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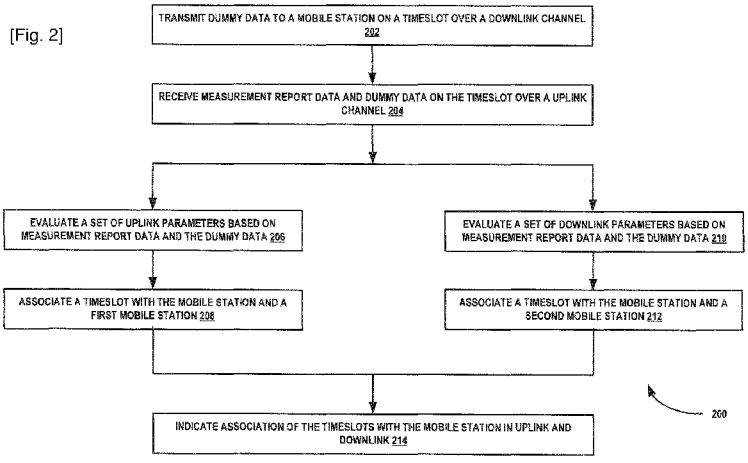
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(54) **Title**: METHOD AND SYSTEM OF ALLOCATING TIMESLOTS IN AN MULTIPLE USERS REUSING ONE TIMESLOT (MUROS) ENVIRONMENT

[Fig. 2]



(57) **Abstract**: The present invention provides a method and system of allocating timeslots in a multiple users reusing one timeslot (MUROS) environment. In one embodiment, a method includes receiving measurement report data from a first mobile station over an uplink channel. The method further includes evaluating a set of parameters associated with pairing the first mobile station in uplink and downlink respectively based on the measurement report data. The method also includes associating a timeslot in a frame between the first mobile station and a second set of mobile stations for uplink data transmission and associating another timeslot in the frame between the first mobile station and a third set of mobile stations for downlink data transmission using the evaluated set of parameters.

WO 2011/142613 A2

Description

Title of Invention: METHOD AND SYSTEM OF ALLOCATING TIMESLOTS IN AN MULTIPLE USERS REUSING ONE TIMESLOT (MUROS) ENVIRONMENT

Technical Field

[1] The present invention relates to the field of wireless communication, and more particularly relates to allocating timeslots in a multiple users reusing single time slot (MUROS) environment.

Background Art

[2] With the recent advancement in digital mobile communication systems, various approaches have been developed to allow multiple communication devices to reuse a single timeslot in a frame, referred to as Multiple Users Reusing One Slot (MUROS) technology. For example, MUROS technology allows pairing of two or more communication devices (e.g., up to four) to use one single timeslot to transmit or receive voice signals in the GSM, GPRS, EDGE wireless systems. Theoretically, MUROS technology enhances a cell capacity through pairing two or more communication devices onto a single timeslot. For example, MUROS can at least double voice capacity of the wireless network without requiring additional transmit and receive radio resources (TRX).

[3] The communication devices in the cell should be paired onto a single timeslot in such a way that link quality of any one of the paired communication devices does not see a drastic degradation. For example, if upon pairing, the link quality sees a sudden degradation, then calls associated with the paired communication devices may get dropped. The link quality of the communication devices that are paired mainly depends on bit error rate (BER) and signal to noise (SNR) characteristics of the communication devices.

[4] MUROS capable mobile terminals typically see different interference profiles in uplink and downlink.

Disclosure of Invention

Technical Problem

[5] As such, the uplink and downlink pairing scenarios are required to be considered separately as the mobile terminals see different interference profiles.

Solution to Problem

[6] A method of a base station for allocating timeslots in an uplink channel and a downlink channel in a multiple users reusing one timeslot (MUROS) environment,

comprising:

[7] receiving measurement data from a first mobile station over a uplink channel;

[8] evaluating a set of parameters associated with pairing the first mobile station in uplink and downlink respectively based on the measurement data; and

[9] associating a timeslot in a frame between the first mobile station and a second set of mobile stations for uplink data transmission and associating another timeslot in the frame between the first mobile station and a third set of mobile stations for downlink data transmission using the evaluated set of parameters.

[10] An apparatus comprising:

[11] a processor; and

[12] memory coupled to the processor and configured to temporarily store instructions, that when executed by the processor, cause the processor to perform a method comprising:

[13] receiving measurement report data from a first mobile station over a uplink channel;

[14] evaluating a set of parameters associated with pairing the first mobile station in uplink and downlink respectively based on the measurement report data; and

[15] associating a timeslot in a frame between the first mobile station and a second set of mobile stations for uplink data transmission and associating another timeslot in the frame between the first mobile station and a third set of mobile stations for downlink data transmission using the evaluated set of parameters.

