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(54) **METHODS AND SYSTEMS FOR TRANSMITTING GROUP DATA USING A DOWNLINK GROUP DATA CHANNEL**

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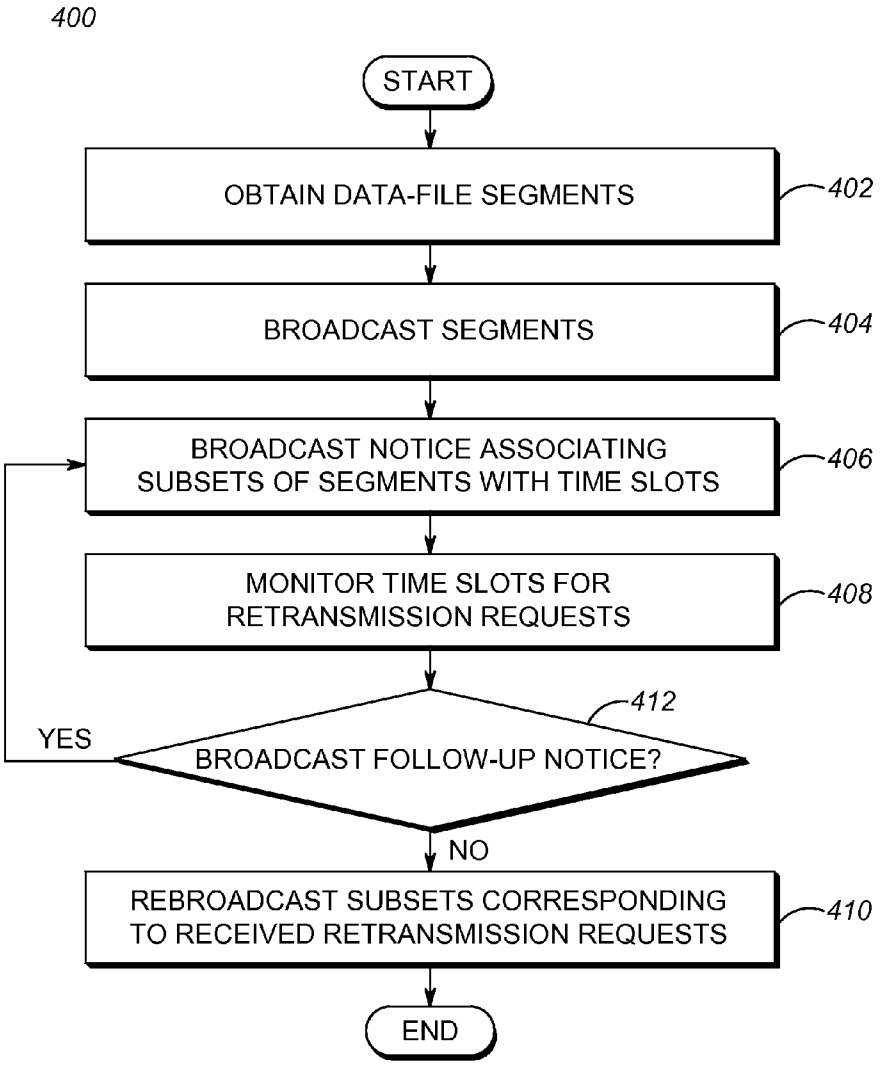
H04W 4/14	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 12/1868*** (2013.01); ***H04W 4/14*** (2013.01); ***H04H 20/72*** (2013.01); ***H04W 24/08*** (2013.01)

(57) **ABSTRACT**

Disclosed herein are methods and systems for transmitting group data using a downlink group data channel. An embodiment takes the form of a process that includes obtaining data-file segments that collectively make up a data file, and broadcasting the data-file segments on a downlink of a group data channel. The process further includes broadcasting retransmission-partition notices of broadcasted data-file segments. Each notice associates subsets of the broadcasted data-file segments with respective uplink time periods. The process also includes monitoring the associated uplink time periods for retransmission requests, and rebroadcasting the data-file segments of the subsets that correspond to any monitored time periods during which at least one retransmission request was received.



