

BEAMFORMING INDICATION TECHNIQUES

TECHNICAL FIELD

This disclosure is directed generally to digital wireless communications.

BACKGROUND

Mobile telecommunication technologies are moving the world toward an increasingly connected and networked society. In comparison with the existing wireless networks, next generation systems and wireless communication techniques will need to support a much wider range of use-case characteristics and provide a more complex and sophisticated range of access requirements and flexibilities.

Long-Term Evolution (LTE) is a standard for wireless communication for mobile devices and data terminals developed by 3rd Generation Partnership Project (3GPP). LTE Advanced (LTE-A) is a wireless communication standard that enhances the LTE standard. The 5th generation of wireless system, known as 5G, advances the LTE and LTE-A wireless standards and is committed to supporting higher data-rates, large number of connections, ultra-low latency, high reliability and other emerging business needs.

SUMMARY

Techniques are disclosed for indicating beamforming related information to a smart node that forwards signals to a base station (BS) and/or a user equipment (UE).

A first example wireless communication method includes receiving, by a first network node from a second network node, a configuration information that indicates information about a number of beams configured for the first network node; and performing, by the first network node, communication with one or more communication nodes by configuring the number of beams according to the configuration information.

In some examples, the performing the communication includes transmitting to a communication node information using a beam from the number of beams, and the information is received by the first network node from the second network node prior to the transmitting. In some examples, the performing the communication includes receiving from a communication node information using a beam from the number of beams, and the first network node sends to the second network node the information received from the communication node. In some examples, the first network node transmits the maximum number of beams supported by the first network node to the second network node prior to the receiving the

configuration information. In some examples, the configuration information includes a bitmap indicating the number of beams to be used by the first network node to send the information to the communication node, and each bit in the bitmap indicates that a corresponding beam is either enabled or disabled to send the information. In some examples, the number of beams is configured by a base station (BS) or an operation, administration, and management (OAM) node.

A second example wireless communication method includes receiving, by a communication node from a second network node, a configuration information that indicates a number of beams that are configured for a first network node; and receiving, by the communication node, information from the first network node on a beam from the number of beams, wherein the information is received by the communication node from the second network node via the first network node.

In some examples, the configuration information includes a bitmap that includes one or more bits, wherein each bit corresponds to one reference signal, and wherein each bit indicates to the communication node whether a reference signal is to be received by the communication node from the second network node via the first network node. In some examples, the configuration information indicates the number of beams associated with each of one or more reference signals that are to be received by the communication node from the second network node via the first network node. In some examples, the configuration information is received in a system information (SI).

A third example wireless communication method includes receiving, by a communication node from a second network node, a configuration information that indicates a forwarding gap when a first network node does not send to the communication node information from the second network node, wherein the forwarding gap indicates a length of time when the communication node receives one or more reference signals from the second network node and does not receive the one or more reference signals from the first network node; and receiving, by the communication node, the one or more reference signals from the second network node during the forwarding gap and the one or more reference signals from the first network node during a time other than the forwarding gap.

In some examples, the configuration information includes a bitmap that includes one or more bits, wherein each bit corresponds to one reference signal, and a value of each bit

indicates whether a reference signal is to be received by the communication node from the second network node via the first network node. In some examples, the configuration information includes a value for the forwarding gap associated with each of the one or more reference signals that are not to be received by the communication node from the second network node during the forwarding gap. In some examples, the configuration information is received in a system information (SI). In some examples, the one or more reference signals includes one or more synchronization signal blocks (SSBs).

A fourth example wireless communication method includes receiving, by a first network node from a second network node, a configuration information that includes: (1) an ordered sequence of a plurality of beams to be used by the first network node, (2) a plurality of time lengths corresponding to the plurality of beams, wherein each time length is associated with one beam, and (3) a valid time interval that indicates a time length when the first network node performs transmissions using the ordered sequence of the plurality of beams and the plurality of time lengths; and performing, by the first network node, the transmissions using the plurality of beams according to the configuration information. In some examples, the first network node repeats the transmissions using the plurality of beams in the time length.