Brief Description of Drawings

[16] Figure 1 is a block diagram illustrating a multiple users reusing one timeslot (MUROS) environment implementing independent pairing of uplink and downlink channels, according to one embodiment.

[17] Figure 2 is a process flowchart illustrating an exemplary method of allocating timeslots in uplink and downlink in the MUROS environment, according to one embodiment.

[18] Figure 3 is a block diagram of the base station showing various components for implementing embodiments of the present subject matter.

Mode for the Invention

[19] The present invention provides a method and system for allocating timeslots in a multiple users reusing one timeslot (MUROS) environment. In the following detailed description of the embodiments of the invention, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and

that changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

[20] Figure 1 is a block diagram illustrating a MUROS environment 100 implementing independent pairing of uplink and downlink channels, according to one embodiment. In Figure 1, the MUROS environment 100 includes a base station 102, and mobile stations 104A-N connected to the base station 102.

[21] Consider that the mobile station 104A has to be allocated a timeslot in the frame 106. In such case, the base station 102 sends dummy data in the timeslot to the mobile station 104A over a downlink channel. The mobile station 104A, upon receiving the dummy data, monitors the timeslots available in the frame 106 and generates measurement report data. The mobile station 104A sends the dummy data and measurement report data to the base station 102 on the timeslot over an uplink channel. The base station 102 then evaluates downlink pairing criteria and uplink pairing criteria based on the measurement report data and the dummy data. Accordingly, the base station 102 associates a timeslot 108 with the mobile station 104A and the mobile station 104C for downlink data transmission based on downlink pairing criteria. Similarly, the base station 102 associates a timeslot 110 with the mobile station 104A and the mobile station 104B for uplink data transmission based on the uplink pairing criteria. The above process is described in greater detail in Figure 2.

[22] Figure 2 is a process flowchart illustrating an exemplary method of allocating timeslots in uplink and downlink in the MUROS environment 100, according to one embodiment. At step 202, a dummy data is transmitted to a mobile station (e.g., the mobile station 104A) on a timeslot of a frame over a downlink channel. Upon receiving the dummy data, the mobile station 104A monitors one or more timeslots of the frame 106 and generates a measurement report including measurement report data based on monitoring of the timeslots.

[23] At step 204, the measurement report data and the dummy data is received from the mobile station 104A over an uplink channel. At step 206, a set of uplink parameters associated with pairing the uplink channel is evaluated based on the measurement report data and the dummy data. Exemplary uplink parameters (also referred as uplink pairing criteria) may include timing advance, signal-to-noise ratio (SNR), FER, BLER, rank of wireless channel matrix and condition number. At step 208, a timeslot 110 in the frame 106 is associated with the mobile station 104A and the mobile station 104B for uplink data transmission over the uplink channel. For example, the timeslot may be the same or different timeslot on which the dummy data is received in the uplink.

[24] At step 210, a set of downlink parameters associated with pairing the downlink channel is evaluated based on the measurement report data and the dummy data.

Exemplary downlink parameters (also referred as uplink pairing criteria) may include timing advance, signal-to-noise ratio (SNR), FER, and BLER. At step 212, a timeslot 108 in the frame 106 is associated with the mobile station 104A and the mobile station 104C for downlink data transmission over the downlink channel.

[25] It can be noted that, the timeslot in the uplink and the downlink can be the same or different and is selected based on ability of the base station 102 and the mobile station 104A to successfully decode uplink data and downlink data. More importantly, the base station 102 determines a timeslot to be allocated for uplink data transmission on the uplink channel based on its ability to decode the dummy data received from the mobile station 104A along with the measurement report data.

[26] In downlink, individual user's decoding performance depends largely on Sub Channel Power Imbalance Ratio (SCPIR) used (e.g., which may depend on type of user). If incorrect SCPIR is used, interference to either of mobile stations from the other paired mobile stations significantly increases, thereby degrading the performance. Also, it is advisable to consider mobile stations with sufficiently high SNR (at least for a subset of users considered for pairing) so that FER after pairing does not increase beyond the threshold so as to result in eventual call drops.

[27] In uplink, paired mobile stations antennas along with the multiple antennas present at the base station 102 form a spatial multiplexing Multiple Input Multiple Output (MIMO) system. A scenario when two users are considered for pairing is given in the following equation.

