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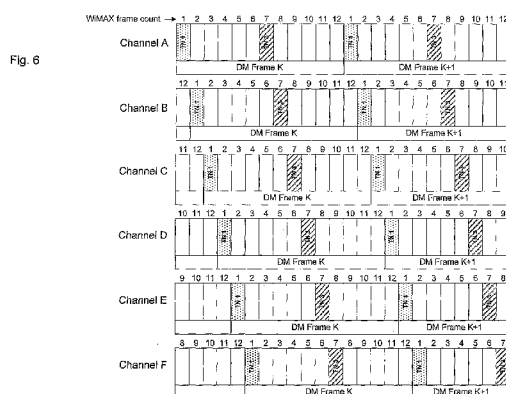
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(54) Title: METHOD TO ENABLE TETRA-LLKE DIRECT MODE OPERATION TO WORK ON BROADBAND NETWORK



**METHOD TO ENABLE TETRA-LIKE DIRECT MODE OPERATION TO WORK ON
BROADBAND NETWORK**

5 The present invention relates generally to network communications, more particularly to digital network communications.

BACKGROUND OF THE INVENTION

10 Broadband communications, such as Worldwide Interoperability for Microwave Access (WiMAX) specification, do not provide mobile station to mobile station communication. WiMAX is a telecommunication technology for providing wireless transmission of data which is based on IEEE 802.16 standard. It needs a base station to broadcast data.

15 Terrestrial Trunked RAdio (TETRA) provides a two way transceiver communication specification. TETRA provides group calling mode in which a single button push will connect a user to other users in a selected group. TETRA mobile stations can communicate in direct mode using trunked infrastructure. Direct mode allows communication to be made when network coverage is not available and allows one
20 of the TETRA terminals to act as relays for a signal. Hence, a base station is not required in direct mode.

US patent 5,953,323 describes the adaptation of private radio system in a cellular mobile network. The private radio system's channel includes a dual-burst type of
25 frequency correction channel and synchronization channel. The burst formats of these two channels are defined according to frequency correction and synchronization channel burst formats used in the cellular mobile network. Consequently, the mobile terminal can be used as a private cordless phone. However, the mobile terminal can't operate in radio mode and cellular at the same
30 time. The mobile terminal also cannot operate in direct mode because it needs a base station.

WiMAX is suitable for centralized broadband transmission but there exists no active work in implementing direct mode communication between mobile stations. The
35 disclosure proposes a method of enabling TETRA-like direct mode operation (direct mode) by emulating TETRA physical layer to work on broadband network, particularly WiMAX network.

SUMMARY OF THE INVENTION

5 A method of producing signals to emulate TETRA direct mode physical layer on a broadband network, particularly WiMAX network is disclosed. A TETRA direct mode multiframe consists of 18 direct mode frames, whereby each of said frames consists of 4 time slots. Part of one specific frame of broadband signals within a duration exactly or close to that of a TETRA direct mode frame is used to emulate a time slot. Eighteen of said frames of broadband signals form the equivalent of a TETRA direct
10 mode multiframe according to TETRA direct mode specification.

Two time slots are provided for a call transaction, a first and third time slot within a direct mode frame, for every direct mode communication channel. A proper modulation is later assigned for each direct mode burst including synchronization
15 burst and normal burst, and optionally, linearization burst. The chosen preambles of direct mode bursts shall be different from the ones used for WiMAX to avoid false synchronization from WiMAX mobile station.

BRIEF DESCRIPTION OF THE DRAWINGS

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The invention will now be described in greater detail, by way of an example, with reference to the accompanying drawings, in which:

Fig. 1 shows an overview of time slots used to form a TETRA direct mode
25 multiframe, said multiframe consists of 18 frames;

Fig. 2 shows a diagram of time slots used in TETRA direct mode communication;

Fig. 3 shows a diagram of linearization burst, normal burst and synchronization burst;
30

Fig. 4 shows a diagram of the emulation of TETRA direct mode multiframe consisting of 204 WiMAX frames;

Fig. 5 shows a diagram of the emulation TETRA direct mode multiframe made up of
35 216 WiMAX frames;

Fig. 6 shows a diagram of time slot arrangement for six active channels within TETRA DM frame emulation consisting of 6 WiMAX frames; and

Fig. 7 shows a diagram of an example configuration of fields used to emulate TETRA direct mode normal burst and synchronization burst within the allocated transparent zone within a WiMAX frame.

