Title: METHOD AND SYSTEM FOR GENERATING SWITCHING TIMING SIGNAL FOR SEPARATING TRANSMITTING AND RECEIVING SIGNAL IN OPTICAL REPEATER OF MOBILE TELECOMMUNICATION NETWORK USING TDD AND OFDM MODULATION

Abstract: Disclosed are a method and system for generating a switching timing signal for separating a transmitting and receiving signal in an optical repeater of a mobile telecommunication network by using a Time Division Duplex (hereinafter, referred to as "TDD") scheme and an Orthogonal Frequency Division Multiplexing (hereinafter, referred to as "OFDM") modulation scheme. According to one aspect of the present invention, there is provided a method for generating a switching timing signal to separate a transmission signal in an optical repeater of a mobile communication system including an AP, an AT and the optical repeater by using a TDD scheme and an OFDM modulation scheme, the method comprising the steps of (a) transmitting an RF signal received from the AP to a remote of the optical repeater via a main donor of the optical repeater; (b) extracting a part of the RF signal in a coupler of the remote, and transmitting the part of the RF signal to a switching timing signal generating circuit of the remote; (c) correlating the RF signal extracted from the coupler with the reference signal generated in the switching timing signal generating circuit; (d) detecting a frame start position of the RF signal by analyzing a correlation result value; (e) calculating starting points of a downlink signal and an uplink signal included in the RF signal on the basis of the frame start position; (f) generating the switching timing signal by using starting point information of the downlink signal and the uplink signal, and transmitting it to a switch of the remote; and (g) separately transmitting the downlink signal from the uplink signal by controlling the switch. According to the present invention, it is possible to operate an optical repeater maintaining stability because the optical repeater of a mobile communication network using the TDD scheme and the OFDM scheme itself distinguishes between a downlink signal and an uplink signal, generates a switching timing signal to provide a path for each signal selectively, and controls a switch.
METHOD AND SYSTEM FOR GENERATING SWITCHING TIMING SIGNAL FOR
SEPARATING TRANSMITTING AND RECEIVING SIGNAL IN OPTICAL
REPEATER OF MOBILE TELECOMMUNICATION NETWORK USING TDD AND
OFDM MODULATION

Technical Field

The present invention relates to a method and system for generating a switching timing signal for separating a transmitting and receiving signal in an optical repeater of a mobile telecommunication network by using a Time Division Duplex (hereinafter, referred to as "TDD") scheme and an Orthogonal Frequency Division Multiplexing (hereinafter, referred to as "OFDM") modulation scheme. More particularly, the present invention relates to a method and system for generating switching a timing signal for separating a transmitting and receiving signal in an optical repeater of a mobile telecommunication network by using a TDD scheme and an OFDM modulation scheme, which transmits a part of a RF signal extracted from a coupler of a remote to a switching timing signal generating circuit when a RF signal transmitted from an Access Point (hereinafter, referred to as "AP") is transmitted to a remote via a main donor of an optical repeater, locates a frame start position of a RF signal by correlating a reference signal generated in a
switching timing signal generating circuit with a RF signal extracted from a coupler, and is capable of transmitting a RF signal by distinguishing between a downlink signal and a uplink signal by using a switching timing signal in a switch when calculating a starting point of a downlink signal and a uplink signal which is included in an RF signal on the basis of a frame starting location, and transmitting to a remote's switch after generating a switching timing signal by using it.

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Background Art

A variety of wireless communication services using a wireless network are provided as computer, electronic and communication technology develops by leaps and bounds. A most basic wireless communication service, which is a wireless voice communication service providing voice communication for subscribers of mobile communication terminal by wireless scheme, has a characteristic to provide service regardless of time and place. Further, besides supplementing a voice communication service by providing a message service, a wireless internet service is brought up recently which provides an internet communication service for subscribers of mobile communication terminal through a wireless communication network.

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Herein, services which are provided by Code Division

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Multiple Access (hereinafter, referred to as "CDMA") mobile communication system have been developed not only to a voice service but also to multimedia communication services which transmit and receive data such as circuit data, packet data and etc.

Further, recently, an International Mobile Telecommunication 2000 (hereinafter, referred to as IMT-2000), which is the 3G mobile communication system, has been commercialized by the development of information and communication. The IMT-2000 is the service which is a CDMA 2000 1x, 3x, EV-DO, WCDMA(Wideband CDMA) and etc., and can provide a wireless internet at transmission rate, more than 144 Kbps much faster than 14.4 Kbps or 56 Kbps, data transmission rate supported in IS-95A and IS-95B network, by using IS-95C network developed from an existing IS-95A and IS-95B network. In Particular, if using IMT-2000 service, it is possible to provide various multimedia services (for example AOD, VOD and etc.) at much faster rate as well as the improvement of existing voice and WAP services quality.

However, due to high cost for constructing a base station, the charge for using is high in an existing mobile communication system. Further, due to a small screen size of a mobile communication terminal, there is a limit to provide very high speed wireless internet services for example a limit to use contents. Furthermore, there is a limit to provide public services owing to the problem of radio wave
interference and narrow using coverage in Wireless Local Area Network (hereinafter, referred to as WLAN). Therefore, in order to guarantee portability and mobility, and provide very high speed wireless internet services at a lower charge, mobile internet technology is emerged which uses a TDD scheme for a duplex scheme and uses a OFDM scheme for a modulation scheme.

Herein, the TDD scheme is a two-way transmission scheme which allocates uplink and downlink in turns timely at the same frequency band. The TDD scheme has higher efficiency than a Frequency Division Duplex (hereinafter, referred to as FDD) scheme allocating two different frequency to uplink and downlink, and has a characteristic to be suitable for transmitting asymmetric or bursting applications.

Herein, an OFDM scheme is a next generation communication scheme adopted as a standard of a wireless LAN (802.11g,a), a W-MAN (802.16), a digital broadcasting, a VDSL and etc., and is a digital modulation scheme for improving transmission speed per band width and preventing multipath interference. The biggest characteristic of the OFDM scheme is to have a quadrature between sub-carriers. That is, it is possible to have an excellent characteristic in multipath fading and to improve transmission content largely by adjusting data transmission rate corresponding to each sub-carrier in the ration of signal to noise in a
particular sub-carrier. Furthermore, the OFDM scheme has a strong characteristic in narrow-band interference because it has influence only on some sub-carriers.

