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(54) Title: HIGH-SPEED DATA TRANSMISSION IN MOBILE COMMUNICATION NETWORKS
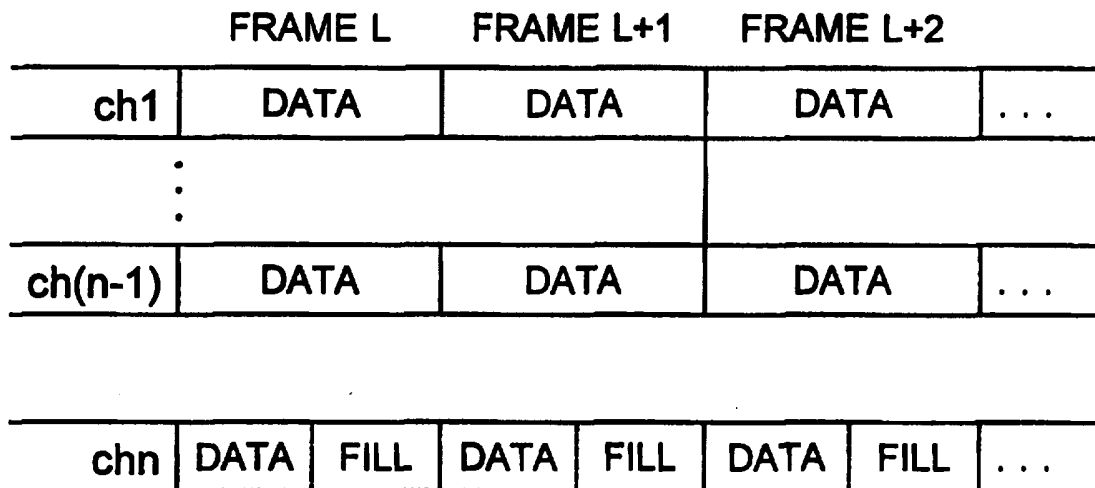
(57) Abstract

The invention relates to a digital mobile system and a method for high-speed data transmission in a digital mobile system. The mobile network allocates n parallel rate-adapted traffic channels to a high-speed user data signal which requires a data transfer rate R_{user} within a range $(n-1)*R_{ch} < R_{user} < n*R_{ch}$, wherein R_{ch} is the maximum transmission rate of a single traffic channel. The user data signal is divided in the transmitter into transmission frames (L, L+1, L+2) for transmission via the parallel traffic channels (ch1-chn) in such a way that all the information bits in the transmission frames of n-1 traffic channels carry user data bits (DATA), and the user data transfer rate of each of the n-1 traffic channels is R_{ch}. In the frames of the nth traffic channel (chn) the number of the information bits carrying user data bits (DATA) is selected to correspond to the user data rate $R_{user}-(n-1)*R_{ch}$ exceeding the capacity of the other n-1 traffic channels. The remaining information bits in the frames of the nth traffic channel carry stuff bits (FILL).

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High-speed data transmission in mobile communication
networks

Field of the Invention

The invention relates to high-speed data
transmission in digital mobile communication networks.

Background of the Invention

In telecommunication systems of the time
division multiple access (TDMA) type, the communication
on the radio path is time-divisional and occurs in
successive TDMA frames each of which consists of several
time slots. A short information packet is transmitted
in each time slot in the form of a radio-frequency burst
that has a limited duration and that consists of a
number of modulated bits. The time slots are primarily
used for conveying control and traffic channels. The
traffic channels are used for transferring speech and
data. The control channels are for signalling between
a base station and mobile stations. An example of a TDMA
radio system is the Pan-European digital mobile system
GSM (Global System for Mobile Communications).

In conventional TDMA systems, one traffic
channel time slot is allocated for communication to each
mobile station for the transmission of data or speech.
For example the GSM system may therefore comprise as
many as eight parallel connections to different mobile
stations on a radio frequency carrier. The maximum data
transfer rate on one traffic channel is limited to a
relatively slow level, e.g. in the GSM system 9.6 Kbps
or 12 Kbps, according to the available bandwidth and the
channel coding and error correction employed in the
transmission. In the GSM system, a so-called half-rate
(max. 4.8 Kbps) traffic channel can also be selected for
low speech coding rates. The half-rate traffic channel
is established when a mobile station operates in an

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assigned time slot only in every other frame, i.e. at half the rate. Another mobile station operates in the same assigned time slot of every other frame. The system capacity, measured in the number of mobile subscribers, can thus be doubled, i.e. as many as 16 mobile stations can operate on the carrier frequency simultaneously.

