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(54) **MAINTAINING COMMUNICATION SESSION INFORMATION**

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(52) **U.S. Cl.**
CPC ***H04W 36/0016*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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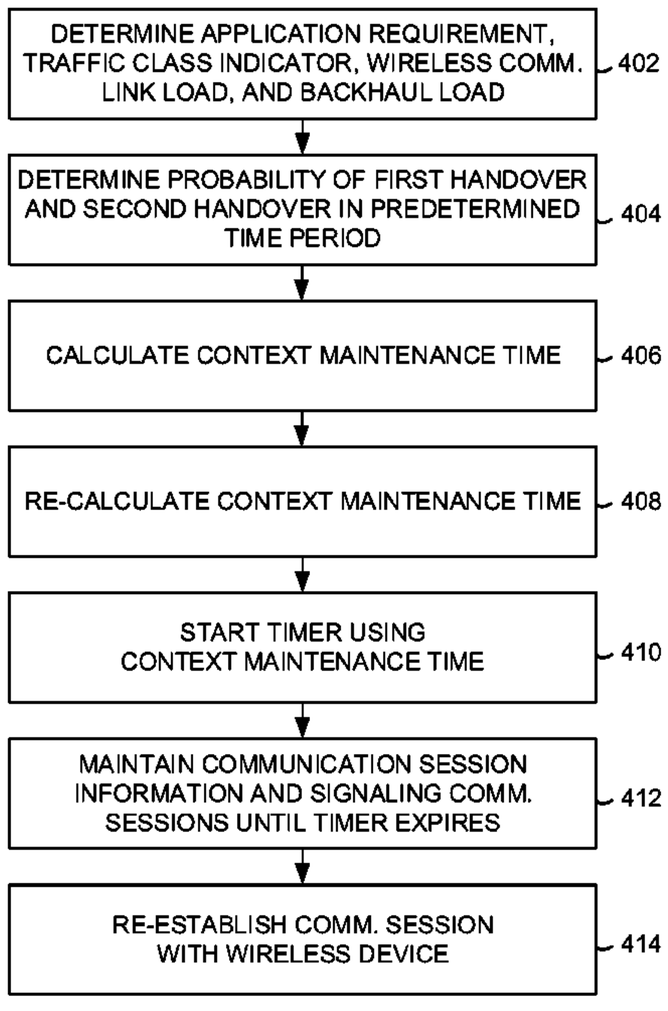
Primary Examiner — Gregory Sefcheck

(57) **ABSTRACT**

An application requirement of an application running on a wireless device in communication with a first access node, a traffic class indicator associated with the wireless device, and a wireless communication link load between the wireless device and the first access node are determined. A probability of performing a first handover of the wireless device to a second access node and a second handover of the wireless device from the second access node to the first access node within a predetermined period of time is also determined. Based on the application requirement, the traffic class indicator, the wireless communication link load, and the determined probability, a context maintenance time is calculated, and a timer is started using the context maintenance time when the first handover is performed, and communication session information related to the communication between the wireless device and the first access node is maintained until the timer expires.

14 Claims, 5 Drawing Sheets



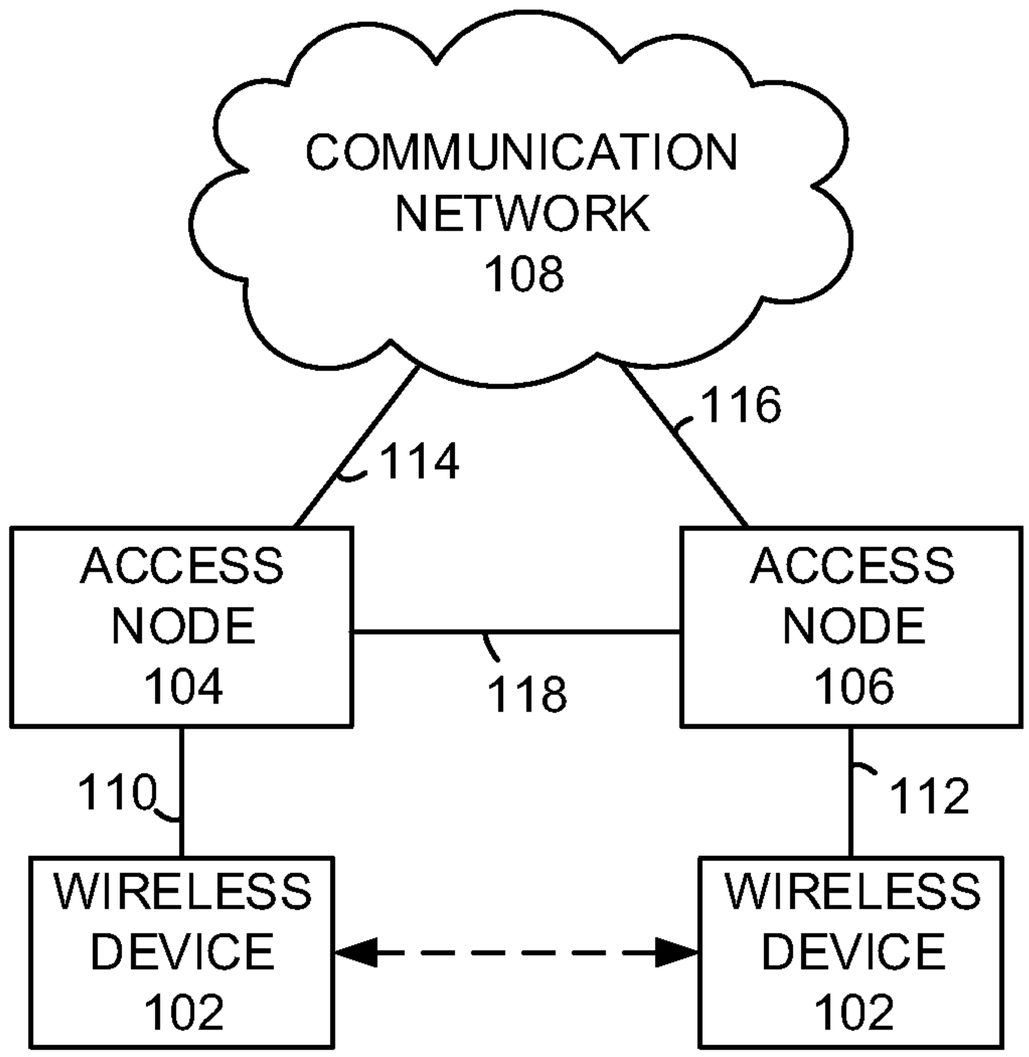

COMMUNICATION
NETWORK
108
114
116
ACCESS
NODE
104
ACCESS
NODE
106
118
110
112
WIRELESS
DEVICE
102
WIRELESS
DEVICE
102
100

