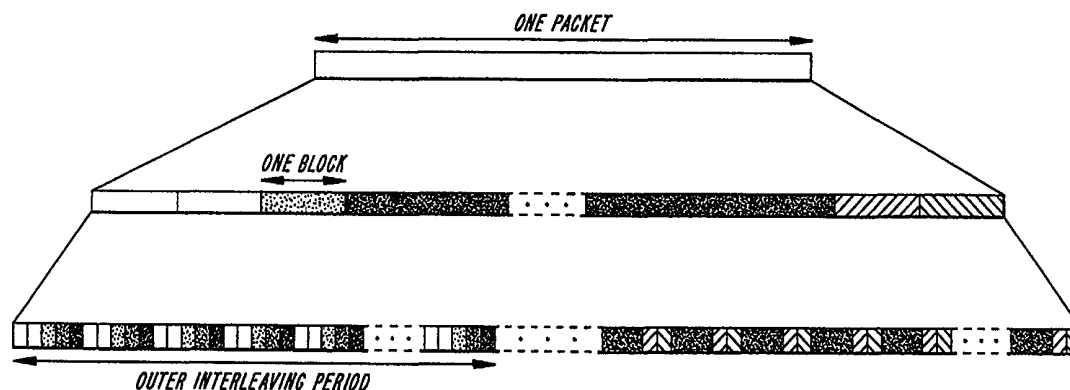




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>H04L 1/18, H04B 1/00, H03M 13/22, H04L 1/00</b>		<b>A1</b>	(11) International Publication Number: <b>WO 99/50990</b>
			(43) International Publication Date: 7 October 1999 (07.10.99)
(21) International Application Number: PCT/SE99/00485 (22) International Filing Date: 26 March 1999 (26.03.99) (30) Priority Data: 09/050,125 30 March 1998 (30.03.98) US (71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE). (72) Inventors: GUSTAFSSON, Maria; Medborgarplatsen 11, 2 trp, S-118 26 Stockholm (SE). PERSSON, Magnus; Kruthornsvägen 40, 1 trp, S-191 53 Sollentuna (SE). DAHLMAN, Erik; Tackjärnsvägen 12, S-168 68 Bromma (SE). (74) Agent: ERICSSON RADIO SYSTEMS AB; Common Patent Dept., S-164 80 Stockholm (SE).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the          claims and to be republished in the event of the receipt of          amendments.</i>	

(54) Title: AN INTERLEAVING SCHEME FOR BLOCKS IN A PACKET SWITCHED SYSTEM



## (57) Abstract

The present invention discloses a method and system for interleaving blocks of a packet to minimize the effects of burst errors and at the same time enhance the effectiveness of the ARQ protocol. A packet is first divided into a plurality of blocks. Each block is then individually encoded and inner-block interleaved. Thereafter the blocks are interleaved over a longer time period. By performing two stages of interleaving, the present invention allows for the size of a packet block to be kept at a minimum, which increases the effectiveness of the ARQ protocol, and provides greater interleaving of the packet's data elements so as to minimize the effects of burst errors.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

## AN INTERLEAVING SCHEME FOR BLOCKS IN A PACKET SWITCHED SYSTEM

### BACKGROUND

5           The present invention is directed towards a packet switched network, and more particularly towards a method of interleaving data associated with a packet so as to optimize transmission of the packet.

          The growth of commercial communication systems and, in particular, the explosive growth of cellular radiotelephone systems have compelled system  
10       designers to search for ways to increase system capacity without reducing communication quality beyond consumer tolerance thresholds. At the same time usage of mobile communication equipment for transmission of data rather than speech has become increasingly popular by consumers. The ability to send and receive electronic mail and to use a web browser to obtain world-wide-web access is  
15       frequently discussed among services that will be used more and more in wireless communication systems. In response to this, communication system designers search for ways to efficiently transfer data information to and from mobile users.

          There are fundamental differences between requirements for data communication and e.g., speech communication. For example, delay requirements  
20       are higher for speech, which is a real time service, and the error requirements are higher for data communication, while the delay constraints are lower. The use of packet data protocols, which are more suitable for transmission of data than circuit switched protocols, has started to find its way into cellular communication systems. Packet service integration in both GSM cellular systems as well as DAMPS cellular  
25       systems is presently being standardized.

          Today, GSM systems provide a circuit switched data service, which can be used to interconnect with external data networks. The circuit switched data service is used for both circuit switched as well as packet switched data communication. To make packet switched data communication more efficient, a new packet switched  
30       data service called GPRS (General Packet Radio Services) is being introduced.

-2-

GPRS will support both connectionless protocols (e.g., IP) as well as a connection-oriented protocols (X.25). One of the advantages with a packet switched data communication protocol is that a single transmission resource can be shared between a number of users. Thus, in the case of e.g., a GSM cellular system, a timeslot on a radio-frequency carrier can be utilized by several mobile users for reception and transmission of data.

Currently, channel access in a cellular system is most commonly achieved using frequency division multiple access (FDMA) and time division multiple access (TDMA) methods. In FDMA, a communication channel is a single radio frequency band into which a signal's transmission power is concentrated. Interference with adjacent channels is limited by the use of bandpass filters which only pass signal energy within the specified frequency band. Thus, with each channel being assigned a different frequency, system capacity is limited by the available frequencies as well as by limitations imposed by channel radios.

In TDMA systems, a channel consists of a time slot in a periodic train of time intervals over the same frequency. Each period of time slots is called a frame. A given signal's energy is confined to one of these time slots. Adjacent channel interference is limited by the use of a time gate or other synchronization element that only passes signal energy received at the proper time. Thus, the portion of the interference from different relative signal strength levels is reduced.

Capacity in a TDMA system is increased by compressing the transmission signal into a shorter time slot. As a result, the information must be transmitted at a correspondingly faster bit rate which increases the amount of occupied spectrum proportionally.