However, the OFDM scheme has a characteristic to be sensitive to frequency offset of a carrier and phase noise, which becomes a main cause to affect the security of quadrature, that is, to deteriorate the capacity of a system, to have relatively a high ratio of average power to the maximum power comparative to one of a single carrier modulation, and to decrease power efficiency of an RF power amplifier. It is possible to overcome the interference between symbols due to multipath channel while it is impossible to reconstruct the signal transmitted to the sub-channel when the attenuation of a particular sub-channel is serious. In order to prevent this, it is possible to solve the problem using error correction code which is called a Coded OFDM (hereinafter, referred to as "COFDM"). Herein, it is possible to use both block code such as Reed-Solomon code and convolutional code as the error correction codes and to take an advantage of a connection code coupling the two codes, turbo codes and etc., too.

There is a High-speed Portable internet (hereinafter, referred to as "HPi") system as representative portable internet technology. The HPi system is the next generation wireless internet technology which the Telecommunications Technology Association (hereinafter, referred to as "TTA") is
developing in association with Samsung Electronics Co., Ltd. and the Electronics and Telecommunications Research Institute (hereinafter, referred to as "ETRI").

The HPi system uses the frequency band of 2.3 GHz and, as described above, uses the TDD as a duplex scheme and the OFDM as a modulation scheme. Furthermore, the HPi system provides the mobility of 60 Km/h and is a wireless data system which has uplink and downlink asymmetric transmission characteristic considering a downlink transmission speed is 24.8 Mbps but a uplink transmission speed is 5.2 Mbps.

FIG. 1 is a diagram schematically showing an HPi system.

As shown in FIG. 1, the HPi system may include an Access Terminal 100 (hereinafter, referred to as "AT"), an Access Point 110 (hereinafter, referred to as "AP"), a Packet Access Router 120 (hereinafter, referred to as "PAR"), a Packet Data Serving Node 130 (hereinafter, referred to as "PDSN"), a Packet Data Gateway Node 140 (hereinafter, referred to as "PDGN"), an Authentication Authorization Accounting 150 (hereinafter, referred to as "AAA"), an IP network 160 and an internet 170.

Herein, the AT 100 refers to a mobile communication terminal which uses a very high speed wireless internet service by connecting with the HPi system and has low power Radio Frequency (hereinafter, referred to as "RF")/Intermediate Frequency (hereinafter, referred to as
"IF") module and controller function, a Media Access
Control (hereinafter, referred to as "MAC") frame variable
control function depending on service characteristics and
radio wave circumstance, a handover function, authentication
and encryption functions and etc.

The AP 110 transmits the data received from PAR 120
as a base station of the HPi system, and has a low-power
RF/IF module and controller function, OFDMA/TDD packet
scheduling and channel multiplex function, an MAC frame
variable control function depending on service
characteristics and radio wave circumstances, a 50 Mbps high
speed traffic real-time control function, a handover
function, and etc.

Further, the AT 100 and the AP 110 have a 50 Mbps
packet transmission modulating demodulating function for
data transmission, a high packet channel coding function, a
real-time modem control function, and etc.

The PAR 120 is a packet access router which
accommodates a number of the AP 110, has a handover control
function of AP 100, a handover control function of the PAR
120, a packet routing function, an internet connection
function and etc., and further connects with IP network.

The PDSN 130 relay transmitting and receiving of
packet data between an external packet data service server
such as the internet 170, etc. and a base station through
the IP network 160 and administers the location information
data of a mobile communication terminal including the AT 100.

The PDGN 140 performs a routing which traces and then connects with an external packet data service server of the internet 170, etc. Further, the AAA 150 links the PDSN 130, carries out accounting for a packet data used by the AT 100 and authenticates the connection with the AP 100.

The IP network 160 connects with the PDSN 130, PDGN 140 and the AAA 150, and then transmits a packet data received from an external packet data service server such as the internet 170, etc. to the AP 100.

Meanwhile, in a mobile communication system, a mobile communication service region has been generally divided into a plurality of cells using a frequency reuse concept in order to extend the coverage of a mobile communication network and a Base Station (hereinafter, referred to as “BS”) have been installed around the center of each of the cells in order to handle the mobile communication service. Herein, the ratio of a cell is set depending on the strength of a signal or the amount of data traffic. That is, the ratio of a cell is set small in an urban center in which there is much amount of traffic and the ratio of a cell is set large in a suburb in which there is comparatively less amount of data traffic so that the amount of traffic should not exceed the treatment content of the wireless BS handling a corresponding mobile communication service.

There have been shade regions of radio waves such as a
basement, a building's interior, a tunnel, etc. which it is difficult for the radio wave to reach in spite of these efforts to support better mobile communication services controlling the ratio of a cell depending on the frequency reuse concept or the amount of traffic, etc.. It may cause undesirable results in cell-construction as well as in weakening the economical efficiency due to equipping expenses, installing expenses and maintenance and repair expenses, etc. to equip a plurality of new base stations for solving the shade of radio wave in the shade regions of radio wave.

In order to solve the above-mentioned problem, it is possible to provide mobile communication services using an optical repeater system in these shade regions of radio waves. The optical repeater system can solve the problem of the shade of radio wave by allowing a communication channel allocated to a base station to transmit to the shade region of radio waves through an optical transmission scheme using the optical transmission scheme. Particularly, it is preferable to use an optical repeater having a small cell ratio because a radio waves loss is more, a diffraction effect is small, and building transmission loss is large in 2.5G, PCS, and 3G using a higher frequency than a 2G mobile communication system.

Meanwhile, in order to repeat a wireless signal between a base station and a terminal, the optical repeater
might be capable of distinguishing an uplink signal from a downlink signal. The optical repeater of a mobile communication system must distinguish an uplink signal from a downlink signal by using a duplex when using the FDD scheme. However, it is impossible to distinguish an uplink signal from a downlink signal by using a duplex because it uses the same frequency in order to distinguish an uplink signal from a downlink signal when using the TDD scheme like the HPl system, etc. Accordingly, the optical repeater using the TDD scheme is able to distinguish an uplink signal from a downlink signal by using a switch and provide a path for each signal selectively. In order to do this, it is necessary for the controlling signal to distinguish between the starting point of a downlink signal and the one of an uplink signal exactly and to change a shifting path by controlling the path of a switch depending on each of signals. In addition, the optical repeater can receive the controlling signal described above.