[28] MathFigure 1

[Math.1]

$$\begin{bmatrix} y1 \\ y2 \end{bmatrix} = \begin{bmatrix} h11 & h12 \\ h21 & h22 \end{bmatrix} \bullet \begin{bmatrix} x1 \\ x2 \end{bmatrix}$$

[29] where, yi indicates received symbol at the receiving antenna i at the base station 102, $h$ij indicates wireless channel between the i^{th} receiving antenna at the base station102, and the j^{th} user, and xj indicates the transmitted symbol from the j^{th} user.

[30] The performance of such a system depends on the capability of separating and decoding the individual user's streams. This depends on 'Rank' and 'Condition number' of a complex matrix formed by wireless channels ([$h$ij]) between the set of transmitting and receiving antennas along with the SNRs seen. The performance at the base station 102 may improve if users are paired such that the condition number is close to 1 or does not deviate too much from 1. This parameter largely depends on the proximity of the users and the angular separation between the transmitting signals. As the governing parameters which affect the performance are different in downlink and

uplink, the uplink and the downlink parameters separately evaluated at the base station 102.

[31] At step 214, the timeslots allocated for the uplink data transmission and the downlink data transmission are indicated to the mobile station 104A such that the mobile station 104A sends and receives the uplink and downlink data on the allocated timeslots 108 and 110. Also, associated frequency hopping sequence for uplink and downlink separately is indicated to the mobile station 104A. The timeslots may be indicated through an enhanced resource allocation message, a channel configuration message, and a handover command message. Exemplary assignment command message indicating allocation of the timeslot is shown below.

[32] Table 1

[Table 1]

IEI	Information element	Type / Reference	Presence	Format	Length
	RR managementProtocol Discriminator	Protocol Discriminator10.2	M	V	½
	Skip Indicator	Skip Indicator10.3.1	M	V	½
	Assignment commandMessage Type	Message Type10.4	M	V	1
	Description of the First Channel, after time	Channel Description 210.5.2.5a	M	V	3
	Power Command	Power Command10.5.2.28	M	V	1
05	Frequency List, after time	Frequency List10.5.2.13	C	TLV	4-132
62	Cell Channel Description	Cell Channel Description10.5.2.1b	O	TV	17
10	Description of the multislot configuration	Multislot Allocation10.5.2.21b	C	TLV	3-12
63	Mode of the First Channel (Channel Set 1)	Channel Mode10.5.2.6	O	TV	2
11	Mode of Channel Set 2	Channel Mode10.5.2.6	O	TV	2
13	Mode of Channel Set 3	Channel Mode10.5.2.6	O	TV	2
14	Mode of Channel Set 4	Channel Mode10.5.2.6	O	TV	2
15	Mode of Channel Set 5	Channel Mode10.5.2.6	O	TV	2
16	Mode of Channel Set 6	Channel Mode10.5.2.6	O	TV	2
17	Mode of Channel Set 7	Channel Mode10.5.2.6	O	TV	2
18	Mode of Channel Set 8	Channel Mode10.5.2.6	O	TV	2
64	Description of the Second Channel, after time	Channel Description10.5.2.5	O	TV	4
66	Mode of the Second Channel	Channe l Mode 210.5.2.7	O	TV	2
72	Mobile Allocation, after time	Mobile Allocation10.5.2.21	C	TLV	3-10

7C	Starting Time	Starting Time10.5.2.38	O	TV	3
19	Frequency List, before time	Frequency List10.5.2.13	C	TLV	4-132
1C	Description of the First Channel, before time	Channel Description 210.5.2.5a	O	TV	4
1D	Description of the Second Channel, before time	Channel Description10.5.2.5	O	TV	4
1E	Frequency channel sequence before time	Frequency channel sequence10.5.2.12	C	TV	10
21	Mobile Allocation, before time	Mobile Allocation10.5.2.21	C	TLV	3-10
9-	Cipher Mode Setting	Cipher Mode Setting10.5.2.9	O	TV	1
01	VGCS target mode Indication	VGCS target mode Indication10.5.2.42a	O	TLV	3
03	Multi-Rate configuration	MultiRate configuration10.5.2.21aa	O	TLV	4-8
04	VGCS Ciphering Parameters	VGCS Ciphering Parameters10.5.2.42b	O	TLV	3-15
	Description of the UL paired Channel, after time	**Paired UL Channel Description xx**	**M**	**V**	**3**
	Description of the DL paired Channel, after time	**Paired DL Channel Description xx**	**M**	**V**	**3**

[33] Further, exemplary channel description information element is illustrated below table 2 and 3.