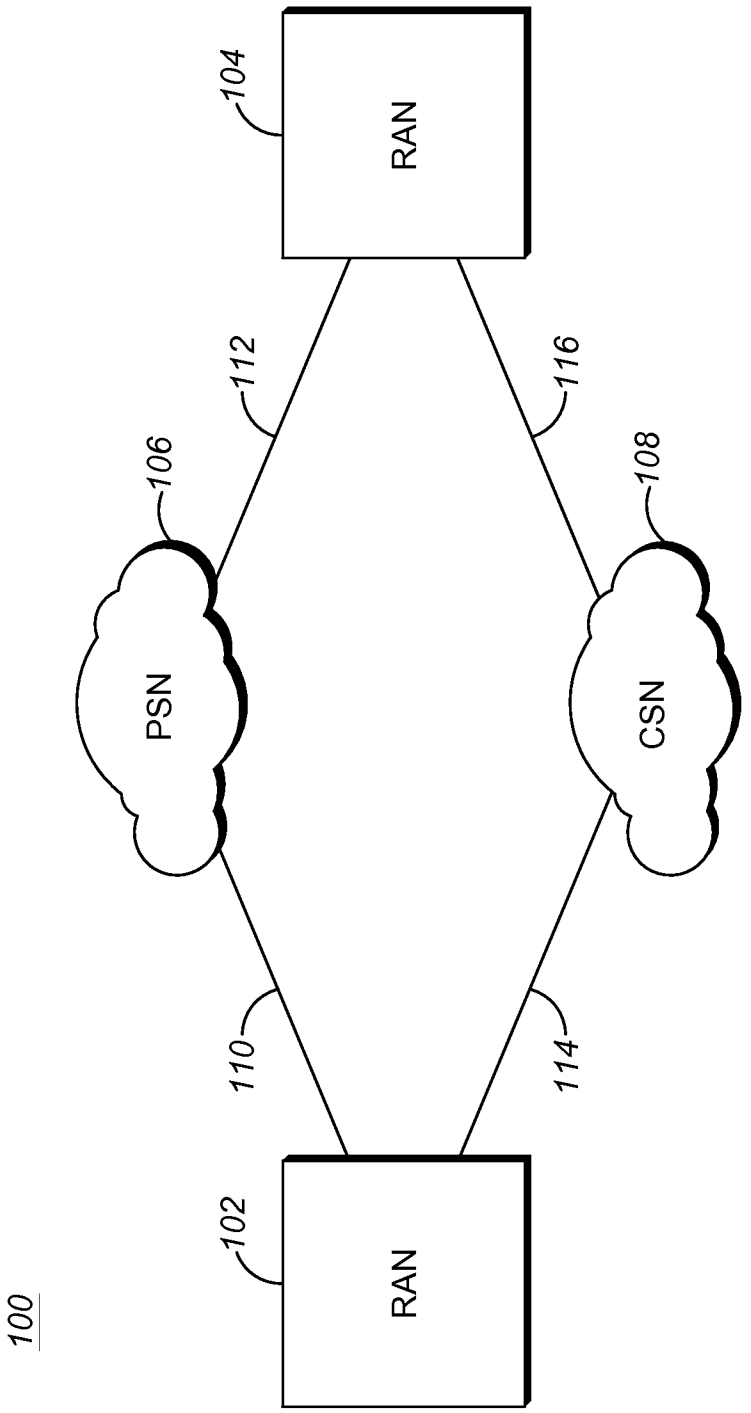


FIG. 1

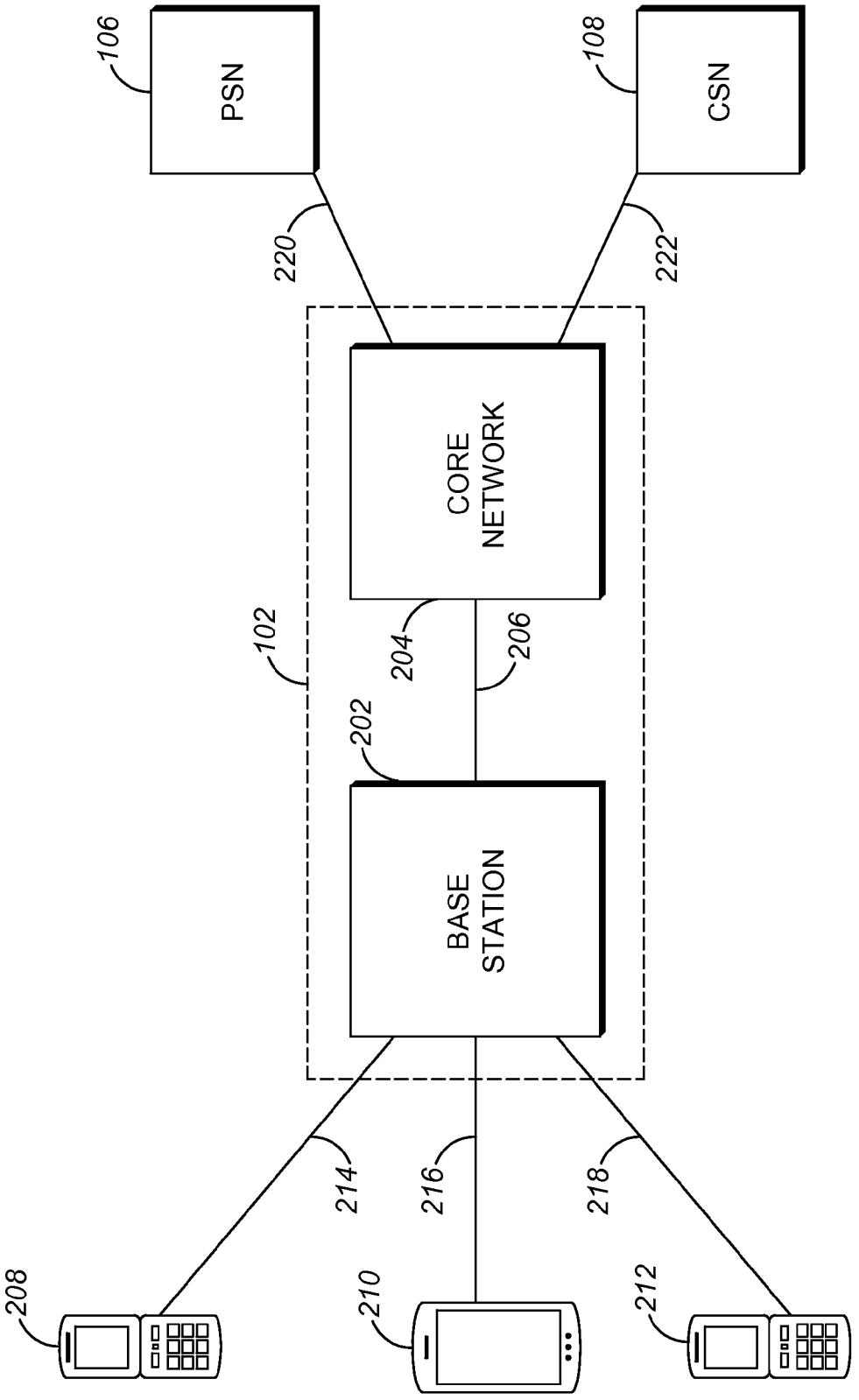

106
PSN
108
CSN
220
222
CORE NETWORK
102
204
206
202
BASE STATION
214
216
218
208
210
212

FIG. 2

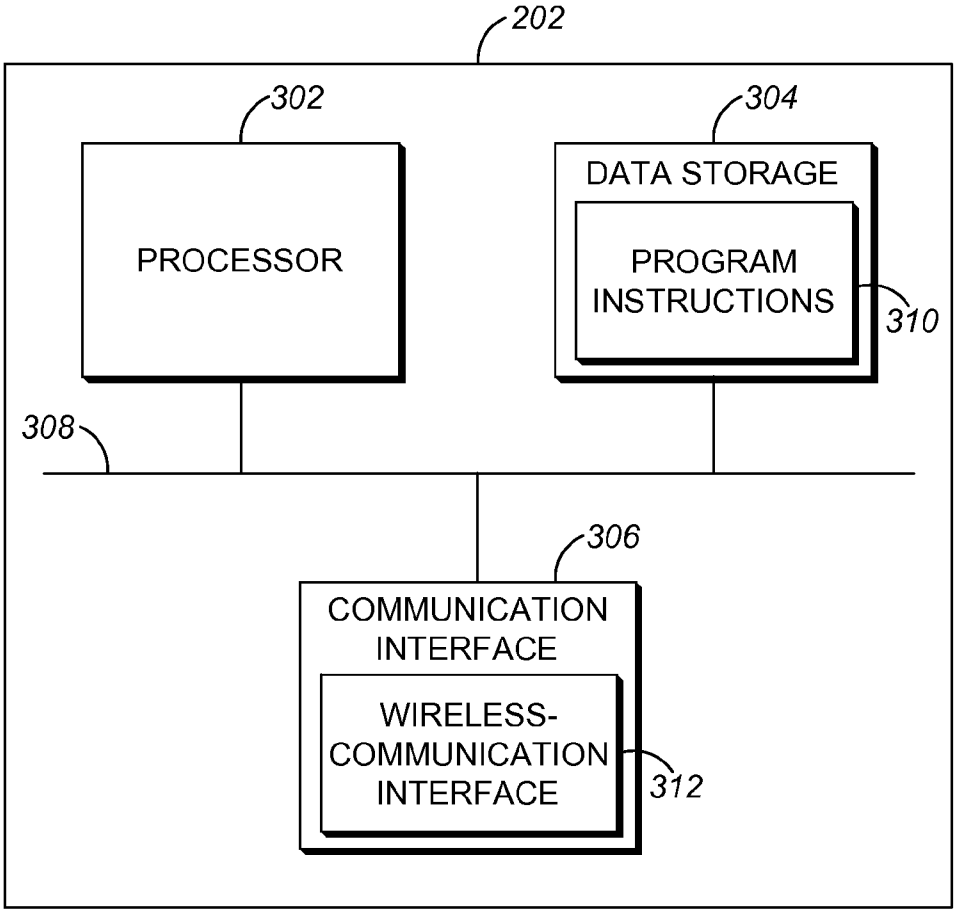

202
302
304
PROCESSOR
DATA STORAGE
PROGRAM INSTRUCTIONS
310
308
306
COMMUNICATION INTERFACE
WIRELESS-COMMUNICATION INTERFACE
312

