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Desai et al.

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(54) **METHOD AND SYSTEM FOR ASSIGNING SLOT RESERVATIONS TO SUBSCRIBER RADIOS IN A TELECOMMUNICATIONS SYSTEM**

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H04W 74/08 (2009.01)
H04B 7/26 (2006.01)

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

CPC ***H04W 72/0406*** (2013.01); *H04B 7/2643* (2013.01); *H04W 72/0446* (2013.01); *H04W 74/08* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,633,558	B1	10/2003	Cho et al.	
6,963,549	B1	11/2005	Jayaraman et al.	
7,006,477	B1	2/2006	Balachandran et al.	
7,486,693	B2	2/2009	Walter et al.	
7,912,081	B2	3/2011	Heidari-Bateni et al.	
7,936,774	B2	5/2011	Kuperschmidt et al.	
8,054,811	B2	11/2011	Honkasalo et al.	
8,107,880	B2	1/2012	Okker	
2007/0153727	A1 *	7/2007	McBeath et al.	370/329
2008/0240146	A1 *	10/2008	Singh et al.	370/458
2012/0099568	A1 *	4/2012	Wentink	H04W 74/04 370/338

* cited by examiner

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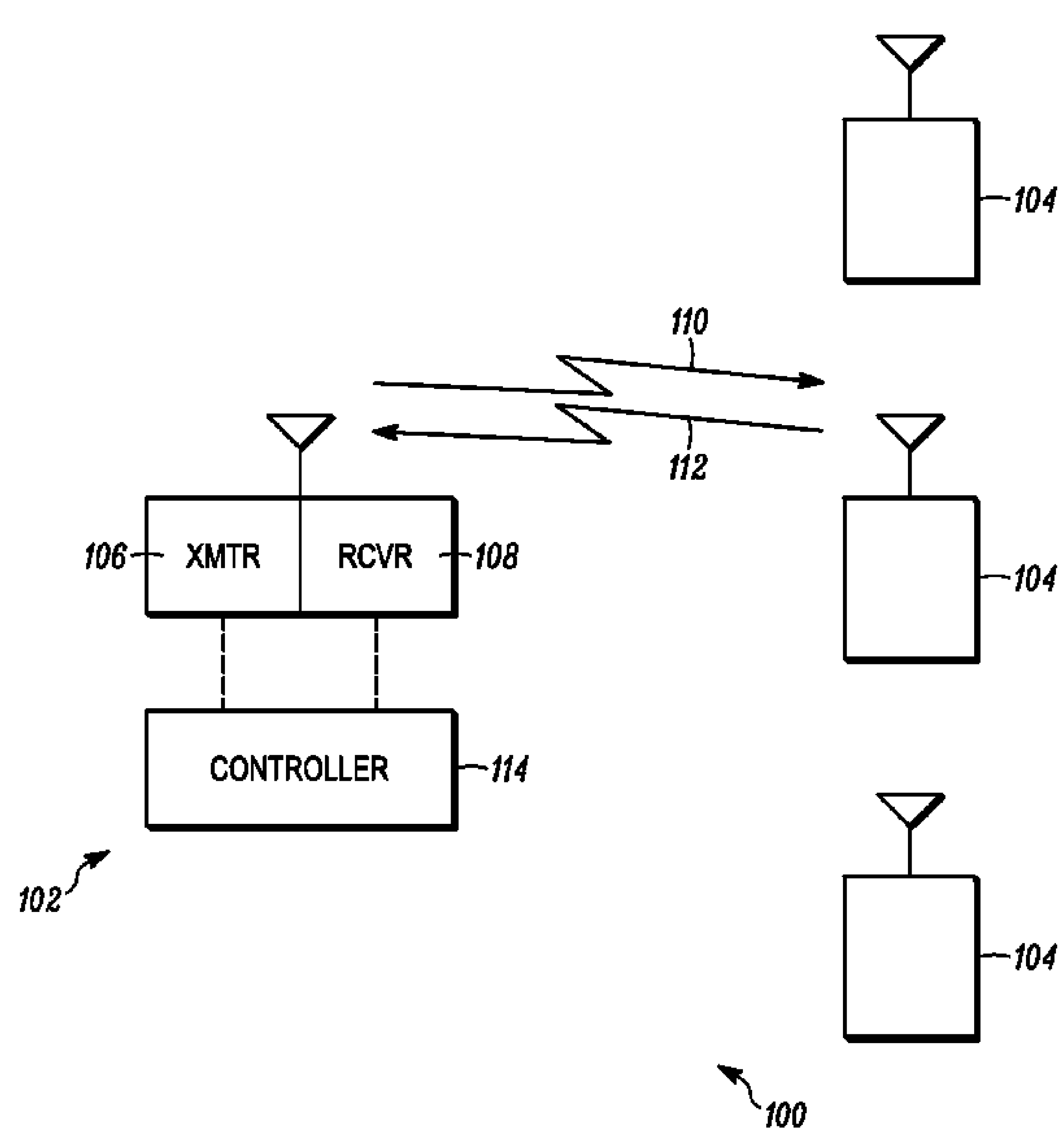
(57) **ABSTRACT**

A method for assigning slot reservations to subscriber radios in a TDMA communications system, where data is arranged into a series of superframes, includes an inbound signaling protocol having a plurality of inbound transmission slots. An outbound signaling protocol includes an inbound reservation scheduling slot, which includes a plurality of subscriber access code fields. Each subscriber access code field corresponds to at least one of the inbound transmission slots. Each subscriber access code field may store a subscriber access code associated with a subscriber radio. The inbound reservation scheduling message includes a subscriber access code in at least one of the subscriber access code fields. As such, the subscriber radio associated with the subscriber access code may transmit data during the inbound transmission slot corresponding to the subscriber access code in which the subscriber access code field is stored.