[34] Table 2

[Table 2]

Channel type and TDMA offset (octet 2) Bits **8 7 6 5 4**
0 0 0 0 0 TCH/F + FACCH/F and SACCH/M at the timeslot indicated by TN, and additional bidirectional or undirectional TCH/Fs and SACCH/Ms according to the multislot allocation information element
0 0 0 0 1 TCH/F + FACCH/F and SACCH/F
0 0 0 1 T TCH/H + ACCHs
0 0 1 T T SDCCH/4 + SACCH/C4 or CBCH (SDCCH/4)
0 1 T T T SDCCH/8 + SACCH/C8 or CBCH (SDCCH/8)
1 1 0 0 0 TCH/F + ACCHs using TSC Set 2
1 1 1 0 T TCH/H + ACCHs using TSC Set 2
The T bits indicate the subchannel number coded in binary.
In the description below "n" is the timeslot number indicated by TN. The description is valid only if all the indicated timeslot numbers are in the range 0 to 7.
1 0 X X X TCH/F + FACCH/F and SACCH/M at the time slot indicated by TN, and additional bidirectional TCH/Fs and SACCH/Ms at other timeslots according to the following:
X X X: 0 0 0 no additional timeslots 0 0 1 at timeslot n-1 0 1 0 at timeslot n+1, n-1 0 1 1 at timeslot n+1, n-1 and n-2 1 0 0 at timeslot n+1, n-1, n-2, and n-3 1 0 1 at timeslot n+1, n-1, n-2, n-3 and n-4 1 1 0 at timeslot n+1, n-1, n-2, n-3, n-4 and n-5 1 1 1 at timeslot n+1, n-1, n-2, n-3, n-4, n-5 and n-6
1 1 0 0 1 to 1 1 0 1 1 TCH/F + FACCH/F and SACCH/M at the time slot indicated by TN and additional unidirectional TCH/FDs and SACCH/MDs at other timeslots according to the following: 1 1 0 0 1 at timeslot n-1 1 1 0 1 0 at timeslot n+1, n-1 1 1 0 1 1 at timeslot n+1, n-1 and n-2
1 1 1 1 0 TCH/F + FACCH/F and SACCH/M at the time slot indicated by TN and additional bidirectional TCH/F and SACCH/M at timeslot n+1 and unidirectional TCH/FD and SACCH/MD at timeslot n-1
All other values are reserved.

[35] Table 3

[Table 3]

```
TN, Timeslot number (octet 2)
The TN field is coded as the binary representation of
the timeslot number as defined in
3GPP TS 3GPP TS 45.010.

Range: 0 to 7.

TSC, Training Sequence Code (octet 3)
The TSC field is coded as the binary representation of
the Training Sequence code as defined in
3GPP TS 45.002
Unless stated otherwise by coding of 'Channel type and
TDMA offset' IE, TSC Set 1 shall be used.

Range: 0 to 7.

H, Hopping channel (octet 3)
Bit
5
0  Single RF channel
1  RF hopping channel

NOTE: The value of H affects the semantics of the
channel selector field

Channel selector (octet 3 and 4)
H = "0": The channel selector field consists of the
absolute RF channel number

Octet 3
Bits
4 3
0 0Spare

ARFCN, (octet 3, bits 2 and 1, and octet 4, bits 8 to
1)
The ARFCN is coded as the binary representation of the
absolute RF channel number

Range: 0 to 1023

H = "1": The channel selector field consists of the
mobile allocation index offset, MAIO, and the hopping
sequence number, HSN.

MAIO, (octet 3 bit 4 to 1 high part and octet 4 bit 8
to 7 low part)
The MAIO field is coded as the binary representation
of the mobile allocation index offset as defined in
3GPP TS 45.002.

Range: 0 to 63.

HSN, (octet 4 bit 6 to 1)
The HSN field is coded as the binary representation of
the hopping sequence number as defined in
3GPP TS 45.002
Range 0 to 63.
```

[36] The base station can assign the same timeslot in the downlink as well as in the uplink for the new mobile station based on the combined evaluation of downlink and uplink parameters so that it can be paired with the best possible incumbent mobile station.

[37] Figure 3 is a block diagram of the base station 102 showing various components for implementing embodiments of the present subject matter. In Figure 3, the base station

102 includes a processor 302, memory 304, a read only memory (ROM) 306, a transceiver 308, a bus 310, a communication interface 312, a display 314, an input device 316, and a cursor control 318.