With FDMA or TDMA systems, or a hybrid FDMA/TDMA system, it is desirable to avoid the case where two potentially interfering signals occupy the same frequency at the same time. In contrast, code division multiple access (CDMA) or wideband CDMA systems, which supports bandwidths of up to 12 times that of standard CDMA systems, allow signals to overlap in both time and frequency.

Thus, all CDMA signals share the same frequency spectrum. In either the

-3-

frequency or the time domain, the multiple access signals appear to be on top of each other.

In a typical CDMA or wideband CDMA system, the information data stream to be transmitted is first coded or spread using a unique spreading code and then  
5 combined with a long PN-sequence or a shorter scrambling-sequence. In the latter case, the scrambling-sequences are planned from cell to cell so that neighboring cells use different scrambling-sequences or scrambling-masks. The information data stream and the PN-sequence or the scrambling sequence can have the same or different bit rates. The information data stream and the PN-sequence or the  
10 scrambling-sequence are combined by multiplying the two bit streams together. A plurality of coded information signals are transmitted on radio frequency carrier waves and jointly received as a composite signal at a receiver. Each of the coded signals overlaps all of the other coded signals, as well as noise related signals, in both frequency and time. By correlating the composite signal with one of the  
15 unique spreading codes, a corresponding information signal is isolated and decoded.

In a typical cellular communication operation, illustrated in Figure 1, a base station 100 will receive a data packet containing, for example, a sequence of digital data from a data source 110, such as a telephone network. Among other processes, the base station will then encode, through the use of an encoder 105, and interleave,  
20 through the use of an interleaver 106, the data packet for transmission to a mobile unit 120. Encoder 105 herein performs channel coding, e.g., convolutional coding, as opposed to forward error correction coding described below. The interleaving process reorders the bits in the data packet. For example, assume that the data packet included four bits that were originally ordered as follows: A1, A2, A3, A4.  
25 The interleaving process would reorder the data bits to produce, by way of example, a result such as A3, A2, A4, A1.

When the interleaved and encoded data packet is received by the mobile unit 120, it is deinterleaved by deinterleaver 125. Deinterleaver 125 places the data bits back into their original order. For the example given above, deinterleaver would  
30 receive the data bits in the order of A3, A2, A4, A1 and would reorder the bits back

into their original order of A1, A2, A3, A4. The deinterleaved, encoded data packet is then forwarded to decoder 126 where it is decoded back into its original form. The data packet is then sent to a processing unit, such as an audio component, for processing.

5 Interleaving, in conjunction with some type of encoding method, operates to lower burst error rates by spreading in time the effects of any burst errors. A burst error is simply a grouping of errors that occur over a short period of time and which affect consecutive bits in a transmitted data packet. When the packet is deinterleaved, the burst error will be spread in time giving a higher likelihood that  
10 the coding can be used to correct errors.

In some situations the packet is disturbed during its transmission from the base station to the mobile unit, for example by a collision with another packet, by an increase in the interference level or bad channel conditions, e.g., fading, and must be retransmitted by the base station. The base station has to retransmit the  
15 packet until a successful transmission is accomplished which is indicated by an acknowledgment from the mobile unit that the packet has been received correctly. For the mobile unit to be able to determine whether a packet has been correctly received, the error correction information, which was added to the packet, must be considered. The forward error correction (FEC) coding can, for example, be  
20 provided in the form of a cyclic redundancy check (CRC).

There exist several schemes that provide an automatic retransmit when the destination does not acknowledge receiving a packet, the so called ARQ (Automatic Repeat Query) methods. If the packet is not acknowledged within a certain period of time, the source automatically repeats the transmission. In its simplest form, the  
25 source waits for an acknowledgment from the destination after every packet transmission, and keeps periodically retransmitting this same packet until an acknowledgment is received. Only after the acknowledgment is received is the next packet transmitted. This is called the stop-and-wait ARQ method.

More efficient methods continue to transmit packets even if their  
30 predecessors have not yet been acknowledged. Packets that have not been

acknowledged are stored for retransmission, and are only then deleted from the storage when they have been acknowledged. In these methods, the packets are provided with a packet number so that the destination can acknowledge the correct packet numbers. Examples of ARQ methods that use packet numbering and do not wait for an acknowledgment before they transmit the next packet are selective ARQ and (cumulative) go-back-N ARQ. These methods provide higher throughputs especially on connections which contain a certain amount of delay.

Wherein conventional communication systems required the retransmission of an entire packet when the transmitted packet was disturbed, state of the art systems allow for the retransmission of individual blocks of the packet. A block, as is recognized by those skilled in the art, is the smallest part of the packet which is retransmittable over the air interface. In such systems, the blocks are individually encoded and interleaved and are provided with overhead information, such as CRC bits and block numbers. Figure 2 illustrates a conventional packet where the blocks are individually encoded and interleaved. To illustrate the interleaving concept of such state of the art systems, consider a set of blocks represented as follows:

$$B_1^1, B_1^2, B_1^3, B_1^4, B_2^1, B_2^2, B_2^3, B_2^4, B_3^1, B_3^2, B_3^3, B_3^4, B_4^1, B_4^2, B_4^3, B_4^4,$$

wherein the group  $B_1^1 - B_1^4$  represents Block 1, the group  $B_2^1 - B_2^4$  represents Block 2, etc. When the individual blocks are interleaved, the elements within each block would be reordered. The resulting packet could be organized, for example, as follows:

$$B_1^3, B_1^2, B_1^4, B_1^1, B_2^3, B_2^2, B_2^4, B_2^1, B_3^3, B_3^2, B_3^4, B_3^1, B_4^3, B_4^2, B_4^4, B_4^1.$$

This type of conventional interleaving process is referred to in this specification as "inner-block interleaving."

As indicated above, packet transmissions are subject to burst errors. To minimize the effects of such errors, a system designer would desire a large

-6-

interleaving period. That is, one skilled in the art would readily recognize that the larger the interleaving period, the more spread out the burst errors would be when the packet is eventually deinterleaved at the receiver. By spreading in time the effects of the burst errors, the effectiveness of the forward error correction coding operation is increased.

