. **4** is a block diagram illustrating exemplary protocol stacks of the communication devices of the communication system of FIG. **1** in accordance with an embodiment of the present invention.

[0009] FIG. **5**A is a logic flow diagram illustrating a distribution of user data from a transmitting communication device to multiple sink communication devices by the communication system of FIG. **1** in accordance with various embodiments of the present invention.

[0010] FIG. **5**B is a continuation of the logic flow diagram of FIG. **5**A illustrating a distribution of user data from a transmitting communication device to multiple sink communication devices by the communication system of FIG. **1** in accordance with various embodiments of the present invention.

[0011] One of ordinary skill in the art will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help improve understanding of various embodiments of the present invention. Also, common and well-understood elements that are useful or necessary in a commercially feasible embodiment are often not depicted in order to facilitate a less obstructed view of these various embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0012] To address the need for a method and an apparatus for wirelessly transmitting a same stereo content to multiple speakers and separating the content at the speakers, a short-range communication system, such as a Bluetooth communication system, is provided that provides for a source communication device to multiplex data packets that are intended for different sink communication devices of multiple sink communication devices into a single stream that is broadcast to all of the multiple sink communication devices, and for each of the multiple sink communication devices to decode only the data packets intended for that sink communication device. Further, the communication system provides for a first sink communication device of the multiple sink communication devices to negotiate connection parameters associated the broadcast and to convey the negotiated connection parameters to a second sink communication device of the multiple sink communication devices, as opposed to each sink communication device setting up its own connection with the source communication device.

[0013] Generally, an embodiment of the present invention encompasses a method for distributing data in a short-range wireless communication system. The method includes negotiating, by a first sink communication device, a connection with a source communication device, wherein the connection is associated with multiple connection parameters, and conveying, by the first sink communication device to a second sink communication device, the multiple connection parameters. The method further includes receiving, by each of the first sink communication device and the second sink communication device, a same broadcast from the source communication device over the negotiated connection, wherein the broadcast comprises multiple channels, self-determining, by one of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of a first channel of the multiple channels, and in response to determining, by the one of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of the first channel, decoding, by the one of the sink communication devices, the first channel but not a second channel of the multiple channels. In addition, the

method includes self-determining, by another of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of the second channel, in response to determining, by the another of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of the second channel, decoding, by the another of the sink communication devices, the second channel but not the first channel, and playing out, by each of the first sink communication device and the second sink communication device, data from the channel decoded by the sink communication device.

[0014] Another embodiment of the present invention encompasses a communication device capable of operating as a sink communication in a Bluetooth communication system, the communication device comprising a radio frequency (RF) transmitter, an RF receiver, a speaker module, and a processor. The processor is configured to negotiate a connection with a source communication device, wherein the connection is associated with multiple connection parameters, convey, to another sink communication device, the multiple connection parameters, receive, via the RF receiver, a broadcast by the source communication device over the negotiated connection, wherein the broadcast comprises multiple channels, self-determine whether the communication device is an intended recipient of a first channel of the multiple channels or a second channel of the multiple channels, in response to determining that the communication device is an intended recipient of the first channel, decode the first channel but not the second channel, in response to determining that the communication device is an intended recipient of the second channel, decode the second channel but not the first channel, and play out, via the speaker module, data from the channel decoded by the communication device.

[0015] Still another embodiment of the present invention encompasses a communication device capable of operating as a sink communication in a Bluetooth communication system, the communication device comprising an RF receiver, a speaker module, and a processor. The processor is configured to receive, from another sink communication device, multiple connection parameters associated with a source communication device and a negotiated connection, receive, via the RF receiver, a broadcast by the source communication device over the negotiated connection, wherein the broadcast comprises a plurality of channels, self-determine whether the communication device is an intended recipient of a first channel of the multiple channels or a second channel of the multiple channels, in response to determining that the communication device is an intended recipient of the first channel, decode the first channel but not the second channel, in response to determining that the communication device is an intended recipient of the second channel, decode the second channel but not the first channel, and play out, via the speaker module, data from the channel decoded by the communication device.