[38] The processor 302, as used herein, means any type of computational circuit, such as, but not limited to, a microprocessor, a microcontroller, a complex instruction set computing microprocessor, a reduced instruction set computing microprocessor, a very long instruction word microprocessor, an explicitly parallel instruction computing microprocessor, a graphics processor, a digital signal processor, or any other type of processing circuit. The processor 302 may also include embedded controllers, such as generic or programmable logic devices or arrays, application specific integrated circuits, single-chip computers, smart cards, and the like.

[39] The memory 304 and the ROM 306 may be volatile memory and non-volatile memory. The memory 304 includes instructions temporarily stored therein to

[40] allocate timeslots to a mobile station separately in uplink channel and downlink channel, according to the embodiments of the present subject matter. A variety of computer-readable storage media may be stored in and accessed from the memory elements. Memory elements may include any suitable memory device(s) for storing data and machine-readable instructions, such as read only memory, random access memory, erasable programmable read only memory, electrically erasable programmable read only memory, hard drive, removable media drive for handling memory cards, Memory Sticks™, and the like.

[41] Embodiments of the present subject matter may be implemented in conjunction with modules, including functions, procedures, data structures, and application programs, for performing tasks, or defining abstract data types or low-level hardware contexts. Machine-readable instructions stored on any of the above-mentioned storage media may be executable by the processor 302. For example, a computer program may include machine-readable instructions capable of allocating timeslots to a mobile station in uplink channel and downlink channel separately, according to the teachings and herein described embodiments of the present subject matter. In one embodiment, the program may be included on a storage medium and loaded from the storage medium to a hard drive in the non-volatile memory. The machine-readable instructions may cause the base station 102 to encode according to the various embodiments of the present subject matter.

[42] The bus 310 acts as interconnect between various components of the base station 102. The components such as the transceiver 308, the communication interfaces 312, the display 314, the input device 316, and the cursor control 318 are well known to the person skilled in the art and hence the explanation is thereof omitted.

[43] The present embodiments have been described with reference to specific example

embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the various embodiments. Furthermore, the various devices, modules, selectors, estimators, and the like described herein may be enabled and operated using hardware circuitry, for example, complementary metal oxide semiconductor based logic circuitry, firmware, software and/or any combination of hardware, firmware, and/or software embodied in a machine readable medium. For example, the various electrical structure and methods may be embodied using transistors, logic gates, and electrical circuits, such as application specific integrated circuit.

Claims

[Claim 1] A method of a base station for allocating timeslots in an uplink channel and a downlink channel in a multiple users reusing one timeslot (MUROS) environment, comprising: receiving measurement data from a first mobile station over a uplink channel; evaluating a set of parameters associated with pairing the first mobile station in uplink and downlink respectively based on the measurement data; and associating a timeslot in a frame between the first mobile station and a second set of mobile stations for uplink data transmission and associating another timeslot in the frame between the first mobile station and a third set of mobile stations for downlink data transmission using the evaluated set of parameters.

[Claim 2] The method of claim 1, wherein the set of parameters includes a set of downlink parameters and a set of uplink parameters.

[Claim 3] The method of claim 1, wherein the set of downlink parameters comprises timing advance, signal-to-noise ratio (SNR), FER, and BLER.

[Claim 4] The method of claim 2, wherein the set of uplink parameters comprises timing advance, signal-to-noise ratio (SNR), FER, BLER, rank of wireless channel matrix and condition number.

[Claim 5] The method of claim 1, further comprises: indicating association of the time slot for uplink transmission and said another timeslot for downlink transmission to the first mobile station.

[Claim 6] The method of claim 1, further comprises: indicating a frequency hopping sequence associated with the uplink transmission and the downlink transmission respectively.

[Claim 7] The method of claim 1, wherein receiving the measurement report data from the first mobile station comprises: sending dummy data to the first mobile station on a timeslot of the frame over a downlink channel; and receiving the measurement report data and the dummy data from the first mobile station on the timeslot of the frame over the uplink channel.

[Claim 8] An apparatus comprising: a processor; and memory coupled to the processor and configured to temporarily store instructions, that when executed by the processor, cause the processor to perform a method comprising: receiving measurement report data from a first mobile station over a uplink channel; evaluating a set of parameters associated with pairing the first mobile station in uplink and downlink respectively

based on the measurement report data; and associating a timeslot in a frame between the first mobile station and a second set of mobile stations for uplink data transmission and associating another timeslot in the frame between the first mobile station and a third set of mobile stations for downlink data transmission using the evaluated set of parameters.