FIG. 3

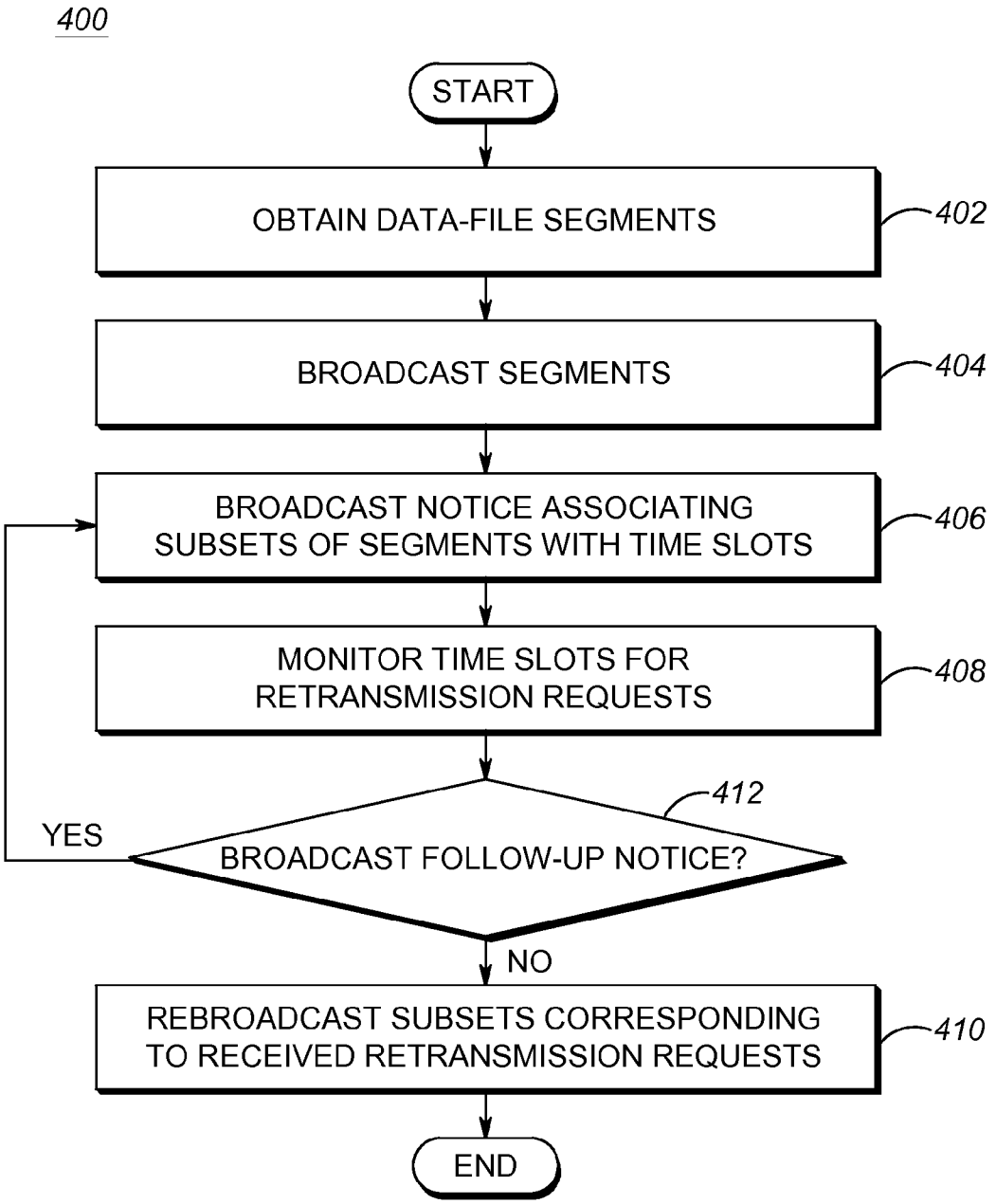

400
START
OBTAIN DATA-FILE SEGMENTS
402
BROADCAST SEGMENTS
404
BROADCAST NOTICE ASSOCIATING SUBSETS OF SEGMENTS WITH TIME SLOTS
406
MONITOR TIME SLOTS FOR RETRANSMISSION REQUESTS
408
412
BROADCAST FOLLOW-UP NOTICE?
YES
NO
REBROADCAST SUBSETS CORRESPONDING TO RECEIVED RETRANSMISSION REQUESTS
410
END