However, because manufacturers of base stations and optical repeaters are generally various, in order to receive a switch controlling signal transmitted from a base station, it causes problems that an extra fee is needed for installing another modem in an optical repeater and the cause of obstacle is not founded easily for controlling a switch of an optical repeater. Further, it is a defect that an extra procedure compensating the controlling signal by
delay value of an optical cable is needed and an extra fee corresponding to this is needed.

Therefore, the plan is demanded which can distinguish between a downlink signal and an uplink signal in the optical repeater itself and generate a switching timing signal to provide a path of each signal selectively in order to use the optical repeater even in the mobile communication system of the TDD scheme.

10 Disclosure of the Invention

Therefore, the present invention has been made in view of the above-mentioned problems, and it is as object of the present invention to provide a method and system for generating switching a timing signal for separating a transmitting and receiving signal in an optical repeater of a mobile telecommunication network by using a Time Division Duplex (hereinafter, referred to as "TDD") scheme and an Orthogonal Frequency Division Multiplexing (hereinafter, referred to as "OFDM") modulation scheme, which transmits a part of a RF signal extracted from a coupler included in a remote of an optical repeater to a switching timing signal generating circuit, locates a frame start position of a RF signal by correlating a reference signal generated in a switching timing signal generating circuit with a RF signal extracted from a coupler, and is capable of transmitting a
RF signal by distinguishing between a downlink signal and an uplink signal by using a switching timing signal in a switch when calculating a starting point of a downlink signal and an uplink signal included in an RF signal on the basis of a frame starting location, generating a switching timing signal by using it, and transmitting to a remote's switch.

According to one aspect of the present invention, there is provided a method for generating a switching timing signal to separate a transmission signal in an optical repeater of a mobile communication system including an AP, an AT and the optical repeater by using a TDD scheme and an OFDM modulation scheme, the method comprising the steps of:

(a) transmitting an RF signal received from the AP to a remote of the optical repeater via a main donor of the optical repeater; (b) extracting a part of the RF signal in a coupler of the remote, and transmitting the part of the RF signal to a switching timing signal generating circuit of the remote; (c) correlating the RF signal extracted from the coupler with the reference signal generated in the switching timing signal generating circuit; (d) detecting a frame start position of the RF signal by analyzing a correlation result value; (e) calculating starting points of a downlink signal and an uplink signal included in the RF signal on the basis of the frame start position; (f) generating the switching timing signal by using starting point information of the downlink signal and the uplink signal, and
transmitting it to a switch of the remote; and (g) separately transmitting the downlink signal from the uplink signal by controlling the switch by using the switching timing signal.

According to another aspect of the present invention, there is provided an switching timing signal generating system for separating a RF signal received from an AP and an AT in a optical repeater of a mobile communication network employing a TDD scheme and an OFDM modulation scheme into a downlink signal and an uplink signal, the switching timing signal generating system comprising a main donor of the optical repeater for converting the RF signal received from the AP to an optical signal, transmitting the optical signal to a remote, converting the optical received from the remoter to a RF signal, and transmitting the RF signal to the AP; a remote of the optical repeater for converting an optical signal received from the main donor to a RF signal, transmitting the RF signal to AT, converting the RF signal received from the AT to an optical signal, and transmitting the optical signal to the main donor; and a switching timing signal generating circuit for extracting a part of the RF signal transmitted to the remote from the main donor, correlating a reference signal generated in itself with an extracted RF signal, detecting a frame start position of the extracted RF signal by analyzing a correlation result value, calculating a starting point of the downlink signal and the
uplink signal included in the RF signal on the basis of the frame start position, and generating a switching timing signal by using starting point information of the downlink signal and the uplink signal, and transmitting the switching timing signal to the switch.

According to further another aspect of the present invention, there is provided a switching timing signal generating circuit for generating a switching timing signal separating a RF signal received from an AP and an AT in an optical repeater of a mobile communication network employing a TDD scheme and an OFDM modulation scheme into a downlink signal and an uplink signal, the switching timing generating circuit comprising a divider for receiving an extracted RF signal extracted from a coupler included in a remote of the optical repeater as a part of the RF signal transmitted from a main donor of the optical repeater to the remote, and providing the extracted RF signal for a level detector and a Variable Gain Amplifier (hereinafter, referred to as “VGA”); a level director for measuring a level of the extracted RF signal received from the divider; a VGA for receiving a level value measured at the level detector, and outputting the level of the extracted RF signal; a log-scale amplifier for allowing a variation of the extracted RF signal received from the VGA to convert from a linear scale to a decibel (dB) scale, and transmitting a converted extracted RF signal to a pulse generator; a pulse generator for
generating a pulse waveform signal by using the extracted RF signal received from the log-scale amplifier, and transmitting the pulse waveform signal to a comparator; a reference pulse generator for generating a reference pulse waveform signal to detect a frame start position of the extracted RF signal after correlating the pulse waveform signal generated in the pulse generator and transmitting the reference pulse waveform signal to the comparator; a comparator for correlating the pulse waveform signal received from the pulse generator with the reference pulse waveform signal received from the reference pulse generator; a timing controller for determining a frame start position of the extracted RF signal by analyzing a correlation result value, calculating a starting point of the downlink signal and the uplink signal included in the RF signal on the basis of the frame start position, and generating a switching timing signal by using the starting point information of the downlink signal and the uplink signal, and transmitting the switching timing signal to a switch of the Optical repeater; and a phase tuning circuit for receiving a phase information of the pulse waveform signal generated in the pulse generator, and tuning the phase of the reference pulse waveform signal.

Brief Description of the Drawings
The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagram schematically showing a an HPi system;

FIG. 2 is a diagram schematically showing the construction of an optical repeater according to a preferred embodiment of the present invention;

FIG. 3 is a diagram showing the construction of a switching timing signal generating circuit according to a preferred embodiment of the present invention;

FIG. 4 is a diagram showing the frame structure of a transmitting and receiving signal by using a TDD scheme and an OFDM modulation scheme;

FIG. 5 is an example screen showing a waveform of a signal when a 10 % probability of data existing in a data symbol of FIG. 4;

FIG. 6 is an example screen showing a waveform of reference signal using for correlation in an optical repeater;

FIG. 7 is an example screen showing a waveform of a signal output in result of correlating the signal illustrated in FIG. 5 and FIG. 6; and

FIG. 8 is a flow diagram illustrating a switching timing signal generating process dividing transmitting and
receiving signals in an optical repeater of a mobile communication network using a TDD scheme and an OFDM modulation scheme according to a preferred embodiment of the present invention.