FIG. 1

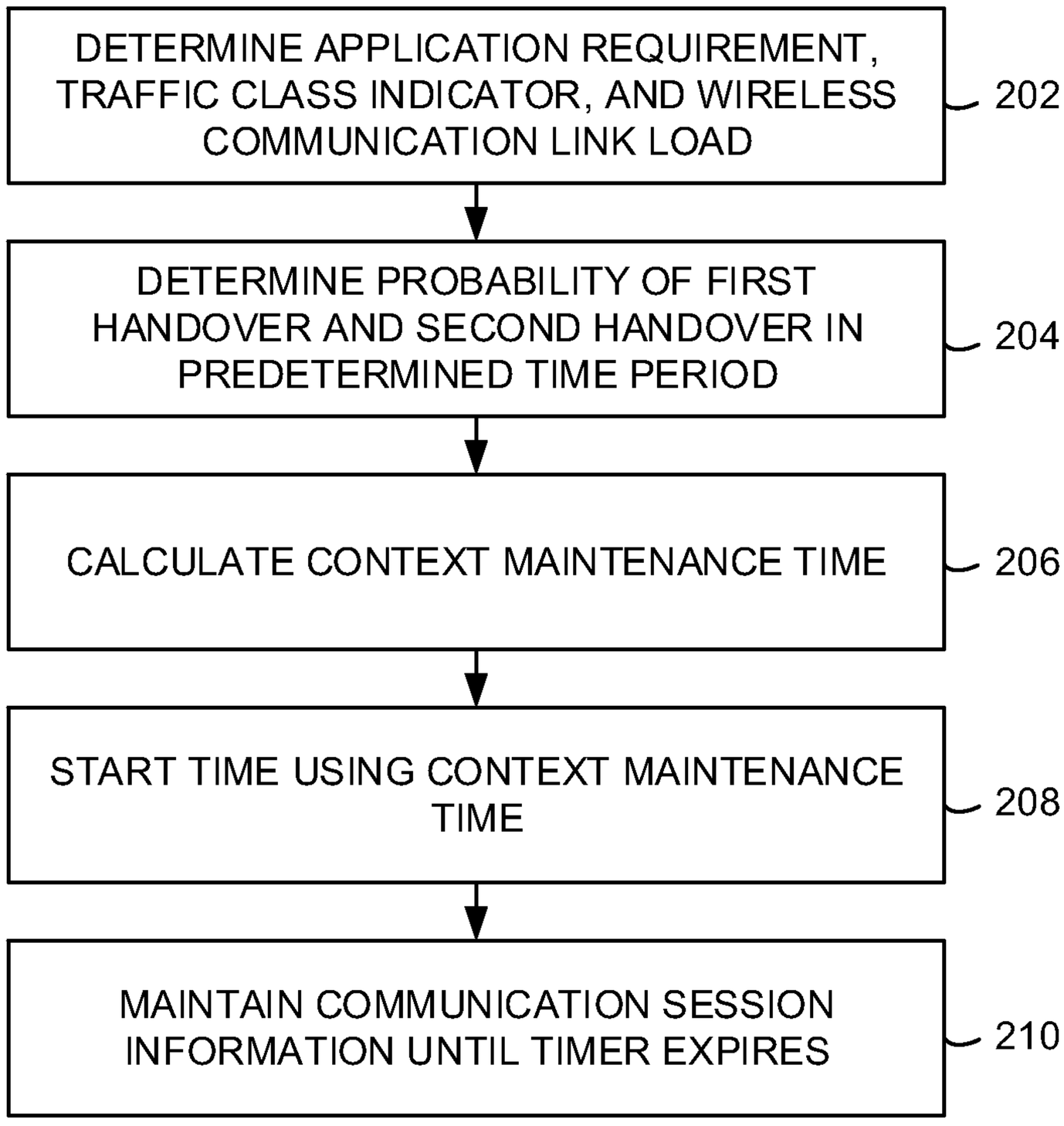

DETERMINE APPLICATION REQUIREMENT, TRAFFIC CLASS INDICATOR, AND WIRELESS COMMUNICATION LINK LOAD
202
DETERMINE PROBABILITY OF FIRST HANDOVER AND SECOND HANDOVER IN PREDETERMINED TIME PERIOD
204
CALCULATE CONTEXT MAINTENANCE TIME
206
START TIME USING CONTEXT MAINTENANCE TIME
208
MAINTAIN COMMUNICATION SESSION INFORMATION UNTIL TIMER EXPIRES
210