[0016] Yet another embodiment of the present invention encompasses an apparatus for receiving data in a short-range wireless communication system. The apparatus comprises a first sink communication device and a second sink communication device, wherein the first sink communication device negotiates a connection with a source communication device, which connection is associated with multiple connection parameters, wherein the first sink communication device conveys the multiple connection parameters to the second sink communication device, wherein each of the first sink communication device and the second sink communication device receives a same broadcast from the source communication device over the negotiated connection, wherein the broadcast comprises multiple channels, wherein one of the first sink communication device and the second sink communication device self-determines that it is an intended recipient of a first channel of the multiple channels and decodes the first channel but not a second channel of the multiple channels, wherein another of the first sink communication device and the second sink communication device self-determines that it is an intended recipient of the second channel of the multiple channels and decodes the second channel but not the first channel, and wherein each of the first sink communication device and the second sink communication device plays out data from the channel decoded by that sink communication device.

[0017] The present invention may be more fully described with reference to FIGS. **1**-**5**B. FIG. **1** is a block diagram of a short-range wireless communication system **100** in accordance with an embodiment of the present invention. Communication system **100** includes multiple wireless communication devices **102**, **104**, **106** (three shown). A first communication device **102** of the multiple communication devices **102**, **104**, **106** functions as a data source in communication system **100** and may be referred to herein as a source transmitting communication device, a transmitting communication device, or a stereo transmitter. Source communication device **102** may be, for example, a Bluetooth-enabled mobile station, such as a cell phone, a smartphone, a wireless music player, such as an MP3 player, or a laptop computer equipped for Bluetooth wireless communications, or may be a desktop computer equipped for Bluetooth wireless communications. Other communication devices of the multiple communication devices **102**, **104**, **106**, such as a communication devices **104** and **106**, reside within a listening area covered by source communication device **102** and function as a data sink in communication system **100**, and may be referred to herein as a sink communication device, a receiving communication device, or an audio speaker. For example, each of the multiple sink communication devices **104**, **106** may be a Bluetooth-enabled stereo loudspeaker or a speaker of a Bluetooth-enabled headphone. While two sink communication devices are depicted herein, one of ordinary skill in the art realizes that communication system **100** may include various numbers of sink communication devices, for example, four or five sink communication devices as in a surround sound wireless audio system, and two sink communication devices are used herein merely for the purpose of illustrating the principles of the present invention.

[0018] Source communication device **102** communicates with the multiple sink communication devices **104**, **106** via a radio link **110**. Radio link **110** comprises a downlink **112** and an uplink **114** that each comprises multiple physical channels and logical channels. For example, each of downlink **112** and uplink **114** of radio link **110** includes one or more control channels, and downlink **112** further includes one or more user data channels. Sink communication devices **104**, **106** may communicate with each other via a bi-directional radio link **120** that comprises one or more physical channels and one or more logical communication channels, including one or more control channels, and/or sink communication devices **104**, **106** may communicate with each other via a wireline link **122**.

[0019] FIG. **2** is a block diagram of source communication device **102** in accordance with an embodiment of the present invention. Source communication device **102** includes a processor **202**, such as one or more microprocessors, microcontrollers, digital signal processors (DSPs), combinations thereof or such other devices known to those having ordinary skill in the art, which processor is configured to execute the functions described herein as being executed by the transmitting device. Communication device **102** further includes an at least one memory device **204** that may comprise random access memory (RAM), dynamic random access memory (DRAM), and/or read only memory (ROM) or equivalents thereof, that maintain data and programs that may be executed by the associated processor and that allow the transmitting device to perform all functions necessary to operate in communication system **100**. The at least one memory device **204** further maintains Bluetooth profiles of the communication device as known in the art. Communication device **102** also includes a radio frequency (RF) receiver **206** and an RF transmitter **208** in communication with processor **202** and for receiving RF signals from, and transmitting RF signals to, sink communication devices, such as communication devices **104** and **106**, over radio link **110**.

[0020] FIG. **3** is a block diagram of a sink communication device **300**, such as communication devices **104**, **106**, in accordance with an embodiment of the present invention. Sink communication device **300** includes a processor **302**, such as one or more microprocessors, microcontrollers, digital signal processors (DSPs), combinations thereof or such other devices known to those having ordinary skill in the art, which processor is configured to execute the functions described herein as being executed by the transmitting device. Sink communication device **300** further includes an at least one memory device **304** that may comprise random access memory (RAM), dynamic random access memory (DRAM), and/or read only memory (ROM) or equivalents thereof, that maintain data and programs that may be executed by the associated processor and that allow the transmitting device to perform all functions necessary to operate in communication system **100**. At least one memory device **304** further maintains Bluetooth profiles of the sink communication device as known in the art. At least one memory device **304** further includes a position determination module **314** that, when executed by processor **302**, determines a position of the sink communication device relative to another sink communication device.