In recent years, the need for high-speed data services in mobile networks has increased considerably. For example transmission rates of at least 64 Kbps would be required for the ISDN (Integrated Services Digital Network) circuit-switched digital data services. The data services of the public switched telephone network (PSTN), for example a modem and G3-type telefax terminals, require higher transmission rates such as 14.4 Kbps. One of the increasing areas of mobile data transmission that requires transmission rates exceeding 9.6 Kbps is mobile video services. Examples of such services include security surveillance by means of cameras, and video databases. The minimum data rate in video transmission may be for example 16 or 32 Kbps.

The transmission rates of the present mobile networks are not sufficient for meeting these new requirements, however.

An arrangement, which is disclosed in a co-pending patent application of the Applicant, WO95/31878 (unpublished on the filing date of the present application), relates to allocating two or more parallel traffic channels (subchannels) on the radio path for one high-speed data connection. The high-speed data signal is divided in the transmitter into these parallel subchannels for the transmission over the radio path, to be restored in the receiver. This approach enables the supply of data transmission services with as high as eight-fold transmission rate compared to the conventional rate, depending on the number of the

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traffic channels allocated. For example in the GSM system, the total user data rate of 19.2 Kbps is obtained by two parallel 9.6 Kbps subchannels, each channel being rate-adapted in the same manner as in the existing transparent 9.6 Kbps bearer services of the GSM system.

A problem relating to the use of parallel traffic channels is the data rates which cannot be rate-adapted with the existing methods of the GSM system even though these data rates can be evenly distributed between the available parallel subchannels.

For example the user data rate of 14.4 Kbps (according to e.g. ITU-T Recommendation V.32bis) requires two transparent GSM traffic channels the data rate in each of which should be 7.2 Kbps (2 × 7.2 Kbps = 14.4 Kbps), but there is no rate adaptation in the GSM system for the subchannel data rate of 7.2 Kbps.

Correspondingly, for example the user data rate of 40 Kbps (ITU-T Recommendation V.120) requires five transparent GSM traffic channels in each of which the data rate should be 8 Kbps (40 Kbps : 5), but there is again no rate adaptation in the GSM system for such a subchannel data rate.

Another problem is the data rates that cannot be evenly divided into a required number of transparent GSM traffic channels. For example the user data rate of 56 Kbps (ITU-T Recommendation V.110) requires at least six transparent GSM traffic channels, but it cannot be divided into these six parallel subchannels in such a way that the (V.110) frames of each subchannel carry the same number of data bits (56 Kbps : 6 = 9333.333 bps).

Disclosure of the Invention

An object of the present invention is to provide a method and a telecommunication system which support the rata adaptation of different transmission

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rates in high-speed data transmission utilizing parallel
traffic channels.

A first aspect of the invention is a method for
high-speed data transmission in a digital mobile
communication system, said method comprising a step of
transmitting data over the radio path between
a mobile station and a fixed mobile network on a rate-
adapted traffic channel allocated to the mobile station.
According to the invention, the method is characterized
by further steps of
allocating n parallel rate-adapted traffic
channels to a high-speed user data signal, which
requires a data rate R_{user} within a range $(n-1)*R_{ch} < R_{user} < n*R_{ch}$, wherein R_{ch} is the maximum transmission
rate of any one of said traffic channels, and $n = 2, 3, \ldots$,
dividing the high-speed user data signal into
transmission frames for transmission via said parallel
traffic channels in such a way that all the information
bits in the transmission frames of n-1 traffic channels
carry user data bits, and the user data transfer rate
of each of said n-1 traffic channels being R_{ch}, and a
number of the information bits carrying user data bits
in transmission frames of said nth traffic channel
corresponds to the user data transfer rate $R_{user} - (n-1)*R_{ch}$
left over from the other n-1 traffic channels, and the
remaining information bits in the transmission frames
of said nth traffic channel carry stuff bits.