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**Best Mode for Carrying Out the Invention**

Reference will now be made in detail to the preferred embodiments of the present invention. The same reference numerals are used to designate the same components as those shown in other drawings. In the following description of the present invention, a detailed description of known configurations and functions incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

FIG. 2 is a diagram schematically showing the construction of an optical repeater according to a preferred embodiment of the present invention.

The optical repeater of the present invention makes both link communication possible by time-dividing the same frequency and distinguishing a downlink signal from an uplink signal due to using a TDD scheme, so that the Optical repeater is allowed to transmit a RF signal by using the same frequency between an AT 100 and an AP 110.

As shown in FIG. 2, the optical repeater according to a preferred embodiment of the present invention may include
a main donor 200 and a remote 250.

The main donor of the optical repeater 200 is connected with the AP 110 via a RF cable, receives a RF signal from the AP 110, converts the RF signal to an optical signal by E/O conversion, transmits the optical signal to the remote 250 via optical communication cable, converts the optical signal received from the remote 250 to a RF signal by O/E conversion, and transmits the RF signal to the AP 110 via a RF cable.

The remote of the optical repeater 250 receives an optical signal from the main donor 200, converts the optical signal to a RF signal by O/E conversion, transmits the RF signal to the AT 100 via an antenna, converts the RF signal received from the AT 100 to an optical signal by E/O conversion, and transmits the optical signal to the main donor 200 via an optical cable.

The main donor 200 may include a Low Noise Amplifier 205 (hereinafter, referred to as "LNA"), an E/O conversion module 210, a Wavelength Division Multiplexer 215 (hereinafter, referred to as "WDM"), an O/E conversion module 220, a High Power Amplifiers 225 (hereinafter, referred to as "HPA") and etc. as internal members. Further, the remote 250 may include a WDM, an O/E conversion module 260, a coupler 265, an HPA 270, a switch 275, a LNA 280, an E/O conversion module 285, a switching timing signal generating circuit 290, and etc. as internal members.
Herein, though not illustrated in a figure, the main donor of the optical repeater 200 can magnify coverage of an optical repeater by being connected with a plurality of remotes 250 through an optical communication cable. For this, the main donor 200 may include a signal divider (not illustrated) having multi-channel and a signal coupler. Further, the main donor 200 divides a RF signal received from the AP 110 by a signal divider, and synthesizes a RF signal received from an HPA 225 and another remote 250’s output by a signal coupler.

The WDM 215 and 255 is an apparatus for being able to separate an optical fiber channel into a plurality of channels and use them as a plural communication channel. When transmitting an optical signal, the WDM 215 and 255 can operate as a wave dividing multiplexer for transmitting several optical waves on one optical fiber. Meanwhile, when receiving an optical signal, the WDM 215 and 255 can operate as a wave diving demultiplexer for dividing several optical wave signals in one optical fiber. The E/O conversion modules 210 and 285 can materialize by using a Laser Diode, O/E conversion modules 220 and 260 can materialize by using a Photo Diode.

The switching timing signal generating circuit 290 generates a switching timing signal for distinguishing a downlink signal and an uplink signal and controlling a switch when extracted a part of RF signals in a coupler 265,
and transmits to the switch 275. The construction of the switching timing signal generating circuit 290 is illustrated below in Fig. 3.

The transmitting process of a signal at a forward and backward channel by using members of the optical repeater described above may be described specifically as follows;

At a forward channel, a RF signal, which has been received through a RF cable, is transmitted to a BPF 210 through a LNA 205 of a main donor 200. The LNA 205 reduces the noise component of the RF signal, amplifies the signal component, and transmits to the E/O conversion module 210, which converts a RF signal to an optical signal by E/O conversion and transmits the optical signal to a WDM 215. The WDM 215 transmits a plurality of optical signals received from the E/O conversion module 210 through an optical communication cable to a remote 250.

A WDM 255 of a remote 250 divides a plurality of optical signal received from the main donor 200 and transmits to the O/E conversion module 260, which converts optical signals to RF signals by O/E conversion and transmits the RF signals to an HPA 270. Herein, the HPA 270 amplifies up to an effective power to transmit the RF signals to a switch 275. The switch 275 radiates the RF signals to the AT 100 through an antenna.

At a backward channel, when receiving a RF signal from the AT 100 through the antenna of the remote 250, the LNA
250 reduces the noise component of the RF signal, amplifies
the signal component, and transmits the RF signal to the E/O
conversion module 285. Further, the E/O conversion module
285 converts the RF signal to an optical signal by E/O
conversion and transmits the optical signal to a WDM 255.
The WDM 255 transmits the optical signal received from the
E/O conversion module 285 through an optical communication
cable to a main donor 200.

A WDM 215 of the main donor 200 divides a plurality
of optical signal received from the remote 250 and transmits
to the O/E conversion module 220, which converts optical
signals to RF signals by O/E conversion and transmits the RF
signals to an HPA 225. Herein, the HPA 225 amplifies up to
an effective power to transmit the RF signals to the AP 110
and transmits amplified RF signals to the AP 110 through a
RF cable.

Meanwhile, a coupler 265 extracts a part of the RF
signals transmitted from the O/E conversion module 220 to
the HPA 270, and transmits a part of the RF signals to a
switching timing signal generating circuit 290. Herein, the
switching timing signal generating circuit 290 analyzes an
extracted RF signal, generates a switching timing signal for
transmitting the RF signal, and transmits to the switch 275.
When receiving a downlink signal by controlling the received
switching timing signal, the switch 275 radiates it to the
AT 100 through an antenna. Further, when receiving a uplink
signal, the switch 275 blocks a path connected with the HPA 270, and sets up a path to transmit the uplink signal to the LNA 280.

FIG. 3 is a diagram showing the construction of a switching timing signal generating circuit according to a preferred embodiment of the present invention.