13 Claims, 5 Drawing Sheets



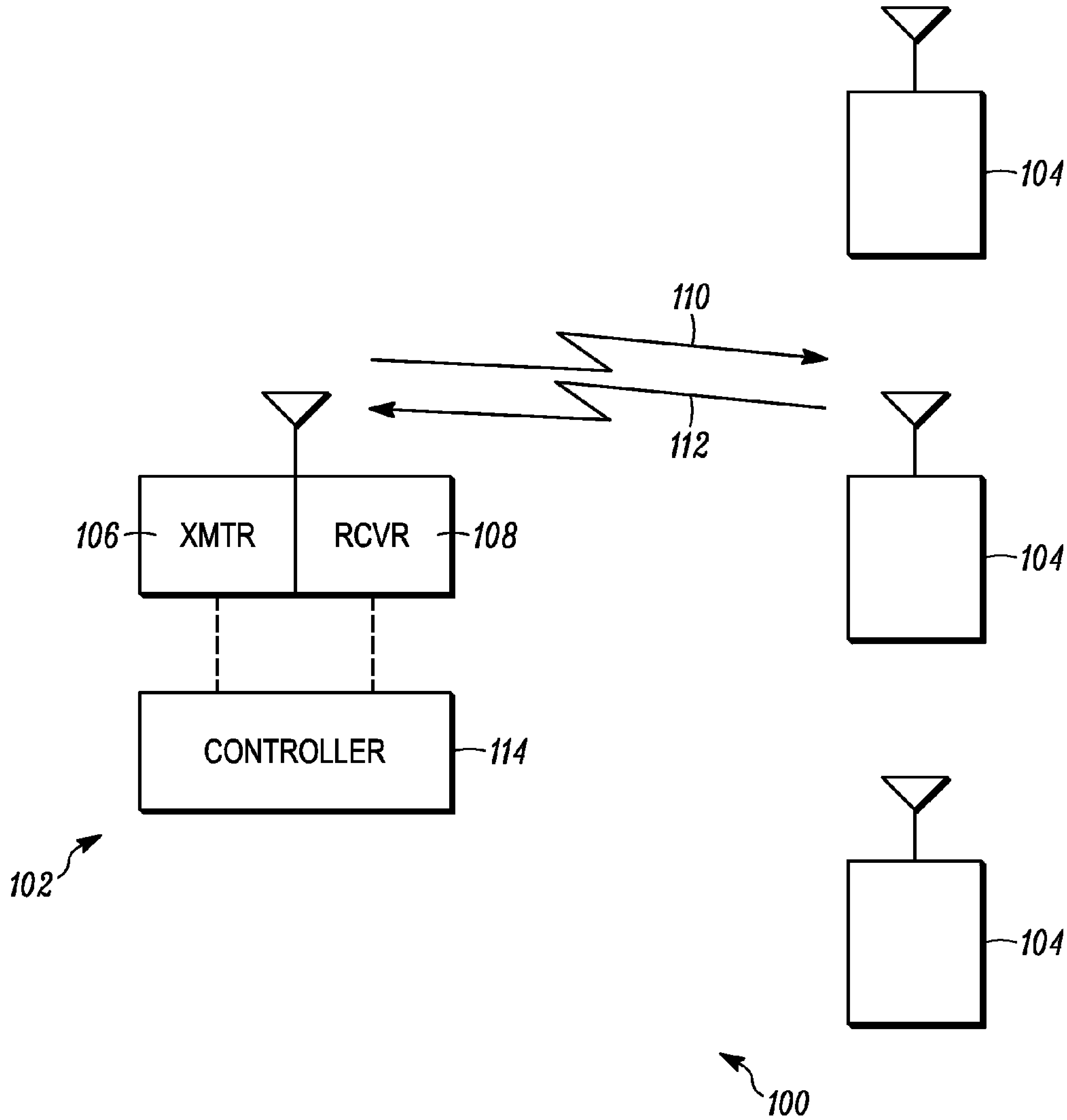
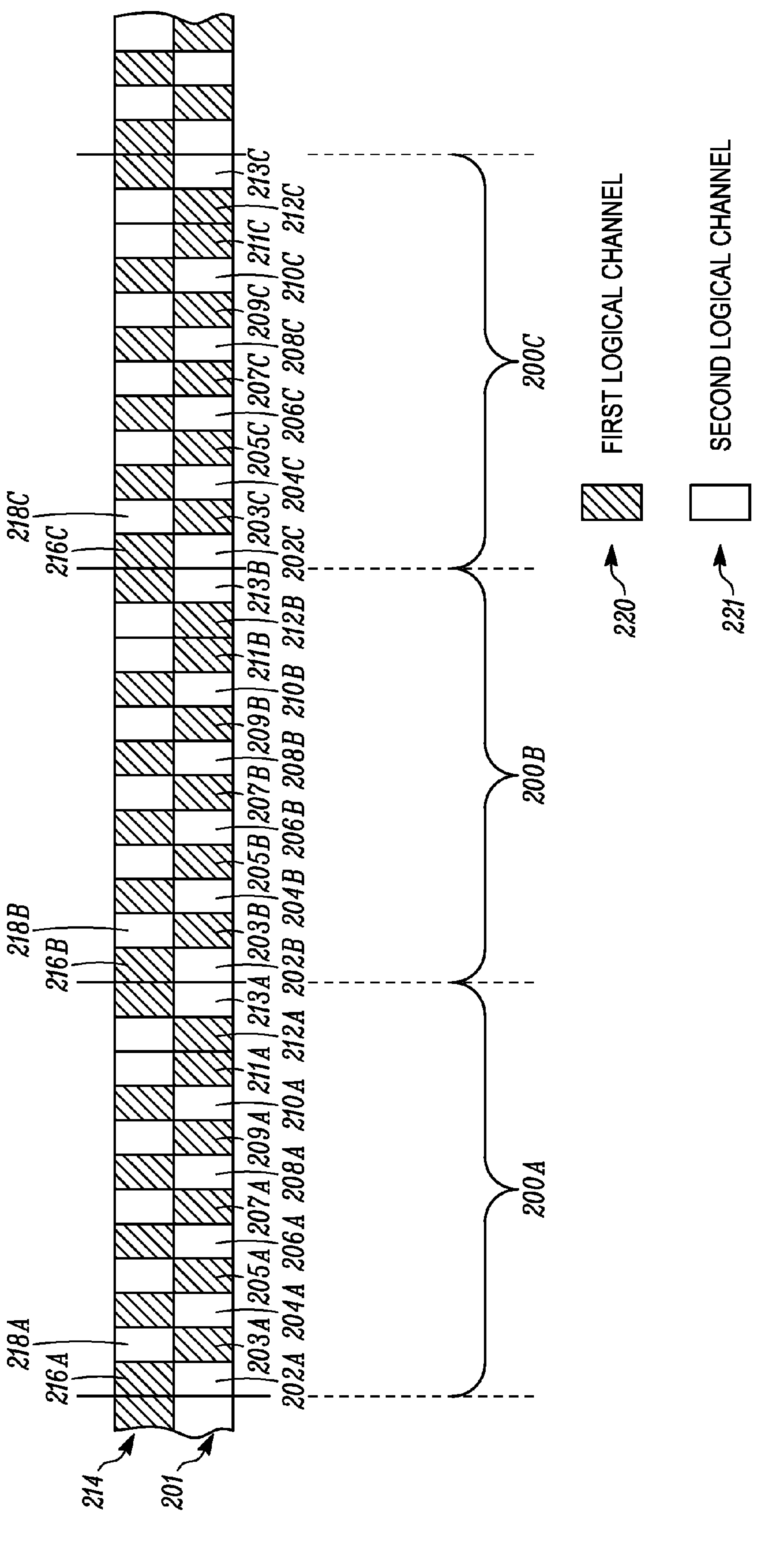