A second aspect of the invention is a digital
mobile communication system wherein a mobile station and
a fixed mobile network comprise a data transmitter and
a data receiver which are capable of data transmission
over the radio path on a traffic channel allocated to
the mobile station. According to the invention, the
system is characterized in that

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the fixed mobile network is arranged to allocate n parallel rate-adapted traffic channels to a high-speed user data signal which requires a data transfer rate R_{user} that is in the range $(n-1)*R_{ch}<R_{user}<n*R_{ch}$, wherein R_{ch} is the maximum transmission rate of an individual traffic channel and $n=2,3,...,$

the data transmitters are arranged to divide the high-speed user data signal into transmission frames for transmission via said parallel traffic channels in such a way that all the information bits in the transmission frames of n-1 traffic channels carry user data bits, and the user data transfer rate of each of said n-1 traffic channel being R_{ch}, and a number of the information bits carrying user data bits in the transmission frames of the nth traffic channel corresponds to the user data transfer rate $R_{user}-(n-1)*R_{ch}$ left over from the other n-1 traffic channels, and the remaining information bits in the transmission frames of said nth traffic channel carry stuff bits.

According to the present invention, if a high-speed user data signal requires the capacity of n traffic channels, the user data is divided into traffic channels in such a way that the capacity of n-1 traffic channels is used completely, i.e. each information bit in each transmission frame carries user data. The remainder of the user data (the user data exceeding the capacity of n-1 channels) is carried in a required number of information bits of the frames on the nth traffic channel. The remaining "extra" information bits on the last-mentioned traffic channel carry stuff bits.

Therefore the transmission frames of all traffic channels contain a fixed number of information bits independently of the data rate of the high-speed signal to be transmitted. The number of the information bits is such that the data rate of the frame is fixed

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and corresponds to the standard rate adaptation of a traffic channel in the mobile communication system, e.g. 9.6 Kbps in the GSM system. Due to the invention, all user transmission rates that have already been and that will be standardized can be transferred via mutually identical traffic channels that have been rate-adapted to one transmission rate, by performing a further rate adaptation within a single traffic channel. The rate adaption of a high-speed user data signal requires changes in the frames of only one traffic channel, and these changes concern the selection of the relative proportion of user data bits and stuff bits to correspond to the transmission rate that is left over from the other traffic channels. The other parallel traffic channels carry a full amount of user data and are therefore completely standard rate-adapted traffic channels.

For example in the GSM system, it is possible to use a standard 9.6 Kbps rata-adapted transparent traffic channel and a transmission frame of 48 information bits according to the CCITT Recommendation V.110. In such a case, different user data rates between 0 and 9.6 Kbps can be transmitted through a 9.6 Kbps rate-adapted traffic channel by varying the number of the information bits used for the user data transmission between 0 and 48 in the V.110 frame.

The centralization of stuff bits in one traffic channel enables the transmission at any standard data rate. Distributing the user data bits and the stuff bits evenly into traffic channels would not be possible with all standard transmission rates, such as 56 or 64 Kbps, but "fragments" of bits would have to be transmitted in the frames. In practice, this would require a long user data buffer in the transmission. In the invention, a fixed number of user data bits and stuff bits are

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transmitted even on the last traffic channel, wherefore no separate buffering is needed and the above-described problem is not encountered.

Brief Description of the Drawings

In the following, the invention will be described by means of preferred embodiments with reference to the accompanying drawings, in which

Figure 1 illustrates a part of a mobile system wherein the invention can be applied,

Figure 2 illustrates high-speed data transmission in two TDMA time slots over the radio path,

Figure 3 illustrates the network architecture according to the invention, which supports the high-speed data transmission of several traffic channels between a mobile station MS and an interworking function IWF in the GSM system,

Figure 4 shows the V.110 frame structure,

Figure 5 illustrates the data transmission according to the invention in the frames of n parallel traffic channels,

Figure 6 illustrates the adaptation of the user rate of 56 Kbps to six 9.6 Kbps traffic channels according to the invention.

Preferred Embodiments of the Invention

The present invention may be applied to high-speed data transmission in digital TDMA-type mobile communication systems, such as the Pan-European digital mobile communication system GSM, DCS1800 (Digital Communication System), the mobile communication system according to the EIA/TIA Interim Standard IS/41.3, etc. The invention will be illustrated below by using as an example a GSM-type mobile system, without being restricted thereto, however. Figure 1 introduces very briefly the basic structural components of the GSM system, without describing their characteristics or the

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other elements of the system. For a more detailed
description of the GSM system, reference is made to the
GSM recommendations and to "The GSM System for Mobile
Communications" by M. Mouly and M. Pautet (Palaiseau,
France, 1992, ISBN:2-9507190-07-7).