As shown in FIG. 3, the switching timing signal generating circuit 290 according to a preferred embodiment of the present invention may include a divider 300, a level director 310, a Variable Gain Amplifier 320 (hereinafter, referred to "VGA"), a log-scale amplifier 330, a pulse generator 340, a comparator 350, a reference pulse generator 360, a phase tuning circuit 370, a timing controller 380, and etc. as internal members.

The process of generating a switching timing signal by using members of the switching timing signal generating circuit 290 described above may be described specifically as follows:

The coupler 265 extracts a part of RF signals, and transmits it to the divider 300. Further, the divider 300 separates the RF signals into the level detector 310 and a VGA 320. Furthermore, the level detector 310 measures a level of the signal and transmits it to the VGA 320. Then, the VGA 320 is received a level value measured in the level detector 310, and always maintains the output signal of the VGA 320 at a steady level. The log-scale amplifier 330 lets
a variation volume of a signal received from the VGA 320 change from a linear scale into a decibel(dB) scale, and then transmits it to a pulse generator 340. Herein, the pulse generator 340 generates a pulse waveform signal, and transmits it to the comparator 350 by using the signal received.

The reference pulse generator 360 generates a reference pulse waveform signal to determine a frame start position of the RF signal after correlating the pulse waveform signal generated in the pulse generator, and transmits the reference pulse waveform signal to the comparator 350. The comparator 350 compares a correlation degree of a signal received from the pulse generator with one of a signal received from the reference pulse generator. That is, the comparator 350 correlates the two signals, and transmits the result value to the timing controller 380.

The timing controller 380 determines a frame start position of the extracted signal by analyzing the received result value, and calculates a starting point of a downlink signal and an uplink signal on the basis of the detected frame start position. Herein, the timing controller 380 calculates a starting point of a downlink signal and an uplink signal included in a RF signal by using the information of a frame structure when detecting a frame position of a RF signal. The timing controller 380 generates a switching timing signal by using the starting point
information of a downlink signal and an uplink signal calculated, and transmits it to the switch 275. The phase tuning circuit 370 receives the phase information of a pulse waveform generated in the pulse generator 340, and tunes the phase of the reference pulse waveform.

When generating a switching timing signal and transmitting to the switch 275 in the switching timing signal generating circuit 290 by the process as described above, a switching timing signal separates a RF signal transmitted to the switch 275 into a downlink signal and an uplink signal. Further, when receiving a downlink signal by controlling the received switching timing signal, the switch 275 radiates it to the AT 100 through an antenna. Furthermore, when receiving a uplink signal, the switch 275 blocks a path connected with the HPA 270, and sets up a path to transmit the uplink signal to the LNA 280. Therefore, the switch 275 adjusts a short circuit according to it, and provide each path of a downlink or a uplink signal selectively.

FIG. 4 is a diagram showing the frame structure of a transmitting and receiving signal by using a TDD scheme and an OFDM modulation scheme.

When using the TDD scheme and the OFDM modulation scheme described below, a frame structure of a transmission signal will be described focusing on an HPi system.

A single frame at an HPi system has a length of 5 mesc
and is comprised of a down link frame, an up link frame, a Tx/Rx Transition Gap (hereinafter, referred to as “TTG”), a Rx/Tx Transition Gap (hereinafter, referred to as “RTG”), etc.

Herein, the down link is a frame for a downlink signal transmitted to the AT 100 through the optical repeater from the AP 110, and the up link is a frame for an uplink signal transmitted to the AP 110 through the optical repeater from the AT 100. The TTG and the RTG is a Guard Time for separating a transmitting time of uplink and downlink, and during this interval, it is not allowed to transmit effective signals including data at the AP 110 and the AT 100. The TTG is defined as an interval between the down link and the up link transmitted following it, and during this interval, the AP 110 is changed into a mode for receiving an uplink signal, while the AT 100 is changed into a mode for transmitting an uplink signal. The RTG is called an interval between the up link and the down link transmitted following it, and during this interval, the AP 110 is changed into a mode for transmitting a downlink signal, while the AT 100 is changed into a mode for transmitting a downlink signal.

The down link and the up link which constructs a frame at an HPi system are composed of a plurality of OFDM symbols. Further, the OFDM symbols are comprised of a data symbol, a pilot symbol, and a preamble. Herein, the data symbol is called a time interval for transmission data, and has a
whole time interval which put a time interval (CP time interval) as much as the last Tg from among an effective symbol time interval (Tb) in front of an effective symbol time interval as for the time interval of the data symbol.

The reason to set the time interval of data symbol the sum of a CP time interval and an effective symbol time interval is for collecting a signal of multipath by using the OFDM scheme and maintaining quadrature among sub-carriers.

Herein, the preamble has the Ts as for a time interval like the data symbol which is a signal used to synchronize a transmitting timing by signifying a point of time to start transmission of data. The pilot symbol has Tp (= Tb/2 + Tg) as for a time interval, and may used to presume whether a communication channel is a down link or an up link by being inserted in the middle of the data symbol.

The ratio of the data symbol comprising a down link and an up link of a frame is capable of supporting the two structures including 16:6 and 13:9, which has been shown in FIG. 4. Of FIG. 4, (a) shows a frame structure when the ratio of the data symbol of a down link and an up link is 16:6, and (b) shows a frame structure when the ratio of the data symbol of a down link and an up link is 13:9.

In case of the down link, the first OFDM symbol of the down link is a preamble and a pilot symbol is inserted in every three data symbols, and the up link is comprised of the data symbols. Further, the up link is comprised of only...
data symbols. As described above, a time interval between the down link and the up link is comprised of TTG and RTG for separating an up/downlink transmitting time. The TTG and RTG have integer times of cycle corresponding to a Sampling Frequency(Fs).

Table 1 shows an individual symbol location of the down link and up link described in FIG. 4.

[Table 1]

<table>
<thead>
<tr>
<th>Number of data symbols</th>
<th>DL:UL = 16:6</th>
<th>DL:UL = 13:9</th>
</tr>
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<td>(0,1,2),(3,4,5),(6,7,8)</td>
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The number of table 1 corresponds to a symbol number designated in each symbols among frames illustrated in FIG. 4. Further, the resource allocation of time dimension for transmitting data is composed of by the unit of symbols in parenthesis.