Since conventional inner-block interleaving spreads data out within each block, increased interleaving suggests larger block sizes. However, the effectiveness of the ARQ protocol decreases when the size of the blocks becomes too large due to an increase in the probability of retransmission of the blocks and, accordingly, an increase in the number of bits to retransmit. Therefore, it is desirable to choose a relatively small block size in order to have the most effective ARQ protocol.

Thus, there exists a need for a technique which provides increased burst error protection by increasing the interleaving of data in a packet, without also increasing the block size.

## SUMMARY

The instant invention overcomes the above deficiencies by providing a technique which provides both a good interleaving scheme and an efficient ARQ protocol.

According to an exemplary method of the present invention, a packet is divided into a plurality of blocks. Each block is individually encoded and inner-block interleaved. The blocks are then interleaved again over a longer period of time. The second interleaving operation is referred to herein as "outer-block interleaving."

By performing two stages of interleaving, the present invention allows for the size of a packet block to be optimized, which increases the effectiveness of the ARQ protocol, and provides greater interleaving of the packet's data elements so as to minimize the effects of burst errors.



## BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

- 5           Figure 1 illustrates a conventional interleaving and encoding scheme;  
            Figure 2 illustrates a conventional method of dividing and interleaving the blocks of a packet;  
            Figure 3 illustrates an exemplary cellular mobile radio telephone system within which the techniques according to the present invention can be implemented;  
10          Figure 4 illustrates a method of dividing and interleaving the blocks of a packet according to the present invention;  
            Figure 5 illustrates a simulation result of the interleaving scheme according to the present invention for a mobile speed of 120 km/h; and  
            Figure 6 illustrates a simulation result of the interleaving scheme according  
15          to the present invention for a mobile speed of 50 km/h.

## DETAILED DESCRIPTION

- Figure 3 illustrates an exemplary cellular mobile radio telephone system within which the techniques according to the present can be implemented. The  
20          cellular mobile radio telephone system includes a base station 300 and a mobile unit or remote unit 320. It is well understood by those skilled in the art that a typical cellular system comprises a plurality of base stations and a plurality of mobile units, but for the sake of simplicity Figure 3 only illustrates one base station and one mobile unit. While the discussion below involves the transfer of packets from a  
25          base station to a mobile unit, one skilled in the art will recognize that the techniques of the instant invention applies equally well to communications from the mobile unit to the base station.

- The base station 300, according to the instant invention, includes a packet divider 304, an encoder 305, and an interleaver 306. The mobile unit 320, on the  
30          other hand, includes a deinterleaver 325, a decoder 326, and processing unit 327.

-8-

General aspects of such a cellular radio telephone system are known in the art, as described by U.S. Patent No. 5,175,867 to Wejke et al., which is incorporated herein by reference. Accordingly, the myriad details associated with the structure and operation of these functional blocks is omitted so as not to obscure the instant invention.

In an exemplary method of the instant invention, the sending unit (i.e., the base station 300) receives a data packet from a source 110, such as a telephone network. The base station 300 first divides the packet into a plurality of blocks through the use of packet divider 304. Each block may then have overhead information, e.g., CRC bits and a block number, added thereto. The blocks are then individually encoded by encoder 305. Those skilled in the art will appreciate that the overhead information can be encoded in a manner different than the payload data, e.g., using a separate encoder. The encoded blocks are then transferred to interleaver 306 which performs the interleaving scheme of the instant invention. The interleaved and encoded data packet is then sent synchronously or asynchronously over the link.

The destination (i.e., the mobile station 320) checks the correctness of the blocks and sends either an acknowledgment signal (ACK) or a non-acknowledgment signal (NAK) dependent upon whether the blocks have been successfully or unsuccessfully received, respectively. When a non-acknowledgment signal is produced, the source can respond with a retransmission of the block which was not successfully received. In many systems, however, non-acknowledgment signals are not used. Instead, the sender waits during a time-out period and if an acknowledgment signal is not received within the time-out period, the sender automatically retransmits the block. This so-called Automatic Repeat Query (ARQ) or Automatic Repeat Request is more secure than the use of non-acknowledgment signals, because if an acknowledgment signal gets disturbed, the sender retransmits the block, however, when a non-acknowledgment signal gets disturbed, some information may never successfully reach the destination. Note that

-9-

acknowledgment messages do not have to be returned separately, but can be embedded in the return data flow.

When the packet has been successfully received, the mobile unit 320 deinterleaves the packet with deinterleaver 325. The encoded packet is then  
 5 decoded by decoder 326 to thereby obtain the original packet. The packet is then processed by the receiving unit in a well known manner. For example, the packet may be transferred to an audio component for processing.

An exemplary method for interleaving the packet in accordance with Applicants' invention is displayed in Figure 4. As discussed above, each packet is  
 10 divided into blocks when it is received in the base station. The blocks are then individually encoded and overhead information, such as CRC bits and block numbers, is added to each block. The blocks are then individually interleaved, i.e., they are inner-block interleaved. The blocks are then interleaved again, except over  
 15 a longer time period. This second interleaving process is known as "outer-block interleaving." By way of example, consider again the four blocks that were set forth above:

$$B_1^1, B_1^2, B_1^3, B_1^4, B_2^1, B_2^2, B_2^3, B_2^4, B_3^1, B_3^2, B_3^3, B_3^4, B_4^1, B_4^2, B_4^3, B_4^4.$$

20 Following the first interleaving process (i.e., the inner-block interleaving process), the resulting packet could, by way of example, be represented as follows:

$$B_1^3, B_1^2, B_1^4, B_1^1, B_2^3, B_2^2, B_2^4, B_2^1, B_3^3, B_3^2, B_3^4, B_3^1, B_4^3, B_4^2, B_4^4, B_4^1.$$

25 The packet is then interleaved again, except over a longer time period. If the time period is selected to be the size of two blocks, then a possible resulting packet could be represented as:

$$B_1^3, B_2^3, B_1^4, B_2^4, B_1^2, B_2^2, B_1^1, B_2^1, B_3^3, B_4^3, B_3^4, B_4^4, B_3^2, B_4^2, B_3^1, B_4^1.$$

-10-

It is apparent from the above example that the outer-block interleaving process, in combination with the inner-block interleaving process, would result in a data representation which is sufficiently interleaved so as to spread the effects from burst errors over time when the packet is ultimately deinterleaved. By lowering the effects of burst errors, the ability to correctly decode the packets is enhanced.