FIG. 1



214
201
216A
218A
216B
218B
216C
218C
202A
203A
204A
205A
206A
207A
208A
209A
210A
211A
212A
213A
202B
203B
204B
205B
206B
207B
208B
209B
210B
211B
212B
213B
202C
203C
204C
205C
206C
207C
208C
209C
210C
211C
212C
213C
200A
200B
200C
FIRST LOGICAL CHANNEL
SECOND LOGICAL CHANNEL
220
221

FIG. 2

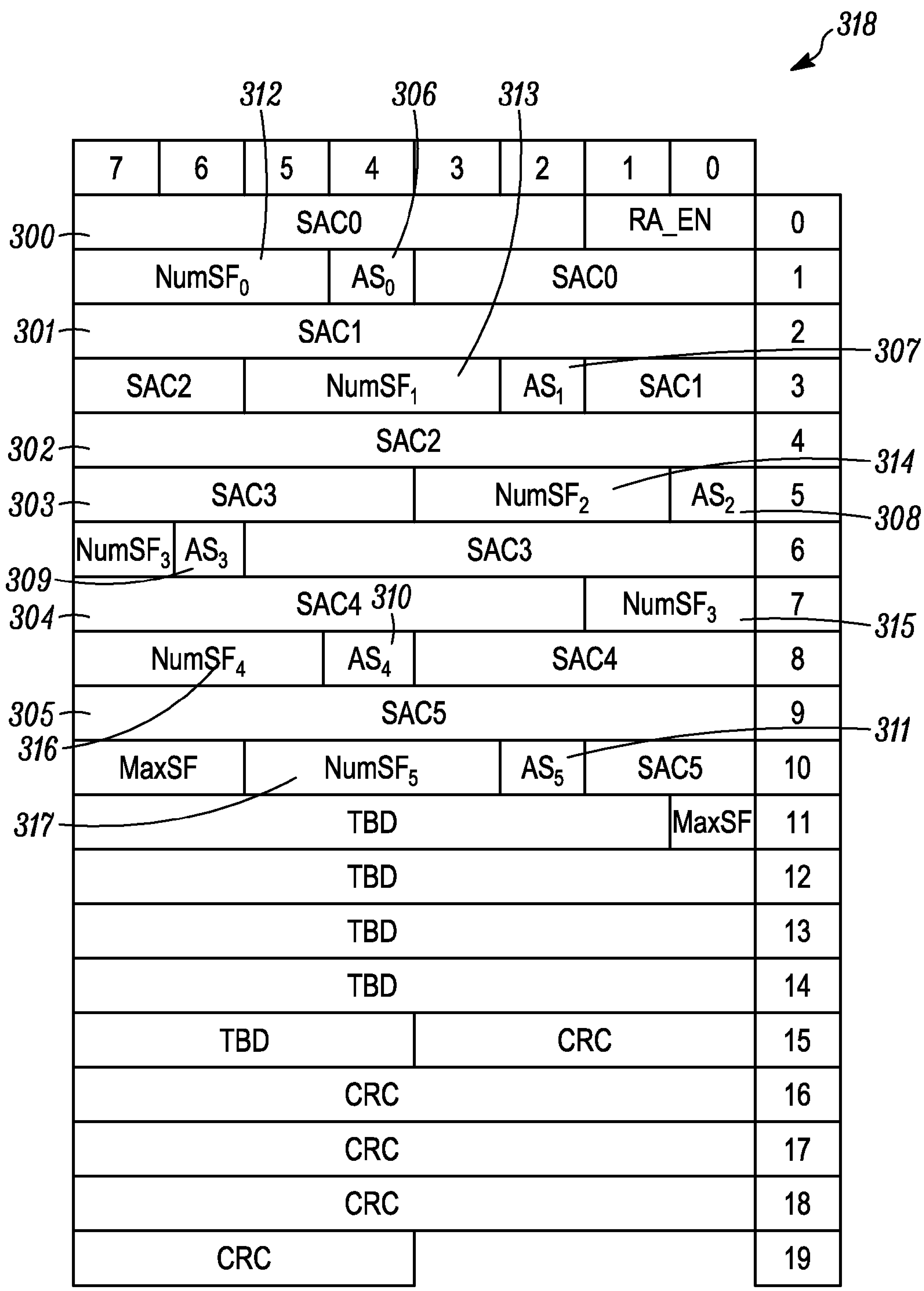

318
312
306
313
7 6 5 4 3 2 1 0
300
SAC0
RA_EN
0
NumSF0
AS0
SAC0
1
301
SAC1
2
307
SAC2
NumSF1
AS1
SAC1
3
302
SAC2
4
314
303
SAC3
NumSF2
AS2
5
308
NumSF3
AS3
SAC3
6
309
304
SAC4
310
NumSF3
7
315
NumSF4
AS4
SAC4
8
305
SAC5
9
316
311
MaxSF
NumSF5
AS5
SAC5
10
317
TBD
MaxSF
11
TBD
12
TBD
13
TBD
14
TBD
CRC
15
CRC
16
CRC
17
CRC
18
CRC
19

FIG. 3

SAC FIELD	INBOUND SLOT ASSIGNED WHEN SAC APPEARS IN FIRST INBOUND RESERVATION SLOT 216A	INBOUND SLOT ASSIGNED WHEN SAC APPEARS IN SECOND INBOUND RESERVATION SLOT 218A
300	205A	206A
301	207A	208A
302	209A	210A
303	211A	213A
304	212A	202B
305	203B	204B

