

US Patent & Trademark Office

Patent Public Search | Text View

United States Patent
Kind Code
Date of Patent
Inventor(s)

12389237
B2
August 12, 2025
Huang; Min et al.

Uplink beam determination in wireless communication system with full-duplex

Abstract

Disclosed are techniques related to wireless communication system to enable full duplex communication. A network node is configured to communicate with a parent node and a child node. The network node may include a transceiver, a memory, and a processor communicatively coupled to the transceiver and the memory. The transceiver, memory, and processor may be configured to determine uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially. The transceiver, memory, and processor may also be configured to determine UL parent and child beams based on the UL parent and child link priorities. The transceiver, memory, and processor may further be configured to notify the parent node of the UL parent beam for the parent and child time-domain resources. The transceiver, memory, and processor may yet further be configured to concurrently transmit parent traffic to the parent node using the UL parent beam and receive child traffic from the child node using the UL child beam.

Inventors:	Huang; Min (Beijing, CN), Wei; Chao (Beijing, CN), Xu; Hao (Beijing, CN)
Applicant:	QUALCOMM Incorporated (San Diego, CA)
Family ID:	1000008750599
Appl. No.:	17/632763
Filed (or PCT Filed):	August 26, 2019
PCT No.:	PCT/CN2019/102495
PCT Pub. No.:	WO2021/035462
PCT Pub. Date:	March 04, 2021

Prior Publication Data

Publication Classification

Int. Cl.: **H04W4/00** (20180101); **H04L5/00** (20060101); **H04L5/14** (20060101); **H04W16/28** (20090101); **H04W72/0446** (20230101); **H04W72/56** (20230101)

U.S. Cl.:

CPC **H04W16/28** (20130101); **H04L5/0051** (20130101); **H04L5/14** (20130101); **H04W72/0446** (20130101); **H04W72/56** (20230101);

Field of Classification Search

CPC: H04W (72/0446); H04W (72/56); H04W (72/04); H04W (72/12); H04W (72/50); H04J (2203/0069)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2017/0201894	12/2016	Byun	N/A	H04W 72/56
2018/0302911	12/2017	Aijaz et al.	N/A	N/A
2019/0132847	12/2018	Abedini et al.	N/A	N/A
2021/0345322	12/2020	Tiirola	N/A	H04W 72/1263
2022/0287123	12/2021	Tiirola	N/A	H04W 76/15
2022/0295503	12/2021	Huang et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
108934030	12/2017	CN	N/A
109275177	12/2018	CN	N/A
2019144841	12/2018	WO	N/A

OTHER PUBLICATIONS

Cewit: “Discussions on Resource Multiplexing Among Backhaul and Access Links”, 3GPP TSG RAN WG1 #96bis, R1-1905210, 3RD Generation Partnership Project, Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, vol. RAN WG1, No. Xi'an, China, Apr. 8, 2019-Apr. 12, 2019 Apr. 7, 2019, XP051700285, 11 Pages, paragraphs [0003]-[0004], figure 1. cited by applicant

Samsung: “Resource Multiplexing Between Backhaul and Access Links”, 3GPP TSG RAN WG1 #96, R1-1902271 IAB Resource Multiplexing_Final, 3RD Generation Partnership Project, Mobile Competence Centre, 650, Route Des Lucioles, F-06921 Sophia-Antipolis Cedex, France, vol. RAN WG1, No. Athens, Greece, Feb. 25, 2019-Mar. 1, 2019 Feb. 15, 2019, XP051599966, 7 Pages, paragraphs [0002]-[0003], figure 1. cited by applicant

Supplementary European Search Report—EP19943509—Search Authority—Munich—Apr. 28, 2023. cited by applicant

AT&T: “Summary of 7.2.3.1 Enhancements to Support NR Backhaul Links”, 3GPP TSG RAN

WG1 Meeting #95, R1-1814127, Spokane, USA, Nov. 16, 2018 (Nov. 16, 2018), 25 pages, Nov. 12, 2018-Nov. 16, 2018, the whole document. cited by applicant
International Search Report and Written Opinion—PCT/CN2019/102495—ISA/EPO—May 26, 2020. cited by applicant
Qualcomm Incorporated, “Enhancements to Support NR Backhaul Links”, 3GPP TSG RAN WG1 Meeting #95, R1-1813417, Spokane, USA, Nov. 16, 2018 (Nov. 16, 2018), 23 pages, Nov. 12, 2018-Nov. 16, 2018, sections 2-9. cited by applicant

Primary Examiner: Heiber; Shantell L

Attorney, Agent or Firm: Muncy, Geissler, Olds & Lowe, P.C

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

(1) The present application claims priority to International Application No. PCT/CN2019/102495, filed Aug. 26, 2019, which is herein incorporated by reference in its entirety.

TECHNICAL FIELD

(2) Various aspects described herein generally relate to wireless communication systems, and more particularly, to uplink beam determination in wireless communication systems with full-duplex (FD).

BACKGROUND

(3) Wireless communication systems have developed through various generations, including a 1G (first-generation) analog wireless phone service, a 2G (second-generation) digital wireless phone service (including interim 2.5G and 2.75G networks), a 3G (third-generation) high speed data, Internet-capable wireless service and a 4G (fourth-generation) service (e.g., Long Term Evolution (LTE) or WiMax). There are presently many different types of wireless communication systems in use, including Cellular and PCS (Personal Communications Service) systems. Examples of known cellular systems include the cellular AMPS (Analog Advanced Mobile Phone System), and digital cellular systems based on CDMA (Code Division Multiple Access), FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access), GSM (Global System for Mobile access) variation of TDMA, etc.

(4) A 5G (fifth generation) mobile standard calls for higher data transfer speeds, greater numbers of connections, and better coverage, among other improvements. The 5G standard (also referred to as NR (New Radio)), according to the Next Generation Mobile Networks Alliance, is designed to provide data rates of several tens of megabits per second to each of tens of thousands of users, with 1 gigabit per second to tens of workers on an office floor. Several hundreds of thousands of simultaneous connections should be supported in order to support large sensor deployments. Consequently, the spectral efficiency of 5G mobile communications should be significantly enhanced compared to the current 4G standard. Furthermore, signaling efficiencies should be enhanced and latency should be substantially reduced compared to current standards.

SUMMARY

(5) The following presents a simplified summary relating to one or more aspects and/or embodiments disclosed herein. As such, the following summary should not be considered an extensive overview relating to all contemplated aspects and/or embodiments, nor should the following summary be regarded to identify key or critical elements relating to all contemplated aspects and/or embodiments or to delineate the scope associated with any particular aspect and/or embodiment. Accordingly, the following summary has the sole purpose to present certain concepts

relating to one or more aspects and/or embodiments relating to the mechanisms disclosed herein in a simplified form to precede the detailed description presented below.

(6) One or more aspects may be directed to a method of a network node configured to communicate with a parent node and a child node. The method may comprise determining uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially. The method may also comprise determining UL parent and child beams based on the UL parent and child link priorities. The method may further comprise notifying the parent node of the UL parent beam for the parent and child time-domain resources. The method may yet further comprise concurrently transmitting parent traffic to the parent node using the UL parent beam and receiving child traffic from the child node using the UL child beam.

(7) One or more aspects may be directed to a network node configured to communicate with a parent node and a child node. The network node may comprise a transceiver, a memory, and a processor communicatively coupled to the transceiver and the memory. The transceiver, memory, and processor may be configured to determine uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially. The transceiver, memory, and processor may also be configured to determine UL parent and child beams based on the UL parent and child link priorities. The transceiver, memory, and processor may further be configured to notify the parent node of the UL parent beam for the parent and child time-domain resources. The transceiver, memory, and processor may yet further be configured to concurrently transmit parent traffic to the parent node using the UL parent beam and receive child traffic from the child node using the UL child beam.

(8) One or more aspects may be directed to a network node for communicating with a parent node and a child node. The network node may comprise means for determining uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially. The network node may also comprise means for determining UL parent and child beams based on the UL parent and child link priorities. The network node may further comprise means for notifying the parent node of the UL parent beam for the parent and child time-domain resources. The network node may yet further comprise means for concurrently transmitting parent traffic to the parent node using the UL parent beam and receiving child traffic from the child node using the UL child beam.

(9) One or more aspects may be directed to a non-transitory computer-readable medium storing computer-executable instructions for a network node to communicate with a parent node and a child node. The computer-executable instructions may comprise one or more instructions causing the network node to determine uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially. The computer-executable instructions may also comprise one or more instructions causing the network node to determine UL parent and child beams based on the UL parent and child link priorities. The computer-executable instructions may further comprise one or more instructions causing the network node to notify the parent node of the UL parent beam for the parent and child time-domain resources. The computer-executable instructions may yet further comprise one or more instructions causing the network node to concurrently transmit parent traffic to the parent node using the UL parent beam and receive child traffic from the child node using the UL child beam.

(10) Other objects and advantages associated with the aspects and embodiments disclosed herein will be apparent to those skilled in the art based on the accompanying drawings and detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) A more complete appreciation of the various aspects and embodiments described herein and many attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings which are presented solely for illustration and not limitation, and in which:
- (2) FIG. 1 illustrates a high-level system architecture of a wireless communications system, according to various aspects;
- (3) FIG. 2 illustrates a view of a wireless communication system involved in full-duplex communication, according to various aspects;
- (4) FIG. 3 illustrates examples of apparatuses configured for full-duplex communication, according to various aspects;
- (5) FIG. 4 illustrates an example view of a wireless communication system involved in full-duplex communication, according to various aspects;
- (6) FIGS. 5-13 illustrate flowcharts of an exemplary method of a network node, according to one or more aspects; and
- (7) FIG. 14 illustrates an extension of full-duplex communication to multi-hop scenario, according to various aspects.

DETAILED DESCRIPTION

(8) Various aspects described herein generally relate to wireless communication systems, and more particularly, to uplink beam determination in wireless communication systems with full-duplex. These and other aspects are disclosed in the following description and related drawings to show specific examples relating to exemplary aspects. Alternate aspects will be apparent to those skilled in the pertinent art upon reading this disclosure, and may be constructed and practiced without departing from the scope or spirit of the disclosure. Additionally, well-known elements will not be described in detail or may be omitted so as to not obscure the relevant details of the aspects disclosed herein.

(9) The word “exemplary” is used herein to mean “serving as an example, instance, or illustration.” Any aspect described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other aspects. Likewise, the term “aspects” does not require that all aspects include the discussed feature, advantage, or mode of operation.