FIG. 2

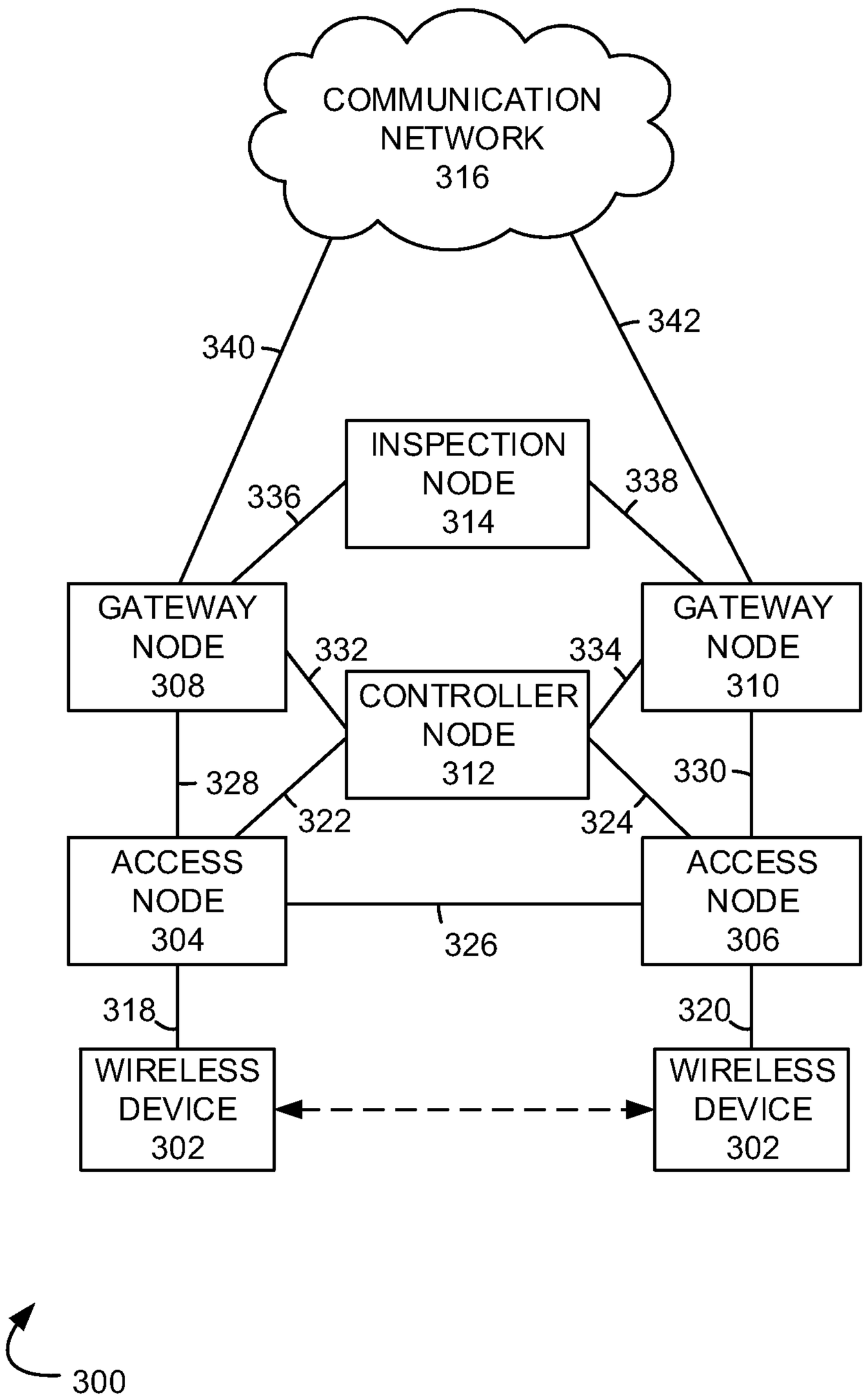

COMMUNICATION NETWORK 316
340
342
INSPECTION NODE 314
336
338
GATEWAY NODE 308
GATEWAY NODE 310
332
334
CONTROLLER NODE 312
328
330
322
324
ACCESS NODE 304
ACCESS NODE 306
326
318
320
WIRELESS DEVICE 302
WIRELESS DEVICE 302
300

FIG. 3

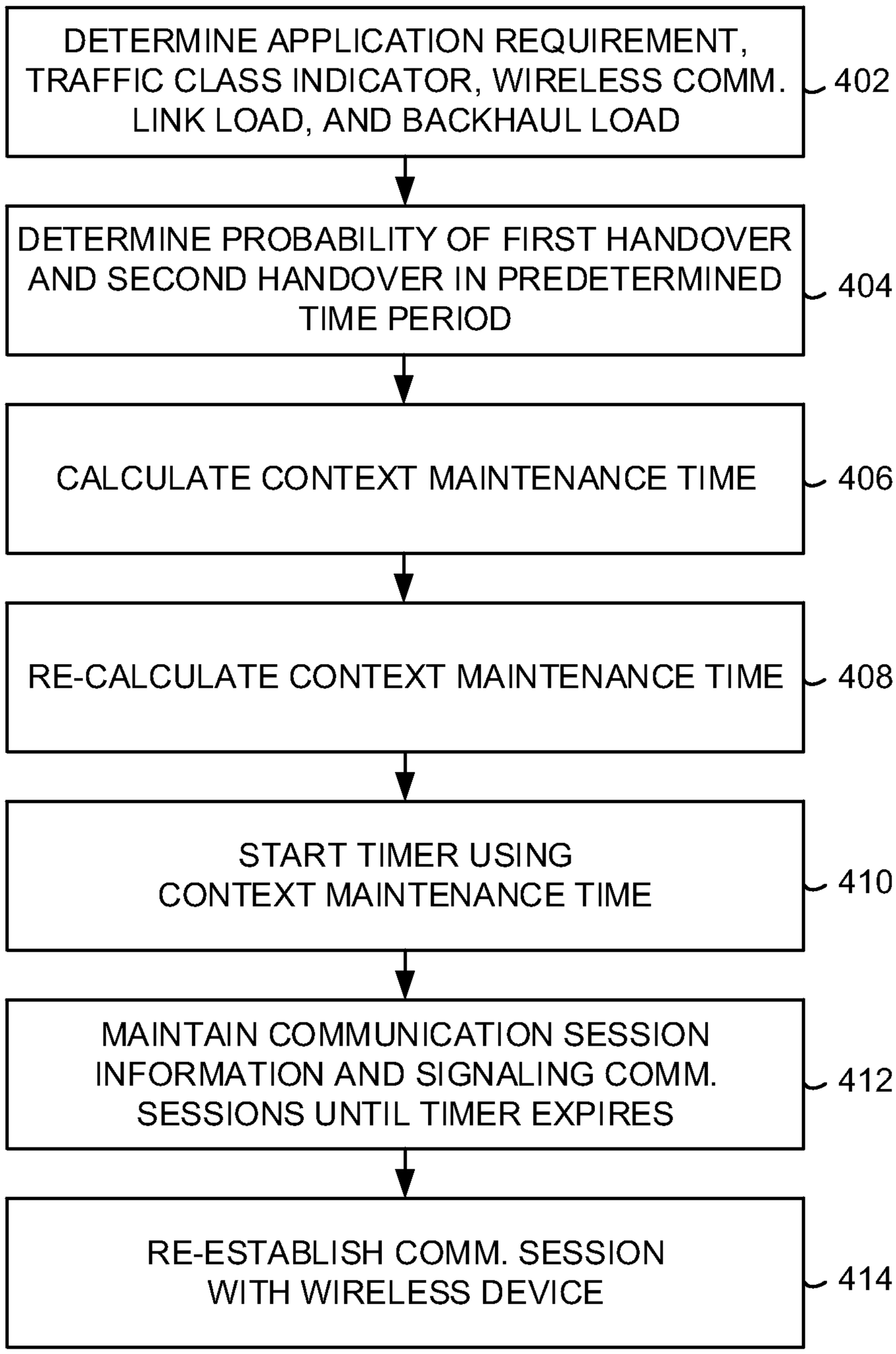

DETERMINE APPLICATION REQUIREMENT, TRAFFIC CLASS INDICATOR, WIRELESS COMM. LINK LOAD, AND BACKHAUL LOAD
402
DETERMINE PROBABILITY OF FIRST HANDOVER AND SECOND HANDOVER IN PREDETERMINED TIME PERIOD
404
CALCULATE CONTEXT MAINTENANCE TIME
406
RE-CALCULATE CONTEXT MAINTENANCE TIME
408
START TIMER USING CONTEXT MAINTENANCE TIME
410
MAINTAIN COMMUNICATION SESSION INFORMATION AND SIGNALING COMM. SESSIONS UNTIL TIMER EXPIRES
412
RE-ESTABLISH COMM. SESSION WITH WIRELESS DEVICE
414