220 221

FIG. 4

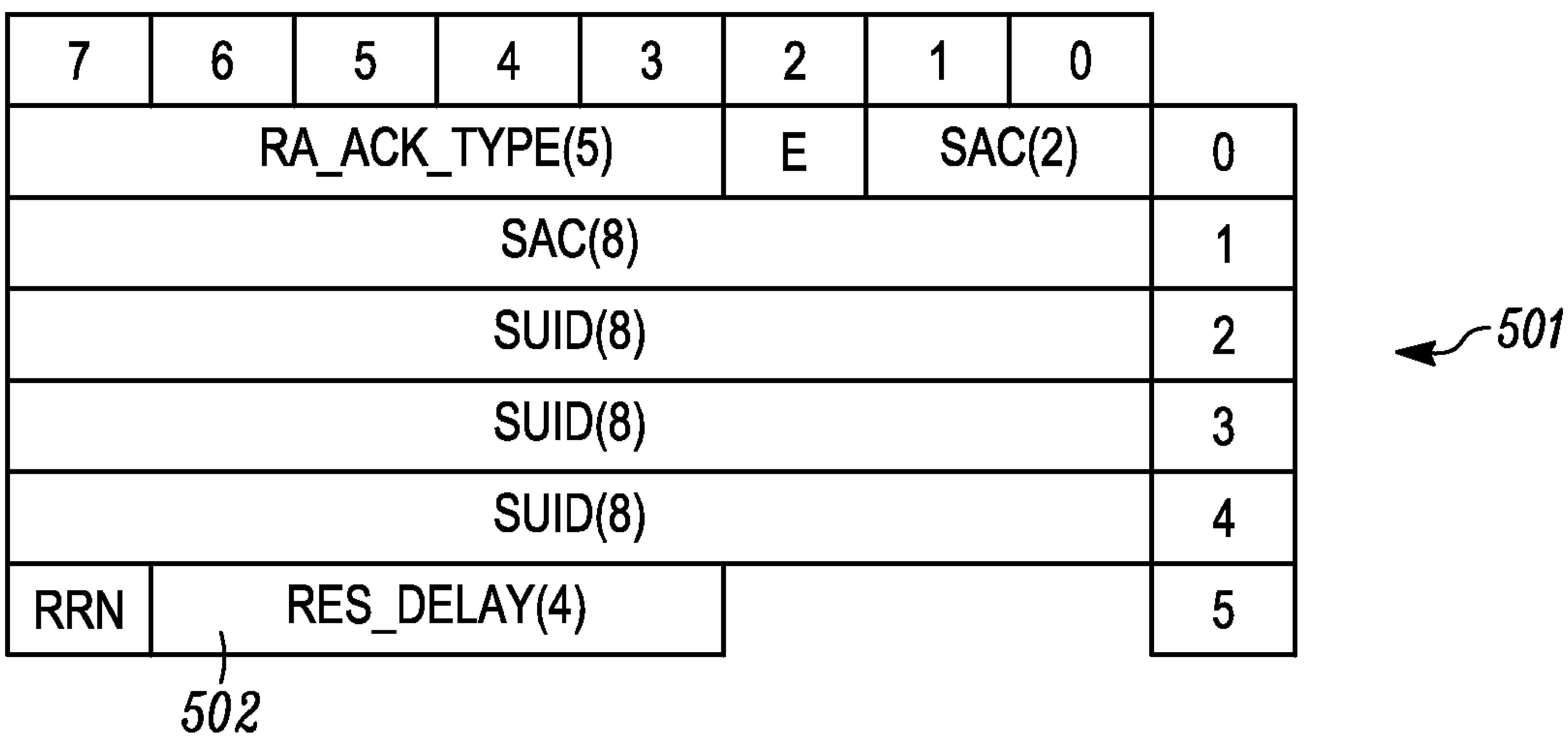

7
6
5
4
3
2
1
0
RA_ACK_TYPE(5)
E
SAC(2)
0
SAC(8)
1
SUID(8)
2
SUID(8)
3
SUID(8)
4
RRN
RES_DELAY(4)
5
501
502

FIG. 5

METHOD AND SYSTEM FOR ASSIGNING SLOT RESERVATIONS TO SUBSCRIBER RADIOS IN A TELECOMMUNICATIONS SYSTEM

FIELD OF THE DISCLOSURE

The present disclosure relates generally to telecommunications systems and more particularly to a method of assigning transmission slot reservations to subscriber radios in a telecommunications system.

BACKGROUND

Time division multiple access (TDMA) communications systems and associated methods are commonly utilized for two-way radio communications between a base station and subscriber radios. These systems and methods utilize multiple superframes of data divided into a plurality of inbound slots for subscriber radios to transmit data to the base station. The inbound slots may further be differentiated into multiple logical channels.

However, contemporary TDMA systems and associated methods have various inefficiencies. For instance, the assigning of the inbound slots to the subscriber radios has been rudimentary. Specifically, in conventional trunked radio systems, a single inbound slot is assigned to a subscriber radio in a single superframe.

Accordingly, there is a need for an improved system and method that overcomes the deficiencies of existing TDMA systems.

BRIEF DESCRIPTION OF THE FIGURES

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.

FIG. **1** is a block diagram of a communication system **100** in accordance with some embodiments.

FIG. **2** is a graphical representation of inbound and outbound slot sequences of a plurality of superframes in accordance with some embodiments.

FIG. **3** is a graphical representation of an inbound reservation scheduling slot in accordance with some embodiments.

FIG. **4** is a chart showing the inbound transmission slots associated with the reservation scheduling slots of one superframe in accordance with some embodiments.

FIG. **5** is a graphical representation of a reservation request response in accordance with some embodiments.

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.

The system 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

A method of assigning slot reservations to subscriber radios in a time division multiple access (TDMA) communications system is described herein. Transmission of data in the system is arranged into a series of superframes. The method includes providing an inbound signaling protocol transported in a plurality of inbound transmission slots. The method also includes providing an outbound signaling protocol. The outbound signaling protocol includes an inbound reservation scheduling message, which includes a plurality of subscriber access code fields. Each subscriber access code field corresponds to at least one of the plurality of inbound transmission slots. Each subscriber access code field is also able to store a subscriber access code associated with a subscriber radio. The method further includes transmitting the inbound reservation scheduling message within an inbound reservation scheduling slot. The inbound reservation scheduling message includes a subscriber access code in at least one of the subscriber access code fields. As such, the subscriber radio associated with the subscriber access code may transmit data during the at least one of the inbound transmission slots corresponding to the subscriber access code field in which the subscriber access code is stored.

A method of operating a time division multiple access (TDMA) communications system is also described herein. The system includes a base station and at least one subscriber radio. Encoded data is mapped to a protocol, i.e., a message format, and the protocol is mapped to a plurality of TDMA time slots. The TDMA time slots are then arranged into a series of superframes. The method includes receiving data in accordance with an inbound signaling protocol transported in a plurality of inbound transmission slots. The method further includes transmitting data in accordance with an outbound signaling protocol. The outbound signaling protocol includes an inbound reservation scheduling message, wherein the inbound reservation scheduling message includes a plurality of subscriber access code fields. Each subscriber access code field corresponds to at least one of the plurality of inbound transmission slots. Each subscriber access code field is able to store a subscriber access code associated with a subscriber radio. The method further includes transmitting the inbound reservation scheduling message within an inbound reservation scheduling slot. The inbound reservation scheduling message includes a subscriber access code in at least one of the subscriber access code fields. As such, the subscriber radio associated with the subscriber access code may transmit data during the at least one of the inbound transmission slots corresponding to the subscriber access code field in which the subscriber access code is stored.

The TDMA communications system is also described herein. Transmission of data in the system is arranged into a series of superframes. The system includes a controller capable of receiving an inbound signaling protocol transported in a plurality of inbound transmission slots. The controller is also capable of providing an outbound signaling protocol having an inbound reservation scheduling message. The inbound reservation scheduling message includes a plurality of subscriber access code fields. Each subscriber access code field corresponds to at least one of the plurality of inbound transmission slots. Each subscriber access code field is able to store a subscriber access code associated with a subscriber radio. The system also includes a transmitter in communication with the controller for transmitting inbound reservation scheduling messages within an inbound reservation scheduling slot. The inbound reservation scheduling message includes a subscriber access code in at least one of the subscriber access code fields. As such, the subscriber radio associated with the subscriber access code may transmit data during the at least one of the inbound transmission slots corresponding to the subscriber access code field in which the subscriber access code is stored.