(10) The terminology used herein describes particular aspects only and should not be construed to limit any aspects disclosed herein. As used herein, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. Those skilled in the art will further understand that the terms “comprises,” “comprising,” “includes,” and/or “including,” as used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

(11) Further, various aspects may be described in terms of sequences of actions to be performed by, for example, elements of a computing device. Those skilled in the art will recognize that various actions described herein can be performed by specific circuits (e.g., ASIC (application specific integrated circuit)), by program instructions being executed by one or more processors, or by a combination of both. Additionally, these sequences of actions described herein can be considered to be embodied entirely within any form of non-transitory computer-readable medium having stored thereon a corresponding set of computer instructions that upon execution would cause an associated processor to perform the functionality described herein. Thus, the various aspects described herein may be embodied in a number of different forms, all of which have been contemplated to be within the scope of the claimed subject matter. In addition, for each of the aspects described herein, the corresponding form of any such aspects may be described herein as,

for example, “logic configured to” and/or other structural components configured to perform the described action.

(12) As used herein, the terms “user equipment” (or “UE”), “user device,” “user terminal,” “client device,” “communication device,” “wireless device,” “wireless communications device,” “handheld device,” “mobile device,” “mobile terminal,” “mobile station,” “handset,” “access terminal,” “subscriber device,” “subscriber terminal,” “subscriber station,” “terminal,” and variants thereof may interchangeably refer to any suitable mobile or stationary device that can receive wireless communication and/or navigation signals. These terms are also intended to include devices which communicate with another device that can receive wireless communication and/or navigation signals such as by short-range wireless, infrared, wireline connection, or other connection, regardless of whether satellite signal reception, assistance data reception, and/or position-related processing occurs at the device or at the other device. In addition, these terms are intended to include all devices, including wireless and wireline communication devices, that can communicate with a CN (core network) via a RAN (radio access network), and through the core network the UEs can be connected with external networks such as the Internet and with other UEs. Of course, other mechanisms of connecting to the core network and/or the Internet are also possible for the UEs, such as over a wired access network, a WLAN (wireless local area network) (e.g., based on IEEE 802.11, etc.) and so on.

(13) A base station may operate according to one of several RATs (radio access technology) in communication with UEs depending on the network in which it is deployed, and may be alternatively referred to as an Access Point (AP), a Network Node, a NodeB, an eNB or eNodeB (evolved NodeB), a gNB or gNodeB (general Node B), etc. In addition, in some systems a base station may provide purely edge node signaling functions while in other systems it may provide additional control and/or network management functions.

(14) UEs can be embodied by any of a number of types of devices including but not limited to PC (printed circuit) cards, compact flash devices, external or internal modems, wireless or wireline phones, smartphones, tablets, tracking devices, asset tags, smart watches and other wearable devices, servers, routers, electronic devices implemented in vehicles (e.g., automobiles, bicycles, motorcycles, etc.) and so on. A communication link through which UEs can send signals to a RAN is called an uplink channel (e.g., a reverse traffic channel, a reverse control channel, an access channel, etc.). A communication link through which the RAN can send signals to UEs is called a downlink or forward link channel (e.g., a paging channel, a control channel, a broadcast channel, a forward traffic channel, etc.). As used herein the term TCH (traffic channel) can refer to either an uplink/reverse or downlink/forward traffic channel.

(15) Next generation wireless networks such as 5G NR are expected to provide ultra-high data rate and support wide scope of application scenarios. Wireless full-duplex communications is an emerging technique and is theoretically capable of doubling the link capacity. The main idea behind wireless full-duplex is to enable radio network nodes to transmit and receive simultaneously at the same time slot. This contrasts with conventional half duplex operation where transmission and reception differs in time.

(16) A full-duplex network node, such as a base station of a cellular network, can communicate simultaneously in UL (uplink) and DL (downlink) with two half-duplex terminals using the same radio resources. Another typical wireless full-duplex application scenario is that one relay node can communicate simultaneously with an anchor node and a UE in a one-hop scenario, or with two other relay nodes in a multi-hop scenario.

(17) FIG. 1 illustrates a high-level system architecture of a wireless communications system **100** in accordance with one or more aspects of the disclosure. The wireless communications system **100** may include a core network **110**, an IAB (integrated access backhaul) donor **120**, IAB nodes **130-1**, **130-2**, **130-3**, **130-4**, **130-5** (collectively IAB nodes **130**), and UEs **140-1**, **140-2**, **140-3** (collectively UEs **140**). Although only one IAB donor **120**, five (5) IAB nodes **130** and three UEs

140 are shown, the actual numbers of these devices can vary. The IAB nodes **130** may be examples of network nodes serving UEs **140** in a network.

(18) In system **100**, the UEs **140** and the IAB nodes **130** may be configured to communicate with each other over wireless access links **135**. For example, as illustrated in FIG. 1, the UE **140-1** and the IAB node **130-1** may communicate over the access link **135-1**, the UE **140-2** may communicate with the IAB node **130-3** over the access link **135-2**, and the UE **140-3** may communicate with the IAB node **130-4** over the access link **135-3**. In an aspect, each IAB nodes **130** may be a base station or a cell of a network (e.g., gNBs, gNodeBs, eNBs, eNodeBs, etc.) configured to serve one or more UEs **140** within its coverage area. Thus, in FIG. 1, the IAB nodes **130-1**, **130-3**, **130-4** may respectively be a serving cell of the UEs **140-1**, **140-2**, **140-3**. The access links **135** may comply with a given cellular communications protocol (e.g., CDMA (Code Division Multiple Access)), E-VDO (Evolution-Data Optimized), eHRPD (Enhanced High Rate Packet Data), GSM (Global System for Mobile communications), W-CDMA (Wideband CDMA), LTE, LTE-U, 5G NR, etc.).

(19) Each IAB node **130** may be configured to communicate with other IAB nodes **130** and/or the IAB donor over wireless backhaul links **125**. For example, as illustrated in FIG. 1, the IAB nodes **130-1**, **130-2**, **130-3** may communicate with the IAB donor **120** respectively over backhaul links **130-1**, **130-2**, **130-3**. Also, the IAB node **130-2** may communicate with the IAB node **130-4** over the backhaul link **125-4**, and communicate with the IAB node **130-5** over the backhaul link **125-5**.

(20) It would be desirable to enable in-band FD (full-duplex) transmission, i.e., concurrently transmitting and receiving using same radio resources (e.g., in frequency and time). In-band FD can be enabled by canceling strong self-interference from transmission link to reception link. Current FD radio designs can suppress such self-interference by combining the technologies of beamforming, analog cancellation, digital cancellation and antenna cancellation.

(21) If the transmit power is large, there may still exist a certain degree of remaining self-interference strength even after cancellation. This may impair the reception performance of received signal. In the process of cancellation, a certain part of the signal energy may leak to adjacent frequency bands, which can causes self-interference at these adjacent frequency bands.

(22) An IAB system may comprise an IAB donor **120**, one or more IAB nodes **130**, and one or more UEs **140**. Thus, the wireless communication system **100** of FIG. 1 may be viewed as an example of an IAB system. FIG. 2 illustrates an example view of an IAB system from a perspective of a particular IAB node **230**. In the IAB system, it may be assumed that the IAB node **230** is serving a UE **240**. An IAB node closer to the IAB donor (not shown in FIG. 2) is a parent IAB node **230-P** and an IAB node further from the IAB donor is a child IAB node **230-C**.

(23) The IAB node **230** may have six (6) kinds of communication links in which three (3) may be transmission links and three may be reception links: Reception Links: DL parent BH (backhaul) link **225-DP**—to receive from the parent IAB node **230-P**; UL child BH link **225-UC**—to receive from the child IAB node **230-C**; UL access link **235-U**—to receive from the UE **240**; Transmission Links: UL parent BH link **225-UP**—to transmit to the parent IAB node **230-P**; DL child BH link **225-DC**—to transmit to the child IAB node **230-C**; DL access link **235-D**—to transmit to the UE **240**.

(24) The DL and UL parent BH links **225-DP**, **225-UP** and the DL and UL child BH links **225-DC**, **225-UC** may be analogous to the backhaul links **125** of FIG. 1. Also, the DL and UL access links **235-D**, **235-C** may be analogous to the access links **135** of FIG. 1.

(25) In the IAB node **230** with full-duplex, a transmitted signal on any transmission link can cause self-interference to a received signal—in-band and/or in adjacent bands—on any reception link. When this interference strength is large enough (e.g. larger than thermal noise power), it can impair the reception performance of the corresponding channel or signal.

(26) Each IAB node **230** may host two NR functions—mobile termination (MT) and distributed unit (DU). When functioning as a MT, the IAB node **230** may maintain the wireless backhaul connection towards an upstream IAB node (e.g., parent node **230-P** or IAB donor **120**). From the

MT perspective, time-domain resources may be indicated for the parent links (e.g., DL parent BH link **225-DP**, UL parent BH link **225-UP**). The time-domain resources for the parent links may include DL parent, UL parent, and Flexible parent time resources.

(27) When functioning as a DU, the IAB node **230** may provide access connection to UEs (e.g., UE **240**) or downstream MTs of other IAB nodes (e.g., child IAB node **230-C**). From the DU perspective, time-domain resources may be indicated for the child links (e.g., DL child BH link **225-DC**, UL child BH link **225-UC**, DL access link **235-D**, UL access link **235-U**). The time-domain resources for the child links may include DL child, UL child, Flexible child, and not-available child (resources not to be used for communication on DU child links) time resources.

(28) The availability of the DL child, UL child, and the Flexible child time resources may be in one of two availability properties: Hard—corresponding time resource is always available for the DU child link; Soft—availability of corresponding time resource may be controlled, explicitly or implicitly, by the parent node.

(29) The IAB node **230** may be configured with IAB node specific resources in time available for the parent and child links.

(30) In legacy IAB system without full-duplex, an IAB node is unable to perform concurrent Tx (transmission) and Rx (reception). This means that among the six communication links, any reception link cannot have concurrent data transfer with any transmission link. This does not necessarily present an issue when transmission and reception traffic are static since the pattern for non-concurrent transmission and reception time slots can be given according to the proportion of transmission traffic and reception traffic.

(31) However, for dynamic transmission and/or reception traffic, urgent traffic can occur in inverse-direction time slots. That is, urgent transmission traffic may occur in a reception time slot and/or urgent reception traffic may occur in a transmission time slot. Non-concurrent transmission-reception patterns cannot satisfy requirements of such urgent traffic. Moreover, the existing half-duplex mode restricts radio resource spectrum efficiency, which in turn lowers the system throughput.