[0021] Communication device **300** further includes an RF receiver **306** and an RF transmitter **308** in communication with processor **302** and a speaker module **310** in communication with the processor and with receiver **306**. RF receiver **306** and RF transmitter **308** provide for receiving RF signals from, and transmitting RF signals to, another communication device, such as source communication device **102** via radio link **110** and/or another sink communication device **104**, **106** via radio link **120**. Speaker module **310** includes an input (not shown) and an output (not shown), wherein the input receives an audio signal that then is amplified and output to a user at the output of the speaker as known in the art. Communication device **300** may further include a wireline interface module **312** for interfacing with another communication device, such as another sink communication device, via a wireline connection.

[0022] In order for source communication device **102** to engage in a communication session with sink communication devices **104**, **106**, each communication device **102**, **104**, **106** operates in accordance with known telecommunications standards. Preferably, communication system **100** is a Bluetooth communication system that operates in accordance with the Bluetooth A2DP (Advanced Audio Distribution Profile) standards, wherein a physical channel, such as the channels of radio links **110** and **120**, comprises one or more time slots of a group of time slots, which group of time slots are frequency hopped over multiple frequencies of a given frequency bandwidth. To ensure compatibility, radio system parameters and communication session procedures are specified by the standards, including communication session set up steps that are executed by the source and sink communication devices. However, one of ordinary skill in the art realizes that communication system **100** may be any wireless communication system that provides short-range radio links, such as other Bluetooth communication systems or a Wireless Local Area Network (WLAN) communication system that operates in accordance with the IEEE (Institute of Electrical and Electronics Engineers) 802.xx standards, for example, the 802.11 standard.

[0023] Referring now to FIG. **4**, exemplary protocol stacks of the communication devices **102**, **104**, **106** of communication system **100** are depicted in accordance with an embodiment of the present invention. Preferably, communication system **100** is a Bluetooth communication system that implements well-known Bluetooth protocol stacks. For example, a top layer, or Application Layer, of each of communication devices **102**, **104**, and **106** may include an application audio source that sources user data for transmission to a sink communication device and that processes the received user data for output to a user at a sink communication device. A next layer down may comprise a Service Layer that includes an Audio/Video Distribution Transport Protocol layer (AVDTP) **404**, **424** and a Service Discovery Protocol layer (SDP) **406**, **426**. AVDTP is a transport protocol based on the Real Time Protocol (RTP) and applies point-to-point signaling between two communication devices over an L2CAP channel, including exchanges of SDP messages to discover the Bluetooth attributes of another communication device, Quality of Service (QoS) and transport status reporting, and data stream set-up, reconfiguration, and tear down signaling.

[0024] A next layer down from the Service Layer may comprise a Link Layer that includes a Link Manager Protocol layer (LMP) **408**, **428** and a Layer Logical Link Control and Adaption Protocol layer (L2CAP) **410**, **430**. The LMP is responsible for the creation and management of logical links between devices and logical transports between devices, encryption on the logical transports, and control of physical link transmit power and QoS settings. The L2CAP supports transmission and reception of data packets by higher layer protocols and supports packet segmentation and reassembly, exchange of QoS information, and per-channel flow control and retransmissions. For example, the L2CAP provides for resource management including segmentation of higher layer service data units (SDUs) into smaller protocol data units (PDUs), fragmentation of the PDUs into data packets for submission to the Baseband Layer and transmission over an air interface, and buffer management to ensure availability for channels and a given Quality of Service (QoS). The L2CAP further may provide error detection and retransmission of L2CAP PDUs. The L2CAP also provides logical channels, and each endpoint of a logical channel is defined by a channel

identifier (CID). In Bluetooth, each communication device can assign CIDs independent of assignments made by other communication devices.