Table 2 shows physical coefficients to the frame structure illustrated in FIG. 4.
[Table 2]

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<td>Duration (µs)</td>
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The frame is illustrated in FIG.4 has the physical coefficients like table 2, each frame has the length of 5 msec described above, when adding up symbols of the up link and the down link, and time intervals of the TTG and the RTG.

Meanwhile, the up link and the down link in the frame are capable of having the asymmetrical structure as described above. At the down link, while it is used a preamble which notifies a point of time to start transmitting data and a pilot symbol which determines a channel, it is possible to use the only preamble without using the pilot symbol. Further, the signal may or may not exist according to the condition of communication channel in the data symbol of the up link and the down link.

The switching timing signal generating circuit 290
generates a switching timing signal by determining start position of a down link and an up link after receiving a signal to have the frame structure as described above.

FIG. 5 is an example screen showing a waveform of a signal when a 10% probability of data existing in a data symbol of FIG. 4. Further, FIG. 6 is an example screen showing a waveform of reference signal using for correlation in an optical repeater. Furthermore, FIG. 7 is an example screen showing a waveform of a signal output in result of correlating the signal illustrated in FIG. 5 and FIG. 6.

The coupler 265 of a remote 250 extracts a part of signals and transmits it to a switching timing signal generating circuit 290 when the signal illustrated in FIG. 5 has been transmitted to the remote 250 through a main donor 200 of an optical repeater from the AP 110. A switching timing signal generating circuit 290 generates a standard signal illustrated in FIG. 6. The signal waveform illustrated in FIG. 7 is to come by when correlating the standard signal with the received signal illustrated in FIG. 5.

Herein, the reference signal illustrated in FIG. 6 has '1', the signal value from 0 second to 0.015 second to perform correlation in the signal interval in which the received signal exists because the received signal illustrated in FIG. 5 has a signal section from 0 second to 0.015 second.
Meanwhile, it is possible to know a frame starting point by identifying the location of a preamble because one of frames is started from a preamble as illustrated in FIG. 4.

A preamble signal composed of '1', simple formation, consecutively because a preamble is not a data symbol, but a signal used in order to synchronize transmitting timing by signifying a starting time point of data symbol. That is, a reference signal in a preamble signal section is equal to a signal value and therefore, the result value becomes the maximum value at a point of time where a preamble locates and this location becomes a start position of each frame when correlating the received signal illustrated in FIG. 5 with the reference signal illustrated in FIG. 6. As a result, the location of the maximum value in the signal waveform illustrated in FIG. 7 becomes a start position of a frame.

As described in FIG. 4, it is possible to calculate a starting point of a down link and up link by calculating a time interval set in each symbol of a frame when knowing a start position of a frame because a frame structure including a up link and down link has been defined in advance. That is, a start position of a frame becomes a starting point of a down link because a frame has started from a down link section. Further, a location to add a TTG to a time interval of a down link becomes a starting point of an up link. Therefore, 0.005 second, 0.01 second and
0.015 second having a maximum value in the waveform of FIG. 7 becomes a starting point of each frame respectively. Further, a starting point of an up link and a down link calculated on the basis of this becomes starting points of an uplink signal and a downlink signal.

The switching timing signal generating circuit 290 controls a switch by generating switching timing signals on the basis of starting points of a downlink signal and an uplink signal. As a result, it is possible to distinguish between a downlink signal and an uplink signal, and provide a transmission path for each signal in the optical repeater.

Meanwhile, it is possible to generate a switching timing signal by distinguishing between a downlink signal and an uplink signal even when using the only preamble without changing a ratio of a data symbol which makes up an up link and a down link of a frame and using a pilot symbol because one frame has started from a preamble, a result value of correlation has become the maximum at a time interval where a preamble has been located, and then it is possible to know a start position of a frame as described above.

FIG. 8 is a flow diagram illustrating a switching timing signal generating process separating transmitting and receiving signals in an optical repeater of a mobile communication network using a TDD scheme and an OFDM modulation scheme according to a preferred embodiment of the
present invention.

As illustrated in FIG. 8, a main donor 250 of an optical repeater receives a RF signal transmitted from the AP 110, converts the RF signal to an optical signal, and transmits it to a remote 250 through an optical communication cable(S800). The remote 250 converts the received optical signal to a RF signal, and transmits it to the AT 100. The coupler 265 located in between the O/E conversion module of the remote 250 and the HPA 270 extracts a part of a RF signal, and transmits it to the switching timing signal generating circuit 290(S802). The switching timing signal generating circuit 290 correlates the signal transmitted from the coupler 265 with the reference signal generated in the reference pulse generated of the switching timing signal generating circuit 290(S804). As a result of the correlation, since the location showing the maximum value at the waveform becomes a start location of a frame, it is allowed to determine a start position or a frame by analyzing the waveform by using the result of the correlation(S806).

Since the frame structure of the signal using the TDD scheme and the OFDM modulation scheme is defined in advance as described in FIG. 4, the switching timing signal generating circuit 290 calculates a starting point of a downlink signal and uplink signal included in the RF signal on the basis of a frame starting point(S808). When the
starting points of the downlink signal and uplink signal are calculated, by using this, the switching timing signal generating circuit 290 generates a switching timing signal for distinguishing the downlink signal from the uplink signal, and transmits it to the switch 275(S810). When the switching timing signal is transmitted to the switch 275, the switch 275 distinguishes the downlink signal from the uplink signal by using the switching timing signal, controls the opening and closing of the switch 275, and then provides path for each signal selectively(S812). Therefore, the optical repeater prevents the switching timing signal from interfering with the downlink signal and uplink signal. Further, the optical repeater repeats the transmission signal between the AP 110 and the AT 100 by transmitting it to the AT 100 in the case of the downlink signal, and transmitting it to the AP 110 in the case of the uplink signal.

While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiment and the drawings, but, on the contrary, it is intended to cover various modifications and variations within the spirit and scope of the appended claims.

**Industrial Applicability**
According to the present invention as described above, it is possible to operate an optical repeater maintaining stability because the optical repeater of a mobile communication network using the TDD scheme and the OFDM scheme itself distinguishes between a downlink signal and an uplink signal, generates a switching timing signal to provide a path for each signal selectively, and controls a switch.