FIG. 4

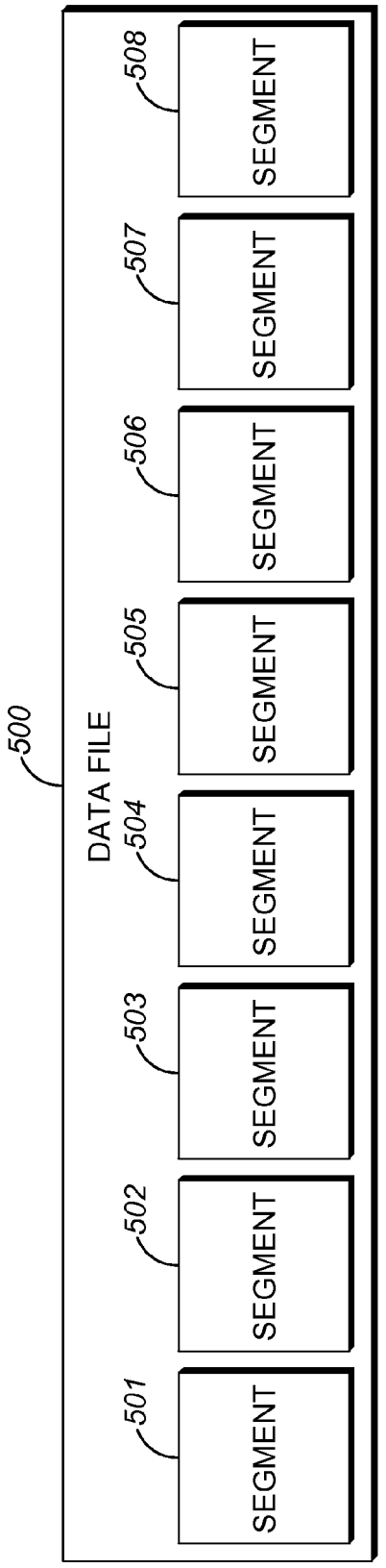

500
DATA FILE
501
SEGMENT
502
SEGMENT
503
SEGMENT
504
SEGMENT
505
SEGMENT
506
SEGMENT
507
SEGMENT
508
SEGMENT

FIG. 5

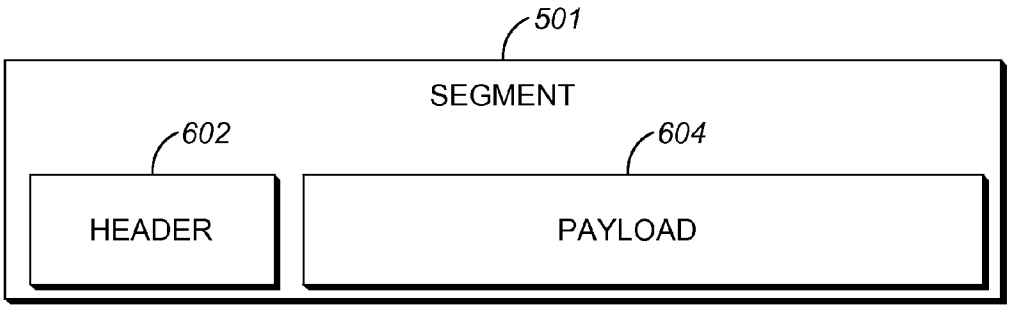


FIG. 6

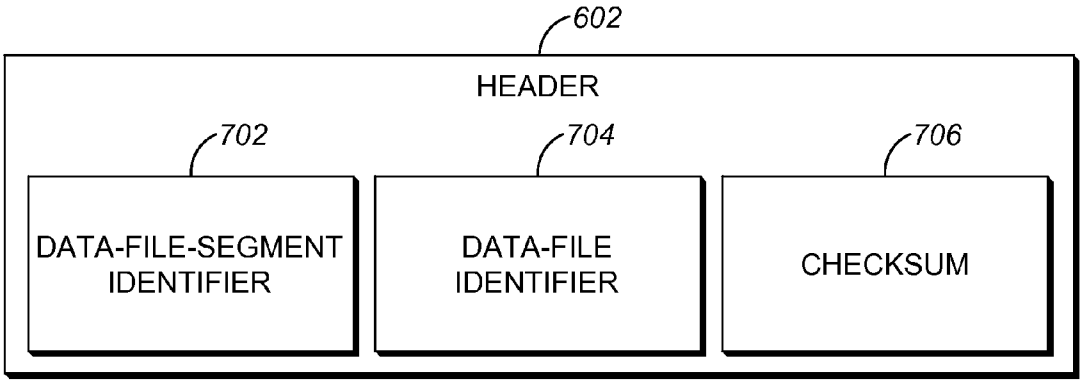


FIG. 7

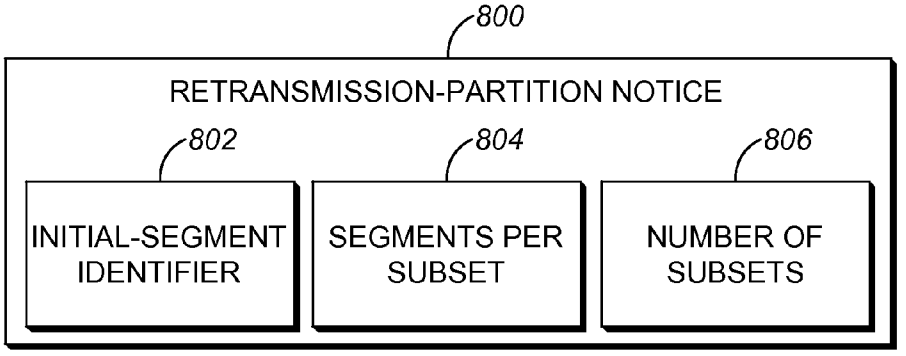


FIG. 8

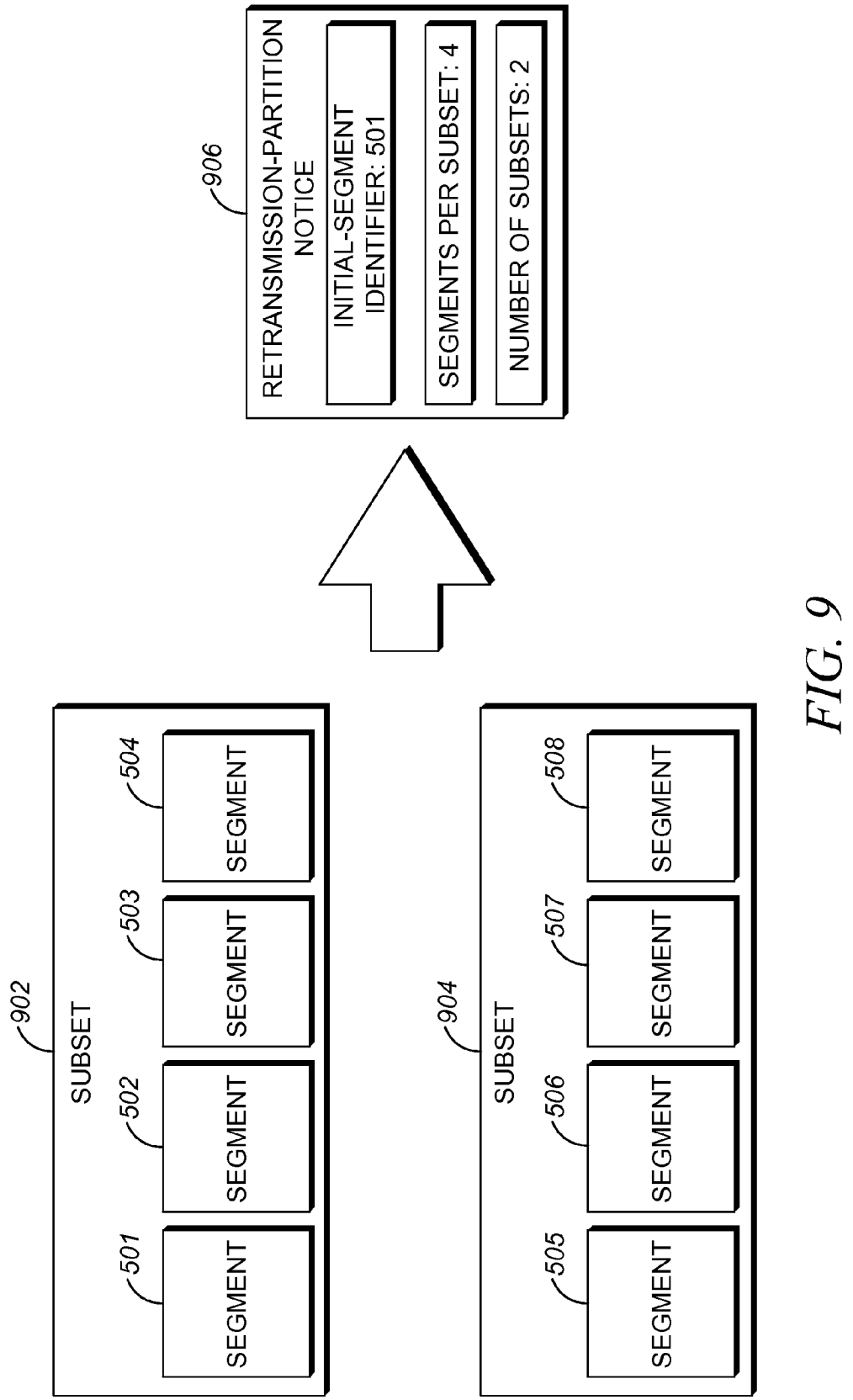

906
RETRANSMISSION-PARTITION NOTICE
INITIAL-SEGMENT IDENTIFIER: 501
SEGMENTS PER SUBSET: 4
NUMBER OF SUBSETS: 2
902
SUBSET
501
SEGMENT
502
SEGMENT
503
SEGMENT
504
SEGMENT
904
SUBSET
505
SEGMENT
506
SEGMENT
507
SEGMENT
508
SEGMENT

FIG. 9

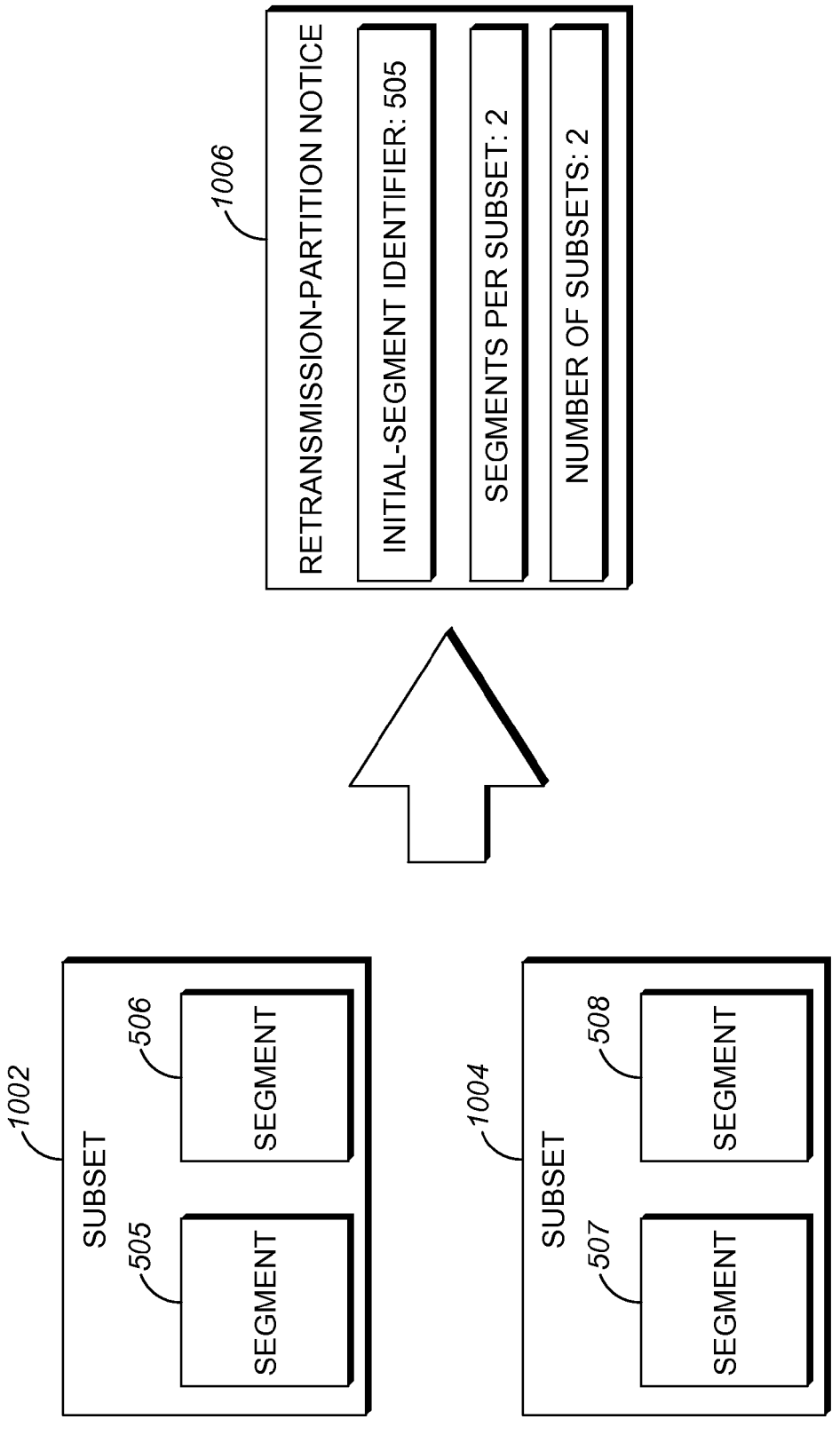

1002
SUBSET
505
SEGMENT
506
SEGMENT
1004
SUBSET
507
SEGMENT
508
SEGMENT
1006
RETRANSMISSION-PARTITION NOTICE
INITIAL-SEGMENT IDENTIFIER: 505
SEGMENTS PER SUBSET: 2
NUMBER OF SUBSETS: 2

FIG. 10

METHODS AND SYSTEMS FOR TRANSMITTING GROUP DATA USING A DOWNLINK GROUP DATA CHANNEL

BACKGROUND OF THE INVENTION

[0001] Millions of people around the world make daily use of various computing and communication devices. Many of these devices can be accurately characterized as being wireless-communication devices (WCDs), in that they are equipped and configured such that they are able to engage in wireless forms of communication directly with one another and/or via various wireless networks. Examples of commonly used WCDs include cell phones, smartphones, tablets, notebook computers, laptop computers, and the like. The wireless networks via which these WCDs engage in wireless communication typically operate according to one or more relatively long-range wireless-communication protocols (e.g., Global System for Mobile Communications (GSM), Long Term Evolution (LTE), and the like), one or more relatively short-range wireless-communication protocols (e.g., Wi-Fi and the like), and/or one or more land mobile radio (LMR) protocols (e.g., European Telecommunications Standards Institute Digital Mobile Radio (ETSI-DMR), Terrestrial Trunked Radio (TETRA), APCO Project 25 (P25), Digital Mobile Radio (DMR), and the like), among numerous other examples.