FIG. **1** is a block diagram of the system **100** according to one embodiment. The system **100** includes at least one base station **102** and at least one subscriber radio **104**. In FIG. **1**, the system is shown with a single base station **102** and a plurality of subscriber radios **104**. However, the system **100** may include any number of base stations **102** and subscriber radios **104**, as readily appreciated by those skilled in the art.

The system **100** of the illustrated embodiment uses a frequency domain duplex ("FDD") configuration, i.e., the system **100** utilizes at least one inbound frequency and at least one outbound frequency. More specifically, the system **100** of the illustrated embodiment utilizes a FDD control channel, a plurality of FDD voice channels, and a plurality of FDD data channels. That is, the system **100** utilizes two frequencies for the control channel, two frequencies for each voice channel, and two frequencies for each data channel. Of course, any number of control channels, voice channels, and/or data channels may be utilized. The data channel of the illustrated embodiment is referred to as an enhanced data capacity ("EDC") channel. Furthermore, those skilled in the art recognize that digital encoding for "data" may be utilized on each control channel, voice channel, and/or data channel. Also, in the illustrated embodiment, the control channel, the voice channels, and the data channels are synchronized to a common clock (not shown).

The base station **102** of the illustrated embodiment is full-duplex, i.e., the base station may transmit on one frequency and receive on another frequency simultaneously. The subscriber radios **104** of the illustrated embodiment are half-duplex, i.e., the subscriber radios **104** cannot transmit and receive at the same time. Of course, in other embodiments, the duplexing of the base station **102** and/or subscriber radios **104** may be different.

The base station **102** includes a transmitter **106** and a receiver **108**. The transmitter **106** and receiver **108** may be combined together as a transceiver (not shown) as is well appreciated by those skilled in the art. The transmitter **106** is capable of transmitting at least one radio frequency (RF) signal **110** and the receiver **108** is capable of receiving at least one RF signal **112**. Likewise, each subscriber radio **104** also includes a transmitter (not shown) and a receiver (not shown), which may be combined as a transceiver. The transmitter and receiver of the subscriber radios **104** are also capable of transmitting and receiving RF signals **112**, **110**.

Digital data (not shown) may be encoded on the RF signals **110**, **112**. In the illustrated embodiment, data is encoded using TDMA techniques well known to those skilled in the art. However, in other embodiments, other techniques may be used to encode the data, as appreciated by those skilled in the art. These techniques include, but are certainly not limited to, frequency division multiple access (FDMA) techniques and code division multiple access (CDMA) techniques. The base station **102** also includes at least one antenna (not numbered) electrically connected to the transmitter **106** and/or the receiver **108** for transmitting and/or receiving RF signals **110**, **112**. Of course, the subscriber radios **104** also include at least one antenna (not numbered) electrically connected to the transmitter and/or receiver for transmitting and/or receiving RF signals **110**, **112**.

The transmitter **106** and receiver **108** are in communication with the controller **114**. As such, the controller **114** may provide the data to be transmitted via the RF signal **110** to the transmitter **106**. Similarly, the controller **114** may receive the data received via the RF signal **112** from the receiver **108**. The controller **114** may include one or more microprocessors (not shown) or other computing devices capable of executing instructions and/or storing data as is appreciated by those skilled in the art. Furthermore, the controller **114** of the illustrated embodiment is capable of executing the steps of the methods described herein. The controller **114** may be implemented as part of the base station **102** or may be remote from the base station **102**. Furthermore, the controller **114** may be in communication with multiple transmitters **106** and/or receivers **108** of multiple base stations **102**.

In the illustrated embodiment, each subscriber unit **104** may tune its receiver to receive an RF signal being transmitted by the base station **102** on the control channel. This RF signal encodes information including, but not limited to, the frequencies of the voice and EDC channels, which voice and EDC channels are in use, and/or which voice and EDC channels are available. Based on this information, the subscriber unit **104** may then tune its transmitter and/or receiver to other voice or EDC channels (i.e., frequencies). Of course, each subscriber unit **104** may return to tune its receiver to the control channel at various times to check for announcements or group calls relevant to the subscriber unit **104**.

Protocols, methods, and operation of the at least one EDC channel of the illustrated embodiment is described in greater detail below. However, those skilled in the art appreciate that these teachings may be applied to other channels and or different systems not specifically described herein.

Transmission of data between the base station **102** and the subscriber radios **104** on the at least one EDC channel is arranged into a series of superframes. Specifically, FIG. **2** shows a first superframe **200**A, a second superframe **200**B, and a third superframe **200**C. However, those skilled in the art realize that superframes of data are continuously transmitted, and the three superframes **200**A, **200**B, **200**C are for exemplary purposes only.

The method may be implemented using the embodiment of the system **100** described herein. However, the method as set forth above and in the claims may be implemented using other systems and embodiments than those specifically recited herein.

As stated above, the method includes providing an inbound signaling protocol (not numbered). The inbound signaling protocol of the illustrated embodiment is transported within inbound random access slots (not shown) and inbound reserved access slots **201**, as shown in FIG. **2**. A subscriber radio **104** may transmit during an inbound random access slot. Furthermore, the assigning of one or more of the inbound reserved access slots **201** to a subscriber radio **104** is achieved by that subscriber radio **104** making a request in one of the inbound random access slots, as described in greater detail below.

The term "slot" as used herein refers generally to a time period dedicated to a specific burst transmission of energy which signals a message, address, protocol, data, voice, media, etc. However the term "slot" may ubiquitously refer to that actual specific transmission of energy which signals a message, address, protocol, data, voice, media, etc. which occurs within that specific time period.

The inbound reserved access slots **201** are referred to hereafter as simply the inbound transmission slots **201**. The inbound transmission slots **201** of the EDC channels may accommodate data, voice, or simultaneous voice and data.

In the illustrated embodiment, there are twelve inbound transmission slots **202**-**213** in each superframe numbered consecutively from a first inbound transmission slot **202** to a twelfth inbound transmission slot **213**. Each inbound transmission slot **202-213** defines a time period at which subscriber radios **104** may transmit to the base station **102**. In the illustrated embodiment, the inbound signaling protocol may be referred to as an inbound media access control ("MAC") layer protocol.

The inbound transmission slots **202-213** may be labeled in the figures and herein with a suffix matching the suffix of the superframe. For example, the inbound transmission slots **202-213** of the first superframe **200**A are labeled from **202**A-**213**A in FIG. **2**.

The inbound transmission slots **201** which transport the inbound signaling protocol may be associated with either a first logical channel **220** or a second logical channel **221**. In the illustrated embodiment, some of the inbound transmission slots **202-213** are associated with the first logical channel **220** and some are associated with the second logical channel **221**. Specifically, inbound transmission slots **203**, **205**, **207**, **209**, **211**, **212** are associated with the first logical channel **220** and inbound transmission slots **202**, **204**, **206**, **208**, **210**, **213** are associated with the second logical channel **221**.