FIG. 4

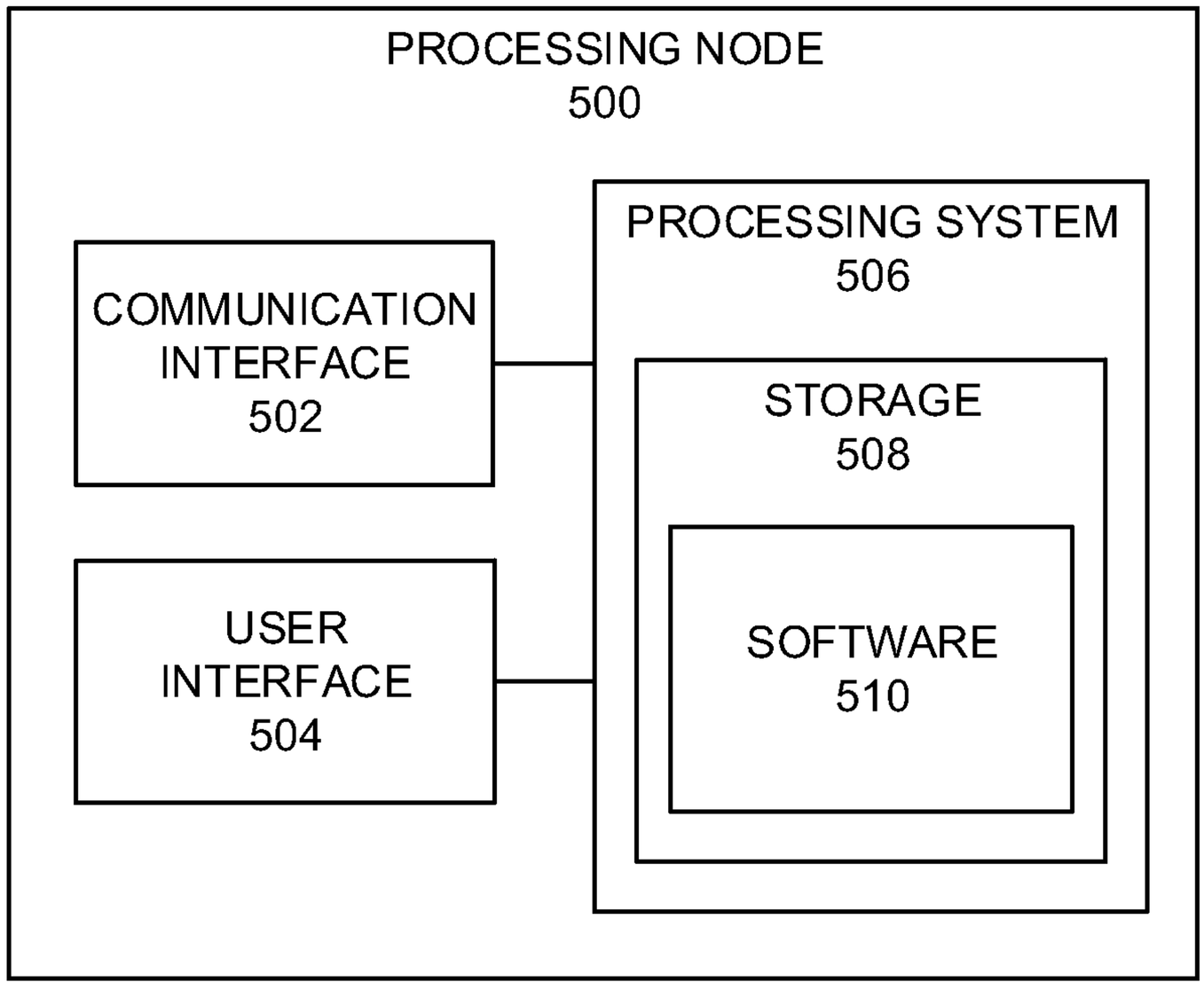

PROCESSING NODE
500
PROCESSING SYSTEM
506
COMMUNICATION INTERFACE
502
STORAGE
508
SOFTWARE
510
USER INTERFACE
504

FIG. 5

MAINTAINING COMMUNICATION SESSION INFORMATION

TECHNICAL BACKGROUND

The ability to perform a handover of a wireless device from one access node to another is a fundamental function of a wireless communication system. To maintain current data sessions and current voice sessions of the wireless device, communication session information for the wireless device is typically maintained in the communication network when a handover is performed. When the communication session information is not retained it will need to be redetermined, which can cause delay in the establishment of communication for the wireless device. Delay can also be caused by the release of signaling communication session information among network elements when a handover is performed, or when a wireless device leaves a coverage area of an access node and returns to the access node within a short period of time.

OVERVIEW

In operation, an application requirement is determined of an application running on a wireless device in communication with a first access node. A traffic class indicator associated with the wireless device is also determined. Further, a wireless communication link load of a communication link between the wireless device and the first access node is determined. A probability of performing a first handover of the wireless device to a second access node and a second handover of the wireless device from the second access node to the first access node within a predetermined period of time is also determined. Based on the application requirement, the traffic class indicator, the wireless communication link load, and the determined probability, a context maintenance time is calculated, and a timer is started using the context maintenance time when the first handover is performed. Communication session information related to the communication between the wireless device and the first access node is maintained until the timer expires. If the wireless device re-establishes communication with the first access node before the timer expires, the communication session information can be maintained until the re-established communication ends.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an exemplary communication system to maintain communication session information.

FIG. **2** illustrates an exemplary method of maintaining communication session information.

FIG. **3** illustrates another exemplary communication system to maintain communication session information.

FIG. **4** illustrates another exemplary method of maintaining communication session information.

FIG. **5** illustrates an exemplary processing node.

DETAILED DESCRIPTION

FIG. **1** illustrates an exemplary communication system **100** to maintain communication session information comprising wireless device **102**, access node **104**, access node **106**, and communication network **108**. Examples of wireless device **102** can comprise a cell phone, a smart phone, a computing platform such as a laptop, palmtop, or tablet, a personal digital assistant, or an internet access device, including combinations thereof. Wireless device **102** can communicate with access node **104** over communication link **110** and with access node **106** over communication link **106**.

Access nodes **104** and **106** are each a network node capable of providing wireless communications to wireless device **102**, and can be, for example, a base transceiver station, a radio base station, an eNodeB device, or an enhanced eNodeB device. Access node **104** is in communication with communication network **106** over communication link **114**, and access node **106** is in communication with communication network **108** over communication link **116**. Access nodes **104** and **106** can also communicate with each other over communication link **118**. In an embodiment, access node **104** can be associated with a first radio access technology and access node **106** can be associated with a second radio access technology.

Communication network **108** can be a wired and/or wireless communication network, and can comprise processing nodes, routers, gateways, and physical and/or wireless data links for carrying data among various network elements, including combinations thereof, and can include a local area network, a wide area network, and an internetwork (including the Internet). Communication network **108** can be capable of carrying voice information and other data, for example, to support communications by a wireless device such as wireless device **102**. Wireless network protocols may comprise code division multiple access (CDMA) 1xRTT, Global System for Mobile communications (GSM), Universal Mobile Telecommunications System (UMTS), High-Speed Packet Access (HSPA), Evolution Data Optimized (EV-DO), EV-DO rev. A, Worldwide Interoperability for Microwave Access (WiMAX), and Third Generation Partnership Project Long Term Evolution (3GPP LTE). Wired network protocols that may be utilized by communication network **108** comprise Ethernet, Fast Ethernet, Gigabit Ethernet, Local Talk (such as Carrier Sense Multiple Access with Collision Avoidance), Token Ring, Fiber Distributed Data Interface (FDDI), and Asynchronous Transfer Mode (ATM). Communication network **108** may also comprise a wireless network, including base stations, wireless communication nodes, telephony switches, internet routers, network gateways, computer systems, communication links, or some other type of communication equipment, and combinations thereof.