(32) To address some or all issues associated with the legacy IAB system, it is proposed to use FD (full-duplex) communication at a network node of a network. In an aspect, the network node may be an IAB node. FIG. 3 illustrates several sample components (represented by corresponding blocks) that may be incorporated into an apparatus **302** (e.g., a UE), an apparatus **304** (e.g., a network node, an IAB node), and an apparatus **306** (e.g., OAM (operation and maintenance, donor node (e.g., IAB donor), CN (core network) node), etc.) to support the operations as disclosed herein. It will be appreciated that the components may be implemented in different types of apparatuses in different implementations (e.g., in an ASIC, in SOC (System-on-Chip), etc.). The illustrated components may also be incorporated into other apparatuses in a communication system. For example, other apparatuses in a system may include components similar to those described to provide similar functionality. Also, a given apparatus may contain one or more of the components. For example, an apparatus may include multiple transceiver components that enable the apparatus to operate on multiple carriers and/or communicate via different technologies.

(33) The apparatus **304** may include a wireless communication device (represented by the communication device **314**) for communicating with other nodes via at least one designated RAT (e.g., LTE, 5G NR). The communication device **314** may at least one transmitter (represented by the transmitter **316**) for transmitting signals (e.g., messages, indications, information, pilots, and so on) and at least one receiver (represented by the receiver **318**) for receiving signals (e.g., messages, indications, information, and so on).

(34) A transmitter and a receiver may comprise an integrated device (e.g., embodied as a transmitter circuit and a receiver circuit of a single communication device) in some implementations, may comprise a separate transmitter device and a separate receiver device in some implementations, or may be embodied in other ways in other implementations. In an aspect, a

transmitter may include a plurality of antennas, such as an antenna array, that permits the respective apparatus to perform transmit “beamforming”. Similarly, a receiver may include a plurality of antennas, such as an antenna array, that permits the respective apparatus to perform receive beamforming. In an aspect, the transmitter and receiver may share the same plurality of antennas, such that the respective apparatus can only receive or transmit at a given time, not both at the same time. A wireless communication device (e.g., one of multiple wireless communication devices) of the apparatus **304** may also comprise a NLM (Network Listen Module) or the like for performing various measurements.

(35) The apparatus **304** may include a communication device (represented by the communication device **320**) for communicating with other nodes. For example, the communication device **320** may comprise a network interface (e.g., one or more network access ports) that is configured to communicate with one or more network entities via a wire-based or wireless backhaul connection. In some aspects, the communication device **320** may be implemented as a transceiver configured to support wire-based or wireless signal communication. This communication may involve, for example, sending and receiving: messages, parameters, or other types of information. Accordingly, in the example of FIG. 3, the communication device **320** is shown as comprising a transmitter **322** and a receiver **324** (e.g., network access ports for transmitting and receiving). The communication devices **314** and **320** may be separate devices or may be integrated together into one device.

(36) The apparatus **304** may also include other components that may be used in conjunction with the operations as disclosed herein. The apparatus **304** may include a processing system **334** for providing functionality relating to, for example, determining interferences as disclosed herein and for providing other processing functionality. In an aspect, the processing system **334** may include, for example, one or more general purpose processors, multi-core processors, ASICs, DSPs (digital signal processor), FGPAs (field programmable gate array), or other programmable logic devices or processing circuitry.

(37) The apparatus **304** may include memory component **340** (e.g., each including a memory device) for maintaining information (e.g., information indicative of reserved resources, thresholds, parameters, and so on). In addition, the apparatus **304** may include a user interface device **346** for providing indications (e.g., audible and/or visual indications) to a user and/or for receiving user input (e.g., upon user actuation of a sensing device such a keypad, a touch screen, a microphone, and so on). For convenience, the apparatus **304** is shown in FIG. 3 as including various components that may be configured according to the various examples described herein. It will be appreciated, however, that the illustrated blocks may have different functionality in different designs.

(38) The components of FIG. 3 may be implemented in various ways. In some implementations, the components of FIG. 3 may be implemented in one or more circuits such as, for example, one or more processors and/or one or more ASICs (which may include one or more processors). Here, each circuit may use and/or incorporate at least one memory component for storing information or executable code used by the circuit to provide this functionality. For example, some or all of the functionality represented by blocks **314**, **320**, **334**, **340**, and **346** may be implemented by processor and memory component(s) of the apparatus **304** (e.g., by execution of appropriate code and/or by appropriate configuration of processor components).

(39) The apparatus **304** may transmit and receive messages via a wireless link **360** with the apparatus **302**, the messages including information related to various types of communication (e.g., voice, data, multimedia services, associated control signaling, etc.). The wireless link **360** may operate over a communication medium **362**, which may be shared with other communications as well as other RATs. A medium of this type may be composed of one or more frequency, time, and/or space communication resources (e.g., encompassing one or more channels across one or more carriers) associated with communication between one or more transmitter/receiver pairs, such as the apparatus **304** and the apparatus **302**.

(40) The apparatus **304** may also transmit and receive messages via a wireless link **370** with the

apparatus **306**, the messages including information related to various types of communication (e.g., voice, data, multimedia services, associated control signaling, etc.). The wireless link **370** may operate over a communication medium **372**, which may be shared with other communications as well as other RATs. A medium of this type may be composed of one or more frequency, time, and/or space communication resources (e.g., encompassing one or more channels across one or more carriers) associated with communication between one or more transmitter/receiver pairs, such as the apparatus **304** and the apparatus **306**. The communication mediums **362** and **372** may overlap in resources—e.g., in frequency, time, and/or in code.

(41) Apparatus **304** may include a channel estimator component **354**, which may be used to estimate and/or predict channel conditions (e.g., interferences) of channels and/or links between the apparatuses **304** and **302**. The channel estimator component **354** may also be used to estimate and/or predict channel conditions of channels and/or links between the apparatuses **304** and **306**.

(42) FIG. **4** illustrates an example view of wireless communication system, e.g., such as the wireless communication system **100**, from a perspective of a network node **430** to enable full-duplex communication. In FIG. **4**, the network node **430** may be serving a UE **440**, and may be in communication with a parent network node (or simply “parent node”) **430-P** which is immediately upstream, and a child network node (or simply “child node”) **430-C** which is immediately downstream.

(43) In an aspect, the network node **430** may correspond to the apparatus **304** of FIG. **3**. The network node **430** may have six (6) kinds of communication links in which three (3) may be transmission links and three may be reception links: Reception Links: DL parent link **455-D**—to receive traffic from the parent node **430-P**; UL child link **465-U**—to receive traffic from the child node **430-C**; UL child link **475-U**—to receive traffic from the UE **440**; Transmission Links: UL parent link **455-U**—to transmit traffic to the parent node **430-P**; DL child link **465-D**—to transmit traffic to the child node **430-C**; DL child link **475-D**—to transmit traffic to the UE **440**.

(44) The DL parent BH link **225-DP**, the UL child BH link **225-UC**, and the UL access link **235-U** may respectively be examples of the reception links DL parent link **455-D**, the UL child link **465-U**, and the UL child link **475-U**. The UL parent BH link **225-UP**, the DL child BH link **225-DC**, and the DL access link **235-D** may respectively be examples of the transmission links UL parent link **455-U**, the DL child link **465-D**, and the DL child link **475-D**.

(45) The network node **430** may be an IAB node, and thus may host mobile termination (MT) and distributed unit (DU) functions. When functioning as a MT, the network node **430** may maintain the wireless connection (e.g., backhaul) towards an upstream network node (e.g., parent node **430-P**, donor node (not illustrated), OAM (not illustrated), etc.). From the MT perspective, time-domain resources may be indicated for the parent links (e.g., DL parent link **455-D**, UL parent link **455-U**). The time-domain resources for the parent links may include DL parent, UL parent, and F (Flexible) parent time resources.

(46) When functioning as a DU, the network node **430** may provide access connection to UEs (e.g., UE **440**) or downstream MTs of other network nodes (e.g., child node **430-C**). From the DU perspective, time-domain resources may be indicated for the child links (e.g., DL child link **465-D**, UL child link **465-U**, DL child link **475-D**, DL child link **475-U**). The time-domain resources for the child links may include DL child, UL child, F (Flexible) child, and NA (not-available) child (resources not to be used for communication on DU child links) time resources.

(47) The availability of the DL child, UL child, and the Flexible child time resources may be in one of two availability properties: H (hard)—corresponding time-domain resource is always available for the DU child link; S (soft)—availability of corresponding time resource may be controlled, explicitly or implicitly, by the parent node.

(48) The network node **430** may be configured with network node specific resources in time available for the parent and child links.

(49) Recall from above that a transmitted signal on any transmission link can cause self-

interference to a received signal on any reception link. In FIG. 4, this implies that in the uplink direction, different beams (e.g., beam forming direction, transmit power) used on the UL parent link **455-U** can cause different self-interferences on the UL child links **465-U**, **475-U**. Different beams used on the UL child links **465-U**, **475-U** may have different immunities to the self-interferences from the UL parent link **455-U**.

(50) Without any mitigation (e.g., without priority regulation), undesirable scenarios may occur. For example, a victim link (e.g., UL child link **465-U** and/or **475-U**) may carry high priority information (e.g., urgent data packet, low latency packet, etc.). Unfortunately, a beam may be chosen for an aggressor link (e.g., UL parent link **455-U**) that causes a strong interference to the victim link.

(51) To address these and other issues, one or more techniques are proposed to efficiently determine beams for the UL child links **465-U/475-U** and the UL parent link **455-U** to enable FD communication—concurrent transmission and reception—at the network node **430**. In this way, dynamic traffic allocation may be supported, system capacity may be improved, and or the capability to quickly deliver packets in any direction may be provided.

(52) Generally, it is proposed to determine FD priorities of the UL parent and child links. For example, one of the links (one of the UL parent and child links) may be determined as a primary link and the other (other of the UL parent and child links) may be determined as a secondary link, in which the primary link is prioritized over the secondary link. In an aspect, the link priorities may be determined based on the resource types of the time-domain resources of the UL parent and child links. Once the primary and secondary links are determined, primary beam—the beam for use on the primary link—may be determined. Thereafter, secondary beam—the beam for use on the secondary link—may be determined such that the interference between the primary and secondary links is minimized, e.g., to below a threshold interference such as thermal noise power, or the interference between the primary and secondary links satisfies other criterion, e.g. maximum signal-to-interference-plus-noise ratio (SINR).

(53) In an aspect, the FD priorities of the UL parent and the UL child links may be determined according to their preconfigured resource types of their time-domain resources. In the discussions that follow, communications between the network node and the child node (e.g., child node **430-C**) will be described. But it should be noted that unless specifically indicated otherwise, the description involving the child node can be readily applied to communication between the network node and a UE (e.g., UE **440**).