The logical channels **220**, **221** may be differentiated by the type of data that the corresponding inbound transmission slots **202-213** carry. For example, the first logical channel **220** may carry voice data while the second logical channel **221** may carry other data.

The method also includes providing an outbound signaling protocol (not numbered). In the illustrated embodiment, the outbound signaling protocol may be referred to as an outbound MAC layer protocol. The outbound signaling protocol of the illustrated embodiment is transported in outbound transmission slots **214** as shown in FIG. **2**. The outbound transmission slots **214** which transport the outbound signaling protocol may also be associated with either the first logical channel **220** or the second logical channel **221**.

The outbound transmission slots **214** include at least one inbound reservation scheduling slot **216**, **218**. For example, in the illustrated embodiment, each superframe **200**A, **200**B, **200**C includes a first inbound reservation scheduling slot **216**A, **216**B, **216**C and a second inbound reservation scheduling slot **218**A, **218**B, **218**C.

In the illustrated embodiment, each first inbound reservation scheduling slot **216** carries an inbound reservation schedule for the first logical channel **220** of part the current superframe and part of the next superframe. Furthermore, each second inbound reservation scheduling slot **218** carries an inbound reservation schedule for the second logical channel **221** of part of the current superframe and part of the next superframe. As such, and for example, in the first superframe **200**A, the first inbound reservation scheduling slot **216**A carries the reservation schedule for the first logical channel **220** of part of the first superframe **200**A and part of the second superframe **200**B. Similarly, the second inbound reservation scheduling slot **218**A carries the reservation schedule for the second logical channel **221** of part the first superframe **200**A and part of the second superframe **200**B.

In an alternative embodiment, in which a full-duplex subscriber radio **104** is utilized, each first inbound reservation scheduling slot **216** carries a reservation schedule for the first logical channel **220** of the current superframe and each second inbound reservation scheduling slot **218** carries a reservation schedule for the second logical channel **221** of the current superframe. As such, in the first superframe **200**A, the first inbound reservation scheduling slot **216**A and the second inbound reservation scheduling slot **218**A carry the reservation schedule for the first logical channel **220** and the second logical channel **221**, respectively, of the first superframe **200**A

Referring now to FIG. **3**, an inbound reservation schedule is signaled using an inbound reservation scheduling message **318** transported in an inbound reservation scheduling slot **216**, **218**. Each inbound reservation scheduling message **318** includes a plurality of subscriber access code fields **300**, **301**, **302**, **303**, **304**, **305**. Each subscriber access code field **300-305** is able to store a subscriber access code (not shown) associated with a subscriber radio **104**. A subscriber access code is a temporary address used to identify each subscriber radio **104**. The subscriber access codes fields **300-305** in the illustrated embodiment are each 10-bits in length to accommodate subscriber access codes up to 10 bits. However, other lengths for the subscriber access codes and subscriber access code fields **300-305** may be utilized in other embodiments. The subscriber access code is assigned by the base station **102** in response to a request from the subscriber radio **104** in one of the inbound random access slots. The request for the subscriber radio **104** may utilize a full 24-bit, 32-bit, or larger subscriber address. The smaller (e.g., 10-bit) subscriber access code is utilized to conserve message bits during the life of the reservation. The base station **102** maps the full subscriber address to the assigned subscriber access code such that each subscriber radio **104** identifies which subscriber access code has been assigned to it. This mapping of full subscriber address to subscriber access code serves as an acknowledgement that the subscriber's reservation request on the random access channel was received by the base station **102**. Using the smaller subscriber access code, instead of the full subscriber address, frees up more bits which can then be dedicated to transporting payload media or other supporting signaling on either or both the inbound and outbound EDC channel. Payload throughput conservation is especially vital for a narrowband, low rate system, because the bit rate is constrained.

In the illustrated embodiment, each inbound reservation scheduling message **318** includes a first subscriber access code field **300**, a second subscriber access code field **301**, a third subscriber access code field **302**, a fourth subscriber access code field **303**, a fifth subscriber access code field **304**, and a sixth subscriber access code field **305**. Each subscriber access code field **300-305** corresponds to at least one of the plurality of inbound transmission slots **202-213**.

In the illustrated embodiment, at least one of the subscriber access code fields **300-305** corresponds to one of the inbound transmission slots **202-213** in the current superframe.

Also, at least one of the subscriber access code fields **300-305** corresponds to one of the inbound transmission slots **202-213** in the next superframe. For example, when the inbound reservation scheduling message **318** is transported in inbound reservation scheduling slot **216**A, **218**A in the first superframe **200**A, at least one of the subscriber access code fields **300-305** corresponds to one of the inbound transmission slots **202**B, **203**B, **204**B in the second superframe **200**B. Likewise, when the inbound reservation scheduling message **318** is transported in the inbound reservation scheduling slot **216**B, **218**B in the second superframe **200**B, at least one of the subscriber access code fields **300-305** corresponds to one of the inbound transmission slots **202**C, **203**C, **204**C in the third superframe **200**C.

More specifically, FIG. **4** shows a table detailing the inbound transmission slots **203-213** associated with the subscriber access code fields **300-305** of the inbound reservation scheduling message **318** for the illustrated embodiment. The left column lists the various subscriber access code fields

300-305. The middle column represents the inbound transmission slots **205**A, **207**A, **209**A, **211**A, **212**A, **203**B that are assigned when a subscriber access code appears in the various subscriber access code fields **300-305** of the inbound reservation scheduling message **318** transported in the first inbound reservation scheduling slot **216**A. The inbound transmission slots **205**A, **207**A, **209**A, **211**A, **212**A, **203**B of the middle column are associated with the first logical channel **220**. Similarly, the right column represents the inbound transmission slots **206**A, **208**A, **210**A, **213**A, **202**B, **204**B that are assigned when a subscriber access code appears in the various subscriber access code fields **300-305** of the inbound reservation scheduling message **318** transported in the second inbound reservation scheduling slot **218**A. The inbound transmission slots **206**A, **208**A, **210**A, **213**A, **202**B, **204**B of the right column are associated with the second logical channel **221**.

For example, if a subscriber access code of a subscriber radio **104** appears in the third subscriber access code field **302** of the inbound reservation scheduling message **318** transported in the first inbound reservation scheduling slot **216**A of the first superframe **200**A, then the subscriber radio **104** associated with that subscriber access code may transmit during the eighth inbound transmission slot **209**A during the first superframe **200**A, i.e., the current superframe. As another example, if a subscriber access code of a subscriber radio **104** appears in subscriber access code field **305** of the inbound reservation scheduling message **318** transported in the second inbound reservation scheduling slot **218**A of the first superframe **200**A, then the subscriber radio **104** associated with that subscriber access code may transmit during the third inbound transmission slot **204**B of the second superframe **200**B, i.e., the next superframe.