Communication links **110**, **112**, **114**, **116** and **118** can be wired or wireless communication links. Wired communication links can comprise, for example, twisted pair cable, coaxial cable or fiber optic cable, or combinations thereof. Wireless communication links can comprise a radio frequency, microwave, infrared, or other similar signal, and can use a suitable communication protocol, for example, Global System for Mobile telecommunications (GSM), Code Division Multiple Access (CDMA), Worldwide Interoperability for Microwave Access (WiMAX), or Long Term Evolution (LTE), or combinations thereof. Other wireless protocols can also be used.

Other network elements may be present in communication system **100** to facilitate wireless communication but are omitted for clarity, such as base stations, base station controllers, gateways, mobile switching centers, dispatch application processors, and location registers such as a home location register or visitor location register. Furthermore, other network elements may be present to facilitate communication between access node **104**, access node **106** and communication network **108** which are omitted for clarity, including additional processing nodes, routers, gateways, and physical and/or wireless data links for carrying data among the various network elements.

When a wireless device is handed over from a first access node to a second access node, where both access nodes are associated with the same radio access technology, to maintain current data sessions and current voice sessions of the wireless device communication session information for the wireless device is typically maintained in the communication network. Communication session information can comprise context information and other information used by the communication network to enable control signaling and bearer data transfer for a communication session with a wireless device. However, when a wireless device changes from communicating with an access node using one radio access technology to communicating with another access node using a second radio access technology, some or all of the communication session information may not be retained. When the communication session information is not retained it will need to be redetermined, which can cause delay in the establishment of communication through the second access node. In addition, network connections among network elements require to support the communication session may also be released or lost, causing further delay in the establishment of communication through the second access node. Further, delay can also be caused by the release of communication session information and/or network element connections when a wireless device is handed over from the first access node to the second access node, and is then handed over back to the first access node within a predetermined period of time (such as so-called ping-ponging between access nodes). In such case, the release of communication session information related to the first access node can cause delay in the reestablishment of communication between the wireless device and the first access node.

In operation, for wireless device **102** in communication with first access node **104**, an application requirement is determined of an application running on wireless device **102**, and a traffic class indicator associated with wireless device **102** is also determined. In addition, a wireless communication link load of communication link **110** is determined. A probability of performing a first handover of wireless device **102** to second access node **106** and a second handover of wireless device **102** from second access node **106** to first access node **104** within a predetermined period of time is also determined. Based on the application requirement, the traffic class indicator, the wireless communication link load, and the determined probability, a context maintenance time is calculated, and a timer is started using the context maintenance time when the first handover is performed. The timer can be started at access node **104**, or at another network element of communication system **100**, such as a controller node, a gateway node, and the like. Communication session information related to the communication between the wireless device and the first access node is maintained until the timer expires. If the wireless device re-establishes communication with the first access node before the timer expires, the communication session information can be maintained until the re-established communication ends.

FIG. **2** illustrates an exemplary method of maintaining communication session information. In operation **202**, an application requirement is determined of an application running on a wireless device in communication with a first access node, and a traffic class indicator associated with the wireless device is also determined. In addition, a wireless communication link load is determined of a wireless communication link between the wireless device and the first access node. For example, an application requirement of an application running on wireless device **102** and a traffic class indicator associated with wireless device **102** can be determined. In addition, a wireless communication link load of communication link **110** can be determined.

The application requirement can comprise, for example, a minimum data rate, a minimum throughput, a maximum permitted data error rate, a maximum permitted packet loss rate, and the like, required by the application to provide a minimum level of performance. The traffic class indicator can comprise a threshold level of priority associated with bearer data being sent from a wireless device, such as a quality of service class indicator (QCI) or similar traffic class indicator. The wireless communication link load can comprise a level of wireless resource utilization, such as a utilization of physical resource blocks or other units of resource allocation, a level of demand for communication link resources, a level of requested wireless communication link resources (such as by a buffer status report or other request for communication link resources), a number of wireless devices in active communication with the first access node, and the like.

Next, the probability of performing a first handover of the wireless device to a second access node and a second handover of the wireless device from the second access node to the first access node within a predetermined period of time is determined (operation **204**). Performing handovers of a wireless device between two access nodes within a relatively short period of time (so-called ping ponging) can be triggered, for example, when signal levels received by wireless device **102** from access nodes **104** and **106** vary over time. Signal levels can comprise a signal strength (such as a received signal strength indicator (RSSI), a reference signal received power (RSRP), and the like), a signal quality (such as a received signal quality indicator (RSQI), a reference signal received quality (RSRQ), and so forth) and similar signal levels or signal level indicators Signal level variation can be caused by wireless device mobility, radio frequency interference, physical interference with the signal levels (such as by a physical obstruction, topographical feature, etc.) and the like. Signal levels can be monitored, and based on signal variation over time a probability of performing repeated handovers between access nodes can be determined. Access node mobility, such as direction of mobility, speed of mobility, and so forth, can also be used to determine the probability.

Additionally, or alternatively, the first access node can have a higher priority or handover preference than the second access node, which priority can also be used to determine the probability of ping ponging. For example, the first access node can use a first radio access technology which is given a higher priority than a second radio access technology used by the second access node. An example of such a case can be where the first radio access technology comprises LTE, WiMAX, or another 4G radio access technology, and the second radio access technology comprises CDMA or another 3G radio access technology, wherein the communication system places a priority on 4G radio access technology over 3G radio access technology. The priority can be imposed on an access node-level basis, or in a designated region, group of access nodes, tracking area, and so forth.

Based on the application requirement, the traffic class indicator, the wireless communication link load, and the determined probability, a context maintenance time is calculated (operation **206**) Determining the context maintenance time according to the application requirement, the traffic class indicator, the wireless communication link load, and the determined probability enables the determination of a context maintenance time which is provides a quality of experience appropriate to the needs of the wireless device and the state of

communication system **100**, while avoiding the over-commitment of resources and/or network communication sessions to wireless device **102**.

When the first handover is performed, a timer is started using the context maintenance time (operation **208**). The timer can be started at access node **104** or at another element of communication system **100**. Communication session information related to the communication between the wireless device and the first access node is maintained until the timer expires (operation **210**). If the wireless device re-establishes communication with the first access node before the timer expires, the communication session information can be maintained until the re-established communication ends. By maintaining the communication session information until the timer expires, a delay in communication with wireless device **102** can be reduced when the wireless device is handed over between access nodes **104** and **106**.

FIG. **3** illustrates another exemplary communication system **300** to maintain communication session information comprising wireless device **302**, access node **304**, access node **306**, gateway node **308**, gateway node **310**, controller node **312**, inspection node **314**, and communication network **316**. Examples of wireless device **302** can comprise a cell phone, a smart phone, a computing platform such as a laptop, palmtop, or tablet, a personal digital assistant, or an internet access device, including combinations thereof. Wireless device **302** can communicate with access node **304** over communication link **318** and with access node **306** over communication link **320**.