[0002] One context in which fast and reliable wireless communication is especially important is the public-safety context. An effective public-safety network should facilitate not only voice communication but also data communication. For example with respect to data communication, public-safety responders may advantageously be provided with digital files representing photographs of suspects, maps of buildings, digital dossiers, and the like. The network should also provide for communication among WCDs from numerous public-safety responders from multiple disciplines (e.g., police, fire, EMS) and from multiple jurisdictions (e.g., city fire, state police, county sheriff, etc.). The communication should make efficient use of limited air-interface resources. Accordingly, there is a need for improved methods and systems for transmitting group data using a downlink group data channel.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0003] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate embodiments of concepts that include the claimed invention, and explain various principles and advantages of those embodiments.

[0004] FIG. **1** depicts an example communication system, in accordance with various embodiments.

[0005] FIG. **2** depicts an example radio access network (RAN) via which one or more WCDs can communicate, in accordance with various embodiments.

[0006] FIG. **3** depicts an example base station, in accordance with various embodiments.

[0007] FIG. **4** is a flowchart of an example process, in accordance with various embodiments.

[0008] FIGS. **5**, **6**, and **7** depict aspects of an example data file, in accordance with various embodiments.

[0009] FIGS. **8-10** depict various aspects of example retransmission-partition notices and of example subsets of data-file segments identified by the respective example notices, in accordance with various embodiments.

[0010] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

[0011] The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Disclosed herein are methods and systems for transmitting group data using a downlink group data channel. An embodiment takes the form of a process that includes obtaining data-file segments that collectively make up a data file, and broadcasting the data-file segments on a downlink of a group data channel. The process further includes broadcasting retransmission-partition notices of broadcasted data-file segments. Each notice associates subsets of the broadcasted data-file segments with respective uplink time periods. The process also includes monitoring the associated uplink time periods for retransmission requests, and rebroadcasting the data-file segments of the subsets that correspond to any monitored time periods during which at least one retransmission request was received.

[0013] FIG. **1** depicts an example communication system, in accordance with various embodiments. As shown, communication system **100** includes respective RANs **102** and **104**, a packet-switched network (PSN) **106**, and a circuit-switched network (CSN) **108**. Networks **102** and **104** are connected to PSN **106** by respective communication links **110** and **112**, and to CSN **108** by respective communication links **114** and **116**. Those having skill in the art will appreciate that additional and/or different entities may be present in communication system **100**. For example, in accordance with some embodiments, the communication system **100** includes only a single RAN.

[0014] RAN **102** is discussed in further detail below with reference to FIG. **2**, though in general, RANs **102** and **104** may be any networks equipped and configured by those of skill in the relevant art to function as described herein. One or both of RANs **102** and **104** may operate according to one or more communication protocols such as TErrestrial Trunked RAdio (TETRA), LTE, Global System for Mobile Communications (GSM), CDMA2000, IEEE 802.11 (Wi-Fi), Bluetooth, ZigBee, and/or any other network protocol or standard, among many other possibilities known to those of skill in the relevant art.

[0015] In an embodiment, RAN **102** and/or RAN **104** is a public-safety network. In such an embodiment, the RAN is equipped, configured, and programmed to provide one or more public-safety agencies with wireless access to one or more networks, to facilitate provision of the communication and computing needs of those one or more public-safety agencies. The RAN may include or be connected to a dispatch center that itself may be communicatively connected with

PSN **106** and/or CSN **108**, for retrieving and transmitting any necessary public-safety-related data and/or communications.

[0016] PSN **106** could be the worldwide network typically referred to as the Internet, but could just as well be any other packet-switched network equipped and configured by those of skill in the relevant art to function as described herein. Entities resident on PSN **106** may be Internet Protocol (IP) entities and may be addressed using IP addresses, as examples. CSN **108** could be the circuit-switched communication network typically referred to as the Public Switched Telephone Network (PSTN), but could just as well be any other circuit-switched network arranged and configured by those of skill in the relevant art to function as described herein.

[0017] Any one or more of communication links **110-116** could include one or more communication devices, networks, connections, switches, bridges, routers, and the like. Any or all of communication links **110-116** could make use of wired and/or wireless forms of communication. Moreover, one or more communication links instead of and/or in addition to communication links **110-116** could be present. As one example, there could be one or more communication links between PSN **106** and CSN **108**.

[0018] FIG. **2** depicts an example RAN via which one or more WCDs can communicate, in accordance with various embodiments. As shown in FIG. **2**, RAN **102** includes a base station **202** and a core network **204** that are communicatively connected via a communication link **206**. Base station **202** is communicatively connected to WCDs **208**, **210**, and **212** via respective air-interface links **214**, **216**, and **218**, and core network **204** is communicatively connected to PSN **106** and CSN **108** via respective communication links **220** and **222**. RAN **104** could take a form identical or similar to RAN **102**.

[0019] Base station **202** may be any network-side entity that is suitably equipped and configured by those of skill in the relevant art to function as described herein, which in general is to provide wireless service to WCDs (such as WCDs **208**, **210**, and **212**) over respective air-interface links (such as respective air-interface links **214**, **216**, and **218**). Base station **202** could take the form of a TETRA base station, a Wi-Fi access point, a GSM/CDMA200 base transceiver station (BTS), and/or an LTE eNodeB, among numerous other examples known to those of skill in the relevant art. Moreover, while one base station **202** and three WCDs **208**, **210**, and **212** are depicted in FIG. **2**, this is by way of illustration and not by way of limitation, as any number of either could be present in a given implementation.

[0020] Air-interface links **214**, **216**, and **218** may each include a respective downlink and a respective uplink, or may form a shared uplink and downlink. Any one or more of the individual or shared downlinks and/or uplinks may take the form of respective air-interface channels and could be modulated using Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), and/or Quadrature Phase-Shift Keying (QPSK), among numerous other examples known to those of skill in the relevant art. In the time domain, a given channel may divided into frames, time slots, sub slots, etc. A respective downlink channel could (though need not) take the form of a shared channel, and could provide one or more of a circuit-mode-data service, a packet-mode-data service, and/or a Short Data Service (SDS) (i.e., a Short Message Service (SMS)), among numerous other examples known to those of skill in the relevant art. Communication over a given channel may be addressed to a single WCD using an identifier uniquely associated with that single WCD (e.g., an Individual Short Subscriber Identity (ISSI)) and/or to multiple WCDs using an identifier that is associated with those multiple WCDs as a group (e.g., a Group Short Subscriber Identity (GSSI)).

[0021] Core network **204** may include one or more network entities such as one or more mobility management entities (MMEs), one or more serving gateways (SGWs), one or more packet data network (PDN) gateways (PGWs), one or more evolved packet data gateways (ePDGs), one or more home subscriber servers (HSSs), one or more access network discovery and selection functions (ANDSFs), and/or one or more other entities deemed suitable for a given implementation by those of skill in the relevant art. Moreover, these entities may be configured and interconnected in a manner known to those of skill in the relevant art to provide wireless service to the WCDs **208**, **210**, and **212** via base station **202**, and to bridge such wireless service with various transport networks. These examples are provided for illustration and not by way of limitation; moreover, those of skill in the relevant art are aware of variations among different protocols and among different implementations of a given protocol, and of similarities across different protocols.

[0022] Communication links **206**, **220**, and **222** may take any suitable form, such as any of the forms described above in connection with links **110-116** of FIG. **1**. Communication link **206** may function as what is known as a "backhaul" with respect to base station **202**, as link **206** may enable core network **204** to bridge (i) communications conducted by base station **202** with WCDs over respective air interfaces with (ii) communications via the rest of RAN **102** and beyond. One or more entities such as one or more network access servers (NASs) and/or Voice over IP (VoIP) gateways may reside on any one or more of the communication links to bridge RAN **102** to one or more other networks.

[0023] WCDs **208**, **210**, and **212** may take the form of respective mobile phones, smart phones, tablet computers, notebook computers, desktop computers, and/or any other types of wireless-communication devices suitably equipped and configured by those of skill in the relevant art to function as described herein.

[0024] As known to those of skill in the relevant art, RAN **102** may include additional and/or different entities deemed suitable to a given implementation by those of skill in the relevant art. Moreover, these entities may be configured and interconnected in any manner known to those of skill in the relevant art to provide wireless service to WCDs via base stations, and to bridge such wireless service with transport networks such as PSN **106** and CSN **108**. In general, other configurations are possible, as those described herein are provided by way of example and not limitation.