(54) For the network node **430**, radio resources for links may be defined based on their properties, e.g., directional property, FD (full-duplex) priority property, availability property, etc. In other words, a radio resource of a link may have various combinations of directional, FD priority, and availability properties. The directional property may be one of: DL (downlink)—the resource is for downlink communication; UL (uplink)—the resource is for uplink communication; F (Flexible)—the resource can be for either downlink or uplink communication.

(55) For the network node **430**, a radio resource of the UL parent link **455-U** may be preconfigured with one of three FD priority properties for the network node **430**: Non-FD—the UL parent link takes full use of the radio resource; P-FD—the UL parent link is the primary link, the UL child link is the secondary link; S-FD—the UL parent link is the secondary link, the UL child link is the primary link.

(56) Similarly, a radio resource of the UL child link **465-U**, **475-U** may be preconfigured in one of three full-duplex (FD) priority types for the network node **430**: Non-FD—the UL child link takes full use of the radio resource; P-FD—the UL child link is the primary link, the UL parent link is the secondary link; S-FD—the UL child link is the secondary link, the UL parent link is the primary link.

(57) It should be noted that the UL parent and the UL child links for a radio resource should not both be primary and also should not both be secondary at the same time. Further, the availability

types of the resources of the child links (e.g., UL child, UL child, Flexible child) may be one of: Hard—corresponding time resource is always available for the DU child link; Soft—availability of corresponding time resource may be controlled, explicitly or implicitly, by the parent node.

(58) The network node **430** may be configured with network node specific resources in time available for the parent and child links. For FD communication (full-duplex transmission and reception), radio resources may be configured for both the parent link and the child link. For ease of description, “child time-domain resources” will be used to refer to radio resources allocated/configured for use on child links (e.g., on DL and UL child links **465-D**, **465-U**, **475-D**, **475-U**), and “parent time-domain resources” will be used to refer to radio resources allocated/configured for use on parent links (e.g., on DL and UL parent links **455-D**, **455-U**). The reason that the term “time-domain” is merely to emphasize the resources considered in the context of FD communication, i.e., concurrent transmission and reception.

(59) For FD communication, a parent radio resource and a child radio resource may be configured/allocated to coincide or at least overlap in time. In other words, the network node **430** may concurrently utilize the parent and child time-domain resources to communicate with the parent and child nodes. For the parent link, the parent time-domain resource (e.g., from the MT perspective/view) may have one of the following directional properties—DL, UL, F (Flexible). For example, if the directional property of a particular parent resource is UL or F, that particular parent resource may be used to send traffic on the UL parent link.

(60) For the child link, the child time-domain resource may one of the following combinations of directional and availability properties-DL-H (hard), DL-S(soft), UL-H, UL-S, F-H, or F-S. For example, if the combination properties of a particular child resource is UL-H, UL-S, F-H, or F-S, that particular child resource may be used to transmit traffic on the UL child link.

(61) TABLE-US-00001 TABLE 1 FD possible time-domain resource type pair MT View: Parent Link DU View: Child Link DL UL F DL-H FD possible (DL) FD possible (DL) DL-S FD possible (DL) FD possible (DL) UL-H FD possible (UL) FD possible (UL) UL-S FD possible (UL) FD possible (UL) F-H FD possible (DL) FD possible (UL) FD possible (DL, UL) F-S FD possible (DL) FD possible (UL) FD possible (DL, UL)

(62) In an aspect, a subset of the (parent, child) resource type pairs may be identified in which full-duplex is possible as seen in Table 1. It should be noted that the Table 1 applies to concurrent or at least overlapping pair of parent/child time-domain resources. When a resource type pair is identified as “FD possible (UL)” or as “FD possible (DL, UL)”, this indicates that under such time-domain resource type configuration, the UL parent link and the UL child link have the possibility of working in full-duplex.

(63) As an illustration, assume that a particular parent resource has UL as its directional property and that a particular child resource has UL-H as its directional and availability properties. Under this resource type pair, FD communication may take place. That is, the network node may concurrently 1) receive traffic carried on the particular child resource from the child node over the UL child link, and 2) transmit traffic carried on the particular parent resource to the parent node over the UL parent link.

(64) Table 1 indicates that the type pairs (UL, UL-H), (UL, UL-S), (UL, F-H), (UL, F-S), (F, UL-H), (F, UL-S), (F, F-H), (F, F-S) are the (parent, child) type pairs in which uplink full-duplex communication may be possible. For each of the configurations in which uplink FD communication is possible, there can be different options for determining which of the UL parent and child links will be the primary and be the secondary links. That is, there can be different FD priority determination options.

(65) Before proceeding further, the terms “primary” and “secondary” are used merely to indicate which link will be prioritized over the other. There may be many different priority levels for the links. The terms “primary” and “secondary” are used merely to indicate that between two links—e.g., between the UL parent link and the UL child link—one of the links will be prioritized over the

other based on their priority levels.

(66) In a first uplink FD determination option, for each uplink FD possible configuration of resource type pair (e.g., FD possible (UL), FD possible (DL, UL)), the UL parent link/UL child link can be either primary/secondary or secondary/primary. In other words, for each uplink FD possible pair, either link may be chosen as the primary or the secondary link.

(67) For the first uplink FD determination option, there may be various ways of configuring full-duplex (FD) priorities of the UL parent and child links. In one configuration way, the FD priorities of the UL parent link and/or the UL child link may be configured by an upstream node of the network node, i.e., any node closer to a donor node. For example, the FD priorities may be configured by a central network node such as an OAM (operation & management) node, a donor node (e.g., IAB donor), or the parent node.

(68) In a second configuration way, an observation is made that in general, a network node can control the channel status of its child links, but not of its parent links. Thus, in the second configuration, the FD priorities may be set, configured or otherwise determined based on the availability type of the UL child link resource. For example, if the availability type of the child time-domain resource is hard (e.g., UL-H, F-H), the network node may initially determine the FD priority of the UL child link and inform the parent node. The parent node may then determine the FD priority of the UL parent link as appropriate. Thus, in this example, if the network node **430** determines the FD priority type of the UL child link as P-FD, S-FD, or Non-FD, then the parent node may respectively set the FD priority type of the UL parent link as S-FD, P-FD, or NULL.

(69) In another example, if the availability type of the child time-domain resource is soft, the network node may wait to receive an indication from the parent node that the FD priority of the UL parent link has been determined. The network node may then determine the FD priority of the UL child link as appropriate. Thus, in this example, if the FD priority type of the UL parent link is indicated as P-FD, S-FD, or Non-FD, then the network node **430** may respectively set the FD priority type of the UL child link as S-FD, P-FD, or NULL.

(70) In a second uplink FD determination option, the FD priorities of the UL parent and child links may be determined based on the availability type of the UL child link. For example, if the availability type of the resource for the UL child link is hard (e.g., UL-H, F-H), then the UL parent link/UL child link may be set as secondary/primary. On the other hand, if the availability type of the resource for the UL child link is soft (e.g., UL-S, F-S), then the UL parent link/UL child link may be set as primary/secondary.

(71) TABLE-US-00002 TABLE 2 primary/secondary possibilities for uplink MT View: Parent Link DU View: Child Link UL F UL-H 1) Primary parent link (Tx), 1) Primary parent link (Tx), Secondary child link (Rx) Secondary child link (Rx) 2) Secondary parent link (Tx), 2) Secondary parent link (Tx), Primary child link (Rx) Primary child link (Rx) (default) (default) UL-S 1) Primary parent link (Tx), 1) Primary parent link (Tx), Secondary child link (Rx) Secondary child link (Rx) (default) (default) 2) Secondary parent link (Tx), 2) Secondary parent link (Tx), Primary child link (Rx) Primary child link (Rx) F-H 1) Primary parent link (Tx), 1) Primary parent link (Tx), Secondary child link (Rx) Secondary child link (Rx) 2) Secondary parent link (Tx), 2) Secondary parent link (Tx), Primary child link (Rx) Primary child link (Rx) (default) (default) F-S 1) Primary parent link (Tx), 1) Primary parent link (Tx), Secondary child link (Rx) Secondary child link (Rx) (default) (default) 2) Secondary parent link (Tx), 2) Secondary parent link (Tx), Primary child link (Rx) Primary child link (Rx)

(72) For each (parent, child) resource type pair combinations in which uplink FD is possible (e.g., (UL, UL-H), (UL, UL-S), (UL, F-H), (UL, F-S), (F, UL-H), (F, UL-S), (F, F-H), (F, F-S)), the primary/secondary link determinations are listed in Table 2. In the first uplink FD determination option, all listed primary/secondary link determinations may be valid. In the second uplink FD determination option, only the determinations indicated as “default” may be valid.

(73) Once the primary and secondary links are determined, then the primary beam (for use on the

primary link) may be determined. Thereafter, the secondary beam (for use on the secondary link) may be determined such that interferences between the primary and secondary links are minimized. In an aspect, the primary and secondary beams may be determined based on the availability type and the FD priorities of the UL parent and child link resources. There are the following two use cases when determining the beams: Use case 1: UL parent link: S-FD, UL child link: P-FD; Use case 2: UL parent link: P-FD, UL child link: S-FD.

(74) In use case 1, the UL child and parent links are respectively the primary and secondary links. Then the primary and secondary beams may respectively be the beam of the UL child link (referred to as the “UL child beam”) and the beam of the UL parent link (referred to as the “UL parent beam”). In use case 2, the priorities of the UL child and parent links are reversed. That is, the UL parent and child links are respectively the primary and secondary links. Then the primary and secondary beams may respectively be the UL parent and child beams.

(75) Recall that the UL child link is a reception link and the UL parent link is a transmission link from the perspective of the network node. Then the UL child beam may be the beam used by the network node to receive traffic over the UL child link from the child node. The UL parent beam may be the beam used by the network node to transmit traffic over the UL parent link to the parent node.

(76) In an aspect, it may be assumed that the network node can take care of the channel status in the UL child link, but not in the UL parent link. This implies that the network node has some level of control over the formation of the UL child beam. That is, the network node may set, configure, or otherwise determine the UL child beam.

(77) Even though the network node does not take care of the DL parent link's channel status, the network node may still “determine” the UL parent beam in some circumstances. For example, the parent node may receive traffic on multiple beams formed by the network node for transmitting data. In this instance, the network node may “determine” the UL parent beam by selecting one of the multiple beams. Of course, it is recognized that in other circumstances, the network node may not be able to determine the UL parent beam. For example, the network node may notify the parent node regarding multiple beams, and the parent node may select the beam out of the multiple beams to communicate with the network node.

(78) The ways in which the UL child and parent beams are determined may differ for the use cases. Since the primary beam is determined before the secondary beam, then the secondary beam may be determined in light of the determined primary beam to minimize self-interferences.