[0025] A next layer down from the Link Layer may comprise a Baseband Layer that includes a Baseband Manager **412**, **432** and a Link Controller **414**, **434**. The Baseband Manager includes a scheduling function that negotiates access to, and grants time on, the physical channels. The Link Controller is responsible for communication of flow control, acknowledgments, and retransmission request signals. A bottom layer may comprise a Physical Layer that includes RF functionality **416**, **436** responsible for transmitting and receiving packets on the physical channels. The RF functionality transforms a stream of data received from the Baseband Layer to a format for transmission over a physical channel and transforms data received from the physical channel to a format appropriate for the Baseband Layer.

[0026] Preferably, each of the Application Layer, Service Layer, Link Layer, and Baseband Layer is implemented by the processor **202**, **302** of a communication device **102**, **104**, **106** based on programs and instructions maintained in the corresponding at least one memory device **204**, **304**, of the communication device. Additionally, the RF functionality preferably is implemented by the transmitter/receiver of the communication device, whichever is appropriate.

[0027] In order to distribute user data to the multiple sink communication devices **104**, **106**, for example, for source communication device **102** to broadcast audio data packets to the multiple sink communication devices **104**, **106**, communication system **100** provides for source communication device **102** to multiplex data packets intended for different sink communication devices into a single stream that is broadcast to all of the multiple sink communication devices **104**, **106**, and for each of the multiple sink communication devices **104**, **106** to decode only the data packets intended for that sink communication device. Thus, communication system **100** avoids the problems resulting from daisy chaining the sink communication devices and the expense of including multiple radios in a source communication device. Further, communication system **100** provides for a first sink communication device of the multiple sink communication devices **104**, **106** to negotiate connection parameters associated the broadcast and to convey the negotiated connection parameters to a second sink communication device of the multiple sink communication devices, as opposed to each sink communication device setting up its own connection with the source communication device.

[0028] Referring now to FIGS. **5**A and **5**B, a logic flow diagram **500** is provided that illustrates a distribution of user data from source communication device **102** to each of the multiple sink communication devices **104**, **106** of communication system **100** in accordance with various embodiments of the present invention. Logic flow diagram **500** begins (**502**) when source communication device **102** discovers (**504**) a first sink communication device, such as sink communication device **104**, of the multiple sink communication devices **104**, **106**, preferably in accordance with known Bluetooth inquiry procedures. For example, source communication device **102** may broadcast an inquiry packet via of radio link **110**. In response to receiving the inquiry packet, sink communication device **104** transmits an inquiry reply back to the source communication device via a control channel of uplink **114** of radio link **110**.

[0029] In response to receiving the inquiry reply, source communication device **102** authenticates (**506**) sink communication device **104** and negotiates (**508**) a connection with first sink communication device **104** for a streaming of user data over downlink **112** of radio link **110** in accordance with known Bluetooth techniques. For example, source communication device **102** may convey a page sequence to first sink communication device **104**. In response to receiving the page sequence, first sink communication device **104** transmits a page response sequence back to the source communication device. In response to receiving the page response sequence, source communication device **102** and first sink communication device **104** then negotiate, and store in the corresponding at least one memory device **204**, **304** of the communication device, connection parameters associated with a connection for streaming stereo data packets, that is, for transmitting a first set of data packets intended for right audio speaker and a second set of data packets intended for a left audio speaker.

[0030] For example, the connection parameters may include information identifying logical and physical channels that will be used to broadcast the stream of user data, for example, identifying a first logical channel that will include data packets intended for a right audio speaker and a second logical channel that will include data packets intended for a left audio speaker, identifying a physical channel, that is, a time slot, over which the logical channels will be multiplexed or identifying a first physical channel, such as a first time slot in a group of time slots, that will be used to broadcast data packets intended for a right audio speaker and a second physical channel, such as a second time slot in the group of time slots, that will be used to broadcast data packets intended for a left audio speaker. For example, such identifiers may include at least one CID assigned by source communication device **102** to the connection (for example, source communication device **102** may assign a CID to each logical channel of multiple logical channels to be included in a broadcast), a CID assigned by sink communication device **104** to the connection, and time slot and hopping pattern information with respect to the physical channel(s). The connection parameters further may include device identifiers, such as a Bluetooth Device Address (BD_ADDR) for each of the source communication device and the sink communication device and an authentication key, that is, a link key.