Selection of the size of the outer-block interleaving period is dependent upon such factors as buffer size and channel conditions. One skilled in the art will recognize that the interleaving process, performed by interleaver 306, would require temporary buffering of the blocks to be interleaved. Therefore, it is evident that the larger the outer-block interleaving period that is chosen, the larger the buffer size that is needed. Similar buffers would be needed for deinterleaving as well. By choosing a shorter outer-block interleaving period, one can minimize the buffer requirement.

A second factor to consider in selecting the outer-block interleaving period is the channel condition. Due to a variety of time-varying factors, including position of the mobile station and environmental conditions, the condition of the transmission channel could be poor (i.e., it could be prone to burst errors or nulls which extend over a large time period). Moreover, interference to any given connection is also time varying. In order to compensate for such poor channel conditions, a larger outer-block interleaving period would be desirable whereby the effects of such burst errors would be more greatly dispersed over time. Alternatively, when transmission conditions are good, a shorter outer-block interleaving period could be chosen. Thus, the outer-block interleaving can be dynamically variable, e.g., if the incidents of requests for retransmission increase beyond a threshold, then the outer-block interleaving period can be increased.

If the size of the outer-block interleaving period is selected to be equal to the packet length, there will inevitably be some delay if there are blocks to be retransmitted. This is evident from the fact that the packet's data elements would be interleaved throughout the packet, requiring the entire packet to be received in order for all the elements of a block to be received. If, however, the outer-block

interleaving period is chosen to be less than or greater than the packet length, then there will be no significant delay for retransmissions. Although the block delay is increased, the overall performance of the system is not affected.

In order to illustrate the effectiveness of the present invention, Figures 5 and 6 set forth results of simulations for an exemplary wideband CDMA system which were performed for mobile speeds of 120 km/h and 50 km/h. In the first simulation, the information bit rate was selected as 240 kbps and the speed of the mobile unit was chosen as 120 km/h which is equivalent to a Doppler frequency of 213 Hz if a 1.9 GHz test spectrum is used. Three interleaving periods were selected: one block (1.25 ms), one frame (10 ms) and two frames (20 ms). As is evident from Figure 5, the gain from the outer-block interleaving, when the one block interleaving is compared to the two frames interleaving, is from approximately 2.2 dB at BLER = 10% to 3.8 dB at BLER = 1%.

In the second simulation, the speed of the mobile unit was decreased to 50 km/h which is equivalent to a Doppler frequency of 93 Hz. The same information bit rate of 240 kbps was also used. The interleaving periods in the second simulation were chosen as one block, one frame and 10 frames. As is evident from Figure 6, when the one block interleaving is compared to the 10 frames interleaving, the gain is from approximately 1.6 dB at BLER = 10% to 2.9 dB at BLER = 1%. Thus, one can see that a substantial gain can be achieved through the use of the present interleaving scheme.

The present invention has been described in terms of specific embodiments to facilitate understanding. The above embodiments, however, are illustrative rather than restrictive. It will be readily apparent to one skilled in the art that departures may be made from the specific embodiments shown above without departing from the central spirit and scope of the invention. Therefore, the invention should not be regarded as being limited to the above examples, but should be regarded instead as being fully commensurate in scope with the following claims.

## WHAT IS CLAIMED IS:

1. A method for transmitting a packet in a communication network comprising the steps of:
  - 5       dividing the packet into a plurality of blocks;  
          individually encoding each of said plurality of blocks;  
          inner-block interleaving the plurality of blocks over a first time period;  
          outer-block interleaving the plurality of blocks over a second time period;  
          and
  - 10       transmitting said packet,  
          wherein the second time period is longer than the first time period; and  
          wherein an effect of burst errors is minimized and an effectiveness of an automatic repeat query protocol is enhanced due to the inner-block and outer-block interleaving steps.
  - 15
2. The method according to claim 1 wherein the outer-block interleaving period is equal to a packet length.
3. The method according to claim 1 wherein the communication network is a  
20    wideband code division multiple access network.
4. A method for conditioning a packet for transmission in a communication network comprising the steps of:
  - 25       dividing the packet into a plurality of blocks;  
          individually encoding each of said plurality of blocks;  
          inner-block interleaving the plurality of blocks over a first time period; and  
          outer-block interleaving the plurality of blocks over a second time period.
5. The method according to claim 4 wherein the second time period is different  
30    than the first time period.

-13-

6. The method according to claim 5 wherein the second time period is longer than the first time period.
7. The method according to claim 4 wherein the outer-block interleaving period  
5 is equal to a packet length.
8. The method according to claim 4 wherein the communication network is a wideband code division multiple access network.
- 10 9. A system for conditioning a packet for transmission in a communication network, said system comprising:  
means for dividing the packet into a plurality of blocks;  
means for individually encoding each of said plurality of blocks;  
means for inner-block interleaving the plurality of blocks over a first time  
15 period; and  
means for outer-block interleaving the plurality of blocks over a second time period.
10. The system according to claim 9 wherein the second time period is different  
20 than the first time period.
11. The system according to claim 10 wherein the second time period is longer than the first time period.
12. The system according to claim 9 wherein the outer-block interleaving period  
25 is equal to a packet length.
13. The system according to claim 9 wherein the communication network is a wideband code division multiple access network.

-14-

14. A method for interleaving blocks of a packet for transmission in a communication network, where each block comprises a plurality of data elements, said method comprising the steps of:

interleaving said plurality of data elements within each of said blocks to  
5 produce a first result; and  
interleaving said first result over a longer time period.

15. The method according to claim 14 further including the step of, prior to interleaving said plurality of data elements, individually encoding said blocks.