A mobile services switching centre controls the
switching of incoming and outgoing calls. It performs
similar functions as the exchange of the PSTN. Further,
it also performs, together with the network subscriber
registers, functions, such as location management, that
are only characteristic of mobile telephone traffic.
Mobile stations MS are connected to the MSC via base
station systems BSS. A base station system BSS consists
of a base station controller BSC and base stations BTS.
For the sake of clarity, Figure 1 only shows a base
station system wherein two base stations are connected
to the base station controller BSC and wherein one
mobile station MS is located within the coverage area
of the base stations.

The GSM system is a time division multiple
access (TDMA) type system. The channel structures used
in the radio interface are defined in greater detail in
the ETSI/GSM recommendation 05.02. During normal
operation, one time slot is allocated from a carrier
frequency to a mobile station MS as a traffic channel
in the beginning of a call (single slot access). The
mobile station MS is synchronized with the allocated
time slot to transmit and receive radio-frequency
bursts. During the remaining time of the frame, the MS
performs different measurements. The Applicant's co-
pending patent applications WO95/31878 and PCT/FI95/
00673 disclose a method wherein two or more time slots
are allocated to a mobile station MS which requires data
transmission with a higher rate than what one traffic
channel can provide. As regards the details of this

procedure, reference is made to the aforementioned patent applications.

In the following, the procedure will be described with reference to Figure 2 only as one way of carrying out high-speed data transmission, based on several parallel traffic channels, in a radio system. It should be noted, however, that the only matter essential for the invention is that a connection comprising several parallel traffic channels is established, and the invention itself relates to carrying out and synchronizing data transmission over such a connection.

Figure 2 shows an example wherein successive time slots 0 and 1 are allocated to a mobile station MS from a single TDMA frame. A high-speed data signal DATAIN, which is to be transmitted over the radio path, is divided in a divider 82 into a required number of lower-speed data signals, namely DATA1 and DATA2. Each lower-speed data signal DATA1 and DATA2 is separately subjected to channel coding, interleaving, burst formation and modulation 80 and 81, respectively, whereafter each lower-speed data signal is transmitted as a radio-frequency burst in a dedicated time slot 0 and 1, respectively. When the lower-speed data signals DATA1 and DATA2 have been transmitted over the radio path through different traffic channels, they are separately subjected in the receiver to demodulation, deinterleaving and channel decoding 83 and 84, respectively, whereafter the signals DATA1 and DATA2 are again combined in a combiner 85 of the receiver into the original high-speed signal DATAOUT.

Figure 3 is a block diagram illustrating the GSM network architecture which implements such data transmission using several parallel traffic channels. The functions of the blocks 80, 81, 83 and 84 of Figure

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3, i.e. channel coding, interleaving, burst formation
and modulation, and correspondingly demodulation,
deinterleaving and channel decoding are situated on the
side of the fixed network preferably at the base station
5   BTS. The above-described TDMA frame is thus transmitted
between the base station BTS and the mobile station MS
in a radio interface Radio I/F. Each time slot is
subjected to separate parallel processing at the base
station BTS. The divider 82 and the combiner 85 of
10   Figure 2 may be located in the fixed network side remote
from the base station BTS in another network element,
such as BSC, whereupon the lower-speed data signals
DATA1 and DATA2 are transmitted between this network
element and the base station in the same way as the
15   signals of normal traffic channels. In the GSM system,
this communication takes place in TRAU frames according
to the ETSI/GSM recommendation 08.60 between the base
station BTS and a special transcoder/rateadapter unit
(TRCU). The TRAU frames and the transmission associated
20   thereto are not essential for the invention, since the
invention relates to carrying out and synchronizing data
transmission over the entire data connection utilizing
several parallel traffic channels, i.e. between the
divider 82 and the combiner 85.
25   In the GSM system, a data link is formed
between a terminal adapter 31 in the mobile station MS
and an interworking function IWF 32 in the fixed
network. In data transmission occurring in the GSM
network, this connection is a V.110 rate-adapted, UDI-
30   coded digital 9.6 Kbps full-duplex connection that is
adapted to V.24 interfaces. The V.110 connection
described herein is a digital transmission channel that
was originally developed for ISDN (Integrated Services
Data Network) technology, that is adapted to the V.24
35   interface, and that also provides the possibility of

transmitting V.24 statuses (control signals). The CCITT
recommendation for a V.110 rate-adapted connection is
disclosed in the CCITT Blue Book: V.110. The CCITT
recommendation for a V.24 interface is disclosed in the

5   CCITT Blue Book: V.24. The terminal adapter 31 adapts
the data terminal connected to the mobile station MS to
a V.110 connection, which is established over a physical
connection utilizing several traffic channels ch0 to
chN. The IWF couples the V.110 connection to another

10   V.110 network, such as an ISDN or another GSM network,
or to some other transit network, such as the public
switched telephone network PSTN. In the first case, the
IWF only contains the divider/combiner 82/85 according
to the invention. In the last-mentioned case, the IWF

15   also contains for example a baseband modem by means of
which data transmission is performed through the PSTN.