[Claim 9] The apparatus of claim 8, wherein the set of parameters includes a set of downlink parameters and a set of uplink parameters.

[Claim 10] The apparatus of claim 8, wherein the set of downlink parameters comprises timing advance, signal-to-noise ratio (SNR), FER, and BLER.

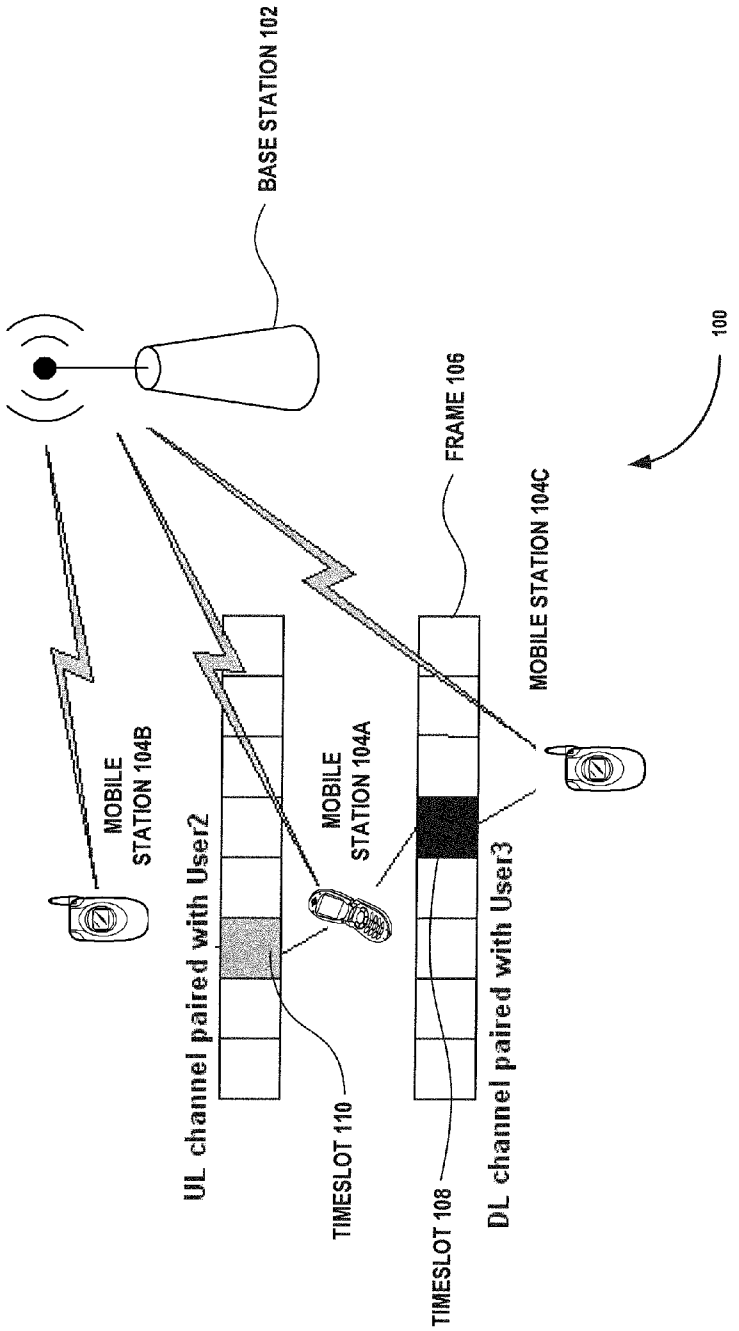
[Claim 11] The apparatus of claim 9, wherein the set of uplink parameters comprises timing advance, signal-to-noise ratio (SNR), FER, BLER, rank of wireless channel matrix and condition number.

[Claim 12] The apparatus of claim 8, wherein the method further comprises: indicating association of the time slot for uplink transmission and said another timeslot for downlink transmission to the first mobile station.