(79) In use case 1, this is equivalent to determining the UL child beam, and then thereafter determining the UL parent beam. In other words, the beam of the reception link is first determined, and the beam of the transmission link is determined thereafter. When the beam of the reception link is the primary beam, this can imply that the reception characteristics of the reception link are more or less set before the beam of the transmission link is determined. Then to minimize self-interference, the beam of the transmission link should be determined such that the interferences to receptions over the reception link are minimized.

(80) Applying this to use case 1, the UL child beam may be determined, and the UL parent beam may be determined thereafter. The UL parent beam may be determined such that transmissions over the UL parent link using the UL parent beam is minimally interferes with the receptions over the UL child link using the UL child beam.

(81) After the UL parent and child beams are determined (e.g., during data transfer), the network node may detect that the actual self-interference impacts the reception performance of the UL child link beyond some tolerable limit. In such instances, the network node may take corrective actions. For example, the network node may trigger a determination of a new UL child beam. The new UL child beam may be determined based on the actual self-interference.

(82) On the other hand, use case 2 is equivalent to determining the UL parent beam, and then thereafter determining the UL child beam. In other words, the beam of the transmission link is first

determined, and the beam of the reception link is determined thereafter. When the beam of the transmission link is the primary beam, this can imply that the transmission characteristics of the transmission link are more or less set before the beam of the reception link is determined. Then to minimize self-interference, the beam of the reception link should be determined so as to immunize the reception link to the extent possible from experiencing interferences due to transmissions over the transmission link.

(83) Applying this to use case 2, the UL parent beam may be determined, and the UL child beam may be determined thereafter. The UL child beam may be determined such that the receptions over the UL child link using the UL child beam is maximally immune to the interferences from transmissions over the UL parent link using the UL parent beam.

(84) In an aspect, after parent node determines the UL parent beam, the parent node may indicate to the network node the determined UL parent beam prior to data transfer. If network node detects that the indicated UL parent beam incurs self-interference on UL child link, the network node may abandon the granted data transfer at UL Parent link. The network node may then send an indication to the parent node about the abandoned operation. Alternatively or in addition thereto, the network node may take corrective active. For example, the network may adjust the UL parent beam in the UL Parent link (e.g. reduce transmit power, adjust beamforming direction, etc.). As another example, the network node may trigger a determination of a new UL parent beam and/or a new UL child beam.

(85) FIG. 5 illustrates a flow chart of an example method of a network node (e.g., network node **430**, apparatus **304**) to perform full-duplex (FD) communication with a parent node (e.g., parent node **430-P**, apparatus **306**) and a child node (e.g., child node **430-C**, UE **440**, apparatus **302**, apparatus **306**). The FD communication may be in-band. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the method of FIG. 5.

(86) In block **510**, the network node may determine UL parent and child link priorities for a parent time-domain resource and a child time-domain resource. For example, one of the UL parent and child links may be determined as a primary link and the other of the UL parent and child links may be determined as a secondary link, with the primary link have a higher priority. In an aspect, means for performing block **510** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(87) The parent time-domain resource may be a radio resource configured for parent traffic over an uplink (UL) parent link, and the child time-domain resource may be a radio resource configured for child traffic over a UL child link. The UL parent link may be a wireless link for use by the network node to send parent traffic to the parent node, and the UL child link may be a wireless link for use by the network node to receive child traffic from the child node.

(88) The parent and child time-domain resources may comprise any combination of resources defined in the time domain. For example, the parent time-domain resource may comprise any combination of one or more symbols, one or more slots, one or more sub-frames, one or more frames, etc. Similarly, the child time-domain resource may comprise any combination of one or more symbols, one or more slots, one or more sub-frames, one or more frames, etc.

(89) The parent and child time-domain resources may be concurrent, or overlap in time at least partially. Then when the network node uses the parent and child time-domain resources, the network node may concurrently communicate with the parent and child nodes. When the communication is in-band, the parent and child time resources may be resources in a same or adjacent frequency bands.

(90) In an aspect, the UL parent and child link priorities for parent and child time-domain resources may have already been determined. For example, an upstream node (e.g., OAM node, donor node, parent node, grandparent node, etc.) may have preconfigured the UL parent and child links for the parent and child time-domain resources as being primary or secondary links. For example, FD

priority of the UL parent link for the parent time-domain resource may have been preconfigured as P-FD or S-FD. Alternatively or in addition thereto, FD priority type of the UL child link for the child time-domain resource may have been preconfigured as P-FD or S-FD.

(91) One caveat may be that the UL parent link for the parent time-domain resource and the UL child link for the child time-domain resource are not both primary links simultaneously and also are not both secondary links simultaneously. This can ensure that both UL parent and child links are not primary links simultaneously and also are not secondary links simultaneously.

(92) But in another aspect, the UL parent and child link priorities for parent and child time-domain resources may be determined based on resource types of the parent and child time-domain resources. FIG. 6 illustrates a flow chart of an example process to implement block 510 to determine the UL parent and child link priorities based on the resource types of the parent and child time-domain resources. In an aspect, the memory component 340 of the apparatus 304 may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. 6.

(93) In block 610, the network node may determine the resource types of the parent and child time-domain resources. In an aspect, means for performing block 610 may comprise the processing system 334 and/or the memory component 340 of the apparatus 304.

(94) The resource type of the parent time-domain resource may be DL, UL or F (Flexible). DL resource type may indicate that the parent time-domain resource is available for traffic from the parent node to the network node. UL resource type may indicate that the parent time-domain resource is available for traffic from the network node to the parent node. Flexible resource type may indicate that the parent time-domain resource is available for traffic in either direction between the parent node and the network node.

(95) The resource type of the child time-domain resource may be DL-Hard, DL-Soft, UL-Soft, UL-Hard, F-Hard or F-Soft. DL-Hard resource type may indicate that the child time-domain resource is always available for traffic from the network node to the child node. DL-Soft may indicate that the availability of the child time-domain resource for traffic from the network node to the child node is controlled by an upstream node. UL-Hard resource type may indicate that the child time-domain resource is always available for traffic from the child node to the network node. UL-Soft may indicate that the availability of the child time-domain resource for traffic from the child node to the parent node is controlled by an upstream node. F-Hard resource type may indicate that the child time-domain resource is always available for traffic in either direction between the network node and the child node. F-Soft may indicate that the availability of the child time-domain resource for traffic in either direction in between the network node and the child node is controlled by an upstream node.

(96) In block 620, the network node may determine whether or not UL FD (uplink full-duplex) communication is possible based on the resource types of the parent and child time-domain resources. In an aspect, means for performing block 620 may comprise the processing system 334 and/or the memory component 340 of the apparatus 304.

(97) The network node may determine whether or not the UL FD communication is possible based on the (parent, child) resource type pair combination of the parent and child time-domain resources. For example, when resource type pair is any of (UL, UL-H), (UL, UL-S), (UL, F-H), (UL, F-S), (F, UL-H), (F, UL-S), (F, F-H), (F, F-S), the network node may determine that the UL FD communication is possible. In other words, when the resource type of the parent time-domain resource is one of UL and F and the resource type of the child time-domain resource is one of UL-H, UL-S, F-H, and F-S, the uplink FD communication may be determined to be possible.

(98) If it is determined that the uplink FD communication is possible ("Y" branch from block 620), then in block 630, the network node may determine primary and secondary links. In an aspect, means for performing block 630 may comprise the processing system 334 and/or the memory component 340 of the apparatus 304. In block 630, the network node may decide that one of the

UL parent and child links will be the primary link and the other of the UL parent and child links will be the secondary.

(99) FIG. 7 illustrates a flow chart of an example process to implement block **630**. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. 7.

(100) In block **710**, the network node may set the UL child link for the child time-domain resource to one of the primary and secondary links and set the UL parent link for the parent time-domain resource to the other of the primary and secondary links. The network node may default to setting the UL child link as the primary link when the child time-domain resource is determined to be hard. In an aspect, means for performing block **710** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(101) In block **720**, the network node may notify the parent node, e.g., of the UL child link setting. By notifying the parent node, the parent node may also set the UL parent link to the other of the primary link and secondary links as appropriate. In an aspect, means for performing block **720** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(102) FIG. 8 illustrates a flow chart of another example process to implement block **630**. In this example process, the network node may initiate the setting of the primary and secondary links or defer the initial setting to the parent node. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. 8.

(103) In block **805**, the network node may determine whether the availability property of the UL child link for the child time-domain resource is hard (e.g., UL-Hard, Flexible-Hard) or soft (e.g., UL-Soft, Flexible-Soft). In an aspect, means for performing block **805** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(104) If the UL child link for the child time-domain resource is determined to be hard (“hard” branch from block **805**), then in block **810**, the network node may set the UL child link to be one of the primary link and secondary links. By setting the UL child link, the UL parent link is effectively set to the other of the primary link and secondary links. While the UL child link can be set to either, the network node may default to setting the UL child link as the primary link when the child time-domain resource is determined to be hard. In an aspect, means for performing block **810** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(105) In block **820**, the network node may notify the parent node of the UL child link setting. In an aspect, means for performing block **820** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**. By notifying the parent node, the parent node may also set the UL parent link to the other of the primary link and secondary links as appropriate.

(106) On the other hand, if the UL child link for the child time-domain resource is determined to be soft (“soft” branch from block **805**), then in block **815**, the network node may wait to receive notification from the parent node indicating that the UL parent link has been set to one of the primary link and secondary links. In an aspect, means for performing block **815** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(107) In block **825**, the network node may set the UL child link for the child time-domain resource to the other of the primary link and secondary links. In an aspect, means for performing block **825** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(108) FIG. 9 illustrates a flow chart of a further example process to implement block **630**. In this example process, the network node may fully determine the setting of the primary and secondary links. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-

transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. 9.

(109) In block **905**, the network node may determine whether the availability property of the UL child link for the child time-domain resource is hard (e.g., UL-Hard, Flexible-Hard) or soft (e.g., UL-Soft, Flexible-Soft). In an aspect, means for performing block **905** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(110) If the UL child link is determined to be hard (“hard” branch from block **905**), then in block **910**, the network node may set the UL child link for the child time-domain resource as the primary link and the UL parent link for the parent time-domain resource as the secondary link. In an aspect, means for performing block **910** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(111) On the other hand, If the UL child link is determined to be soft (“soft” branch from block **905**), then in block **915**, the network node may set the UL child link for the child time-domain resource as the secondary link and the UL parent link for the parent time-domain resource as the primary link. In an aspect, means for performing block **915** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(112) In block **920**, the network node may notify the parent node of the UL parent and/or child link settings. By notifying the parent node, the parent node may also set the UL parent link to the other of the primary link and secondary links as appropriate. In an aspect, means for performing block **920** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(113) FIGS. 7 and 8 may be analogous to the first uplink FD determination option discussed above in which all listed primary/secondary link determinations of Table 2 may be considered to be valid. On the other hand, FIG. 9 may be analogous to the second uplink FD determination option in which the determinations indicated as “default” may be valid.