DETAILED DESCRIPTION OF THE DRAWINGS

10 For TETRA direct mode, a basic radio unit which is a time slot has a duration of 14.167 milliseconds. A time slot in TETRA consists of 510 modulation bit durations. Four time slots form a 56.65-millisecond direct mode frame, as shown in Fig. 1. Control and traffic data are cyclically sent in multiframes, which is made up of 18 frames. A multiframe takes up exactly 1.02 second. Frame 18 of multiframe is
15 reserved for control signal.

A direct mode physical channel comes into existence when a call is active. A TETRA direct mode channel is defined as one radio frequency carrier and two time slots per frame, as shown in Fig. 2. Since there are four time slots per frame, at frame K, two
20 calls can be active at the same time. A call can occur in direct mode first channel, Channel A using a first and third time slot at time slot 1 and 3, while another call occurs in direct mode second channel, Channel B using a second and fourth time slot at time slot 2 and 4. When both channels are used, TETRA direct mode operation is working in a frequency efficient mode.

25 The physical content within a time slot is carried by a burst. A burst is duration of radio carrier modulated with data. There are three different kinds of burst, as shown in Fig. 3.

30 The first burst is a linearization burst. It is used by a transmitting mobile station to ramp and linearize its power amplifier (PA). Synchronization burst, the second burst, carries control information and receive synchronization information from mobile station. The third burst, normal burst, is used to carry traffic data. Ramping & PA linearization, preamble, phase adjustment, block 1 and block 2 data bits, normal
35 training sequence (seq), tail bits, and guard bits are basic components of direct mode burst. Ramping & PA linearization, preamble, phase adjustment, frequency

correction, block 1 and block 2 data bits, synchronization training sequence, tail bits, and guard bits are basic components of synchronization burst.

Normal burst and synchronization burst contain two independent fields containing modulation bits of the same type. These fields are called a first block and a second block. A separate logical channel may be mapped to each block.

Normal burst and synchronization burst have a preamble and a training sequence field. Normal burst has the option of using two different preambles, a first preamble and a second preamble. Synchronization burst uses one preamble, a third preamble. Different preamble and training sequence are used in synchronized burst to indicate whether one or two logical channels are mapped to the first and second block, in the burst.

Direct mode logical channels are mapped to the physical channel when a call is active. As mentioned earlier, the physical channel is allocated with two time slots per TETRA direct mode frame. The logical channels are mapped to the appropriate time slots in the frames within the cyclical 18-frame multiframe structure during a call.

Logical channels can be divided into two categories: traffic channels carrying speech or user data and control channels carrying data signal. Other than these two channels, there are linearization channel, signaling channel and stealing channel.

In TETRA direct mode, the transmitting mobile station defines the timing used in a call. It defines the multiframe structure as well. The transmitting mobile station is the master while a receiving mobile station is the slave. The slave station derives synchronization data from master station. There could be more than one slave in a call group.

Based on the TETRA direct mode discussed, the disclosure proposes a method of producing signals to map TETRA direct mode physical layer to a broadband network, particularly WiMAX physical layer. The frames of broadband signals are arranged as time slots to form a direct mode multiframe.

As explained, a direct mode multiframe takes exactly 1.02 seconds. To form the same direct mode multiframe duration in WiMAX, a direct mode multiframe will require 204 WiMAX frames. To form 18 direct mode frames within a multiframe, each

direct mode frame will require 11 WiMAX frames. Six extra WiMAX frames are padded to form a 1.02 second multiframe.

- 5 The six extra padding frames can be lumped together into an extended direct mode frame or they can be evenly distributed within a multiframe so that each pad exists in every three direct mode frames, as shown in Fig. 4.