Further, it is possible to receive a switch controlling signal without setting up an extra modem, and operate an optical repeater without extra procedure for compensating delaying value of an optical cable because a transmission signal is distinguished in an optical repeater itself.
Claims

1. A method for generating a switching timing signal to separate a transmission signal in an optical repeater of a mobile communication system including an AP, an AT and an optical repeater by using a TDD scheme and an OFDM modulation scheme, the method comprising the steps of:

   (a) transmitting an RF signal received from the AP to a remote of the optical repeater via a main donor of the optical repeater;

   (b) extracting a part of the RF signal in a coupler of the remote, and transmitting the part of the RF signal to a switching timing signal generating circuit of the remote;

   (c) correlating the RF signal extracted from the coupler with the reference signal generated in the switching timing signal generating circuit;

   (d) detecting a frame start position of the RF signal by analyzing a correlation result value;

   (e) calculating starting points of a downlink signal and an uplink signal included in the RF signal on the basis of the frame start position;

   (f) generating the switching timing signal by using starting point information of the downlink signal and the uplink signal, and transmitting the switching timing signal to a switch of the optical repeater; and

   (g) separately the switch for transmitting the
downlink signal from the uplink signal by controlling the switch by using the switching timing signal.

2. The method as claimed in claim 1, wherein, at step (d), the position corresponding to the maximum correlation result value is determined as a frame start position of the RF signal.

3. The method as claimed in claim 1, wherein, at step (g), when receiving a downlink signal by controlling the received switching timing signal, the switch 275 radiates the downlink signal to the AT 100, and when receiving a uplink signal, the switch 275 blocks a path connected with an HPA 270 of the remote, and sets up a path to transmit the uplink signal to a LNA 280 of the remote.

4. The method as claimed in claim 1, wherein a frame of the RF signal includes a down link frame, an up link frame, a Tx/Rx Transition Gap (hereinafter, referred to as "TTG") and a Rx/Tx Transition Gap (hereinafter, referred to as "RTG").

5. The method as claimed in claim 4, wherein the frame has the length of 5 msec as a result of adding all time intervals of the down link, the up link, the TTG and the RTG.
6. The method as claimed in claim 6, wherein the down link is a frame for a downlink signal transmitted from the AP through the optical repeater to the AT, and the up link is a frame for an uplink signal transmitted from the AT through the optical repeater to the AP.

7. The method as claimed in claim 6, wherein the TTG is a Guard Time for separating a transmission time of the down link from a transmission time of the up link, an interval between the down link and the up link transmitted consecutively, and during the TGG, the AP is changed into a mode for receiving the up link while the AT is changed into a mode for transmitting the down link.

8. The method as claimed in claim 6, wherein the RTG is a Guard Time for separating a transmission time of the up link from a transmission time of the down link, an interval between the up link and the down link transmitted consecutively, and during the TGG, the AP is changed into a mode for receiving the down link while the AT is changed into a mode for transmitting the up link.

9. The method as claimed in claim 7 or claim 8, wherein during the TTG or the RTG, each of the AP and the AT does not transmit an effective signal including data.
10. The method as claimed in claim 6, wherein in step (e), the frame start position is detected as the starting point of the down link and a location of a TTG plus a time interval of a down link is detected as the starting point of the up link, and then the starting point of the down link is set as the starting point of the downlink signal and the starting point of the up link is set as the starting point of the uplink signal.

11. The method as claimed in claim 4, wherein the down link and the up link is comprised of a plurality of OFDM symbols, the OFDM symbols including a data symbol, a pilot symbol and a preamble.

12. The method as claimed in claim 11, wherein a ratio of the data symbol comprising the down link and the up link of the frame has an asymmetric structure of 16:6 or 13:9.

13. The method as claimed in claim 11, wherein the first OFDM symbol of the down link is the preamble and a pilot symbol is inserted in every three data symbols, and the up link is comprised of the data symbols.

14. The method as claimed in claim 11, wherein the first OFDM symbol of the down link is the preamble and the remaining OFDM is comprised of the data symbols, and the up
link is comprised of the data symbols.

15. The method as claimed in claim 11, wherein the time interval of the data symbol corresponds to a time interval \( T_s = T_g + T_b \) which is the last \( T_g \) from among an effective symbol time interval \( T_b \) plus effective symbol time interval.

16. The method as claimed in claim 15, wherein the preamble has the \( T_s \) as for a time interval, and is used to synchronize a transmission timing by notifying a point of time to start transmission of data.

17. The method as claimed in claim 15, wherein the pilot symbol has \( T_p (= T_b / 2 + T_g) \) as for a time interval, and is used to determine whether a communication channel is a down link or an up link by being inserted in the middle of the data symbol.

18. A switching timing signal generating system for separating a RF signal received from an AP and an AT in a optical repeater of a mobile communication network employing a TDD scheme and an OFDM modulation scheme into a downlink signal and an uplink signal, the switching timing signal generating system comprising a main donor of the optical repeater for converting the RF signal received from the AP
to an optical signal, transmitting the optical signal to a remote, converting the optical received from the remote to a RF signal, and transmitting the RF signal to the AP;

a remote of the optical repeater for converting an optical signal received from the main donor to a RF signal, transmitting the RF signal to AT, converting the RF signal received from the AT to an optical signal, and transmitting the optical signal to the main donor;

and a switching timing signal generating circuit for extracting a part of the RF signal transmitted to the remote from the main donor, correlating a reference signal generated in itself with an extracted RF signal, detecting a frame start position of the extracted RF signal by analyzing a correlation result value, calculating a starting point of the downlink signal and the uplink signal included in the RF signal on the basis of the frame start position, and generating a switching timing signal by using starting point information of the downlink signal and the uplink signal, and transmitting the switching timing signal to the switch.

19. The switching timing signal generating system as claimed in claim 18, wherein the AP transmits the RF signal to AT through the optical repeater and receives the RF signal transmitted by the AT through the optical repeater while the AT receives the RF signal transmitted by the AP through the optical repeater and transmits the RF signal to
the AP through the optical repeater.

20. The switching timing signal generating system as claimed in claim 18, wherein the main donor of the optical repeater transmits the RF signal to the AP through a RF cable.

21. The switching timing signal generating system as claimed in claim 18 or claim 19, wherein the main donor of the optical repeater includes a Low Noise Amplifier (hereinafter, referred to as "LNA"), an E/O conversion module, a Wavelength Division Multiplexer 215 (hereinafter, referred to as "WDM"), an O/E conversion module, a High Power Amplifiers (hereinafter, referred to as "HPA").