        The frame structure used for data transmission
on a V.110 connection (9.6 Kbps) is shown in Figure 4.
The frame comprises 80 bits. Octet 0 contains binary

20   zeroes, whereas octet 5 contains a binary one which is
followed by seven E bits. Octets 1 to 4 and 6 to 9
comprise a binary one in bit position 1, a status bit
(S or X bit) in bit position 8, and 6 data bits (D bits)
in bit positions 2 to 7. The bits are transmitted from

25   left to right and from top to bottom. The frame thus
comprises 48 information bits D1 to D48 (user data).
Bits S and X are used to transmit channel control
information associated to the data bits in the data
transmission mode.

30   As described above, the problem with such high-
speed data transmission is the data rates which cannot
be rate-adapted with the present methods of the
telecommunications systems. For example in the GSM
system, such rates include all data rates that are not

35   multiples of 9.6 Kbps.

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This is solved in the invention by diving a high-speed user data signal in the transmitter into parallel traffic channels in such a way that the full capacity of as many traffic channels as possible is first used for the transmission of user data, whereafter the user data that is left over from these "full rate" traffic channels is transmitted on one "lower rate" traffic channel together with stuff bits. This method according to the invention will be described generally below.

Assume that the data transfer rate R_{user} required by a high-speed user data signal and arriving at a divider 82 in Figure 2 is in the range $(n-1)*R_{ch} < R_{user} < n*R_{ch}$, wherein R_{ch} is the maximum transmission rate of an individual traffic channel, and the integer $n \geq 2$. In such a case, the signal DATA IN requires n parallel traffic channels which are allocated by the fixed network (e.g. MSC). The divider 82 divides the data signal DATA IN into the transmission frames which will then be transmitted via the allocated parallel traffic channels in a manner illustrated in Figure 5. All the information bits in the transmission frames of traffic channels ch1, ch2 and ch(n-1) are user data bits, whereupon the transmission rate of the user data is R_{ch} on all these traffic channels. Therefore the traffic channels ch1, ch2, ch(n-1) carry the user data at the total transmission rate of $(n-1)*R_{ch}$. The information bits of the last traffic channel chn comprise user data bits DATA only in an amount corresponding to the user data transfer rate $R_{user}-(n-1)*R_{ch}$ left over from the other traffic channels, and the rest of the information bits are stuff bits FILL. The frames are transmitted via transmitters 80 and 81 to receivers 83 and 84, and combined in a combiner 85 to provide a high-speed user data signal DATA OUT. The

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traffic channels between the divider 82 and the combiner
85 may then be standard rate-adapted and mutually
identical traffic channels. Therefore, it is not
necessary to introduce new rate adaptation into the
5   mobile system separately for each standard user
transmission rate.

The application of the present invention to the
GSM system will be described below. It is then assumed
that rate-adapted transparent full-rate 9.6 Kbps traffic
10   channels are used as the parallel traffic channels, and
V.110 frames of Figure 4 are transmitted on the traffic
channels. A frame then comprises 48 information bits D1
to D48.

A few examples of the adaptation of high-speed
15   data to such a V.110 frame of a GSM traffic channel will
be examined below.

Example 1

Assume that the user data rate R_{user} = 56 Kbps,
whereupon six parallel GSM traffic channels are needed
20   (R_{ch} = 9.6 Kbps). The rate adaptation according to the
invention may then be carried out as shown in Figure 6.
All the 48 information bits D1 to D48 in each V.110
frame on traffic channels ch1, ch2, ch3, ch4 and ch5
carry user data, whereupon the user data rate on each
25   of these channels is 9.6 Kbps. Therefore the total
transmission rate of the channels ch1 to ch5 is 5*9.6
Kbps = 48 Kbps. The remaining user transmission rate is
thus 56-48 Kbps = 8 Kbps, which is transmitted on the
last traffic channel ch6. This is carried out in such
30   a way that 40 information bits (e.g. D1 to D40) in each
V.110 frame on traffic channel ch6 carry user data bits
and 8 information bits (e.g. D41 to D48) carry stuff
bits. In this manner, a 56 Kbps signal can be
transmitted through six GSM traffic channels.