10

16. The method according to claim 14 wherein the longer time period is equal to a length of the packet.

17. A system for interleaving blocks of a packet for transmission in a  
15 communication network, where each block comprises a plurality of data elements, said method comprising the steps of:

means for interleaving said plurality of data elements within each of said  
blocks to produce a first result; and  
means for interleaving said first result over a longer time period.

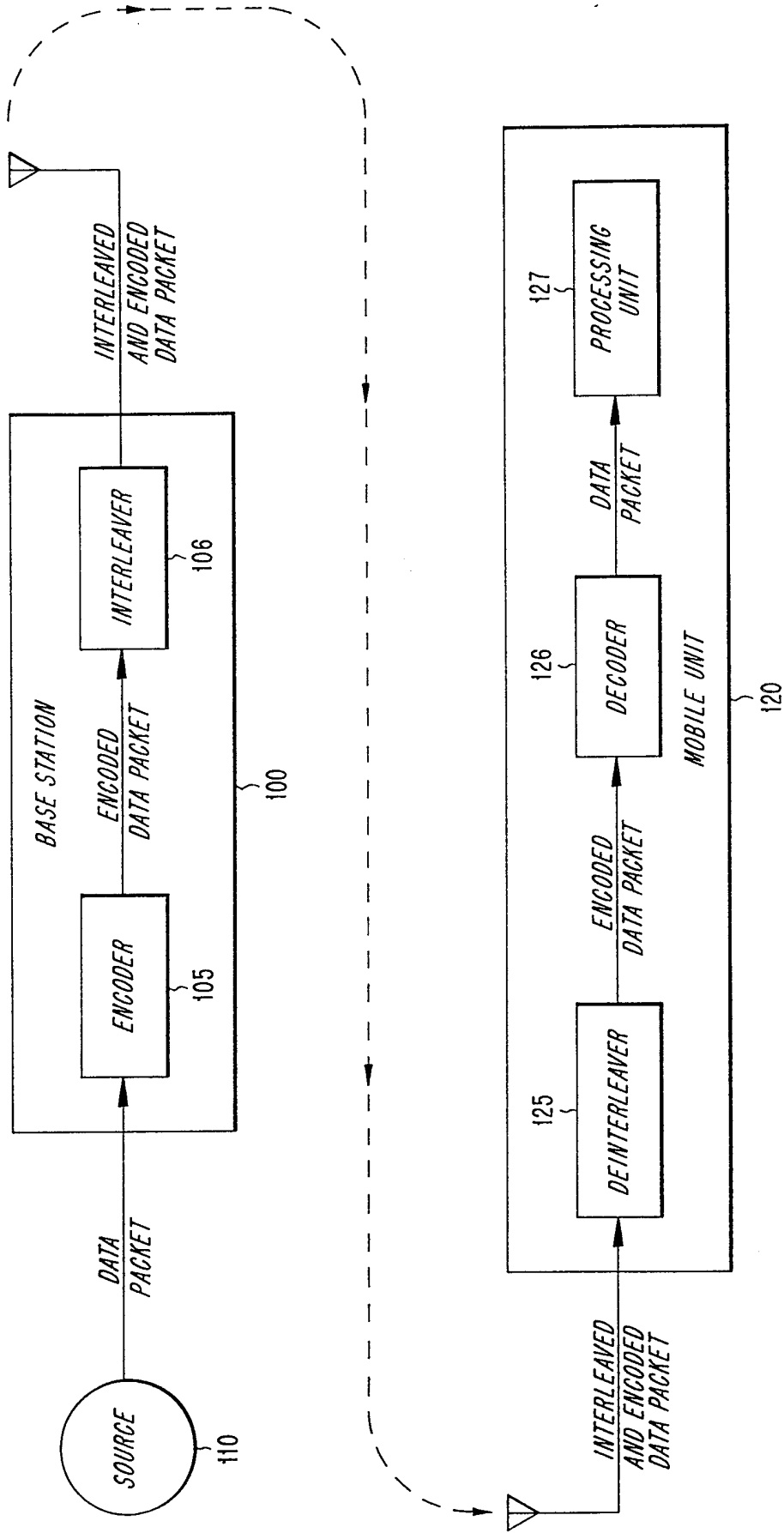
20

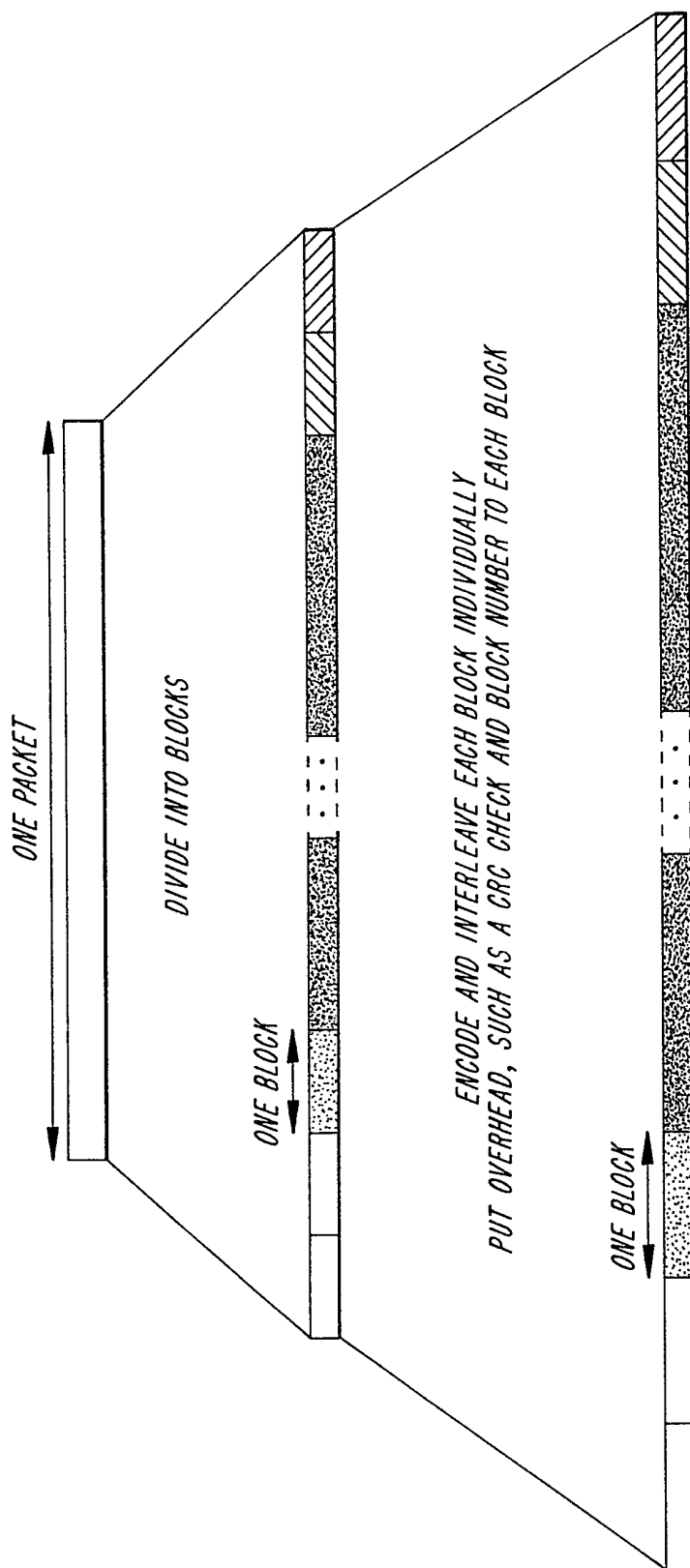
18. The system according to claim 17 further comprising means for individually encoding said blocks.

19. The system according to claim 17 wherein the longer time period is equal to  
25 a length of the packet.



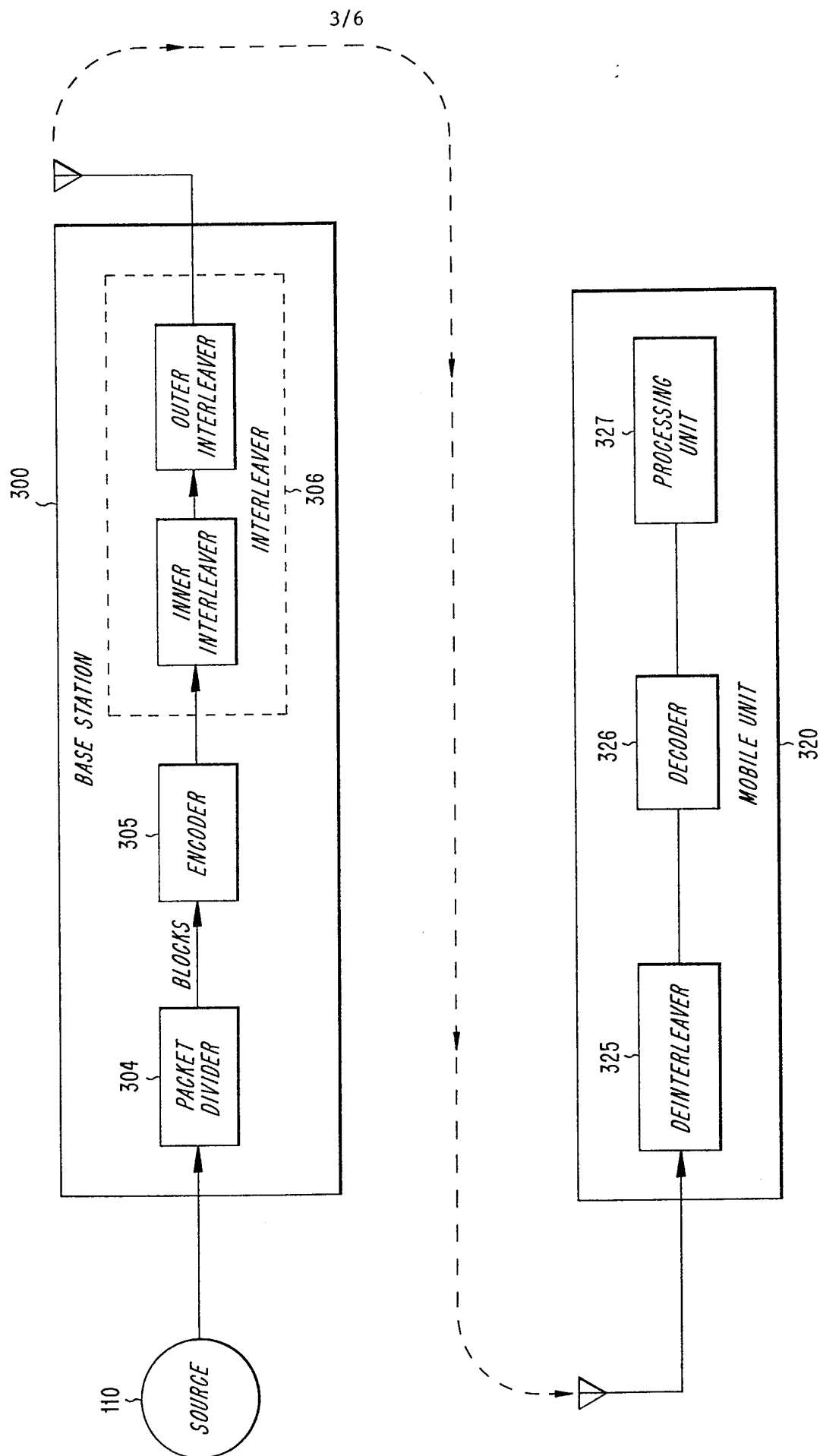
FIG. 1  
(PRIOR ART)





*FIG. 2*  
(PRIOR ART)