22. The switching timing signal generating system as claimed in claim 21, wherein the main donor is connected with the remote of a plurality of the optical repeaters through an optical communication cable.

23. The switching timing signal generating system as claimed in claim 22, wherein the main donor includes a signal divider having multi-channel and a signal coupler.

24. The switching timing signal generating system as claimed in claim 18 or claim 19, wherein the remote of the
optical repeater includes a Wavelength Division Multiplexer (hereinafter, referred to as "WDM"), an O/E conversion module, an High Power Amplifiers (hereinafter, referred to as "HPA"), a switch, a Low Noise Amplifier (hereinafter, referred to as "LNA") and an E/O conversion module.

25. The switching timing signal generating system as claimed in claim 24, further comprising a coupler located in between the O/E conversion module and the HPA, for extracting a part of the RF signal transmitted from the O/E conversion module to the HPA, and transmitting the RF signal to the switching timing signal generating circuit.

26. The switching timing signal generating system as claimed in claim 25, wherein the switching timing signal generating circuit located within the remote of the optical repeater receives the RF signal extracted from the coupler, generates the switching timing signal, and transmits the switching timing signal to the switch.

27. A switching timing signal generating circuit for generating a switching timing signal separating a RF signal received from an AP and an AT in an optical repeater of a mobile communication network employing a TDD scheme and an OFDM modulation scheme into a downlink signal and an uplink
signal, the switching timing generating circuit comprising:

- a divider for receiving an extracted RF signal extracted from a coupler included in a remote of the optical repeater as a part of the RF signal transmitted from a main donor of the optical repeater to the remote, and providing the extracted RF signal for a level detector and a Variable Gain Amplifier (hereinafter, referred to as "VGA");
- a level director for measuring a level of the extracted RF signal received from the divider;
- a VGA for receiving a level value measured at the level detector, and outputting the level of the extracted RF signal;
- a log-scale amplifier for allowing a variation of the extracted RF signal received from the VGA to convert from a linear scale to a decibel (dB) scale, and transmitting a converted extracted RF signal to a pulse generator;
- a pulse generator for generating a pulse waveform signal by using the extracted RF signal received from the log-scale amplifier, and transmitting the pulse waveform signal to a comparator;
- a reference pulse generator for generating a reference pulse waveform signal for use in determining a frame start position of the extracted RF signal after correlating the pulse waveform signal generated in the pulse generator and transmitting the reference pulse waveform signal to the comparator;
a comparator for correlating the pulse waveform signal received from the pulse generator with the reference pulse waveform signal received from the reference pulse generator; a timing controller for determining a frame start position of the extracted RF signal by analyzing a correlation result value, calculating a starting point of the downlink signal and the uplink signal included in the RF signal on the basis of the frame start position, and generating a switching timing signal by using the starting point information of the downlink signal and the uplink signal, and transmitting the switching timing signal to a switch of the Optical repeater; and

a phase tuning circuit for receiving a phase information of the pulse waveform signal generated in the pulse generator, and tuning the phase of the reference pulse waveform signal.

28. The switching timing signal generating circuit as claimed in claim 27, wherein the timing controller detects a frame start position of the extracted RF signal as a location where the correlation result value is the maximum by analyzing the correlation result value.

29. The switching timing signal generating circuit as claimed in claim 27, wherein the switching timing signal separates the RF signal transmitted to the switch into a
downlink signal and an uplink signal, controls the switch to 
radiate the downlink signal to the AT 100 through an antenna 
when receiving the downlink signal, and controls the switch 
to transmit the uplink signal to the LNA of the remote when 
receiving the uplink signal through the antenna.
FIG. 2
Start

S800 Transmit RF signal received from AP to remote through main donor

S802 Transmit a part of RF signal extracted from coupler of remote to switching timing signal generating circuit

S804 Correlate extracted signal with reference signal generated in switching timing signal generating circuit

S806 Determine frame start position of signal extracted by analyzing correlation result value

S808 Calculate starting points of transmission signal and receipt signal on the basis of frame start position

S810 Generate switching timing signal by using starting point information of transmitting signal and receiving signal

S812 Control switch according to switch timing signal, distinguish between transmission signal and receipt signal and transmit it

End

FIG. 8
COPY FOR IB
PATENT COOPERATION TREATY
PCT
INTERNATIONAL SEARCH REPORT
(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference | FOR FURTHER ACTION | see Form PCT/ISA/220 as well as, where applicable, item 5 below.
|--------------------------------------|---------------------|---------------------------------------------------
| PCT/KR2005/002484                   | International filing date (day/month/year) | (Earliest) Priority Date (day/month/year) |

Applicant
SK TELECOM CO., LTD. et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report
   a. With regard to the language, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
      ☐ The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.

2. ☐ Certain claims were found unsearchable (See Box No. II)

3. ☐ Unity of invention is lacking (See Box No. III)

4. With regard to the title,
   ☒ the title is approved as submitted by the applicant.
   ☐ the title has been established by this Authority to read as follows:

5. With regard to the abstract,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,
   a. the figure of the drawings to be published with the abstract is Figure No. 2
      ☐ as suggested by the applicant.
      ☒ because the applicant failed to suggest a figure.
      ☐ because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (April 2005)
### A. CLASSIFICATION OF SUBJECT MATTER

**IPC7 H04L 27/26**

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)

- IPC 7 H04L H04B

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

- Korean Patents and applications for Inventions since 1975, Korean Utility models and applications for Utility models since 1975
- Japanese Utility models and applications for utility models since 1975

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

- D/B: eKIPASS (Searching System of KIPO), ESPACENET, IEEE

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>KR 2002-44827 A (KIM, DONG WOO) 19, June 2002 See abstract, detailed description page 4, line 18, pg 5, line14, Fig5</td>
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<td>A</td>
<td>US 05933421 A (AT&amp;T Wireless Services Inc.) 03, August 1999 See abstract, Fig 1</td>
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* 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.
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified).
  - "O" document referring to an oral disclosure, use, exhibition or other means of publication by the inventor 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.
  - "A" document member of the same patent family.

- Date of the actual completion of the international search: 19 OCTOBER 2005 (19.10.2005)
- Date of mailing of the international search report: 20 OCTOBER 2005 (20.10.2005)

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