Access nodes **304** and **306** are each a network node capable of providing wireless communications to wireless device **302**, and can be, for example, a base transceiver station, a radio base station, an eNodeB device, or an enhanced eNodeB device. Access node **304** is in communication with gateway node **308** over communication link **328**, and with controller node **312** over communication link **322**. Access node **306** is in communication with gateway node **310** over communication link **330**, and with controller node **312** over communication link **324**. Access nodes **304** and **306** can also communicate with each other over communication link **326**. In an embodiment, access node **304** can be associated with a first radio access technology and access node **306** can be associated with a second radio access technology. In an embodiment, access node **304** and gateway node **308** can be associated with a first communication network, and access node **306** and gateway node **310** can be associated with a second network. While communication links **324** and **334** are illustrated between access node **306**, controller node **312**, and gateway node **310**, in an embodiment access node **306** and gateway node **310** may be in communication with a separate controller node (not illustrated).

Gateway nodes **308** and **310** can each comprise a processor and associated circuitry to execute or direct the execution of computer-readable instructions, and can be configured to maintain network connection information associated with wireless device **302**. Gateway nodes **308** and **310** can retrieve and execute software from storage, which can include a disk drive, flash drive, memory circuitry, or some other memory device, and which can be local or remotely accessible. The software comprises computer programs, firmware, or some other form of machine-readable instructions, and may include an operating system, utilities, drivers, network interfaces, applications, or some other type of software, including combinations thereof. Gateway nodes **308** and **310** can receive instructions and other input at a user interface. Examples of gateway nodes **308** and **310** can include a standalone computing device, a computer system, or a network component, such as an access service network gateway (ASN-GW), a packet data network gateway (P-GW), a serving gateway (S-GW), a mobile switching controller (MSC), a packet data serving node (PDSN), call processing equipment, a home agent, a radio node controller (RNC), a subscriber profile system (SPS), and an authentication, authorization, and accounting (AAA) equipment, including combinations thereof. Gateway node **308** is in communication with inspection node **314** over communication link **336**, and with communication network **316** over communication link **316**. Gateway node **310** is in communication with inspection node **314** over communication link **338**, and with communication network **316** over communication link **342**.

Controller node **312** can comprise can comprise a processor and associated circuitry to execute or direct the execution of computer-readable instructions, and can be configured to maintain network connection information associated with wireless device **302**. Controller node **312** can control the setup and maintenance of a communication session over communication network **316** by wireless device **302**. Controller node **312** can comprise a mobile switching center (MSC), a dispatch call controller (DCC), a mobility management entity (MME), or other similar network node. Controller node **312** can retrieve and execute software from storage, which can include a disk drive, flash drive, memory circuitry, or some other memory device, and which can be local or remotely accessible. The software comprises computer programs, firmware, or some other form of machine-readable instructions, and may include an operating system, utilities, drivers, network interfaces, applications, or some other type of software, including combinations thereof. Controller node **312** can receive instructions and other input at a user interface.

Inspection node **314** is a network element which can comprise a processor and associated circuitry to execute or direct the execution of computer-readable instructions. Inspection node **314** can retrieve and execute software from storage, which can include a disk drive, flash drive, memory circuitry, or some other memory device, and which can be local or remotely accessible. The software comprises computer programs, firmware, or some other form of machine-readable instructions, and may include an operating system, utilities, drivers, network interfaces, applications, or some other type of software, including combinations thereof. Inspection node **314** can, among other things, perform deep packet inspection of packets sent from and/or to wireless device **302**. Deep packet inspection generally involves an inspection of packets beyond Open Systems Interconnection (OSI) layer 2 including an inspection of the data portion (also referred to as the payload portion) of a packet (and possibly also the header of a packet). That is deep packet inspection can involve an examination of any of layers 2 through 7 of the OSI model. The data portion of a packet remains distinct from a header portion, even where the packet receives additional header information (such as by packet encapsulation or a similar process). In other words, when a packet is encapsulated, any additional header information does not combine information from the data portion with any header portion. Inspection node **314** can be for example, a standalone computing device or network element, or the functionality of mode inspection node **314** can be included in another network element, such as a mobility management entity (MME), a gateway node, a proxy node, or another network element.

Communication network **316** can be a wired and/or wireless communication network, and can comprise processing nodes, routers, gateways, and physical and/or wireless data links for carrying data among various network elements, including combinations thereof, and can include a local area

network, a wide area network, and an internetwork (including the Internet). Communication network **316** can be capable of carrying voice information and other data, for example, to support communications by a wireless device such as wireless device **302**. Wireless network protocols may comprise code division multiple access (CDMA) 1xRTT, Global System for Mobile communications (GSM), Universal Mobile Telecommunications System (UMTS), High-Speed Packet Access (HSPA), Evolution Data Optimized (EV-DO), EV-DO rev. A, Worldwide Interoperability for Microwave Access (WiMAX), and Third Generation Partnership Project Long Term Evolution (3GPP LTE). Wired network protocols that may be utilized by communication network **108** comprise Ethernet, Fast Ethernet, Gigabit Ethernet, Local Talk (such as Carrier Sense Multiple Access with Collision Avoidance), Token Ring, Fiber Distributed Data Interface (FDDI), and Asynchronous Transfer Mode (ATM). Communication network **108** may also comprise a wireless network, including base stations, wireless communication nodes, telephony switches, internet routers, network gateways, computer systems, communication links, or some other type of communication equipment, and combinations thereof.

Communication links **318**, **320**, **322**, **324**, **326**, **328**, **330**, **332**, **334**, **336**, **338**, **340** and **342** can be wired or wireless communication links. Wired communication links can comprise, for example, twisted pair cable, coaxial cable or fiber optic cable, or combinations thereof. Wireless communication links can comprise a radio frequency, microwave, infrared, or other similar signal, and can use a suitable communication protocol, for example, Global System for Mobile telecommunications (GSM), Code Division Multiple Access (CDMA), Worldwide Interoperability for Microwave Access (WiMAX), or Long Term Evolution (LTE), or combinations thereof. Other wireless protocols can also be used.

Other network elements may be present in communication system **300** to facilitate wireless communication but are omitted for clarity, such as base stations, base station controllers, gateways, mobile switching centers, dispatch application processors, and location registers such as a home location register or visitor location register. Furthermore, other network elements may be present to facilitate communication between access nodes **304** and **306**, gateway nodes **308** and **310**, controller node **312**, inspection node **314**, and communication network **316** which are omitted for clarity, including additional processing nodes, routers, gateways, and physical and/or wireless data links for carrying data among the various network elements.

FIG. **4** illustrates another exemplary method of maintaining communication session information. In operation **402**, an application requirement is determined of an application running on a wireless device in communication with a first access node, and a traffic class indicator associated with the wireless device is also determined. In addition, a wireless communication link load of a wireless communication link between the wireless device and the first access node, and a backhaul load of the first access node, can be determined.