Each inbound reservation scheduling message **318** may also include an adjacent slot bit **306-311** associated with each subscriber access code field **300-305**. Specifically, a first adjacent slot bit **306** is associated with the first subscriber access code field **300**, a second adjacent slot bit **307** is associated with the second subscriber access code field **301**, a third adjacent slot bit **308** is associated with the third subscriber access code field **302**, a fourth adjacent slot bit **309** is associated with the fourth subscriber access code field **303**, a fifth adjacent slot bit **310** is associated with the fifth subscriber access code field **304**, and a sixth adjacent slot bit **311** is associated with the sixth subscriber access code field **305**.

In the illustrated embodiment, the adjacent slot bit indicates whether the subscriber radio **104** may also transmit data during the inbound transmission slot **202-213** immediately adjacent to the inbound transmission slot **202-213** corresponding with the subscriber access code field **300-305**. The adjacent inbound transmission slot **202-213** may be immediately preceding or following the inbound transmission slot **202-213** corresponding with the subscriber access code field **300-305**, dependent on whether the inbound transmission slot **202-213** is scheduled in the first or second inbound reservation scheduling slot **216**, **218**.

For example, when a subscriber access code of a subscriber radio **104** is stored in the first subscriber access code field **300** and the first adjacent slot bit **306** is set, then that subscriber radio **104** may transmit during the fourth inbound transmission slot **205** and the fifth inbound transmission slot **206** when the inbound reservation scheduling message **318** is transported in the first inbound reservation scheduling slot **216**. Similarly, when a subscriber access code of a subscriber radio **104** is stored in the first subscriber access code field **300** and the first adjacent slot bit **306** is set, then that subscriber radio **104** may transmit during the fourth inbound transmission slot **205** and the fifth inbound transmission slot **206** when the inbound reservation scheduling message **318** is transported in the second inbound reservation scheduling slot **218**.

Of course, the prior examples are illustrative of only when the subscriber access code is stored in the first subscriber access code field **300**. It follows that when other subscriber access code fields **301-305** are utilized in concert with the other associated adjacent slot bits **307-311**, the adjacent inbound transmission slots utilized will differ from those described in the previous examples. As such, the subscriber radio **104**, of the previous example, may transmit during the third inbound transmission slot **204** and the fourth inbound transmission slot **205** or the fifth inbound transmission slot **206** and the sixth inbound transmission slot **207** depending on whether the inbound reservation scheduling message **318** is transported in the first or second inbound reservation scheduling slot **216**, **218**.

In an alternative embodiment, the adjacent slot bit may indicate whether the subscriber radio **104** may also transmit data during multiple inbound transmission slots **202-213** immediately adjacent to the inbound transmission slot **202-213** corresponding with the subscriber access code field **300-305**. For example, when a subscriber access code of a subscriber radio **104** is stored in the first subscriber access code field **300** and the first adjacent slot bit **306** is set, then that subscriber radio **104** may transmit during the third, fourth and fifth inbound transmission slots **204-206** when the inbound reservation scheduling message **318** is transported in the first inbound reservation scheduling slot **216**. Similarly, when a subscriber access code of a subscriber radio **104** is stored in the first subscriber access code field **300** and the first adjacent slot bit **306** is set, then that subscriber radio **104** may transmit during the fourth, fifth and sixth inbound transmission slots **205-207** when the inbound reservation scheduling message **318** is transported in the second inbound reservation scheduling slot **218**.

In yet another embodiment, the adjacent slot bit may indicate whether the subscriber radio **104** may also transmit data during one or more inbound transmission slots **202-213** that are not immediately adjacent to the inbound transmission slot **202-213** corresponding with the subscriber access code field **300-305**.

By utilizing the adjacent slot bits **306-311**, the disclosed system **100** and methods allow for multiple inbound transmission slot **202-213** assignments without repeating the subscriber access code over multiple subscriber access code fields **300-305**.

Each inbound reservation scheduling message **318** may further include number of superframes fields **312-317**. Each number of superframes field **312-317** is associated with one of the subscriber access code fields **300-305**. Specifically, in the illustrated embodiment, a first number of superframes field **312** is associated with the first subscriber access code field **300**, a second number of superframes field **313** is associated with the second subscriber access code field **301**, a third number of superframes field **314** is associated with the third subscriber access code field **302**, a fourth number of superframes field **315** is associated with the fourth subscriber access code field **303**, a fifth number of superframes field **316** is associated with the fifth subscriber access code field **304**, and a sixth number of superframes field **317** is associated with the sixth subscriber access code field **305**.

Each number of superframes field **312-317** indicates a number of superframes for which the inbound transmission slot may be utilized by the subscriber radio **104** associated with the subscriber access code field **300-305**. For example, when a subscriber access code of a subscriber radio **104** is stored in the third subscriber access code field **302** of the inbound reservation scheduling message **318** transported in the first inbound reservation scheduling slot **216**A of the first superframe **200**A, and the number "3" is stored in the third number of superframes field **314**, then the subscriber radio **104** may transmit during the eighth inbound slots **209**A, **209**B, **209**C of the first, second, and third superframes **300**A, **300**B, **300**C.

By utilizing the number of superframes field **312-317**, the system **100** and method may assign multiple inbound transmission slots **202-213** in one data burst from the base station. As such, the subscriber radio **104** may utilize the assigned inbound transmission slot **202-213**, even if future assignments from the base station are missed by the subscriber radio **104**.

In the illustrated embodiment, each number of superframes field **312-317** has a length of three bits. As such, up to eight consecutive superframes may be authorized for the subscriber radio **104** to transmit during the associated inbound slot **202-213**. Of course, in other embodiments, the length of the number of superframes fields **312-317** may be longer or shorter.

As briefly discussed above, a subscriber radio **104** may transmit during an inbound random access slot to begin the process of reserving inbound reserved access slots **201**. The base station **102** then transmits at least one reservation request response **501**, as shown in FIG. **5**. The reservation request response **501** of the illustrated embodiment includes a subscriber access code, the full 24-bit subscriber address, and a reservation delay value **502**. The reservation delay value **502** indicates an amount of time that will pass before the slot assignment is sent. Specifically, in the illustrated embodiment, the reservation delay value **502** provides a number of super frames (or number of slots) that will occur before the slot assignment is sent. The reservation delay value **502** is utilized to allow the base station **102** to take into account other subscriber radios **104** requests. The subscriber radio **104**, which now knows how long until the slot assignment is sent, may refresh data or perform other "housekeeping" duties. As an example of a "housekeeping" duty, the subscriber radio **104** may return to the outbound control channel to listen if there is an announcement of a group call relevant to the given subscriber radio **104**. If there is a group voice call relevant to the given subscriber radio **104**, the subscriber radio **104** may tune to the specified voice channel to receive the voice call. Because the EDC channels, voice channels and control channels are synchronized, and because the subscriber radio **104** knows the exact time it must return to the EDC channel for its reservation (i.e., the inbound reservation slot **202-213**) the subscriber radio **104** may stay tuned to the outbound control channel or outbound voice channel and know when to leave the control channel or voice channel to arrive within microseconds of the precise time to transmit on its inbound reservation slot **202-213** on the EDC channel.