A fifth example wireless communication method includes receiving, by a first network node from a second network node, a configuration information that includes: (1) one or more beams to be used by the first network node, and (2) a time length indication that indicates a time length when the first network node performs transmissions using the one or more beams; and performing, by the first network node, the transmissions using the one or more beams during the time length.

A sixth example wireless communication method includes receiving, by a first network node from a second network node, a beam sweeping period that indicates a length of time when the first network node is to perform a transmission using beam sweeping; and performing, by the first network node, the beam sweeping operation during the beam sweeping period by using a plurality of controllable reflecting elements of the first network node. In some examples, the beam sweeping period is configured by a base station (BS) or an operation, administration, and management (OAM) node.

A seventh example wireless communication method includes receiving, by a first network node from a second network node, a report that indicates a quality of signal transmission

performed by the first network node over a beam sweeping period, wherein the beam sweeping period indicates a length of time when the first network node performs transmissions using a plurality of controllable reflecting elements; and performing, by the first network node, the transmission using the plurality of controllable reflecting elements according to the report.

In some examples, the report indicates the quality of signal transmission for each of a plurality of time units within the beam sweeping period. In some examples, the report indicates that the quality of signal transmission is high during a number of time interval, wherein each time interval is identified by a first time when a time interval starts and a second time when the time interval ends. In some examples, the report indicates that the quality of signal transmission is high during a number of time interval, wherein each time interval is identified by a time when a time interval starts and a length of time of the time interval. In some examples, the second network node includes a base station (BS), and wherein the communication node includes a user equipment (UE).

In a first aspect, the present disclosure provides a wireless communication method comprising: receiving, by a first network node from a second network node, a configuration information that indicates information about a number of spatial settings configured for the first network node, wherein each of the number of spatial settings corresponds to a spatial domain filter used by the first network node to communicate with one or more communication nodes.

In some examples, the first network node transmits a maximum number of spatial settings supported by the first network node to the second network node prior to the receiving the configuration information. In some examples, the configuration information includes a bitmap indicating the number of spatial settings to be used by the first network node to communicate with a communication node, and each bit in the bitmap indicates that a corresponding spatial setting is either enabled or disabled in communication with the communication node. In some examples, the number of spatial settings is configured by a base station (BS) or an operation, administration, and management (OAM) node. In some examples, the method further comprises performing, by the first network node, communication with the one or more communication nodes by using a spatial setting from the number of spatial settings according to the configuration information. In some examples, the performing the communication includes transmitting to a communication node information using the spatial setting, and the information is received by the first network node from the second

network node prior to the transmitting. In some examples, the performing the communication includes receiving from a communication node information using the spatial setting, and the first network node sends to the second network node the information received from the communication node.

In a second aspect, the present disclosure provides a wireless communication method comprising: receiving, by a communication node from a second network node, a configuration information that includes: a bitmap corresponding to one or more reference signals, a number of spatial settings that are configured for a first network node, and a number of forwarding gaps associated with one or more reference signal.

In some examples, the bitmap includes one or more bits, wherein each bit corresponds to one reference signal, and wherein each bit indicates to the communication node whether a reference signal is to be received by the communication node from the second network node via the first network node. In some examples, the configuration information indicates the number of spatial settings associated with each of the one or more reference signals that are to be received by the communication node from the second network node via the first network node. In some examples, the configuration information indicates a forwarding gap when a first network node does not send to the communication node information from the second network node, the forwarding gap indicates a length of time when the communication node receives the one or more reference signals from the second network node and does not receive the one or more reference signals from the first network node, and the method comprises receiving, by the communication node, the one or more reference signals from the second network node during the forwarding gap and the one or more reference signals from the first network node during a time other than the forwarding gap.