[0031] In response to negotiating the connection parameters with source communication device **102**, first sink communication device **104** then performs a handshake with a second sink communication device of the multiple sink communication devices **104**, **106**, that is, sink communication device **106**, preferably via the Link Manager Protocol layer of each device. That is, first sink communication device **104** then conveys (**514**) the connection parameters to second sink communication device **106**. For example, in another embodiment of the present invention, each of the multiple sink communication devices **104**, **106** may be pre-programmed as to which of the two sink communication devices is to be a 'master' sink communication device, that is, a sink communication device that sets up a connection with source communication device **102**, and which of the two sink communication devices is to be a 'slave' sink communication device, that is, a sink communication device that receives connection parameters from the 'master' device. In another embodiment of the present invention, the determination of which of the two sink communication devices **104**, **106** is to be the 'master' sink communication device and which of the two sink communication

devices is to be the 'slave' sink communication device may be negotiated between the two devices, for example, the 'slave' device may be whichever device first detects a page sequence from the other device in the event that they communicate with each other over a radio link.

[0032] As part of the handshake, first sink communication device **104** also may inform second sink communication device **106** whether the first sink communication device is a left device or right device, such as a left or right audio speaker, and that the second sink communication device is the other, that is, a right device (if the first sink communication device is a left device) or a left device (if the first sink communication device is a right device).

[0033] In various embodiments of the present invention, first sink communication device **104** may convey the connection parameters, and any left/right device designation, to second sink communication device **106** over wireline **122** or over a control channel in radio link **120** that is pre-programmed into the at least one memory devices **304** of each of the sink communication devices **104**, **106**. That is, in the latter instance, when the multiple sink communication devices **104**, **106** power up, they may discover (**510**) each other via radio link **120** and in accordance with the inquiry procedure described above. Upon discovering each other, each of the multiple sink communication devices **104**, **106** may monitor a pre-programmed control channel in radio link **120**, that is, a control channel that is pre-programmed into the at least one memory device **304** of each sink communication device **104**, **106**, for control information, such as the connection parameters, from the other sink communication device. First sink communication device **104** then conveys to second communication device **106** over the monitored control channel in radio link **120** the information identifying a channel that will be used for the exchange of user data, communication device identifiers associated with the connection, such as the Bluetooth Device Addresses for each of source communication device **102** and first sink communication device **104**, and the CIDs assigned by each of the source communication device and the first sink communication device to the connection, and any authentication keys and encryption keys that were exchanged. In effect and to a limited extent, the first sink communication device thus creates a clone of itself in the second sink communication device.

[0034] Second sink communication device **106** then stores the received connection parameters, and any received indication as to whether the second sink communication device is a left device or a right device, in the at least one memory device **304** of the communication device. In addition to, and when conveying the connection parameters over the pre-programmed control channel in radio link **120**, one or both of sink communication devices **104**, **106** also may authenticate (**512**) the other sink communication device via radio link **120**. In one such embodiment of the present invention, the sink communication devices **104**, **106** may exchange authentication information over the pre-programmed control channel and authenticate each other. In yet another embodiment of the present invention, only the 'master' sink communication device may authenticate the 'slave' sink communication device while the 'slave' device need not authenticate the 'master' device.

[0035] Subsequent to negotiating the connection with first sink communication device **104**, source communication device **102** broadcasts (**516**), over the negotiated connection and to all of the multiple sink communication devices **104**, **106**, a stream of user data packets comprising data packets intended for a first, or left, device, which data packets are conveyed over a first, or left, logical channel, and data packets intended for a second, or right, device, which data packets are conveyed over a second, or right, logical channel. For example, source communication device **102** may multiplex the first/left logical channel and the second/right logical channel over a same time slot, alternating transmissions of the two channels, or may multiplex the first/left logical channel and the second/right logical channel by transmitting each in a separate time slot of a group of time slots, which group of time slots are frequency hopped together.