[0025] FIG. **3** depicts an example base station, in accordance with various embodiments. As illustrated, base station **202** includes a processor **302**, data storage **304**, and a communication interface **306**, all of which are communicatively connected by a system bus **308** (or other suitable communication network, connection, and/or the like). Different and/or additional components may be present: for example, base station **202** could further include a Global Positioning System (GPS) receiver (among other possibilities). It should be understood that base station **202** may take other forms as well.

[0026] Processor **302** may include one or more processors of any type deemed suitable by those of skill in the relevant

art, some examples including a general-purpose microprocessor, a dedicated digital signal processor (DSP), and a graphics processor.

[0027] Data storage **304** may take the form of any non-transitory computer-readable medium or combination of such media, some examples including flash memory, read-only memory (ROM), and random-access memory (RAM) to name but a few, as any one or more types of non-transitory data-storage technology deemed suitable by those of skill in the relevant art could be used. In the embodiment that is depicted in FIG. **3**, data storage **304** contains program instructions **310** executable by processor **302** for carrying out various combinations of the various functions described herein, such as one or more of those steps set forth in FIG. **4**. The data storage could include additional data as well, including (for example) data files, data-file segments, network routing data, and/or any other types of data deemed suitable by those of skill in the relevant art for carrying out the functions described herein.

[0028] Communication interface **306** is depicted as including a wireless-communication interface **312**, which in turn could include components such as one or more antennae, one or more transmitters and/or receivers designed and configured for one or more types of wireless communication, and/or any other components deemed suitable by those of skill in the relevant art. In addition to wireless-communication interface **312**, communication interface **306** could further include additional communication-interface technology such as one or more wired (e.g., Ethernet) communication interfaces for facilitating communication with various network entities.

[0029] FIG. **4** is a flowchart of an example process, in accordance with various embodiments. As shown, the process **400** begins at step **402** with a base station obtaining data-file segments that collectively make up a data file. At step **404**, the base station broadcasts the data-file segments on a downlink of a group data channel, and at step **406**, broadcasts retransmission-partition notices of broadcasted data-file segments. Each retransmission-partition notice associates subsets of the broadcasted data-file segments with respective uplink time periods. At step **408**, the base station monitors the associated uplink time periods for retransmission requests, and at step **410**, rebroadcasts the data-file segments of the subsets that correspond to any monitored time periods during which at least one retransmission request was received. After broadcasting a given retransmission-partition notice but before rebroadcasting the data-file segments, base station **300** may determine at step **412** whether to broadcast a follow-up retransmission-partition notice.

[0030] The following example illustrates an operation of process **400** in the context of delivering a data file to WCDs **208-212** that are communicatively connected to public-safety network **102**. At step **402**, base station **202** receives, from core network **204**, one thousand data-file segments that collectively make up a data file that is a photo of a criminal suspect. The data-file segments have respective segment identifiers ranging from **1601** to **2600**, inclusive. Base station **202** broadcasts, to WCDs **208-212**, a notification that identifies (i) the data file (e.g., the file name, file type, etc.), (ii) the identifiers of the data-file segments (e.g., **1601** to **2600**) that collectively make up the data file, and (iii) a group-data channel on which the data-file segments will be broadcast. At step **404**, base station **202** broadcasts data-file segments **1601-1900** on the group-data channel (each data-file segment being broadcast during a respective network-standard time slot in this example), and WCDs **208-212**, in order to obtain the data file, tune to the given group-data channel (if not already tuned to that channel) and store any broadcasted data-file segments that have segment identifiers within the range of **1601-2600**, inclusive.

[0031] At step **406**, base station **202** offers to rebroadcast data-file segments **1601-1800** by broadcasting an initial retransmission-partition notice during time slot t=0. The initial retransmission-partition notice associates data-file segments **1601-1700** with time slot t=1 and segments **1701-1800** with time slot t=2. At step **408**, base station **212** monitors the associated uplink time slots for retransmission requests.

[0032] WCD **208**, which did not receive data-file segment **1652**, receives the initial retransmission-partition notice and responsively broadcasts a retransmission request during time slot t=1. The retransmission request could (though need not) identify WCD **208** as the requesting WCD and/or data-file segment **1652** as the requested data-file segment. WCD **212** did not receive data-file segment **1683**; the WCD thus also broadcasts a retransmission request during time slot t=1 in response to receiving the initial retransmission-partition notice. WCD **210**, having received all of data-file segments **1601-1700**, does not broadcast any retransmission requests during time slot t=1. Additionally, because each of WCDs **208-212** received all of data-file segments **1701-1800**, none of these WCDs broadcast any retransmission requests during time slot t=2.

[0033] As stated above, at step **408**, base station **202** monitors uplink time slots t=1 and t=2 associated with subsets of data-file segments **1601-1700** and **1701-1800**, respectively. During time slot t=1, base station **202** detects a received signal energy that is consistent with one or more retransmission requests.

[0034] In this example, because both WCDs **208** and **212** were broadcasting retransmission requests during time slot t=1, the retransmission requests collided, making any decoding of the respective retransmission requests difficult or impossible. However, base station **202** need not determine the identities of any requesting WCDs or requested data-file segments specified in the retransmission requests because (i) the identities of the requested data-file segments are determined by the time slots during which the retransmission requests were broadcast and (ii) the identities of the WCDs requesting retransmission are irrelevant given that any rebroadcasted data-file segments are rebroadcast to all of the WCDs that are communicatively connected to base station **202**. Accordingly, the base station need only determine that the energy level of a signal received during a given monitored uplink time slot exceeds a given threshold (this indicating that at least one WCD was likely broadcasting a retransmission request during the given uplink time slot).

[0035] Accordingly, having determined that the level of signal energy received during time slot t=1 exceeds an uplink-request threshold, base station **202** determines at step **412** whether to broadcast one or more follow-up retransmission-partition notices. A given base station may make this determination based on, for example, (i) the amount of time required to rebroadcast all of data-file segments corresponding to a given uplink time slot and (ii) the amount of time by which any eventual rebroadcast of the requested data-file segments would be delayed by broadcasting the follow-up retransmission notices (among other possible factors).

[0036] Indeed, in various different embodiments, one or more factors among numerous possible factors are consid-

ered by the base station **202** at step **412** in making a determination as to whether to broadcast one or more follow-up retransmission-partition notices (or rather instead to rebroadcast all of the data-file segments that correspond to uplink time periods in which at least one retransmission request was received). And moreover, in some implementations, a given factor being in a given state (e.g., air-interface conditions being poor) could tend towards a decision to send out one or more additional notices (i.e., to "drill down" further in an effort to gain more granular information as to which segment (s) actually need(s) to be rebroadcasted) while, in other implementations, that same factor being in that same given state could tend towards a decision to drill down no further, and instead to rebroadcast a likely over-inclusive set of data-file segments. These are choices for those of skill in the art to make in the context of various different implementations.

[0037] Some example factors, one or more of which could be considered in the context of a given implementation, include air-interface conditions, number of WCDs to which rebroadcasts would be sent, number of data-file segments total in a given file, number of data-file segments already broadcast, number of data-file segments yet to be (initially broadcast), size of data file as a whole, size of each data-file segment, amount of data represented by data-file segments yet to be broadcast, number of data-file segments that would need to be rebroadcast if no further notices were sent (i.e., if no further "drilling down" were conducted, amount of data represented by that set of data-file segments, and/or one or more other similar factors deemed suitable by those of skill in the relevant art for a given implementation or in a given context. And again, some designers may consider a certain factor being high (or low) to make further notices advisable, while other designers may consider that same factor being in that same state to make it advisable to conduct an immediate rebroadcast (i.e., with no further "drilling down" notices) of a likely overinclusive set of data-file segments.

[0038] In this example, a follow-up retransmission-partition notice could identify two subsets of data-file segments selected from segments **1601-1700**—e.g., a subset that includes segments **1601-1650** and a subset that includes segments **1651-1700**—and could associate each subset with time slots t=5 and t=6, respectively. Since the amount of time required to rebroadcast all of data-file segments **1601-1700** (one hundred time slots) is significantly greater than the delay resulting from broadcasting a follow-up retransmission-partition notice (one time slot for broadcasting the notice and two time slots for monitoring the associated uplink slots), base station **202** determines to broadcast the follow-up retransmission-partition notice.