Furthermore, if the reservation delay value **502** is greater than or equal to 15 superframes, then the subscriber radio **102** may return to the control channel or make another random access request.

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.

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.

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

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.

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.

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 of assigning slot reservations to subscriber radios in a time division multiple access (TDMA) communications system, wherein transmission of data is arranged into a series of superframes, said method comprising:

providing an inbound signaling protocol transported in a plurality of inbound transmission slots;

providing an outbound signaling protocol having an inbound reservation scheduling message, the inbound reservation scheduling message including a plurality of subscriber access code fields, each subscriber access code field corresponding to a particular one of the plurality of inbound transmission slots, and each subscriber access code field able to store a subscriber access code associated with a subscriber radio; and

transmitting the inbound reservation scheduling message within an inbound reservation scheduling slot including a particular subscriber access code in one or more of the subscriber access code fields such that the subscriber radio associated with the particular subscriber access code may transmit data during the one or more inbound transmission slots corresponding to the one or more subscriber access code fields in which the particular subscriber access code is stored;

wherein the outbound signaling protocol further includes an adjacent slot bit associated with each subscriber access code field indicating whether the subscriber radio may also transmit data during the inbound transmission slot adjacent to the inbound transmission slot corresponding with the subscriber access code field.

2. The method as set forth in claim **1**, wherein at least one of the subscriber access code fields correspond to inbound transmission slots in a current superframe and at least one of the subscriber access code fields correspond to inbound transmission slots in a next superframe, to be transmitted after the current superframe.

3. The method as set forth in claim **1**, further comprising associating the subscriber access code fields of the inbound reservation scheduling message with inbound transmission slots of a first logical channel, the method further comprising transmitting a second inbound reservation scheduling message within a second inbound reservation schedule slot, the second inbound reservation scheduling message associating second subscriber access code fields of the second inbound reservation scheduling message with inbound transmission slots of a second logical channel.

4. The method as set forth in claim **3**, wherein the second inbound reservation scheduling message includes a plurality of second subscriber access code fields, each second subscriber access code field corresponding to a particular one of the plurality of inbound transmission slots of the second logical channel, and each second subscriber access code field able to store a subscriber access code associated with a subscriber radio.

5. The method as set forth in claim **1**, wherein the outbound signaling protocol further includes a superframes field associated with each subscriber access code field indicating a number of superframes for which the inbound transmission slot may be utilized by the subscriber radio associated with the subscriber access code field.

6. The method as set forth in claim **1**, further comprising transmitting a reservation delay value prior to transmitting the inbound reservation scheduling message, the reservation delay value indicating an amount of time that will pass before the inbound reservation scheduling message is transmitted.

7. A method of operating a time division multiple access (TDMA) communications system having a base station and at least one subscriber radio, wherein encoded data is arranged into a series of superframes, said method comprising:

receiving data in accordance with an inbound signaling protocol transported in a plurality of inbound transmission slots;

transmitting data in accordance with an outbound signaling protocol having an inbound reservation scheduling message, the inbound reservation scheduling message including a plurality of subscriber access code fields, each subscriber access code field corresponding to a particular one of the plurality of inbound transmission slots, and each subscriber access code field able to store a subscriber access code associated with a subscriber radio; and

transmitting the inbound reservation scheduling message during an inbound reservation scheduling slot including a particular subscriber access code in one or more of the subscriber access code fields such that the subscriber radio associated with the particular subscriber access code may transmit data during the one or more inbound transmission slots corresponding to the one or more subscriber access code fields in which the particular subscriber access code is stored;

wherein the outbound signaling protocol further includes an adjacent slot bit associated with each subscriber access code field indicating whether the subscriber radio may also transmit data during the inbound transmission slot adjacent to the inbound transmission slot corresponding with the subscriber access code field.

8. The method as set forth in claim **7**, wherein at least one of the subscriber access code fields correspond to inbound transmission slots in a first superframe and at least one of the subscriber access code fields correspond to inbound transmission slots in a second superframe, to be transmitted after the first superframe.

9. The method as set forth in claim **7**, further comprising associating the subscriber access code fields of the inbound reservation scheduling message with inbound transmission slots of a first logical channel, the method further comprising transmitting a second inbound reservation scheduling message within a second inbound reservation schedule slot, the second inbound reservation scheduling message associating second subscriber access code fields of the second inbound reservation scheduling message with inbound transmission slots of a second logical channel.

10. The method as set forth in claim **9**, wherein the second inbound reservation scheduling message includes a plurality of second subscriber access code fields, each second subscriber access code field corresponding to a particular one of the plurality of inbound transmission slots of the second logical channel, and each second subscriber access code field able to store a subscriber access code associated with a subscriber radio.

11. A time division multiple access (TDMA) communications system wherein transmission of data is arranged into a series of superframes, said system comprising:

a controller capable of receiving an inbound signaling protocol transported in a plurality of inbound transmission slots and providing an outbound signaling protocol having an inbound reservation scheduling message, the inbound reservation scheduling message including a plurality of subscriber access code fields, each subscriber access code field corresponding to a particular one of the plurality of inbound transmission slots, and each subscriber access code field able to store a subscriber access code associated with a subscriber radio; and

a transmitter in communication with said controller for transmitting the inbound reservation scheduling message during an inbound reservation scheduling slot including a particular subscriber access code in one or more of the subscriber access code fields such that the subscriber radio associated with the particular subscriber access code may transmit data during the one or more inbound transmission slots corresponding to the one or more subscriber access code fields in which the particular subscriber access code is stored;

wherein the subscriber access code Melds of the inbound reservation scheduling message are associated with inbound transmission slots of a first logical channel, the controller further capable of receiving a second inbound reservation scheduling message within a second inbound reservation schedule slot, the second inbound reservation scheduling message associating second subscriber access code fields of the second inbound reservation scheduling message with inbound transmission slots of a second logical channel;

wherein the outbound signaling protocol further includes an adjacent slot bit associated with each subscriber access code field indicating whether the subscriber radio may also transmit data during the inbound transmission slot adjacent to the inbound transmission slot corresponding with the subscriber access code field.

12. The system as set forth in claim **11**, wherein at least one of the subscriber access code fields correspond to inbound transmission slots in a current superframe and at least one of the subscriber access code fields correspond to inbound transmission slots in a next superframe, to be transmitted after the current superframe.

13. The system as set forth in claim **11**, wherein the second inbound reservation scheduling message includes a plurality of second subscriber access code fields, each second subscriber access code field corresponding to a particular one of the plurality of inbound transmission slots of the second logical channel, and each second subscriber access code field able to store a subscriber access code associated with the subscriber radio.

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