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Example 2

Assume that the user data rate R_{user} = 14.4 Kbps. Two traffic channels (R_{ch} = 9.6 Kbps) are then needed. In such a case, all the information bits D1 to D48 of the V.110 frame on the first traffic channel carry user data bits, whereupon the transmission rate is 9.6 Kbps. The remaining data rate, i.e. 14.4-9.6 Kbps = 4.8 Kbps, is adapted to the second traffic channel in such a way that 24 information bits (e.g. D1 to D24) in each V.110 frame carry user data and 24 information bits (e.g. D25 to D48) carry stuff bits.

Example 3

Assume that the user data rate R_{user} = 26.4 Kbps, whereupon three traffic channels (R_{ch} = 9.6 Kbps) are needed. In such a case, all the information bits D1 to D48 in the V.110 frames of two traffic channels carry user data. The total transmission rate of these two traffic channels is then 19.2 Kbps. The remaining user data rate, i.e. 26.4-19.2 Kbps = 7.2 Kbps, is adapted to a third channel in such a way that 36 information bits (e.g. D1 to D36) of each V.110 frame carry user data and 12 information bits (e.g. D37 to D48) carry stuff bits.

Example 4

Assume that the user data rate R_{user} = 38.4 Kbps, whereupon four traffic channels (R_{ch} = 9.6 Kbps) are needed. Since the user data rate is divided evenly into four traffic channels in such a way that the total capacity of all the traffic channels is used, no stuff bits being needed on any traffic channel.

Even though the invention is described above with reference to certain embodiments, it should be understood, however, that the description is only exemplary and it may be varied and modified without

deviating from the spirit and scope of the invention defined in the appended claims.

Claims

1. A method for high-speed data transmission
in a digital mobile system, said method comprising a
step of

transmitting data over the radio path between
a mobile station and a fixed mobile network on a rate-
adapted traffic channel allocated to the mobile station,
c h a r a c t e r i z e d   by further steps of

allocating n parallel rate-adapted traffic
channels to a high-speed user data signal, which
requires a data rate R_{user} within a range $(n-1)*R_{ch} < R_{user} < n*R_{ch}$, wherein R_{ch} is the maximum transmission
rate of any one of said traffic channels, and $n = 2, 3, \ldots$,

dividing the high-speed user data signal into
transmission frames for transmission via said parallel
traffic channels in such a way that all the information
bits in the transmission frames of $n-1$ traffic channels
carry user data bits, and the user data transfer rate
of each of said $n-1$ traffic channels being R_{ch}, and a
number of the information bits carrying user data bits
in transmission frames of said nth traffic channel
corresponds to the user data transfer rate $R_{user} - (n-1)*R_{ch}$
left over from the other $n-1$ traffic channels, and the
remaining information bits in the transmission frames
of said nth traffic channel carry stuff bits.

2. A method according to claim 1,
c h a r a c t e r i z e d   by transmitting V.110 frames
according to a CCITT recommendation on the parallel
traffic channels.

3. A digital mobile system wherein a mobile
station (MS) and a fixed mobile network (BTS, BSC, MSC)
comprise a data transmitter (31, 32, 82) and a data
receiver (31, 32, 81) which are capable of data

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transmission over the radio path on a traffic channel allocated to the mobile station, c h a r a c - t e r i z e d in that

5   the fixed mobile network (BTS, BSC, MSC) is arranged to allocate n parallel rate-adapted traffic channels to a high-speed user data signal which requires a data transfer rate R_{user} that is in the range (n-1)$*R_{ch}<R_{user}<n*R_{ch}$, wherein R_{ch} is the maximum transmission rate of an individual traffic channel and n=2,3,...,

10   the data transmitters (31, 32, 82) are arranged to divide the high-speed user data signal into transmission frames for transmission via said parallel traffic channels in such a way that all the information bits in the transmission frames of n-1 traffic channels

15 carry user data bits, and the user data transfer rate of each of said n-1 traffic channel being R_{ch}, and a number of the information bits carrying user data bits in the transmission frames of the nth traffic channel corresponds to the user data transfer rate $R_{user}-(n-1)*R_{ch}$

20 left over from the other n-1 traffic channels, and the remaining information bits in the transmission frames of said nth traffic channel carry stuff bits.

4.   A system according to claim 3, c h a r a c t e r i z e d in that the traffic channels

25 are V.110 rate-adapted channels and the transmission frames are V.110 frames according to a CCITT recommendation.