Alternatively, to avoid using padding frames, a fixed number of WiMAX frames can be allocated for each direct mode frame. If ten WiMAX frame is used per direct mode
10 frame, the multiframe will have a duration of 900 milliseconds. If eleven WiMAX frame is used per direct mode frame, the multiframe will have a duration of 990 milliseconds. If twelve WiMAX frame is used per direct mode frame, the multiframe will have a duration of 1080 ms, which is shown in Fig. 5.

- 15 The exact timing of a direct mode multiframe of 1.02 second against one in TETRA is important for a direct implementation of TETRA speech at 7.2 kbps from upper layers.

In the discussion that follows, twelve WiMAX frame per direct mode frame is chosen
20 to achieve 1.08 second of direct mode multiframe duration. The direct mode multiframe contains 216 WiMAX frames in total. A person skilled in the art should be able to apply the discussion on mapping with any given number of WiMAX frames per direct mode frame, with or without padding frames.

- 25 As discussed earlier, TETRA direct mode makes use of two time slots per direct mode frame for a call transaction. Two time slots are provided for a call transaction, a first and third time slot (TN1, TN3) within a direct mode frame, for every communication channel. Since there are twelve WiMAX frames per direct mode frame, six call transactions (Channel A to F) can be mapped in one direct mode
30 frame, frame K, as shown in Fig. 6. One direct mode time slot is mapped into one WiMAX frame. This is akin to frequency efficient mode of operation in TETRA direct mode where it supports up to two concurrent calls.

When a base station is operating, the base station provides an extra zone, called transparent zone, within its frames. Within each WiMAX frame assigned to a direct
35 mode time slot, a transparent zone is allocated by the base station so that it will not transmit, to allow for operating direct mode time slot in a WiMAX network. More

transparent zones or one larger transparent zone can be accommodated for more direct mode channels to enable more concurrent calls.

The base station may allocate fixed transparent zones for direct mode operation. Alternatively, some bandwidth request protocol to the base station may be defined so that a mobile station that wants to make a direct mode call may be allocated one or more direct mode channels.

In subsequent discussion, a fixed transparent zone is allocated with one transparent zone in a WiMAX frame per direct mode time slot. A person skilled in the art should be able to expand the discussion using dynamically allocated direct mode channels by the base station or using more than one transparent zone for direct mode operation.

The mapping of TETRA synchronization burst and normal burst to WiMAX will now be described. A downlink subchannel permutation, known as Downlink Full Usage of Subchannels (DL FUSC) is used to carry data bits. While DL FUSC is used, it does not preclude the use of other subchannel permutations. In DL FUSC, the basic transmission unit, which is called a slot, is one subchannel by one symbol. There are eight subchannels for 512-point Fast Fourier Transform (FFT) and sixteen subchannels for 1024-point FFT. Each subchannel has 48 data subcarriers. It follows that for 512-point FFT there are 384 data subcarriers and for 1024 point FFT, there are 768 data subcarriers. The table below shows the number of data bits in DL FUSC for various FFT points and modulations.

OFDMA Modulation	Number of bits	
	512-point FFT	1024-point FFT
QPSK $\frac{1}{2}$	384	768
QPSK $\frac{3}{4}$	576	1152
16 QAM $\frac{1}{2}$	768	1536

A transmitting direct mode mobile station will use all the subcarriers for transmission. In FUSC, and also in Partial Usage of SubChannels (PUSC) permutation, it is also possible for multiple direct-mode mobile stations to transmit at the same time on different subchannels. However, this may complicate the design of direct mode receiver because the transmission may potentially be received by a slave mobile station at different timing, frequency and phase offsets.

The emulation of TETRA synchronization burst in WiMAX frame shall carry a preamble symbol before its data symbol. The preamble will be used by slave mobile station to synchronize with the transmitting mobile station. In TETRA, the synchronization burst carries 336 bits; hence QPSK rate $\frac{1}{2}$ may be used for the data symbol. QPSK rate $\frac{3}{4}$ is sufficient to emulate TETRA normal burst although a higher modulation rate may be chosen to increase data bandwidth.