For example, an application requirement of an application running on wireless device **302** and a traffic class indicator associated with wireless device **302** can be determined. The application requirement can comprise, for example, a minimum data rate, a minimum throughput, a maximum permitted data error rate, a maximum permitted packet loss rate, and the like, required by the application to provide a minimum level of performance. The traffic class indicator can comprise a threshold level of priority associated with bearer data being sent from a wireless device, such as a quality of service class indicator (QCI) or similar traffic class indicator. The application requirement and/or the traffic class indicator can be determined by access node **304**, or by inspection node **314** which can perform deep packet inspection of data traffic from wireless device **302**, or by another network element of communication system **300**.

The wireless communication link load can comprise a level of wireless resource utilization, such as a utilization of physical resource blocks or other units of resource allocation, a level of demand for communication link resources, a level of requested wireless communication link resources (such as by a buffer status report or other request for communication link resources), a number of wireless devices in active communication with the first access node, and the like. The backhaul load of access node **304** can comprise a level of resource utilization of communication link **328**, such as an amount of bandwidth used for bearer and/or control data.

In operation **404**, the probability of performing a first handover of the wireless device to a second access node and a second handover of the wireless device from the second access node to the first access node within a predetermined period of time is determined. Performing handovers of a wireless device between two access nodes within a relatively short period of time can be triggered, for example, when signal levels received by wireless device **302** from access nodes **304** and **306** vary over time, which can be caused by wireless device mobility, radio frequency interference, physical interference with the signal levels (such as by a physical obstruction, topographical feature, etc.) and the like. Signal levels can be monitored, and based on signal variation over time a probability of performing repeated handovers between access nodes can be determined. Access node mobility, such as direction of mobility, speed of mobility, and so forth, can also be used to determine the probability.

Additionally, or alternatively, the first access node can have a higher priority or handover preference than the second access node, which priority can also be used to determine the probability of ping ponging. For example, the first access node can use a first radio access technology which is given a higher priority than a second radio access technology used by the second access node. An example of such a case can be where the first radio access technology comprises LTE, WiMAX, or another 4G radio access technology, and the second radio access technology comprises CDMA or another 3G radio access technology, wherein the communication system places a priority on 4G radio access technology over 3G radio access technology. The priority can be imposed on an access node-level basis, or in a designated region, group of access nodes, tracking area, and the like.

Additionally, or alternatively, a number of re-connection requests during a period of time can be monitored, and the number can be used to determine the probability. For example, a number of re-connection requests received by access node **304** can be monitored, such as re-connection requests made by wireless device which are handed over to a second access node (such as access node **306**). Such a historical number of re-connection requests can be used, alone or together with other information, in the determination of the probability.

Based on the application requirement, the traffic class indicator, the wireless communication link load, and the determined probability, a context maintenance time is calculated (operation **406**). In an embodiment, a number of signaling communication sessions related to the wireless device is also determined and used in the determination of the context maintenance time. For example, when wireless device **302** is in active communication with access node **304**, in order to control and support the communication session, signaling com-

munication sessions can be established between access node **304** and controller node **312**, and between access node **304** and gateway node **308**. A signaling communication session can comprise a logical communication session established between network elements related to a communication session of a wireless device. One example of a signaling communication session is an S1 communication link. In an embodiment, a maximum time limit can be imposed on the context maintenance time. For example, a maximum signaling communication session time can be determined, and the context maintenance time can be required to be no greater than the maximum signaling communication session time. When the maximum signaling communication session time is reached, the signaling communication sessions can be release, to free up network communication resources among network elements.

When factors change over time, the context maintenance time is re-calculated (operation **408**). For example, the application requirement can change when the wireless device uses a different application, or when the application activity changes so as change its requirements. Thus, when the application requirement of the application running on the wireless device meets a first criteria the context maintenance time is increased, and when the application requirement meets a second criteria the context maintenance time is decreased. The first criteria can comprise an application with a relatively high minimum data rate requirement, a relatively low permitted data loss rate, a relatively low maximum permitted data error rate, and the like, such as a voice over Internet Protocol (VoIP) application, a streaming video application, a streaming audio application, and the like. The second criteria can comprise an application with a relatively low minimum data rate requirement, a relatively high permitted data loss rate, a relatively high maximum permitted data error rate, and the like, such as a web browsing application, an email application, a messaging application, and the like.

As another example, the traffic class indicator can change when the wireless device uses a different application, or when the application sends and receives different data. Thus, when the traffic class indicator meets a third criteria the context maintenance time is increased, and when the traffic class indicator meets a fourth criteria the context maintenance time is decreased. The third criteria can comprise a traffic class indicator associated with a relatively high routing priority, such as a guaranteed bit rate (GBR) priority and the like. The fourth criteria can comprise a traffic class indicator associated with a relatively low routing priority, such as a non-guaranteed bit rate (NGBR) and the like.

Similarly, the loading of wireless communication link (e.g., of communication link **318**) can change as resource demands change over time. In an embodiment, when the wireless communication link load meets a fifth criteria the context maintenance time is increased, and when the wireless communication link load meets a sixth criteria the context maintenance time is decreased. The fifth criteria can comprise a wireless communication link load which is greater than or equal to a threshold level of wireless communication link loading. The sixth criteria can comprise a wireless communication link load which is less than the threshold level of wireless communication link loading. The backhaul load of access node **304** (e.g., of communication link **328**) can also change over time, and can also be taken into consideration in determining (and re-determining) the context maintenance time.

Moreover, the probability of the wireless device experiencing repeated handovers between access nodes can also change over time. In an embodiment, when the probability of performing the first handover and the second handover within a predetermined period of time meets a seventh criteria the context maintenance time is increased, and when the probability of performing the first handover and the second handover within the predetermined period of time meets an eighth criteria meets an eighth criteria the context maintenance time is decreased. The seventh criteria can comprise a threshold probability which can be met when the probability of performing the first handover and the second handover within a predetermined period of time is greater than or equal to the threshold probability. The eighth criteria can be met when the probability of performing the first handover and the second handover within a predetermined period of time is less than the threshold probability. Thus, the context maintenance time can be re-calculated and updated when one or more conditions change.

When the first handover is performed, a timer is started using the context maintenance time (operation **410**). The timer can be started at access node **304**, or at gateway node **308**, or at controller node **312**, or at another element of communication system **300**. Communication session information and the signaling communication sessions related to the communication between the wireless device and the first access node are maintained until the timer expires (operation **412**). By maintaining the communication session information until the timer expires, a delay in communication with wireless device **302** can be reduced when the wireless device is handed over between access nodes **304** and **306**, and subsequently handed over back to access node **304**. The communication session information can be maintained by sending a message instructing that the communication session information is not to be deleted or released until the timer has expired. The communication session information can also be maintained by delaying (or blocking) the sending of an instruction to delete the communication session information. Other methods of maintaining the communication session information are possible, including combinations thereof. Similarly, the signaling communication sessions can be maintained by sending an instruction to maintain them until the timer expires, by blocking or delaying an instruction to release the signaling communication sessions, and the like, including combinations thereof.