[0039] At step **408**, base station **202** monitors uplink time slots t=5 and t=6 associated with subsets of data-file segments **1601-1650** and **1651-1700**, respectively. WCDs **208** and **212**, in need of data-file segments **1652** and **1683**, respectively, both broadcast a retransmission request during time slot t=6, and base station **202** determines that the level of signal energy received during time slot t=6 exceeds the uplink-request threshold. After broadcasting the follow-up retransmission-partition notice and monitoring the associated uplink-request time slots, base station **202** determines at step **412** to not broadcast another follow-up retransmission-partition notice (though it certainly could), and instead rebroadcasts data-file segments **1651-1700**.

[0040] The above-described example operation of process **400** is discussed in the context of public safety, those of skill in the art will appreciate, however, that process **400** may be employed in various other contexts as well. Further, operation of process **400** is not limited to the example described above, as many embodiments of process **400** exist, as is further discussed below.

[0041] FIGS. **5**, **6**, and **7** depict aspects of an example data file, in accordance with various embodiments. As shown in FIG. **5**, data file **500** includes several data-file segments **501-508**, though a given data file may include more or fewer segments. As illustrated in FIG. **6**, data-file segment **501** includes a header **602** and a payload **604**. The header **602** may contain, e.g., metadata for identifying respective data-file segments and/or facilitating transfer of respective data-file segments between network entities, and the payload **604** may include a part of a respective data file, among other possible variations. As depicted in FIG. **7**, header **602** includes a data-file-segment identifier **702**, a data-file identifier **704**, and a checksum **706**. Data file **500** could take various forms, including (but not limited to) an image file, a video file, an audio file, and/or a document file (such as a text file), among other possibilities. Data file **500**, data-file segment **501**, and/or header **602** could include additional and/or different data as well.

[0042] Data-file-segment identifier **702** may take the form of (or include) a sequence identifier that sequentially identifies the data-file segment **501** with respect to the other segments (e.g., segments **502-508**) of data file **500**. The sequence identifiers of the sequential segments could take the form of sequential integers starting from zero (e.g., 0 to 7) or another number (e.g., **501-508**), sequential letters starting from A (e.g., A to H) or another letter, and/or any other sequential identifiers, among numerous other possibilities. In some embodiments, data-file segment **501** is sent using a short messaging service such as SDS, SMS, or the like. In an example in which SDS is used, data-file segment **501** takes the form of an SDS message and data-file-segment identifier **702** takes the form of an SDS-message address field. Data-file-segment identifier **702** could take other forms as well.

[0043] It should be noted that, throughout the detailed description, respective data-file segments may be referred to as being "less than" or "greater than" other data-file segments. These references (and other references using similar language) should be understood to mean that the data-file-segment identifier of a given data-file segment is less than or greater than the respective data-file-segment identifiers of other data-file segments.

[0044] Data-file identifier **704** may include data-file identifiers that identify the data file of which the respective segments are part. The identifiers could take the form of (or include) file names (e.g., "suspect.jpg" or "dossier.pdf"), or possibly arbitrary strings of numbers and letters that uniquely identify the file during broadcast and/or rebroadcast, among other possibilities. In some embodiments, all of the data-file segments of the data file comprise the same data-file identifier. In some embodiments, a respective data-file identifier takes the form of a data-file-segment identifier (such as a sequence identifier). For example, if a base station indicates a range of sequence identifiers of data-file segments that collectively make up a given data file (indicated perhaps via an SDS message prior to broadcasting the data-file segments), then the sequence identifiers would indicate the data file of which the respective segments are part. Those of skill in the art will appreciate that data-file identifier **704** may take other forms.

[0045] Checksum **706** may take the form of (or be based on) a result of a checksum function. The result of the checksum function could be based on other data in header **602** and/or based on payload **604**, among other possibilities. The checksum function could take the form of (or include) a cyclic redundancy check (CRC) algorithm, and/or a cryptographic hash function such as MD5, SHA-2, and/or SHA-3, among numerous other possibilities.

[0046] With respect to step **402**, obtaining the data-file segments may involve base station **202** receiving data file **500**, and/or any one or more of data-file segments **501-508**, from another network entity known to those of skill in the art such as another base station, gateway, router, and the like. In an embodiment, data-file segments are obtained by segmenting the data file into the obtained data-file segments. For example, base station **202** may receive data file **500** from core network **204** in RAN **102**, and may obtain data-file segments **501-508** by segmenting the data file. Those of skill in the art will appreciate that other variations are possible as well.

[0047] In an embodiment, base station **202** obtains the data-file segments by receiving the data-file segments from a network entity (such as core network **204**). The data-file segments received by base station **202** may be the same data-file segments received by one or more other base stations in RAN **102**, which may (re)broadcast the data-file segments in a manner similar to that in which the segments are (re)broadcast by base station **202**. Accordingly, base station **202** may broadcast (and rebroadcast) data-file segments of a given data file to WCDs that received one or more segments of the data file from a different base station in RAN **202**, facilitating the mobility of the WCDs throughout the network by virtue of network-standard segmentation of files and numbering of corresponding segments.

[0048] Regarding step **404**, broadcasting a given data-file segment could include addressing the data-file segment using its associated sequence identifier. For example, the data-file segments could be broadcast as SDS messages. An address field of the SDS message could include a segment identifier of a respective data-file segment (instead of or in addition to a GSSI or an ISSI), and a payload of the SDS message could include a respective portion of the data file. In some embodiments, the address field includes both the segment identifier and the data-file identifier. A given WCD receiving a respective data file may filter (e.g., silently discard) any received SDS messages except for those that are part of that data file.

[0049] The base station may broadcast segment-transmission notices for indicating to WCDs that the base station is (or soon will be) broadcasting one or more data-file segments. The segment-transmission notice could be broadcast on a control channel (perhaps as an SDS message) and could specify the segment identifier of the first segment of a data file, a number of segments of the data file that are to be broadcast, and a group data channel on which the data-file segments will be broadcast. A given WCD may tune to the group data channel specified in the segment-transmission notice in order to receive the data-file segments. The segment-transmission notice could be broadcast on one or more other channels (instead of or in addition to the control channel) and could include different and/or additional data.

[0050] The base station could periodically broadcast the segment-transmission notices, for example, until a given number (e.g., all) of the data-file segments have been broadcast at least once, among other possibilities. Broadcasting subsequent segment-transmission notices may allow WCDs that did not receive the initial notice (e.g., if the WCD was not in range of the base station at the time) to nevertheless receive the data file associated with the data-file segments indicated in the notification.

[0051] FIGS. **8-10** depict various aspects of example retransmission-partition notices and of example subsets of data-file segments identified by the respective example notices, in accordance with various embodiments. As shown in FIG. **8**, an example retransmission-partition notice **800** includes a sequence identifier **802** of an initial data-file segment, a number **804** of sequential data-file segments per subset, and a number **806** of subsets. A first example retransmission-partition notice **906** of FIG. **9** identifies subsets **902** and **904** of data-file segments, and a second example retransmission-partition notice **1006** of FIG. **10** identifies subsets **1002** and **1004** of data-file segments. Those of skill in the art will appreciate that notices **800**, **906**, and/or **1006** may include different and/or additional data, and that subsets **902**, **904**, **1002**, and/or **1004** may take other forms, without departing from the scope of the claims.

[0052] As depicted in FIGS. **9** and **10**, the subsets identified by a respective notice may be mutually exclusive with respect to one another. As shown, subsets **902** and **904** are disjoint sets (and are thus mutually exclusive) in that the intersection of these two subsets is the empty set—in other words, they are disjoint because none of segments **501-508** are in both of subsets **902** and **904**. Subsets **1002** and **1004** are similarly disjoint because none of segments **505-508** are in both of subsets **1002** and **1004**.

[0053] The subsets identified by a respective notice may include data-file segments having sequential identifiers within respective subsets. For example, as shown in FIG. **9**, none of the data-file segments in subset **902** have a respective identifier that is the same as that of any other segment in the subset. Subsets **904**, **1002**, and **1004** similarly include segments with sequential identifiers.

[0054] The subsets identified by a respective notice may collectively take the form of an ordered set such that any two subsets identified in the notice are comparable. FIGS. **9** and **10** depict embodiments where a first subset of data-file segments is less than a second subset of segments in that the respective identifier of each segment in the first subset is less than the respective identifiers of all of the segments in the second subset. As shown in FIG. **9**, the identifier of segment **501** of subset **902** is less than the respective identifiers of all the segments in subset **904** (i.e., segments **505-508**). Likewise, the respective identifier of each of segments **502-504** is less than the respective identifiers of segments **505-508**. Therefore, in this embodiment, subset **902** is less than subset **904**. Similarly, subset **1002** is less than subset **1004** because the respective identifier of each of segments **505** and **506** of subset **1002** is less than the respective identifiers of each of segments **507** and **508** of subset **1004**.