The disclosure does not specify the structure of preamble symbol used for direct mode operation. However, a person skilled in the art should be able to allocate the direct mode preamble structure that will not cause false synchronization with normal WiMAX mobile station. To avoid false synchronization, the structure of the preamble for direct mode operation shall be different from the one used in WiMAX. In WiMAX, three carrier sets are used to carry preamble. In each carrier set, every three subcarriers are modulated using boosted BPSK modulation with specific pseudo noise sequence. The specific sequence used depends on the segment used and the identity of cell parameter.

For emulating TETRA direct mode normal burst, to simplify allocation of transparent zone for direct mode operation, the number of OFDMA symbols used is set to two, which is the same number of symbols allocated for synchronization burst. Whereas one symbol is used for preamble and another for data in synchronization burst emulation, both symbols are used for data bits in the mapped normal burst. The pilot carriers in the FUSC slots used in the two symbols may be used for channel tracking until another synchronization burst arrives.

TETRA direct mode normal burst makes use of two preambles, a first and second preamble. Different preamble is used to indicate if one or two logical channels are mapped to the two blocks, a first block and second block, in the direct mode time slot. Instead of using preamble symbols, this disclosure proposes the use of flag bit in the data symbols of the mapped noise burst.

To emulate the first and second block in normal burst and synchronization burst, the DL FUSC burst will be logically divided into two blocks. The division could be symmetric or asymmetric depending on which method would give better overall throughput. One possible configuration for the synchronization burst and normal burst mapped to WiMAX symbols is shown in Fig. 7. Other configurations are possible. Fig. 7 illustrates a transparent zone selected between the downlink

subframe and uplink subframe of a WiMAX frame. To allow for the master direct-mode mobile station to switch to direct-mode transmit mode, Receive/Transmit Transition Gap (RTG) is required at the beginning of the transparent zone. Similarly, to allow for a slave direct-mode mobile station to switch back to normal WiMAX transmit mode, Receive/Transmit Transition Gap (RTG) is required at the end of the transparent zone. The emulation of direct-mode synchronization burst requires the use of a preamble which occupies symbol 0 of the transparent zone. The two blocks for modulated data bits, BKN1 and BKN2, for said synchronization burst is emulated within the same symbol, symbol 1. Some control bits (C) may also be added in symbol 1. To simplify design, the exemplary emulation of direct-mode normal burst makes use of the same number of symbols as in the emulation of direct-mode synchronization burst. However, since emulation of normal burst does not make use of a preamble symbol, each block of the modulated data bits, BKN1 and BKN2, may occupy separate symbols, symbol 0 and symbol 1, respectively. Control bits (C) may also be added to the symbols. The control bits may be used, for example, to indicate whether one or two logical channels are mapped to the two blocks of modulated data bits.

With the TETRA direct mode operation physical layer fully emulated within WiMAX physical layer, a fully compatible service access point can be provided for the physical layer so that existing implementation of the higher-level layers can be reused with minimal modification.

Accordingly, the invention disclosed a method to enable TETRA network to work on broadband network. It is the combination of the above features and its technical advantages give rise to the uniqueness of such invention. Although the descriptions above contain much specificity, these should not be construed as limiting the scope of the embodiment but as merely providing illustrations of some of the presently preferred embodiments.

CLAIMS

1. A method for enabling a mobile station (MS) to communicate directly with another mobile station using complete, subset or superset of TETRA-like direct mode features and at the same time be compatible with a target wireless broadband network air interface, said method comprising the steps of:
 - providing one or more transparent zones, by the base station within its communication frame, wherein the base station will not transmit to allow direct mobile station (MS) to mobile station communication to occur; and
 - mapping TETRA direct mode 18-frame multiframè structure, which includes TETRA direct-mode frames, time slots, bursts and logical channels, by the transmitting direct-mode mobile station (DM-MS) to the transparent zones within the wireless broadband network frames.
2. The method of claim 1, wherein said step of mapping TETRA direct mode multiframe structure is performed by mapping a number of wireless broadband network frames such that the TETRA direct mode multiframe duration of 1.02 second is achieved, with the addition of padding frames within the wireless broadband network.
3. The method of claim 1, wherein said step of mapping TETRA direct mode multiframe structure is performed by mapping a number of wireless broadband network frames such that the TETRA direct mode multiframe duration of 1.02 second is achieved.
4. The method of claim 1, wherein one or more time slot is allocated to one or more transparent zones in a target wireless broadband network frame.
5. The method of claim 4, further comprising the step of mapping one or more TETRA direct mode physical channels, each of which is made of two time slots per TETRA direct mode frame, to the available time slot allocations among the target wireless broadband network frames within a TETRA direct mode frame duration.
6. The method of claim 4, further comprising the step of a mobile station transmitting in a time slot allocation the direct mode synchronization burst (DSB) comprising of one preamble symbol used for synchronization; and one or more data symbols.