(114) Referring back to FIG. 5, in block **520**, the network node may determine the UL parent and child beams based on the UL parent and child link priorities. The UL parent beam may be used by the network node to send parent traffic carried on the parent time-domain resource to the parent node over the UL parent link, and the UL child beam may be used by the network node to receive child traffic carried on the child time-domain resource from the child node over the UL child link. In an aspect, means for performing block **520** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(115) FIG. 10 illustrates a flow chart of an example process to implement block **520** when the primary link is the UL child link and the secondary link is the UL parent link. Since the UL child beam is the primary beam, in this process, the UL child beam may be determined before the UL parent beam. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. 10.

(116) In block **1010**, the network node may determine the UL child beam for the UL child link. In an aspect, means for performing block **1010** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(117) In block **1020**, the network node may select a set of parent beams based on the UL child beam. The set of parent beams may comprise one or more beams for communication between the network node and the parent node. In an aspect, means for performing block **1020** may comprise the processing system **334**, the memory component **340**, and/or the channel estimator **354** of the apparatus **304**.

(118) The set of parent beams may be selected based on impact or lack thereof on the UL child link. For example, for each parent beam included in the set of parent beams, self-interference from the UL parent link using that parent beam to the UL child link using the UL child beam is at or below a threshold interference and/or does not degrade a channel quality of the UL child link.

(119) In block **1030**, the network node may notify the parent node regarding the selected set of parent beams. In an aspect, means for performing block **1030** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(120) To notify the parent node, the network node may transmit an uplink reference signal (RS) over the UL parent link using each parent beam in the set of parent beams. The uplink RS may indicate that the uplink RS is for time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) whose resource types are UL-Hard or Flexible-Hard.

(121) The uplink RS may be a sounding reference signal (SRS). The SRS sent using each beam may be sent in SRS resources of a SRS resource set specified in a CSI report configuration message from the parent node, in which the SRS configuration message indicates that the specified SRS resource set is for beam management for time-domain resources where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

(122) In block **1040**, the network node may receive a notification from the parent node about a determination of the UL parent beam. The UL parent beam may be a parent beam of the set of parent beams. In an aspect, means for performing block **1040** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(123) FIG. **11** illustrates a flow chart of an example process to implement block **520** when the primary link is the UL parent link and the secondary link is the UL child link. Since the UL parent beam is the primary beam, in this process, the UL parent beam may be determined before the UL child beam. In particular, the parent node may determine the UL parent beam. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. **11**.

(124) In block **1105**, the network node may send a request for an indication of the UL parent beam. In an aspect, means for performing block **1105** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(125) To make the request, the network node may transmit an uplink reference signal (RS) over the UL parent link. The uplink RS may indicate that the uplink RS is for time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) where the FD priority of the UL parent link is primary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) whose resource types are UL-Soft or Flexible-Soft.

(126) The uplink RS may be a sounding reference signal (SRS). The SRS may be sent in SRS resources of a SRS resource set specified in a CSI report configuration message from the parent node, in which the SRS configuration message indicates that the specified SRS resource set is for beam management for time-domain resources where the FD priority of the UL parent link is primary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft.

(127) In block **1110**, the network node may receive a notification from the parent node about a determination of the UL parent beam. The notification may indicate that the UL parent beam is for time-domain resources where the FD priority of the UL parent link is primary FD. In an aspect, means for performing block **1110** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(128) The parent node may include in the notification an indication of a SRS Resource Indicator (SRI) that corresponds to the SRS with the UL parent beam for the UL parent link for time-domain resources where the FD priority of the UL parent link is primary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource

types are UL-Soft or Flexible-Soft.

(129) In block **1120**, the network node may determine a self-interference from the UL parent link using the UL parent beam to the UL child link. In an aspect, means for performing block **1120** may comprise the processing system **334**, the memory component **340** and/or the channel estimator **354** of the apparatus **304**.

(130) In block **1130**, the network node **430** may determine the UL child beam based on the self-interference. In an aspect, means for performing block **1130** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(131) The UL child beam may be determined such that the self-interference at the UL child link due to transmissions on the UL parent link using the UL parent beam is at or below a threshold interference. An example of the threshold interference may be thermal noise power.

(132) Alternatively or in addition thereto, a child beam from a set of child beams may be selected as the UL child beam. The set of child beams may comprise one or more beams for communication between the network node and the child node. The selected UL child beam may be the child beam whose beamforming gain divided by the determined self-interference strength is the largest among the set of child beams.

(133) It should be noted that the network node may receive the notification from the parent node regarding the determination of the UL parent beam without requesting such notification. In that sense, block **1105** may be considered as being optional.

(134) FIG. **12** illustrates a flow chart of another example process to implement block **520** when the primary link is the UL parent link and the secondary link is the UL child link. In this process, the parent node may still determine the UL parent beam. However, the network node can have some influence in that determination. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. **12**.

(135) In block **1210**, the network node may determine a plurality of parent beams. Each parent beam may be a beam for communication between the network node and the parent node. In an aspect, means for performing block **1210** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(136) In block **1220**, the network node may notify the parent node regarding the plurality of parent beams. In an aspect, means for performing block **1220** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(137) To notify the parent node, the network node may transmit an uplink reference signal (RS) over the UL parent link to the using each parent beam in the plurality of parent beams. The uplink RS may indicate that the uplink RS is for time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) whose resource types are UL-Hard or Flexible-Hard.

(138) The uplink RS may be a sounding reference signal (SRS). The SRS sent using each beam may be sent in SRS resources of a SRS resource set specified in a CSI report configuration message from the parent node, in which the SRS configuration message indicates that the specified SRS resource set is for beam management for time-domain resources where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

(139) In block **1230**, the network node may receive a notification from the parent node about a determination of the UL parent beam. The UL parent beam may be a parent beam of the plurality of parent beams. In an aspect, means for performing block **1230** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(140) In block **1240**, the network node may determine a plurality of self-interferences from the UL parent link using the UL parent beam to the UL child link using a plurality of child beams. Each

child beam may be a beam for communication between the network node and the child node. In an aspect, means for performing block **1240** may comprise the processing system **334**, the memory component **340** and/or the channel estimator **354** of the apparatus **304**.

(141) In block **1250**, the network node **430** may determine the UL child beam from the plurality of child beams based on the plurality of self-interferences. In an aspect, means for performing block **1250** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(142) The child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is at or below a threshold interference (e.g., thermal noise power) may be selected as the UL child beam. Alternatively or in addition thereto, child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is the lowest among the plurality of child beams may be selected as the UL child beam.

(143) FIG. **13** illustrates a flow chart of yet another example process to implement block **520** when the primary link is the UL parent link and the secondary link is the UL child link. In this process, the network node can have even more influence in determining the UL parent beam. In an aspect, the memory component **340** of the apparatus **304** may be an example of a non-transitory computer-readable medium storing computer-executable instructions of a network node to perform the process of FIG. **13**.

(144) In block **1310**, the network node may determine a plurality of parent beams. Each parent beam may be a beam for communication between the network node and the parent node. In an aspect, means for performing block **1310** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(145) In block **1320**, the network node may notify the parent node regarding the plurality of parent beams. In an aspect, means for performing block **1320** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(146) To notify the parent node, the network node may transmit an uplink reference signal (RS) over the UL parent link to the using each parent beam in the plurality of parent beams. The uplink RS may indicate that the uplink RS is for time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources (e.g., symbols, slots, sub-frames, frames, etc.) whose resource types are UL-Hard or Flexible-Hard.

(147) The uplink RS may be a sounding reference signal (SRS). The SRS sent using each beam may be sent in SRS resources of a SRS resource set specified in a CSI report configuration message from the parent node, in which the SRS configuration message indicates that the specified SRS resource set is for beam management for time-domain resources where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

(148) In block **1330**, the network node may receive a notification from the parent node about a set of parent beams. The set of parent beams may comprise one or more parent beams of the plurality of parent beams. In an aspect, means for performing block **1340** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(149) In block **1340**, the network node may determine the UL parent beam from the set of parent beams. In an aspect, means for performing block **1310** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(150) In block **1350**, the network node may determine a set of self-interferences from the UL parent link using the UL parent beam to the UL child link using a set of child beams. The set of child beams may comprise one or more beams for communication between the network node and the child node. In an aspect, means for performing block **1350** may comprise the processing system

334, the memory component **340** and/or the channel estimator **354** of the apparatus **304**.

(151) In block **1360**, the network node **430** may determine the UL child beam from the set of child beams based on the set of self-interferences. In an aspect, means for performing block **1360** may comprise the processing system **334** and/or the memory component **340** of the apparatus **304**.

(152) The child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is at or below a threshold interference (e.g., thermal noise power) may be selected as the UL child beam. Alternatively or in addition thereto, child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is the lowest among the set of child beams may be selected as the UL child beam.

(153) Referring back to FIG. 5, in block **530**, the network node may notify the parent node of the UL parent beam for the parent and child time-domain resources. In an aspect, means for performing block **530** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(154) When the UL parent and child beams are determined in accordance with FIG. 10, to perform block **530**, the network node may send a notification to the parent node indicating that the notification is for time-domain resources where the FD priority of the UL parent link is secondary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

(155) With respect to FIG. 10, block **530** may effectively be achieved in blocks **1030**, **1040**. Recall that in block **1030**, the network node may indicate to the parent node that the uplink RS sent in the set of parent beams is for such time-domain resources, and in block **1040**, the network node may receive a selection of one of the parent beams as the UL parent beam.

(156) When the UL parent and child beams are determined in accordance with FIGS. 11, 12, and 13, to perform block **530**, the network node may send a notification to the parent node indicating that the notification is for time-domain resources where the FD priority of the UL parent link is primary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft.

(157) With respect to FIG. 11, block **530** may effectively be achieved in blocks **1105**, **1110**. Recall that in block **1105**, the network node may indicate that the request is for such time-domain resources, and in block **1110**, the network node may receive the SRI.

(158) With respect to FIG. 12, block **530** may effectively be achieved in blocks **1220**, **1230**. Recall that in block **1220**, the network node may indicate to the parent node that the uplink RS sent in the plurality of parent beams is for such time-domain resources, and in block **1230**, the network node may receive a selection of one of the parent beams as the UL parent beam.