[0036] Each sink communication device **104**, **106** receives (**518**) the same broadcast of the stereo data packets, that is, receives the broadcast of both the left and right logical channels. Position determination module **314** of each sink communication device determines (**520**) whether the device comprises a left device or a right device and, in response to determining, by each sink communication device **104**, **106**, whether the sink communication device comprises the left device or the right device, the sink communication device decodes (**522**) the corresponding channel. That is, in response to a sink communication device, such as sink communication device **104**, determining that it is a left device, the sink communication device then decodes the corresponding left logical channel but not the right logical channel. Similarly, in response to a sink communication device, such as sink communication device **106**, determining that it is a right device, the sink communication device then decodes the corresponding right logical channel but not the left logical channel. Each sink communication device **104**, **106** then processes the decoded data packets in accordance with well-known techniques and plays out (**524**) the decoded and processed data packets via the corresponding speaker module **310** of the communication device, and logic flow **500** then ends (**526**).

[0037] For example, in one embodiment of the present invention as described above, when the first sink communication device conveys connection information to the second sink communication device, the first sink communication device may designate itself as one of the right or left device and inform the second sink communication device that the second device is, correspondingly, the other device, that is, the left or right device. Each of the two sink communication devices stores this left/right designation in its corresponding at least one memory device **304**. When a broadcast is received from source communication device **102**, position determination module **314** of each sink communication device determines whether the device is the right or left device based on the stored left/right designation.

[0038] By way of another example, in another embodiment of the present invention, each of the first and second sink communication devices **104**, **106**, may be pre-programmed, in at least one memory device **304** of the sink communication device, with a right device designation or a left device designation. When the broadcast is received from source communication device **102**, position determination module **314** of each sink communication device determines whether the device is the right or left device based on the stored left/right designation.

[0039] By way of yet another example, in yet another embodiment of the present invention and in the event that each of the first and second sink communication devices **104**, **106** are part of a Bluetooth headphone, each of the first and second sink communication devices may determine whether

it is a right device or a left device based on an orientation of the device with respect to the headphone. That is, suppose that a default position for each of the speakers of the headphone is that the speakers face directly at each other, such that a vector normal to each speaker points directly at the other speaker. When the headphone is placed on a user's head, typically a right speaker, that is, a speaker on a right side of the user's head, is rotated to the left of the default position, that is, a vector normal to the right speaker is angled to the left of the position of the speaker's normal vector when the speaker is in the default position. Similarly, a left speaker, that is, a speaker on a left side of the user's head, is rotated to the right of the default position, that is, a vector normal to the left speaker is angled to the right of the position of the speaker's normal vector when the speaker is in the default position. Accordingly, each of the first and second sink communication devices **104**, **106** may determine whether it is a right device or a left device based on a orientation, that is, a rotation, of the device relative to the device's default position. For example, such a determination may be implemented by including a switching module comprising one or more switches (not shown) in each sink communication device, which switching module detects whether the device is rotated to the left (and accordingly is a right device) or the right (and accordingly is a left device) of the default position and stores the determined position in a corresponding at least one memory device **304**. However, one of ordinary skill in the art can think of many other schemes whereby a device can determine whether it is rotated to the left or the right of a default position, and any such scheme may be used herein without departing from the spirit and scope of the present invention. When a broadcast is received from source communication device **102**, position determination module **314** of each sink communication device determines whether the device is the right or left device based on the stored left/right position. By way of still another example, in still another embodiment of the present invention, each sink communication device **104**, **106**, may determine whether it is a left device or a right device based on a direction of arrival of the broadcast signal broadcast by source communication device and a direction of arrival of a RF control signal received from the other sink source communication device. For example, based on the signaling exchanged between sink communication devices **104**, **106** each sink communication device **104**, **106** may determine a direction of arrival of the signals from the other sink communication device in accordance with known direction of arrival determination techniques. Further, based on the broadcast received from source communication device **102**, each sink communication device **104**, **106** may determine a direction of arrival of the broadcast, again in accordance with known direction of arrival determination techniques. Based on the determined direction of arrival of the signals from the other sink communication device and the determined direction of arrival of the broadcast, each the position determination module **314** of sink communication device may determine whether it is the right device, such as a right audio speaker, or a left device, such as a left audio speaker. For example, when the sink communication devices are audio speakers of a Bluetooth headphone and the direction of arrival of the signals from one such sink communication device is to the right of the direction of arrival of the broadcast, then such sink communication device may determine that it is the left speaker, and visa versa. On the other hand, when the sink communication devices are freestanding speakers, and the direction of arrival of the signals from one such sink communication device is to the right of the direction of arrival of the broadcast, then such sink communication device may determine that it is the right speaker, and visa versa. Based on the determination of whether the sink communication device is a left device or a right device, the sink communication device then decodes the channel corresponding to a left device or a right device, whichever is appropriate.