7. The method of claim 4, further comprising the step of a mobile station transmitting in a time slot allocation the direct mode normal burst (DNB) comprising one or more data symbols; and, optionally, if more robust synchronization is required, one preamble symbol.
8. The method of claim 7, wherein the step to indicate the use of one or two logical channels through a bit in the data symbol; or, when preamble symbol is used, through two different preamble sequences.
9. The method of one of claims 6 to 8, further comprising the step of modulating the preamble sequence in such a way that will not cause a false synchronization from standard non-direct mode capable mobile stations.
10. A system for enabling a mobile station (MS) to communicate directly with another mobile station using complete, subset or superset of TETRA direct mode-like features and at the same time to be compatible with the target wireless broadband network air interface, said system comprising:
- a base station, employing a target wireless broadband network, having a means to add a transparent zone to its target wireless broadband network frames wherein the base station will not transmit; and
 - one or more Direct-Mode Mobile Station (DM-MS), having a means to perform direct MS to MS communication within the allocated transparent zone defined by the base station.
11. The system of claim 10, further comprising one or more receiving DM-MS, having a means to synchronize to a transmitting DM-MS.
12. The system of claim 10, wherein said DM-MS further including a means to detect the availability of the transparent zones when a base station is operating, for said DM-MS to perform direct mode transmission.

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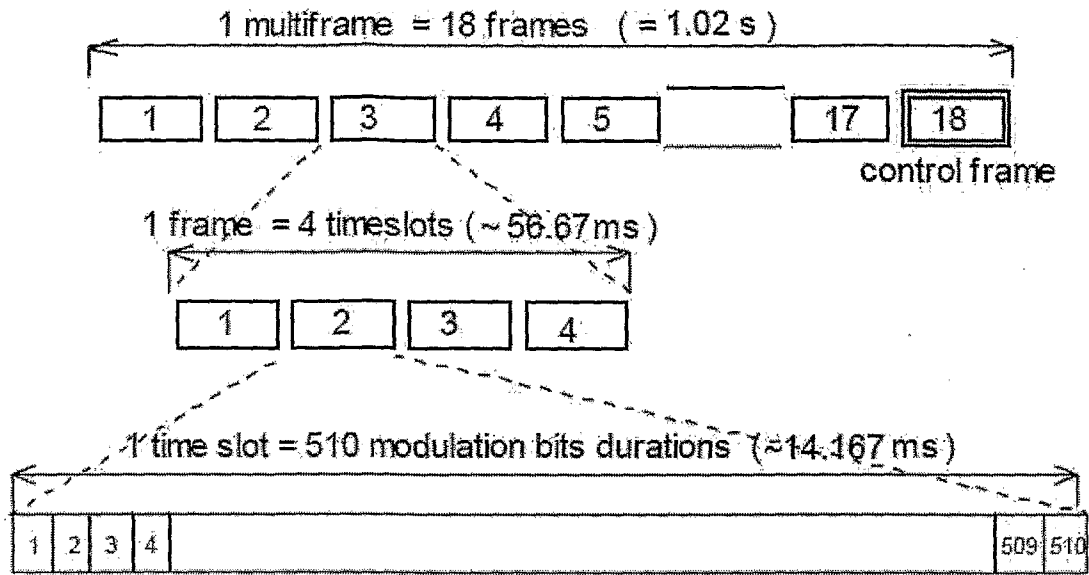