(159) With respect to FIG. 12, block **530** may effectively be achieved in blocks **1320**, **1330**. Recall that in block **1320**, the network node may indicate to the parent node that the uplink RS sent in the plurality of parent beams is for such time-domain resources, and in block **1330**, the network node may receive a set of parent beam, from which the UL parent may be selected.

(160) In block **540**, the network node may concurrently 1) transmit to the parent node the parent traffic carried on the parent time-domain resource over the UL parent link using the UL parent beam, and 2) receive from the child node the child traffic carried on the child time-domain resource over the UL child link using the UL child beam. In an aspect, means for performing block **540** may comprise the processing system **334**, the memory component **340**, and/or the communication device **320** of the apparatus **304**.

(161) Note that each of the UL parent beam and the UL child beam may be characterized by respective transmit power, transmit beamforming direction, and/or receive beamforming direction.

(162) FIG. 14 illustrates an example extension of FD communication to a multi-hop scenario. FIG. 14 includes network nodes 1-4 connected through links 1-3. Of course, there can be any number of network nodes connected through any number of links. In FIG. 14, all network nodes are assumed

to be configured for FD communication. The following list some examples (not necessarily exhaustive) of establishing beams are listed as in scenarios of the links having relative FD link priorities:

(163) Links **1, 2, 3** are configured as FD with priorities from high to low, e.g., network node **2** is configured as P-FD @ link **1** and S-FD @ link **2**; network node **3** is configured as P-FD @ link **2** and S-FD @ link **3**: beam of link **1** may be first determined by network node **1**; beam of link **2** may be determined second by network node **2**, which does not interfere with link **1** with the determined beam; beam of link **3** may be determined by network node **3**, which does not interfere with link **2** with determined beam.

(164) Links **1, 2, 3** are configured as FD with priorities from low to high, e.g., network node **2** is configured as S-FD @ link **1** and P-FD @ link **2**; network node **3** is configured as S-FD @ link **2** and P-FD @ link **3**: beam of link **3** may be first determined by network node **3**; beam of link **2** may be determined second by network node **2**, which does not interfere with link **3** with determined beam; beam of link **1** may be determined by network node **1**, which does not interfere with link **2** with determined beam.

(165) Links **1, 3** are configured as P-FD while link **2** is configured as S-FD: beam of link **1** and **3** may be first determined by network node **1** and **3**, respectively; beam of link **2** may be determined by network node **2**, which does not interfere with links **1** or **3** with each determined beam.

(166) Those skilled in the art will appreciate that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

(167) Further, those skilled in the art will appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the aspects disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted to depart from the scope of the various aspects described herein.

(168) The various illustrative logical blocks, modules, and circuits described in connection with the aspects disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or other such configurations).

(169) The methods, sequences, and/or algorithms described in connection with the aspects disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in Random Access Memory (RAM), flash memory, Read-Only Memory (ROM), Erasable Programmable ROM (EPROM), Electrically Erasable Programmable ROM (EEPROM), registers, hard disk, a removable disk, a CD-ROM, or any other form of non-transitory computer-readable medium known in the art. An exemplary non-transitory computer-readable medium may be coupled to the

processor such that the processor can read information from, and write information to, the non-transitory computer-readable medium. In the alternative, the non-transitory computer-readable medium may be integral to the processor. The processor and the non-transitory computer-readable medium may reside in an ASIC. The ASIC may reside in a user device (e.g., a UE) or a base station. In the alternative, the processor and the non-transitory computer-readable medium may be discrete components in a user device or base station.

(170) In one or more exemplary aspects, the functions described herein may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a non-transitory computer-readable medium. Computer-readable media may include storage media and/or communication media including any non-transitory medium that may facilitate transferring a computer program from one place to another. A storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of a medium. The term disk and disc, which may be used interchangeably herein, includes a Compact Disk (CD), laser disc, optical disk, Digital Video Disk (DVD), floppy disk, and Blu-ray discs, which usually reproduce data magnetically and/or optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

(171) While the foregoing disclosure shows illustrative aspects, those skilled in the art will appreciate that various changes and modifications could be made herein without departing from the scope of the disclosure as defined by the appended claims. Furthermore, in accordance with the various illustrative aspects described herein, those skilled in the art will appreciate that the functions, steps, and/or actions in any methods described above and/or recited in any method claims appended hereto need not be performed in any particular order. Further still, to the extent that any elements are described above or recited in the appended claims in a singular form, those skilled in the art will appreciate that singular form(s) contemplate the plural as well unless limitation to the singular form(s) is explicitly stated.

Claims

1. A method of a network node configured to communicate with a parent node and a child node, the method comprising: determining uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially, wherein determining UL parent and child link priorities comprises: determining resource types of the parent and child time-domain resources; and determining primary and secondary links based on the resource types of the parent and child time-domain resources, the primary link being one of the UL parent and child links and the secondary link being other of the UL parent and child links, and the primary link having a higher priority than the secondary link; determining UL parent and child beams based on the UL parent and child link priorities, wherein when the primary link is the UL child link, the determining of the UL parent and child beams comprises: determining the UL child beam; selecting a set of parent beams based on the UL child beam, the set of parent beams comprising one or more beams for communication between the network node and the parent node; notifying the parent node about the selecting; and receiving an indication from the parent node about a determination of the UL

parent beam, the UL parent beam being a parent beam of the set of parent beams; notifying the parent node of the UL parent beam for the parent and child time-domain resources; and concurrently transmitting parent traffic to the parent node using the UL parent beam and receiving child traffic from the child node using the UL child beam, wherein one of the UL parent and child links is a higher priority link and the other of the UL parent and child links is a lower priority link in which a primary beam is associated with the higher priority link and a secondary beam is associated with the lower priority link, the primary beam being one of the UL parent and child beams and the secondary beam being the other of the UL parent and child beams, and wherein in determining UL parent and child beams, the primary beam is determined, and then the secondary beam is determined based on the primary beam.

2. The method of claim 1, wherein the network node is an integrated access backhaul (IAB) node.

3. The method of claim 1, wherein the parent time-domain resource comprises any combination of one or more symbols, one or more slots, one or more sub-frames, and one or more frames, and/or wherein the child time-domain resource comprises any combination of one or more symbols, one or more slots, one or more sub-frames, and one or more frames.

4. The method of claim 3, wherein determining UL parent and child link priorities comprises: determining primary and secondary links, the primary link being one of the UL parent and child links and the secondary link being other of the UL parent and child links, the primary link having a higher priority than the secondary link.

5. The method of claim 4, wherein the UL parent link for the parent time-domain resource is preconfigured to be one of the primary and secondary links, and the UL child link for the child time-domain resource is preconfigured to be other of the primary and secondary links.

6. The method of claim 5, wherein the UL parent and child links for the parent and child time-domain resources are preconfigured by an upstream node of the network node.

7. The method of claim 5, wherein a full-duplex (FD) priority of the UL parent link for the parent time-domain resource is preconfigured to be one of primary FD and secondary FD, wherein a full-duplex (FD) priority of the UL child link for the child time-domain resource is preconfigured to be one of primary FD and secondary FD, wherein for the UL parent link, primary FD indicates that the UL parent link is the primary link and the UL child link is the secondary link, and secondary FD indicates that the UL parent link is the secondary link and the UL child link is the primary link, wherein for the UL child link, primary FD indicates that the UL child link is the primary link and the UL parent link is the secondary link, and secondary FD indicates that the UL child link is the secondary link and the UL parent link is the primary link, and wherein the UL parent link and the UL child link are not both primary links simultaneously and also are not both secondary links simultaneously.

8. The method of claim 1, wherein the resource type of the parent time-domain resource is DL, UL, or Flexible (F), and the resource type of the child time-domain resource is DL-Hard, DL-Soft, UL-Hard, UL-Soft, Flexible-Hard, or Flexible-Soft, wherein for the parent time-domain resource, DL indicates that the parent time-domain resource is available for traffic from the parent node to the network node, UL indicates that the parent time-domain resource is available for traffic from the network node to the parent node, and Flexible indicates that the parent time-domain resource is available for traffic in either direction between the network node and the parent node, and wherein for the child time-domain resource, DL-Hard indicates that the child time-domain resource is always available for traffic from the network node to the child node, DL-Soft indicates that the availability of the child time-domain resource for traffic from the network node to the child node is controlled by an upstream node, UL-Hard indicates that the child time-domain resource is always available for traffic from the child node to the network node, UL-Soft indicates that the availability of the child time-domain resource for traffic from the child node to the network node is controlled by an upstream node, Flexible-Hard indicates that the child time-domain resource is always available for traffic in either direction between the network node and the child node, and Flexible-

Soft indicates that the availability of the child time-domain resource in either direction between the network node and the child node is controlled by an upstream node.

9. The method of claim 8, further comprising: determining whether uplink full-duplex (UL FD) communication is possible based on the resource types of the parent and child time-domain resources, wherein the primary and secondary links are determined when it is determined that the UL FD communication is possible.

10. The method of claim 9, wherein the UL FD communication is determined to be possible when the resource type of the parent time-domain resource is one of UL and F and the resource type of the child time-domain resource is one of UL-Hard, UL-Soft, Flexible-Hard, and Flexible-Soft.

11. The method of claim 1, wherein determining the primary and secondary links comprises: setting the UL child link as one of the primary and secondary links and the UL parent link as other one of the primary and secondary links; and notifying the parent node of the primary and/or secondary link settings.

12. The method of claim 1, wherein determining the primary and secondary links comprises: determining an availability property of the child time-domain resource; when the availability property of the child time-domain resource is Hard indicating that the child time-domain resource is always available for the UL child link, setting the UL child link as one of the primary and secondary links, and notifying the parent node of the UL child link setting; and when the availability property of the child time-domain resource is Soft indicating that the availability of the child time-domain resource the UL child link is controlled by an upstream node, receiving a notification from the parent node indicating that the UL parent link is set to one of the primary and secondary links, and setting that the UL child link as other of the primary and secondary links.

13. The method of claim 1, wherein determining the primary and secondary links comprises: determining an availability property of the child time-domain resource; when the availability property of the child time-domain resource is Hard indicating that the child time-domain resource is always available for the UL child link, setting the UL child link as the primary link and the UL parent link as the secondary link; when the availability property of the child time-domain resource is Soft indicating that the availability of the child time-domain resource the UL child link is controlled by an upstream node, setting the UL child link as the secondary link and the UL parent link as the primary link; and notifying the parent node of the primary and/or secondary link settings.

14. The method of claim 1, wherein determining the set of parent beams comprises including in the set of parent beams one or more parent beams such that for each parent beam included in the set of parent beams, self-interference from the UL parent link using that parent beam to the UL child link using the UL child beam is at or below a threshold interference and/or does not degrade a channel quality of the UL child link.