[0040] By multiplexing data packets that are intended for different sink communication devices, for example, a left sink communication device and a right sink communication device, of multiple sink communication devices into a single stream that a source communication device broadcasts to all of the multiple sink communication devices, communication system **100** avoids the problems of the prior art resulting from daisy chaining the sink communication devices and the expense of including multiple radios in a source communication device. Further, by communication system **100** providing for a first sink communication device of multiple sink communication devices to negotiate connection parameters associated the broadcast and to convey the negotiated connection parameters to a second sink communication device of the multiple sink communication devices, communication system **100** provides a more efficient data distribution system than where each sink communication device sets up its own connection with the source communication device, or where a source communication device transmits data packets that are intended for different sink communication devices only to a first, for example, a left, sink communication device, which first sink communication device then forwards data packets intended for the second communication device, for example, a right device, to that device.

[0041] Additionally, communication system **100** provides for each sink communication device to self-determine which channel, of multiple channels broadcast by a source communication device, to decode. Such a determination may be made as a result of a prior consultation with other sink communication devices of the multiple sink communication devices, or the determination may be completely self-contained. In either event, only a single sink communication device of the multiple sink communication devices need negotiate, with the source communication device, a connection for the broadcast. Furthermore, by each sink communication device self-determining which channel to decode, when there are two sink communication devices the devices should not end up decoding the same channel, such as a left channel, and failing to decode the other channel, that is, the right channel. Furthermore, by providing for each sink communication devices to self-determine a channel to decode, communication system **100** is easily expandable to additional sink communication devices. Unless otherwise specified herein, the functionality described herein as being performed by source communication device **102** and sink communication devices **104** and **106** is implemented with or in software programs and instructions stored in the respective at least one memory device **204**, **304** associated with the transmitting and sink communication devices and executed by the processor **202**, **302** associated with the transmitting and sink communication devices. However, one of ordinary skill in the art realizes that the embodiments of the present invention alternatively may be implemented in hardware, for example, integrated circuits (ICs), application specific integrated circuits (ASICs), and the like, such as ASICs implemented in one or more of the transmitting and sink communication devices.

Based on the present disclosure, one skilled in the art will be readily capable of producing and implementing such software and/or hardware without undo experimentation.

[0042] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0043] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0044] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises . . . a", "has . . . a", "includes . . . a", "contains . . . a" does not without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially," "essentially," "approximately," "about," or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0045] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

What is claimed is:

1. A method for distributing data in a short-range wireless communication system, the method comprising:

negotiating, by a first sink communication device, a connection with a source communication device, wherein the connection is associated with a plurality of connection parameters;

conveying, by the first sink communication device to a second sink communication device, the plurality of connection parameters;

receiving, by each of the first sink communication device and the second sink communication device, a same broadcast from the source communication device over the negotiated connection, wherein the broadcast comprises a plurality of channels;

self-determining, by one of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of a first channel of the plurality of channels;

in response to determining, by the one of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of the first channel, decoding, by the one of the sink communication devices, the first channel but not a second channel of the plurality of channels;

self-determining, by another of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of the second channel of the plurality of channels;

in response to determining, by the another of the first sink communication device and the second sink communication device, that the sink communication device is an intended recipient of the second channel, decoding, by the another of the sink communication devices, the second channel but not the first channel; and

playing out, by each of the first sink communication device and the second sink communication device, data from the channel decoded by the sink communication device.

2. The method of claim **1**, wherein establishing a connection comprising discovering, by the source communication device, the first sink communication device.

3. The method of claim **1**, wherein the connection parameters comprise a channel identifier assigned to the connection by the source communication device and a channel identifier assigned to the connection by the first sink communication device.

4. The method of claim **1**, wherein the wireless communication system is a Bluetooth communication system, wherein the source communication device is a data source, and each of the first sink communication device and the second sink communication device is a data sink.

5. The method of claim **1**, wherein each of the first channel of the plurality of channels and the second channel of the plurality of channels is conveyed over a same time slot of a group of time slots.

6. The method of claim **1**, wherein the first channel of the plurality of channels is conveyed over a first time slot of a group of time slots and the second channel of the plurality of channels is conveyed over a second time slot of the group of time slots.