In some examples, the configuration information includes a value for the forwarding gap associated with each of the one or more reference signals that are not to be received by the communication node from the second network node during the forwarding gap. In some examples, the configuration information is received in a system information (SI). In some examples, the method further comprises receiving, by the communication node, information from the first network node using a spatial setting from the number of spatial settings, wherein the information is received by the communication node from the second

network node via the first network node. In some examples, the one or more reference signals includes one or more synchronization signal blocks (SSBs).

In a third aspect, the present disclosure provides a wireless communication method comprising: receiving, by a first network node from a second network node, an indication information that includes any one or more of the following: (1) an ordered sequence of a plurality of spatial settings to be used by the first network node, and a plurality of time lengths corresponding to the plurality of spatial settings, wherein each time length is associated with one spatial settings, (2) a valid time interval that indicates a time length when the first network node performs transmissions using the ordered sequence of the plurality of spatial settings and the plurality of time lengths; and performing, by the first network node, the transmissions using the plurality of spatial settings according to the indication information, wherein the first network node repeats the transmissions using the plurality of spatial settings in the time length in response to receiving the valid time interval.

In a fourth aspect, the present disclosure provides a wireless communication method comprising: receiving, by a first network node from a second network node, an indication information that includes: (1) a spatial setting sweeping period that indicates a length of time when the first network node is to perform a transmission using spatial setting sweeping, wherein the spatial setting sweeping period indicates a length of time when the first network node performs transmissions using a plurality of controllable reflecting elements, and (2) a report that indicates a quality of signal transmission performed by the first network node over the spatial setting sweeping period; and performing, by the first network node, the transmission using the plurality of controllable reflecting elements according to the report.

In some examples, the spatial setting sweeping period is configured by a base station (BS) or an operation, administration, and management (OAM) node. In some examples, the report indicates the quality of signal transmission for each of a plurality of time units within the spatial setting sweeping period. In some examples, the report indicates that the quality of signal transmission is high during a number of time interval, wherein each time interval is identified by a first time when a time interval starts and a second time when the time interval ends. In some examples, the report indicates that the quality of signal transmission is high during a number of time interval, wherein each time interval is identified by a time when a time interval starts and a length of time of the time interval. In some examples,

the second network node includes a base station (BS), and wherein the communication node includes a user equipment (UE).

In yet another exemplary example, the above-described methods are embodied in the form of processor-executable code and stored in a non-transitory computer-readable storage medium. The code included in the computer readable storage medium when executed by a processor, causes the processor to implement the methods described in this patent document.

In a fifth aspect, the present disclosure provides an apparatus for wireless communication comprising a processor configured to implement a method according to any one of the first to fourth aspects.

The above and other aspects and their implementations are described in greater detail in the drawings, the descriptions, and the claims.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1A and 1B show examples of use cases for a smart node.

FIGS. 2A and 2B show example configurations of the smart node's beams.

FIG. 3 shows a base station (BS) indicating $N_{port}^{repeater}$ and the associated synchronization signal blocks (SSBs) to a user equipment (UE).

FIG. 4 shows an example scenario of a two-path propagation model.

FIG. 5 shows illustration of received reference signal receive power (RSRP) during a smart node's forwarding period.

FIG. 6 shows an exemplary block diagram of a hardware platform that may be a part of a network node, a smart node, or a user equipment.

FIG. 7 shows an example of wireless communication including a base station (BS) and user equipment (UE) based on some implementations of the disclosed technology.

FIGS. 8 to 18 show exemplary flowcharts for a wireless communication method.

DETAILED DESCRIPTION

With the development of the new radio (NR) access technologies (e.g., 5G), a broad range of use cases including enhanced mobile broadband, massive machine-type communications (MTC), critical MTC, etc., can be realized. To support at least these use cases, more stringent requirements such as ultra-high data rate, energy efficiency, global coverage and

connectivity, as well as extremely high reliability and low latency should be met. Higher frequency bands including millimeter wave (mmWave) and even terahertz have been used in NR

CLAIMS

What is claimed is:

1. A wireless communication method, comprising:
 - receiving, by a first network node from a second network node, a configuration information that indicates information about a number of spatial settings configured for the first network node,
 - wherein each of the number of spatial settings corresponds to a spatial domain filter used by the first network node to communicate with one or more communication nodes.
2. The method of claim 1, wherein the first network node transmits a maximum number of spatial settings supported by the first network node to the second network node prior to the receiving the configuration information.
3. The method of claim 1,
 - wherein the configuration information includes a bitmap indicating the number of spatial settings to be used by the first network node to communicate with a communication node, and
 - wherein each bit in the bitmap indicates that a corresponding spatial setting is either enabled or disabled in communication with the communication node.
4. The method of claim 1, wherein the number of spatial settings is configured by a base station (BS) or an operation, administration, and management (OAM) node.
5. The method of claim 1, further comprising:
 - performing, by the first network node, communication with the one or more communication nodes by using a spatial setting from the number of spatial settings according to the configuration information, wherein the performing the communication includes transmitting to a communication node information using the spatial setting or receiving from the communication node information using the spatial setting.

6. A wireless communication method, comprising:
 - receiving, by a communication node from a second network node, a configuration information that includes:
 - a bitmap corresponding to one or more reference signals,
 - a number of spatial settings that are configured for a first network node,
 - and
 - a number of forwarding gaps associated with one or more reference signal.
7. The method of claim 6, wherein the bitmap includes one or more bits, wherein each bit corresponds to one reference signal, and wherein each bit indicates to the communication node whether a reference signal is to be received by the communication node from the second network node via the first network node.
8. The method of claim 6, wherein the configuration information indicates the number of spatial settings associated with each of the one or more reference signals that are to be received by the communication node from the second network node via the first network node.
9. The method of claim 6,
 - wherein the configuration information indicates a forwarding gap when a first network node does not send to the communication node information from the second network node,
 - wherein the forwarding gap indicates a length of time when the communication node receives the one or more reference signals from the second network node and does not receive the one or more reference signals from the first network node, and
 - wherein the method comprises receiving, by the communication node, the one or more reference signals from the second network node during the forwarding gap and the one or more reference signals from the first network node during a time other than the forwarding gap.

10. The method of claim 6, wherein the configuration information includes a value for the forwarding gap associated with each of the one or more reference signals that are not to be received by the communication node from the second network node during the forwarding gap, or wherein the configuration information is received in a system information (SI).
11. The method of claim 6, further comprising:
 - receiving, by the communication node, information from the first network node using a spatial setting from the number of spatial settings, wherein the information is received by the communication node from the second network node via the first network node.
12. The method of any of claims 6 to 11, wherein the one or more reference signals includes one or more synchronization signal blocks (SSBs).
13. A wireless communication method, comprising:
 - receiving, by a first network node from a second network node, an indication information that includes any one or more of the following:
 - (1) an ordered sequence of a plurality of spatial settings to be used by the first network node, and a plurality of time lengths corresponding to the plurality of spatial settings, wherein each time length is associated with one spatial settings,
 - (2) a valid time interval that indicates a time length when the first network node performs transmissions using the ordered sequence of the plurality of spatial settings and the plurality of time lengths; and
 - performing, by the first network node, the transmissions using the plurality of spatial settings according to the indication information,
 - wherein the first network node repeats the transmissions using the plurality of spatial settings in the time length in response to receiving the valid time interval.

14. A wireless communication method, comprising:
- receiving, by a first network node from a second network node, an indication information that includes:
 - (1) a spatial setting sweeping period that indicates a length of time when the first network node is to perform a transmission using spatial setting sweeping, wherein the spatial setting sweeping period indicates a length of time when the first network node performs transmissions using a plurality of controllable reflecting elements, and
 - (2) a report that indicates a quality of signal transmission performed by the first network node over the spatial setting sweeping period; and
 - performing, by the first network node, the transmission using the plurality of controllable reflecting elements according to the report.
15. An apparatus for wireless communication comprising a processor, configured to implement a method recited in one or more of claims 1 to 14.