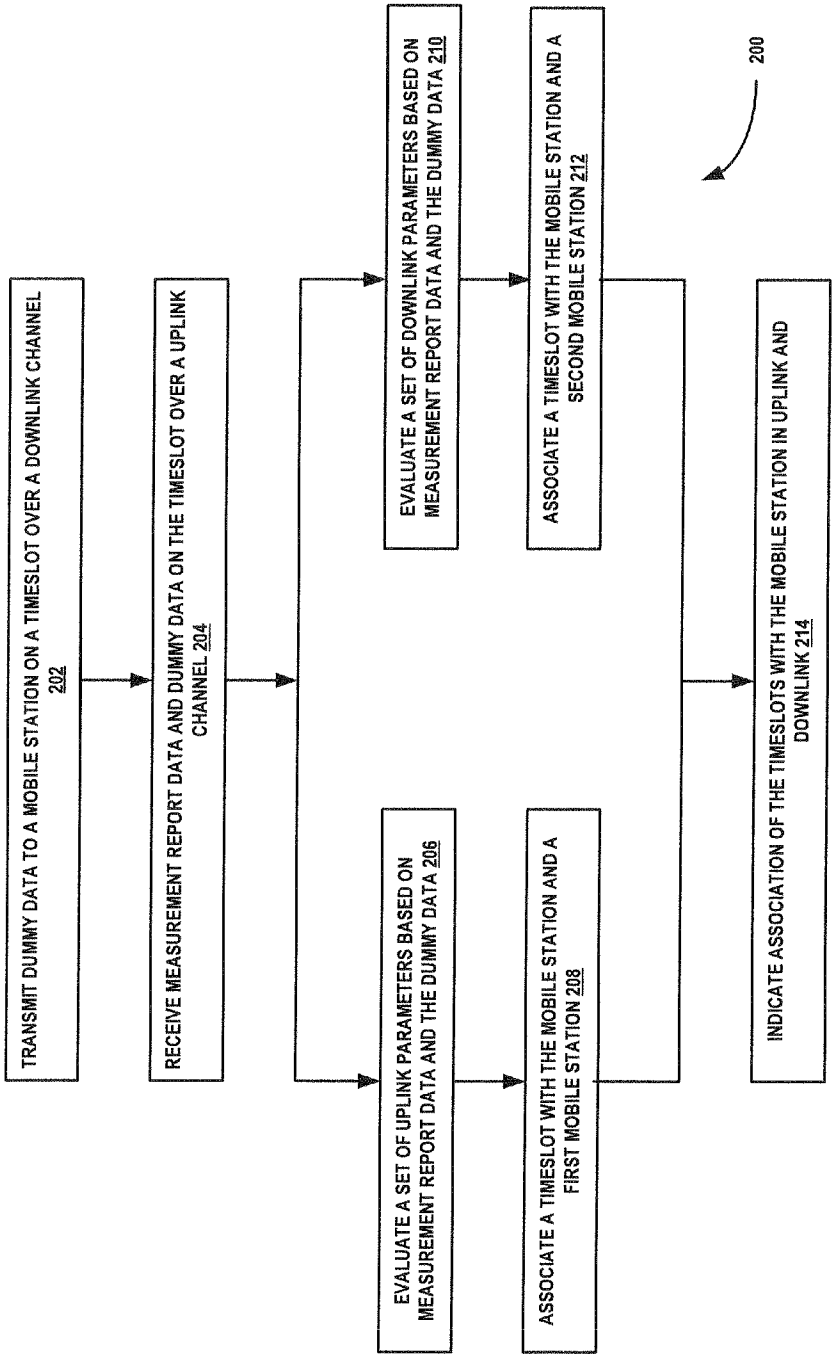
[Claim 13] The apparatus of claim 8, wherein the method further comprises: indicating a frequency hopping sequence associated with the uplink transmission and the downlink transmission respectively.

[Claim 14] The apparatus of claim 8, wherein receiving the measurement report data from the first mobile station comprises: sending dummy data to the first mobile station on a timeslot of the frame over a downlink channel; and receiving the measurement report data and the dummy data from the first mobile station on the timeslot of the frame over the uplink channel.