Fig. 1

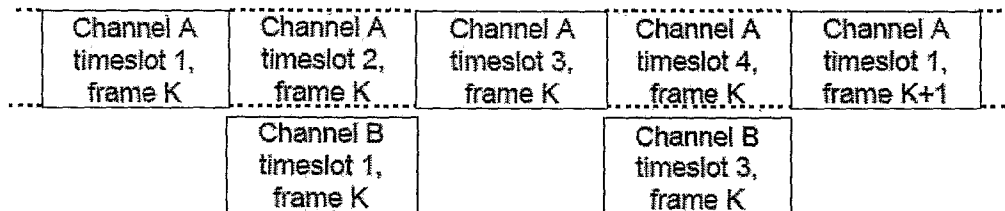


Fig. 2

2/5

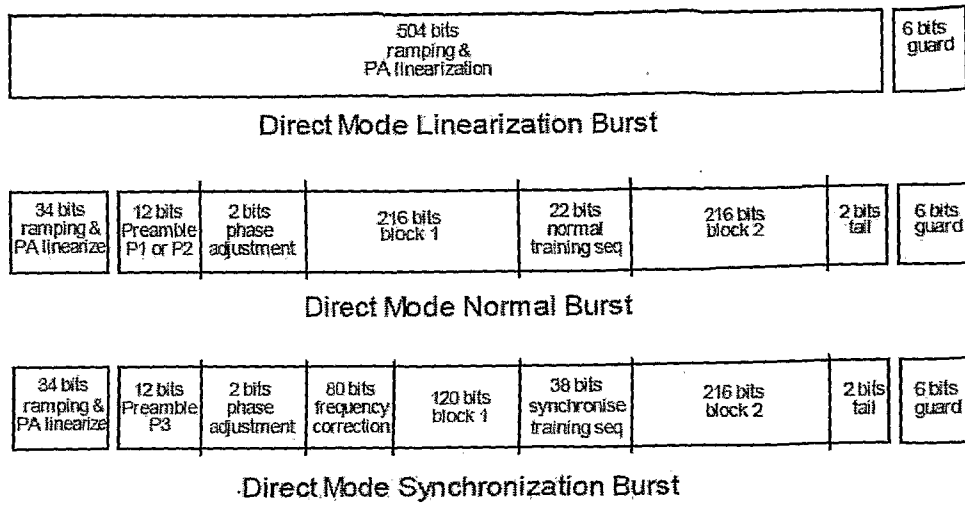


Fig. 3

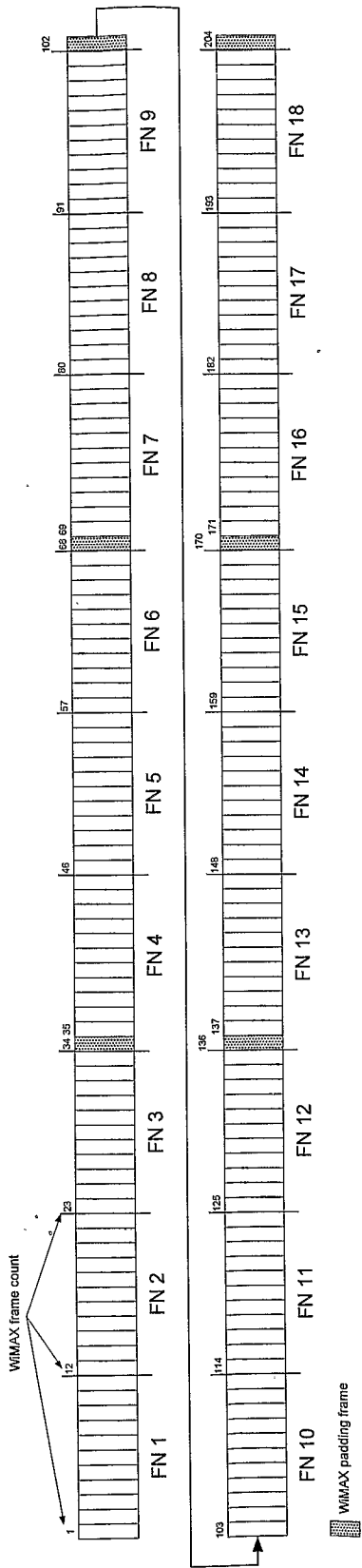


Fig. 4

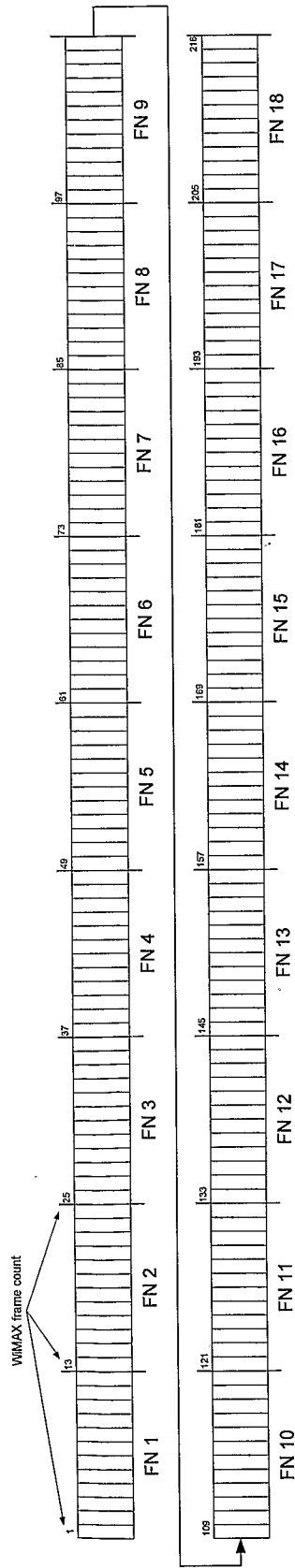


Fig. 5

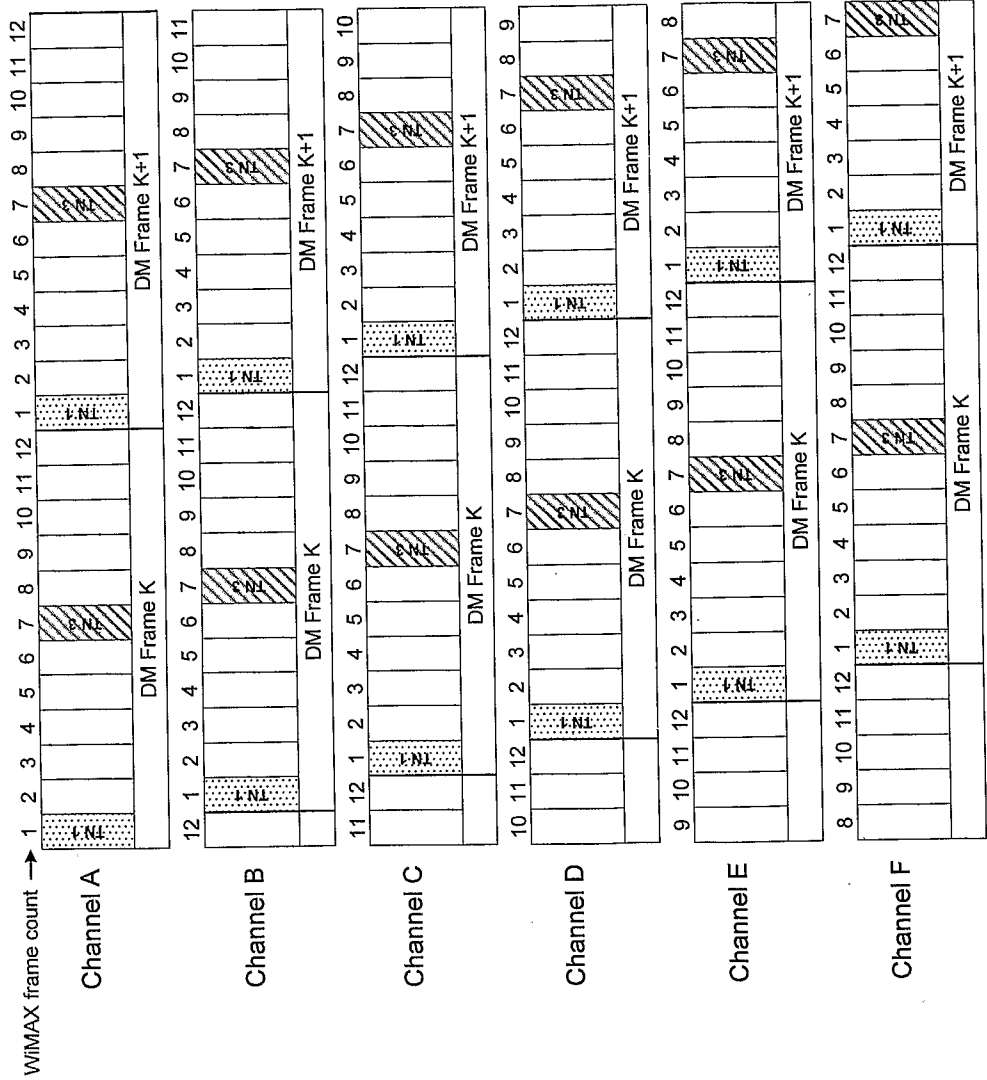


Fig. 6

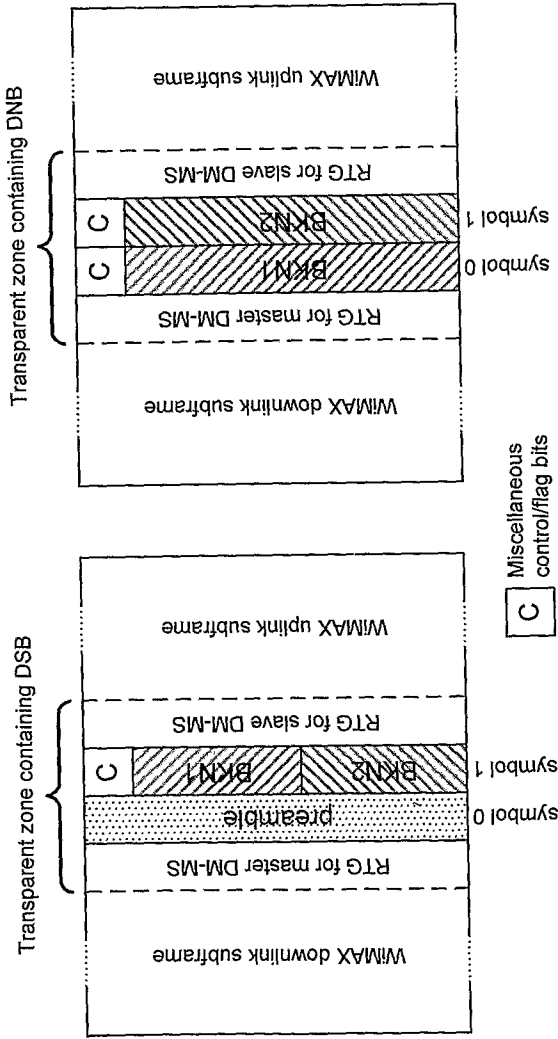


Fig.7

A. CLASSIFICATION OF SUBJECT MATTER***H04B 7/26(2006.01)i***

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04B 7/26; H04M 3/00; H04Q 7/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

(Chinese Patents and application for patent)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: WiMAX, multiframe, direct mode

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009-0005057 A1 (LEE SANG-MIN et al.) 01 January 2009 See the abstract, paragraphs [34]-[37],[52]-[64], and [79]-[87], figures 2,7,5A, and 5B	1-12
A	US 2009-0082002 A1 (KIM YUNG-SOO et al.) 26 March 2009 See the abstract, paragraphs [105]-[111] and [113]-[119], figures 9 and 10	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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02 MARCH 2010 (02.03.2010)

Name and mailing address of the ISA/KR

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Telephone No. 82-42-481-8356



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/MY2009/000088

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009-0005057 A1	01.01.2009	KR 10-2009-0001095 A WO 2009-005251 A2 WO 2009-005251 A3	08.01.2009 08.01.2009 08.01.2009
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