When the second handover is performed, communication is re-established with the wireless device using the communication session information and the signaling communication sessions (operation **414**). For example, when wireless device **302** is handed over from access node **306** to access node **304**, and the context maintenance timer has not expired, the communication session information related to the communication session between wireless device **302** and access node **304** can be used to re-establish the communication session. Further, when the context maintenance timer has not expired, the signaling communication sessions have not been released, and so the signaling communication sessions (e.g., between access node **304** and controller node **312**, and between access node **304** and gateway node **308**) can also be used in the re-establishment of the communication session with wireless device **302**. Maintaining the communication session information and the signaling communication sessions can reduce delay in re-establishing communication with wireless device **302**.

FIG. **5** illustrates an exemplary processing node **500** in a communication system. Processing node **500** comprises communication interface **502**, user interface **504**, and processing system **506** in communication with communication interface **502** and user interface **504**. Processing node **500** can be configured to maintain communication session informa-

tion. Processing system **506** includes storage **508**, which can comprise a disk drive, flash drive, memory circuitry, or other memory device. Storage **508** can store software **510** which is used in the operation of the processing node **500**. Storage **508** may include a disk drive, flash drive, data storage circuitry, or some other memory apparatus. Software **510** may include computer programs, firmware, or some other form of machine-readable instructions, including an operating system, utilities, drivers, network interfaces, applications, or some other type of software. Processing system **506** may include a microprocessor and other circuitry to retrieve and execute software **510** from storage **508**. Processing node **500** may further include other components such as a power management unit, a control interface unit, etc., which are omitted for clarity. Communication interface **502** permits processing node **500** to communicate with other network elements. User interface **504** permits the configuration and control of the operation of processing node **500**.

Examples of processing node **500** include access nodes **104**, **106**, **304** and **306**, gateway nodes **308** and **310**, controller node **312**, and inspection node **314**. Processing node **500** can also be an adjunct or component of a network element, such as an element of the aforementioned network elements. Processing node **500** can also be another network element in a communication system. Further, the functionality of processing node **500** can be distributed among two or more network elements of a communication system.

The exemplary systems and methods described herein can be performed under the control of a processing system executing computer-readable codes embodied on a computer-readable recording medium or communication signals transmitted through a transitory medium. The computer-readable recording medium is any data storage device that can store data readable by a processing system, and includes both volatile and nonvolatile media, removable and non-removable media, and contemplates media readable by a database, a computer, and various other network devices.

Examples of the computer-readable recording medium include, but are not limited to, read-only memory (ROM), random-access memory (RAM), erasable electrically programmable ROM (EEPROM), flash memory or other memory technology, holographic media or other optical disc storage, magnetic storage including magnetic tape and magnetic disk, and solid state storage devices. The computer-readable recording medium can also be distributed over network-coupled computer systems so that the computer-readable code is stored and executed in a distributed fashion. The communication signals transmitted through a transitory medium may include, for example, modulated signals transmitted through wired or wireless transmission paths.

The above description and associated figures teach the best mode of the invention. The following claims specify the scope of the invention. Note that some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Those skilled in the art will appreciate that the features described above can be combined in various ways to form multiple variations of the invention, and that various modifications may be made to the configuration and methodology of the exemplary embodiments disclosed herein without departing from the scope of the present teachings. Those skilled in the art also will appreciate that various features disclosed with respect to one exemplary embodiment herein may be used in combination with other exemplary embodiments with appropriate modifications, even if such combinations are not explicitly disclosed herein. As a result, the invention is not limited to the specific embodiments described above, but only by the following claims and their equivalents.

What is claimed is:

1. A method of maintaining communication session information, comprising:

determining, at an inspection node, an application requirement of an application running on a wireless device, a traffic class indicator associated with the wireless device, and a wireless communication link load;

determining a probability for performing repeated handovers of the wireless device between a first access node using a first radio access technology and a second radio access technology based on a monitored number of reconnection requests made by the wireless device within a predetermined period of time;

determining a backhaul load of the first access node;

calculating a context maintenance time for the wireless device, wherein the context maintenance time is calculated based on the determined application requirement, traffic class indicator, wireless communication link load, backhaul load, and probability for performing repeated handovers;

starting a timer using the calculated context maintenance time when a first handover of the wireless device is performed; and

maintaining, at a network node, information related to a communication session between the wireless device and at least the first access node until the timer expires.

2. The method of claim **1**, further comprising:

maintaining a signaling communication session related to the wireless device between the first access node and a controller node until the timer expires.

3. The method of claim **1**, further comprising:

maintaining a signaling communication session related to the wireless device between the first access node and a gateway node until the timer expires.

4. The method of claim **1**, wherein the communication session with the wireless device is re-established using the maintained information when a second handover of the wireless device is performed before the timer expires.

5. The method of claim **1**, wherein the context maintenance time is less than a maximum signaling communication session time.

6. The method of claim **1**, wherein the context maintenance time is increased when the application requirement of the application running on the wireless device meets a first criteria, and decreased when the application requirement meets a second criteria.

7. The method of claim **1**, wherein when the traffic class indicator is associated with a guaranteed bit rate (GBR) routing priority the context maintenance time is increased, and when the traffic class indicator is associated with a non-guaranteed bit rate (NGBR) routing priority the context maintenance time is decreased.

8. The method of claim **1**, wherein when the wireless communication link load is greater than or equal to a link load threshold the context maintenance time is increased, and when the wireless communication link load is less than the link load threshold the context maintenance time is decreased.

9. The method of claim **4**, wherein the context maintenance time is increased when the probability of performing the first handover and the second handover within the predetermined period of time meets a probability threshold, and the context maintenance time is decreased when the probability of performing the first handover and the second handover within the predetermined period of time is less than the probability threshold.

10. The method of claim 4, further comprising:

re-calculating the context maintenance time based on a change in at least one of the application requirement, the traffic class indicator, the wireless communication link load, and the probability of performing the first handover and the second handover within the predetermined period of time.

11. A system for maintaining communication session information, comprising:

a processing node configured to:

determine, at an inspection node, an application requirement of an application running on a wireless device, a traffic class indicator associated with the wireless device, and a wireless communication link load;

determine a probability of performing repeated inter-access node technology handovers between a first access node using a first radio access technology and a second access node using a second radio access technology based on a monitored number of re-connection requests made by the wireless device within a predetermined period of time;

determine a backhaul load of the first access node;

calculate a context maintenance time for the wireless device, wherein the context maintenance time is calculated based on the determined application requirement, traffic class indicator, wireless communication link load, backhaul load, and probability of performing repeated inter-access node technology handovers;

start a timer using the calculated context maintenance time when a first handover of the wireless device is performed; and

maintain, at a network node, information related to a communication session between the wireless device and at least the first access node until the timer expires.

12. The system of claim 11, wherein the processing node is further configured to:

maintain a signaling communication session related to the wireless device between the first access node and a controller node until the timer expires.

13. The system of claim 11, wherein the processing node is further configured to:

maintain a signaling communication session related to the wireless device between the first access node and a gateway node the timer expires.

14. The system of claim 11, wherein the processing node is further configured to:

re-establish a communication session with the wireless device using the maintained information when a second handover is performed before the timer expires.

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