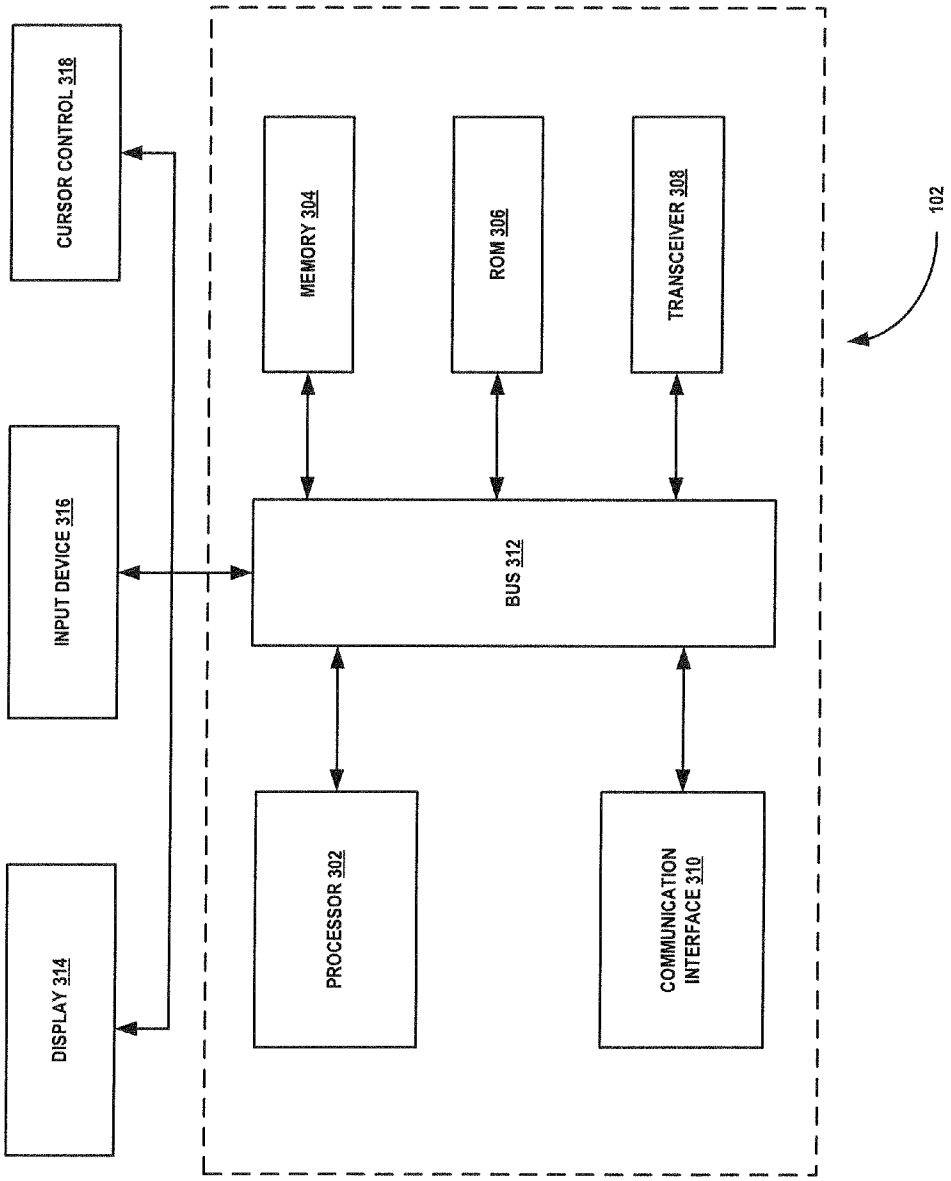
[Fig. 1]


BASE STATION 102
100
FRAME 106
MOBILE STATION 104C
MOBILE STATION 104B
MOBILE STATION 104A
UL channel paired with User2
DL channel paired with User3
TIMESLOT 110
TIMESLOT 108

[Fig. 2]


200
TRANSMIT DUMMY DATA TO A MOBILE STATION ON A TIMESLOT OVER A DOWNLINK CHANNEL 202
RECEIVE MEASUREMENT REPORT DATA AND DUMMY DATA ON THE TIMESLOT OVER A UPLINK CHANNEL 204
EVALUATE A SET OF UPLINK PARAMETERS BASED ON MEASUREMENT REPORT DATA AND THE DUMMY DATA 206
ASSOCIATE A TIMESLOT WITH THE MOBILE STATION AND A FIRST MOBILE STATION 208
EVALUATE A SET OF DOWNLINK PARAMETERS BASED ON MEASUREMENT REPORT DATA AND THE DUMMY DATA 210
ASSOCIATE A TIMESLOT WITH THE MOBILE STATION AND A SECOND MOBILE STATION 212
INDICATE ASSOCIATION OF THE TIMESLOTS WITH THE MOBILE STATION IN UPLINK AND DOWNLINK 214

[Fig. 3]


CURSOR CONTROL 318
INPUT DEVICE 316
DISPLAY 314
MEMORY 304
ROM 306
TRANSCEIVER 308
BUS 312
PROCESSOR 302
COMMUNICATION INTERFACE 310
102