15. The method of claim 1, wherein notifying the parent node about the selecting comprises: transmitting an uplink reference signal (RS) over the UL parent link to the parent node using each parent beam in the set of parent beams, the uplink RS indicating that the uplink RS is for time-domain resources where a full-duplex (FD) priority of the UL parent link is secondary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard, wherein for the UL parent link, secondary FD priority indicates that the UL parent link is the secondary link and the UL child link is the primary link, and wherein for the UL child link, UL-Hard indicates that the time-domain resource is always available for traffic from the child node to the network node.

16. The method of claim 15, wherein the uplink RS is a sounding reference signal (SRS), and wherein the SRS sent using each beam are sent in SRS resources of a SRS resource set specified in a SRS configuration message from the parent node, the SRS configuration message indicating that the specified SRS resource set is for beam management for time-domain resources where a full-

duplex (FD) priority of the UL parent link is secondary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

17. The method of claim 1, wherein when the primary link is the UL parent link, determining the UL parent and child beams comprises: receiving a notification from the parent node about a determination of the UL parent beam; determining a self-interference from the UL parent link using the UL parent beam to the UL child link; and determining the UL child beam based on the self-interference.

18. The method of claim 17, further comprising: requesting the notification of the UL parent beam to the parent node prior to receiving the notification from the parent node.

19. The method of claim 18, wherein requesting the notification comprises: transmitting an uplink reference signal (RS) over the UL parent link to the parent node, the uplink RS indicating that the uplink RS is for time-domain resources where a full-duplex (FD) priority of the UL parent link is primary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft, wherein for the UL parent link, primary FD priority indicates that the UL parent link is the primary link and the UL child link is the second link, and wherein for the UL child link, UL-Soft indicates that the availability of the time-domain resource for traffic from the child node to the network node is controlled by an upstream node.

20. The method of claim 19, wherein the uplink RS is a sounding reference signal (SRS), and wherein the SRS sent in SRS resources of a SRS resource set specified in a SRS configuration message from the parent node, the SRS configuration message indicating that the specified SRS resource set is for beam management for time-domain resources where a full-duplex (FD) priority of the UL parent link is primary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft.

21. The method of claim 17, wherein the notification includes an indication of a sounding reference signal (SRS) resource indicator (SRI) that corresponds to a SRS with the UL parent beam for the UL parent link for time-domain resources where the FD priority of the UL parent link is primary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft, wherein for the UL parent link, primary FD priority indicates that the UL parent link is the primary link and the UL child link is the second link, and wherein for the UL child link, UL-Soft indicates that the availability of the time-domain resource for traffic from the child node to the network node is controlled by an upstream node.

22. The method of claim 17, wherein determining the UL child beam comprises: determining the UL child beam such that the self-interference at the UL child link using the UL child beam due to transmissions on the UL parent link using the UL parent beam is at or below a threshold interference.

23. The method of claim 17, wherein determining the UL child beam comprises: selecting a child beam from a set of child beams as the UL child beam, the set of child beams comprising one or more beams for communication between the network node and the child node, the UL child beam being the child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is the lowest among the set of child beams.

24. The method of claim 1, wherein when the primary link is the UL parent link, determining the UL parent and child beams comprises: determining a plurality of parent beams, each parent beam being a beam for communication between the network node and the parent node; notifying the parent node about the determining; receiving a notification from the parent node about a determination of the UL parent beam; determining a plurality of self-interferences from the UL parent link using the UL parent beam to the UL child link using a plurality of child beams, each child beam being a beam for communication between the network node and the child node; and

determining the UL child beam from the plurality of child beams based on the plurality of self-interferences.

25. The method of claim 24, wherein notifying the parent node about the determining comprises: transmitting an uplink reference signal (RS) over the UL parent link to the parent node using each parent beam in the plurality of parent beams, the uplink RS indicating that the uplink RS is for time-domain resources where a full-duplex (FD) priority of the UL parent link is primary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft, wherein for the UL parent link, primary FD priority indicates that the UL parent link is the primary link and the UL child link is the second link, and wherein for the UL child link, UL-Soft indicates that the availability of the time-domain resource for traffic from the child node to the network node is controlled by an upstream node.

26. The method of claim 25, wherein the uplink RS is a sounding reference signal (SRS), and wherein the SRS sent using each beam are sent in SRS resources of a SRS resource set specified in a SRS configuration message from the parent node, the SRS configuration message indicating that the specified SRS resource set is for beam management for time-domain resources where a full-duplex (FD) priority of the UL parent link is secondary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

27. The method of claim 24, wherein the notification from the parent node includes an indication of a sounding reference signal (SRS) resource indicator (SRI) that corresponds to a SRS with the UL parent beam for the UL parent link for time-domain resources where the FD priority of the UL parent link is primary FD, and/or is for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Soft or Flexible-Soft, wherein for the UL parent link, primary FD priority indicates that the UL parent link is the primary link and the UL child link is the second link, and wherein for the UL child link, UL-Soft indicates that the availability of the time-domain resource for traffic from the child node to the network node is controlled by an upstream node.

28. The method of claim 24, wherein determining the UL child beam comprises: selecting a child beam from the plurality of child beams as the UL child beam, the UL child beam being the child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is at or below a threshold interference.

29. The method of claim 24, wherein determining the UL child beam comprises: selecting a child beam from the plurality of child beams as the UL child beam, the UL child beam being the child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is the lowest among the plurality of child beams.

30. The method of claim 1, wherein when the primary link is the UL parent link, determining the UL parent and child beams comprises: determining a plurality of parent beams, each parent beam being a beam for communication between the network node and the parent node; notifying the parent node about the determining; receiving a notification from the parent node about a set of parent beams comprising one or more parent beams of the plurality of parent beams; determining the UL parent beam from the set of parent beams; determining a set of self-interferences from the UL parent link using the UL parent beam to the UL child link using a set of child beams comprising one or more beams for communication between the network node and the child node; and determining the UL child beam from the set of child beams based on the set of self-interferences.

31. The method of claim 30, wherein notifying the parent node about the determining comprises: transmitting an uplink reference signal (RS) over the UL parent link to the parent node using each parent beam in the plurality of parent beams, the uplink RS indicating that the uplink RS is for time-domain resources where a full-duplex (FD) priority of the UL parent link is primary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain

resources whose resource types are UL-Soft or Flexible-Soft, wherein for the UL parent link, primary FD priority indicates that the UL parent link is the primary link and the UL child link is the second link, and wherein for the UL child link, UL-Soft indicates that the availability of the time-domain resource for traffic from the child node to the network node is controlled by an upstream node.

32. The method of claim 31, wherein the uplink RS is a sounding reference signal (SRS), and wherein the SRS sent using each beam are sent in SRS resources of a SRS resource set specified in a SRS configuration message from the parent node, the SRS configuration message indicating that the specified SRS resource set is for beam management for time-domain resources where a full-duplex (FD) priority of the UL parent link is secondary FD, and/or for time-domain resources where the UL child link is correspondingly in time-domain resources whose resource types are UL-Hard or Flexible-Hard.

33. The method of claim 30, wherein determining the UL child beam comprises: selecting a child beam from the set of child beams as the UL child beam, the UL child beam being the child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is at or below a threshold interference.

34. The method of claim 30, wherein determining the UL child beam comprises: selecting a child beam from the set of child beams as the UL child beam, the UL child beam being the child beam whose self-interference from the UL parent link using the UL parent beam to the UL child link using the child beam is the lowest among the set of child beams.

35. The method of claim 1, wherein the UL parent beam is characterized by its transmit power, transmit beamforming direction, and/or receive beamforming direction, and wherein the UL child beam is characterized by its transmit power, transmit beamforming direction, and/or receive beamforming direction.

36. A network node configured to communicate with a parent node and a child node, the network node comprising: a transceiver; a memory; and a processor communicatively coupled to the transceiver and the memory, wherein the processor, the transceiver, and the memory are configured to: determine uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially, wherein determining UL parent and child link priorities comprises: determining resource types of the parent and child time-domain resources; and determining primary and secondary links based on the resource types of the parent and child time-domain resources, the primary link being one of the UL parent and child links and the secondary link being other of the UL parent and child links, and the primary link having a higher priority than the secondary link; determine UL parent and child beams based on the UL parent and child link priorities wherein when the primary link is the UL child link, the determining of the UL parent and child beams comprises: determining the UL child beam; selecting a set of parent beams based on the UL child beam, the set of parent beams comprising one or more beams for communication between the network node and the parent node; notifying the parent node about the selecting; and receiving an indication from the parent node about a determination of the UL parent beam, the UL parent beam being a parent beam of the set of parent beams; notify the parent node of the UL parent beam for the parent and child time-domain resources; and concurrently transmit parent traffic to the parent node using the UL parent beam and receive child traffic from the child node using the UL child beam, wherein one of the UL parent and child links is a higher priority link and the other of the UL parent and child links is a lower priority link in which a primary beam is associated with the higher priority link and a secondary beam is associated with the lower priority link, the primary beam being one of the UL parent and child beams and the secondary beam being the other of the UL parent and child beams, and wherein in determining UL parent and child beams, the primary beam is determined, and then the secondary beam is determined based on the primary beam.

37. A network node for communicating with a parent node and a child node, the network node

comprising: means for determining uplink (UL) parent and child link priorities for parent and child time-domain resources that overlap in time at least partially, wherein the means for determining UL parent and child link priorities further comprises: determining resource types of the parent and child time-domain resources; and determining primary and secondary links based on the resource types of the parent and child time-domain resources, the primary link being one of the UL parent and child links and the secondary link being other of the UL parent and child links, and the primary link having a higher priority than the secondary link; means for determining UL parent and child beams based on the UL parent and child link priorities wherein when the primary link is the UL child link, the means for determining of the UL parent and child beams comprises: determining the UL child beam; selecting a set of parent beams based on the UL child beam, the set of parent beams comprising one or more beams for communication between the network node and the parent node; notifying the parent node about the selecting; and receiving an indication from the parent node about a determination of the UL parent beam, the UL parent beam being a parent beam of the set of parent beams; means for notifying the parent node of the UL parent beam for the parent and child time-domain resources; and means for concurrently transmitting parent traffic to the parent node using the UL parent beam and receiving child traffic from the child node using the UL child beam, wherein one of the UL parent and child links is a higher priority link and the other of the UL parent and child links is a lower priority link in which a primary beam is associated with the higher priority link and a secondary beam is associated with the lower priority link, the primary beam being one of the UL parent and child beams and the secondary beam being the other of the UL parent and child beams, and wherein in determining UL parent and child beams, the primary beam is determined, and then the secondary beam is determined based on the primary beam.