[0055] A given notice may identify multiple subsets of data-file segments. For example, notice **906** identifies a first subset **902** and a second subset **904**. Notice **1006** likewise identifies a first subset **1002** and a second subset **1004**. As another possibility, a given notice may identify a single subset of data-file segments. The combination of distinct segments in the identified subsets may be a (coextensive or non-coextensive) subset of the already-broadcasted segments. For example, a given notice could identify a single subset of segments that includes all of the already-broadcasted segments.

[0056] In an embodiment, the subsets identified by a respective notice include subsets of an earlier-identified subset (i.e., a subset that had been identified by a previously-broadcasted notice). For example, subsets **1002** and **1004** identified by notice **1006** are subsets of the data-file segments of subset **904** identified by notice **906**. The combination of segments in subset **1002** (that is, segments **505** and **506**) and the segments in subset **1004** (i.e., segments **507** and **508**) is coextensive with subset **904** (that includes segments **505**, **506**, **507**, and **508**).

[0057] Regarding step **406**, the uplink time periods may be any periods of time suitable for carrying out the embodiments described herein. For example, a respective time period may take the form of one, part of one, and/or more than one time slot, frame, multi frame, packet, etc., according to one or more protocols such as TETRA, LTE, GSM, CDMA2000, and/or Internet Protocol (IP), among other possibilities (though the time periods need not be based on any given communication standard). The uplink time periods may be associated with respective subsets based on a time period during which a respective retransmission-partition notice is broadcasted. In an embodiment, each subset is associated with a respective successive time period following the time period during which the notice is broadcast. For example, if base station **202** broadcasts notice **906** during time period t=100, then subset **902** would be associated with time period t=101 and subset **904** would be associated with time period t=102. If notice **1006** were broadcast during time period t=103, then subsets **1002** and **1004** would be associated with time periods t=104 and t=105, respectively. If a given notice spans more than one time period, then each subset may be associated with respective successive time periods following the last time period during which the notice is broadcast. Other variations are possible as well.

[0058] After broadcasting a given retransmission-partition notice, the base station may broadcast one or more additional retransmission-partition notices so as to narrow the number of data-file segments to be rebroadcast. For example, the base station might broadcast notice **906** associating subsets **902** and **904** with time periods t=101 and t=102, respectively. If base station **202** were to receive a retransmission request during time period t=102, then the base station could responsively broadcast notice **1006** identifying subsets **1002** and **1004**. Thus, in various embodiments, the wasting of air-interface resources is avoided by not rebroadcasting data-file segments (or further retransmission-partition notices pertaining thereto) for which no retransmission request was received (e.g., data-file segments **501-504** that are part of subset **902**).

[0059] The base station may select the number of subsets of broadcasted data-file segments based on, for example, a number of unique data-file segments for which at least one retransmission request was received and/or a number of retransmission requests received with respect to at least one subset identified by a previously-broadcasted notice, among other possibilities. In an embodiment, the base station selects the number of subsets of broadcasted data-file segments based on a number of unique data-file segments already broadcast. For example, if all of data-file segments **501-508** have already been broadcast, then base station **202** may select a relatively greater number of subsets each having relatively fewer data-file segments, thus allowing for relatively more granular identification of data-file segments during a (possibly) more error-prone initial broadcasting of segments. Those of skill in the art will appreciate that other bases for selecting the number of subsets are possible as well.

[0060] Regarding step **408**, the associated uplink time periods may be monitored for levels of received signal energy that exceed an uplink-request threshold. Collisions are possible if multiple WCDs attempt to send a communication during a given associated uplink time. However, in various embodiments, information such as the identity of the requesting WCD is unnecessary for identifying a need to rebroadcast a given data-file segment, because the data-file segments are broadcast (and rebroadcast) to all WCDs on a given channel, not just to the requesting WCD. Accordingly, an event such as the received signal energy (during a given uplink time period) exceeding the corresponding threshold can be presumed to be a retransmission request (i.e., one or more retransmission requests) regardless of the content (or identification of a sender) of a given communication during that uplink time period.

[0061] Regarding step **410**, in an embodiment, at least one retransmission-partition notice is broadcast before at least one other data-file segment is initially broadcast. For example, after initially broadcasting data-file segments **501-504**, the base station may broadcast a retransmission-partition notice identifying one or more subsets of those already-broadcasted segments. In an embodiment, at least one data-file segment is rebroadcast before at least one other data-file segment is initially broadcast. For example, after broadcasting the retransmission-partition notice identifying one or more subsets of data-file segments **501-504**, base station **202** may initially broadcast data-file segment **505** while also monitoring the associated uplink time periods for retransmission requests. After initially broadcasting segment **505**, but before initially broadcasting any of segments **506-508**, the base station may rebroadcast any one or more of segments **501-504** for which a retransmission request was received. And certainly other examples could be listed.

[0062] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0063] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0064] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other ele-

ments not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises . . . a", "has . . . a", "includes . . . a", "contains . . . a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially", "essentially", "approximately", "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0065] It will be appreciated that some embodiments may be comprised of one or more generic or specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

[0066] Moreover, an embodiment can be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

[0067] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

We claim:

1. A method comprising:

obtaining data-file segments that collectively make up a data file;

broadcasting the data-file segments on a downlink of a group data channel;

broadcasting retransmission-partition notices of broadcasted data-file segments, each notice associating subsets of the broadcasted data-file segments with respective uplink time periods;

monitoring the associated uplink time periods for retransmission requests; and

rebroadcasting the data-file segments of the subsets that correspond to any monitored time periods during which at least one retransmission request was received.

2. The method of claim **1**, wherein the data file comprises at least one of an image file, a video file, an audio file, and a text file.

3. The method of claim **1**, wherein obtaining the data-file segments comprises segmenting the data file into the obtained data-file segments.

4. The method of claim **1**, wherein obtaining the data-file segments comprises receiving the data-file segments from a network entity.

5. The method of claim **1**, wherein all of the data-file segments comprise the same data-file identifier.

6. The method of claim **1**, wherein the data-file segments comprise sequence identifiers that sequentially identify respective segments with respect to other segments of the data file.

7. The method of claim **6**, wherein broadcasting or rebroadcasting a given data-file segment comprises addressing the given data-file segment using its associated sequence identifier.

8. The method of claim **1**, wherein the data-file segments are broadcasted using a short messaging service.

9. The method of claim **1**, wherein the subsets identified by a respective notice comprise subsets of one subset identified by a previously-broadcasted notice.

10. The method of claim **1**, wherein the subsets identified by a respective notice comprise subsets of data-file segments having sequential identifiers within respective subsets.

11. The method of claim **1**, wherein the subsets identified by a respective notice are mutually exclusive with respect to one another.

12. The method of claim **11**, wherein the subsets identified by a respective notice further comprise subsets of data-file segments having sequential identifiers within respective subsets.

13. The method of claim **11**, wherein at least one of the notices comprises a sequence identifier of an initial data-file segment, a number of sequential data-file segments per subset, and a number of subsets.

14. The method of claim **1**, wherein at least one of the notices comprises a sequence identifier of an initial data-file segment, a number of sequential data-file segments per subset, and a number of subsets.

15. The method of claim **1**, further comprising selecting a number of subsets of broadcasted data-file segments based on a number of unique data-file segments already broadcast.

16. The method of claim **1**, further comprising selecting a number of subsets of broadcasted data-file segments based on a number of retransmission requests received with respect to at least one subset identified by a previously-broadcasted notice.

17. The method of claim **1**, further comprising selecting a number of subsets of broadcasted data-file segments based on a number of unique data-file segments for which at least one retransmission request was received.

18. The method of claim **1**, wherein monitoring the associated uplink time periods for retransmission requests comprises monitoring the associated uplink time periods for levels of received signal energy that exceed an uplink-request threshold.

19. The method of claim **1**, wherein at least one data-file segment is rebroadcast before at least one other data-file segment is initially broadcast.

20. A system comprising:

a communication interface comprising a wireless-communication interface;

a processor; and

data storage containing instructions executable by the processor for causing the system to carry out a set of functions, the set of functions comprising:

obtaining data-file segments that collectively make up a data file;

broadcasting the data-file segments on a downlink of a group data channel;

broadcasting retransmission-partition notices of broadcasted data-file segments, each notice associating subsets of the broadcasted data-file segments with respective uplink time periods;

monitoring the associated uplink time periods for retransmission requests; and

rebroadcasting the data-file segments of the subsets that correspond to any monitored time periods during which at least one retransmission request was received.

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