7. The method of claim **1**, wherein the wireless communication system is a Bluetooth communication system.

8. The method of claim **1**, further comprising broadcasting, by the source communication device, the plurality of channels over the negotiated connection.

9. A communication device capable of operating as a sink communication device in a Bluetooth communication system, the communication device comprising:

a radio frequency (RF) transmitter;

an RF receiver;

a speaker module; and

a processor that is configured to:

negotiate a connection with a source communication device, wherein the connection is associated with a plurality of connection parameters;

convey, to another sink communication device, the plurality of connection parameters;

receive, via the RF receiver, a broadcast by the source communication device over the negotiated connection, wherein the broadcast comprises a plurality of channels;

self-determine whether the communication device is an intended recipient of a first channel of the plurality of channels or a second channel of the plurality of channels;

in response to determining that the communication device is an intended recipient of the first channel, decode the first channel but not the second channel;

in response to determining that the communication device is an intended recipient of the second channel, decode the second channel but not the first channel; and

play out, via the speaker module, data from the channel decoded by the communication device.

10. The communication device of claim **9**, wherein the processor is configured to assign a channel identifier to the connection and wherein the plurality of connection parameters comprise the assigned channel identifier and a channel identifier assigned to the connection by the source communication device.

11. A communication device capable of operating as a sink communication device in a Bluetooth communication system, the communication device comprising:

a radio frequency (RF) receiver;

a speaker module; and

a processor that is configured to:

receive, from another sink communication device, a plurality of connection parameters associated with a source communication device and a negotiated connection;

receive, via the RF receiver, a broadcast by the source communication device over the negotiated connection, wherein the broadcast comprises a plurality of channels;

self-determine whether the communication device is an intended recipient of a first channel of the plurality of channels or a second channel of the plurality of channels;

in response to determining that the communication device is an intended recipient of the first channel, decode the first channel but not the second channel;

in response to determining that the communication device is an intended recipient of the second channel, decode the second channel but not the first channel; and

play out, via the speaker module, data from the channel decoded by the communication device.

12. The communication device of claim **11**, wherein the plurality of connection parameters comprise a channel identifier assigned to the connection by the another sink communication device and a channel identifier assigned to the connection by the source communication device.

13. An apparatus for receiving data in a short-range wireless communication system, the apparatus comprising:

a first sink communication device;

a second sink communication device; and

wherein the first sink communication device negotiates a connection with a source communication device, which connection is associated with a plurality of connection parameters, wherein the first sink communication device conveys the plurality of connection parameters to the second sink communication device, wherein each of the first sink communication device and the second sink communication device receives a same broadcast from the source communication device over the negotiated connection, wherein the broadcast comprises a plurality of channels, wherein one of the first sink communication device and the second sink communication device self-determines that it is an intended recipient of a first channel of the plurality of channels and decodes the first channel but not a second channel of the plurality of channels, wherein another of the first sink communication device and the second sink communication device self-determines that it is an intended recipient of the second channel of the plurality of channels and decodes the second channel but not the first channel, and wherein each of the first sink communication device and the second sink communication device plays out data from the channel decoded by that sink communication device.

14. The apparatus of claim **13**, wherein establishing a connection comprises discovering, by the source communication device, the first sink communication device.

15. The apparatus of claim **13**, wherein the connection parameters comprise a channel identifier assigned to the connection by the source communication device and a channel identifier assigned to the connection by the first sink communication device.

16. The apparatus of claim **13**, wherein the wireless communication system is a Bluetooth communication system, wherein the source communication device is a data source, and each of the first sink communication device and the second sink communication device is a data sink.

17. The apparatus of claim **13**, wherein each of the first channel of the plurality of channels and the second channel of the plurality of channels is conveyed by the source communication device over a same time slot of a group of time slots.

18. The apparatus of claim **13**, wherein the first channel of the plurality of channels is conveyed over a first time slot of a group of time slots and the second channel of the plurality of channels is conveyed by the source communication device over a second time slot of the group of time slots.

19. The apparatus of claim **13**, wherein the wireless communication system is a Bluetooth communication system.

20. The apparatus of claim **19**, wherein the apparatus comprises a Bluetooth headphone.

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