5.   A system according to claim 3 or 4, c h a r a c t e r i z e d in that the maximum

30 transmission rate R_{ch} of the traffic channel is 9.6 Kbps.

6. A system according to claim 3, 4 or 5, c h a r a c t e r i z e d in that the system is a GSM mobile system or a mobile system based thereon.
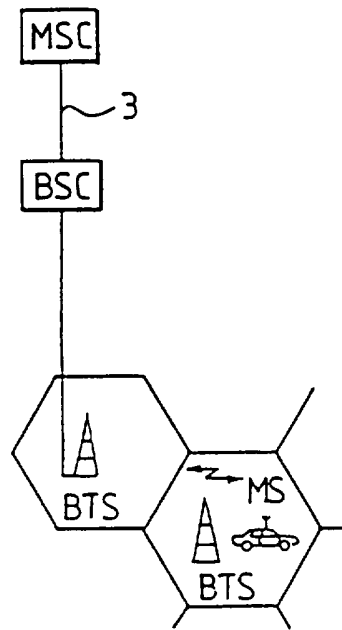
FIG. 1

OCTET NO.	BIT NUMBER							
	1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0	0
1	1	D1	D2	D3	D4	D5	D6	S1
2	1	D7	D8	D9	D10	D11	D12	X
3	1	D13	D14	D15	D16	D17	D18	S3
4	1	D19	D20	D21	D22	D23	D24	S4
5	1	E1	E2	E3	E4	E5	E6	E7
6	1	D25	D26	D27	D28	D29	D30	S6
7	1	D31	D32	D33	D34	D35	D36	X
8	1	D37	D38	D39	D40	D41	D42	S8
9	1	D43	D44	D45	D46	D47	D48	S9

FIG. 4

FIG. 2

FIG. 3
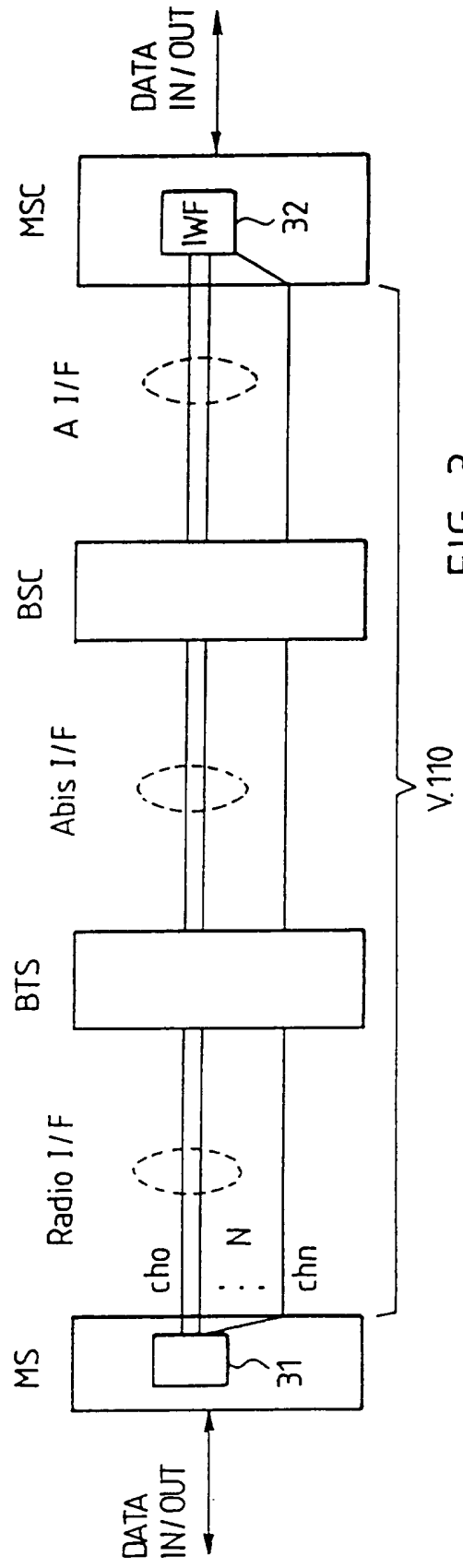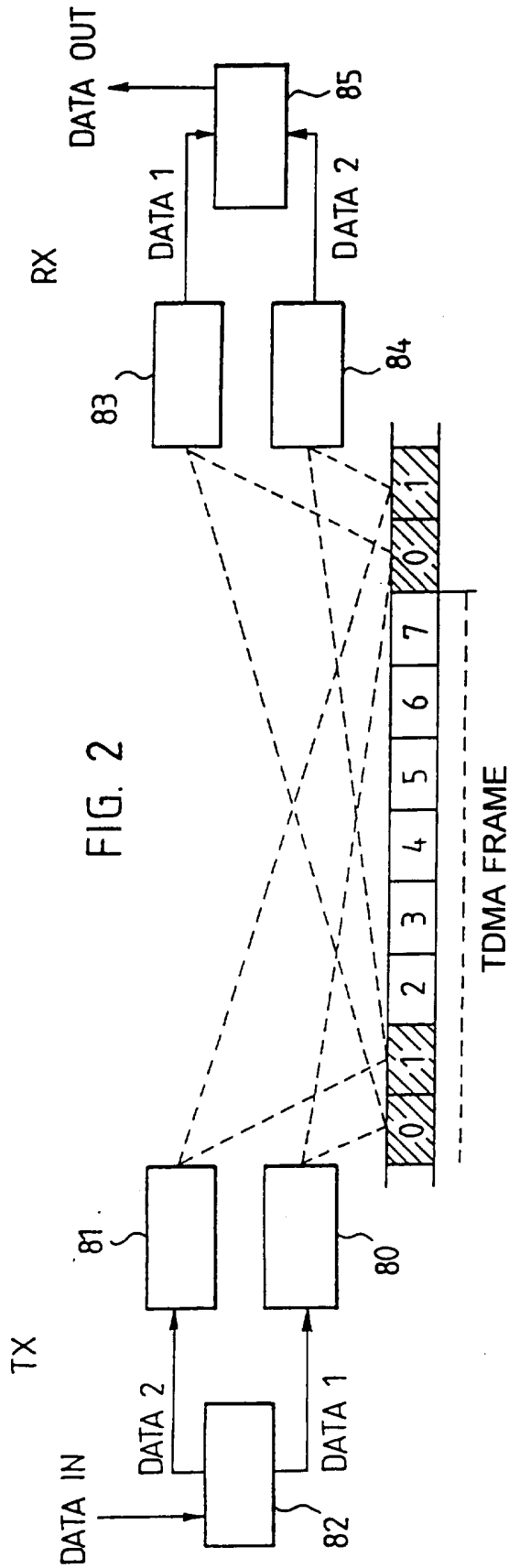
	FRAME L	FRAME L+1	FRAME L+2	
ch1	DATA	DATA	DATA	. . .
⋮				
ch(n-1)	DATA	DATA	DATA	. . .

chn	DATA	FILL	DATA	FILL	DATA	FILL	. . .

FIG. 5

	FRAME L	FRAME L+1	
ch1	48 DATA BITS	48 DATA BITS	. . .
⋮			
ch5	48 DATA BITS	48 DATA BITS	. . .

ch6	40 DATA BITS + 8 STUFF BITS	40 DATA BITS + 8 STUFF BITS	. . .

R_{user} = 56 Kbps

R_{user} = 9.6 Kbps

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 96/00134

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04J 3/16, H04B 7/26 // H04Q 7/22
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)

IPC6: H04J, H04B, H04Q

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

SE,DK,FI,NO classes as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0534493 A2 (FUJITSU LIMITED), 31 March 1993 (31.03.93), column 1, line 5 - line 12; column 4, line 49 - column 5, line 38, figure 7	1,3
Y	WO 9008434 A1 (MOTOROLA, INC.), 26 July 1990 (26.07.90), page 1; page 3, line 14 - line 30	1,3
A	EP 0382363 A2 (DATA GENERAL CORPORATION), 16 August 1990 (16.08.90), column 2, line 35 - column 3, line 23	1,3
A	US 5005170 A (D.R. NELSON), 2 April 1991 (02.04.91), column 2, line 17 - column 3, line 42	1,3

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

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*    Special categories of cited documents:
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     means
"P"  document published prior to the international filing date but later than
     the priority date claimed
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Date of the actual completion of the international search	Date of mailing of the international search report
6 August 1996	0 8 -08- 1996

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 96/00134

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9114319 A1 (NEWBRIDGE NETWORKS CORPORATION), 19 Sept 1991 (19.09.91), abstract	1,3

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		CA-A,C-	2005507	23/07/90
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		EP-A,A,A	0454776	06/11/91
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