FIG. 3



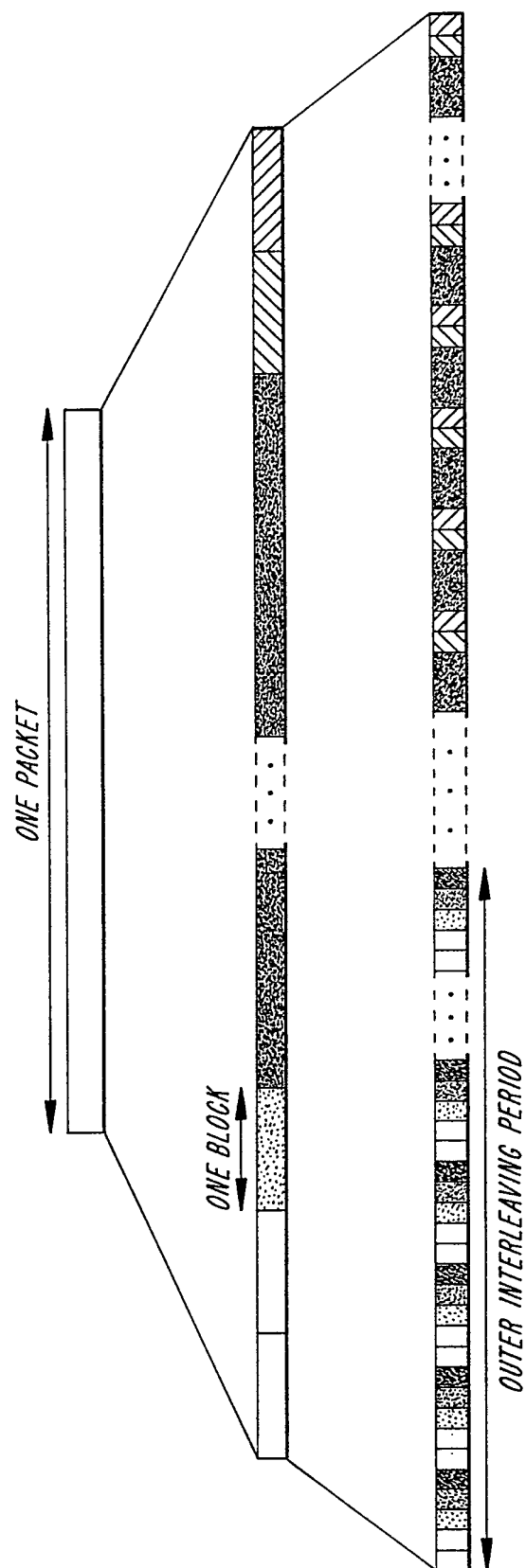


FIG. 4

FIG. 5

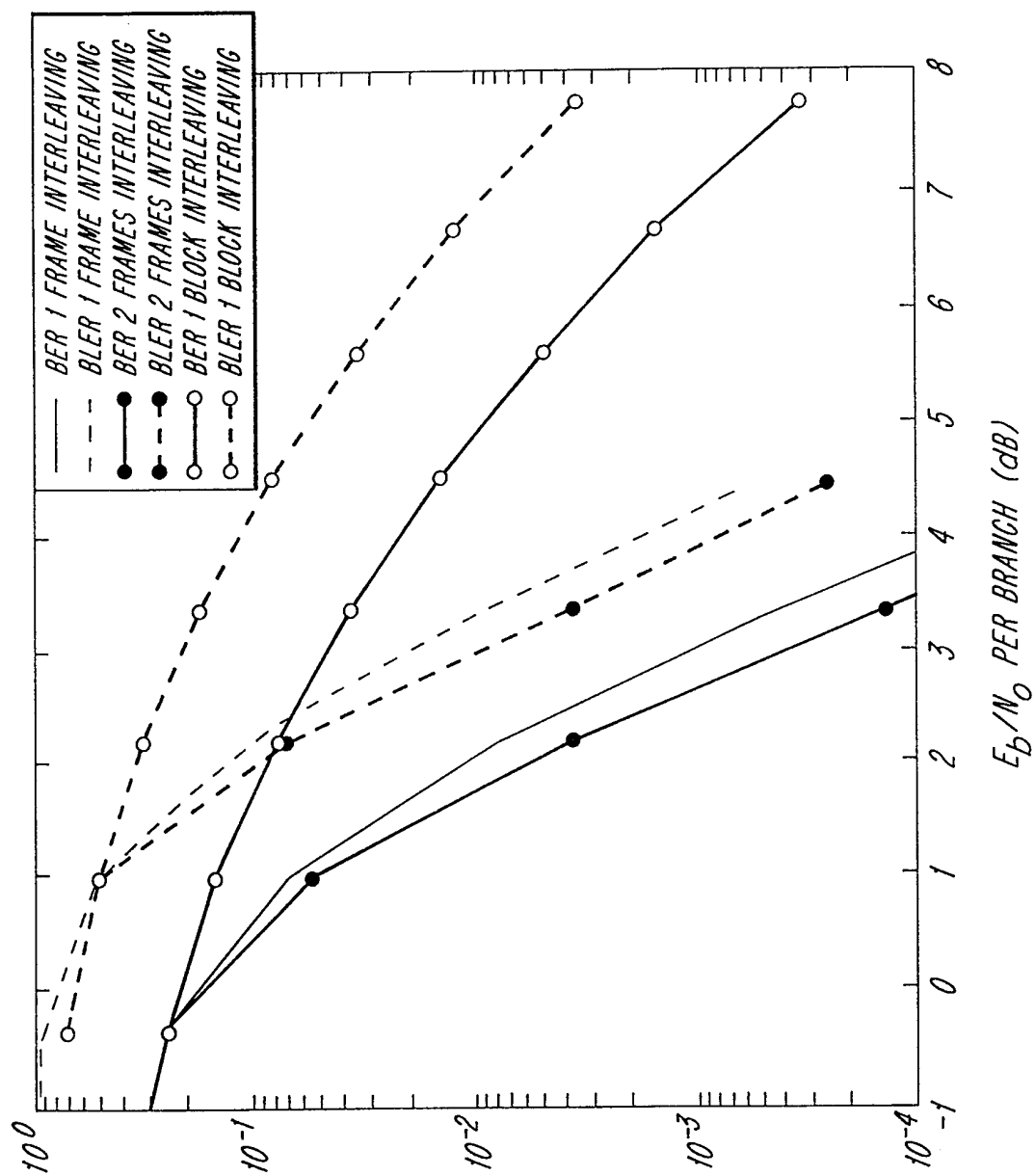
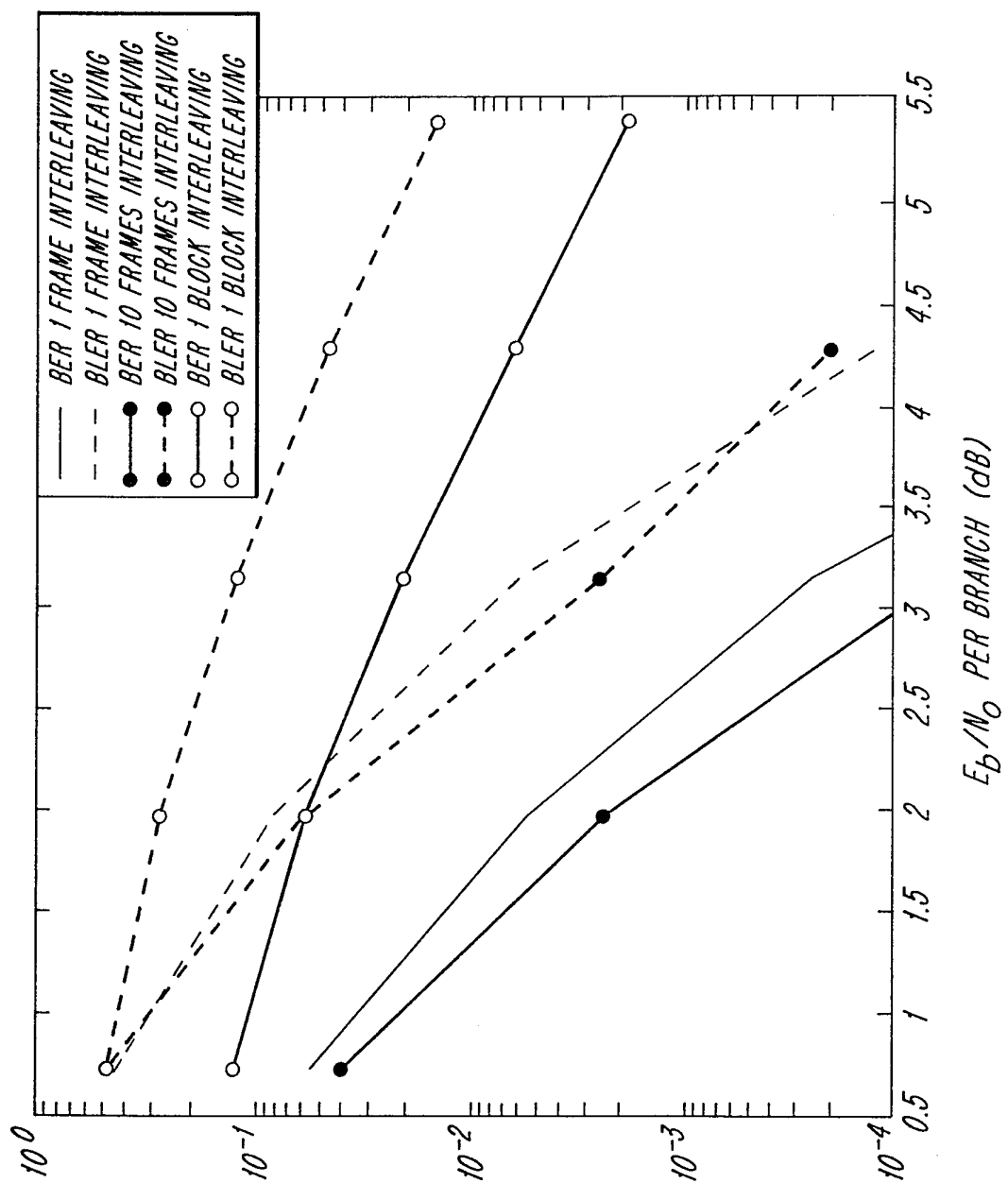


FIG. 6



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/SE 99/00485

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04L1/18 H04B1/00 H03M13/22 H04L1/00

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 6 H04L H04B H03M

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

Electronic data base consulted during the international search (name of data base and, where practical, 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.
X	EP 0 551 973 A (E-SYSTEMS; AMPEX) 21 July 1993 (1993-07-21) column 5, line 28 - line 49 column 5, line 54 - column 6, line 3 column 11, line 46 - line 52 column 15, line 54 - line 58 ---	1-19
X	WO 96 02100 A (ZENITH ELECTRONICS CORP) 25 January 1996 (1996-01-25)	4,5,9, 10,14, 17,18
A	page 6, line 6 - page 7, line 3; figure 2A --- -/--	1



Further documents are listed in the continuation of box C.



Patent family members are listed in 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 document 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 another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

23 July 1999

Date of mailing of the international search report

30/07/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Scriven, P

# INTERNATIONAL SEARCH REPORT

In: International Application No

PCT/SE 99/00485

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GHOSH M: "ERROR CORRECTION SCHEMES FOR DIGITAL TELEVISION BROADCASTING" IEEE TRANSACTIONS ON CONSUMER ELECTRONICS, vol. 41, no. 3, August 1995 (1995-08), pages 400-404, XP000539483 page 401, left-hand column, paragraph 3 - paragraph 1; figure 1 ---	1,4,9, 14,17
A	EP 0 497 280 A (SANYO ELECTRIC CO) 5 August 1992 (1992-08-05) column 1, line 51 - column 2, line 20 column 6, line 13 - line 19 column 6, line 32 - line 57 ---	1,4,9, 14,17
A	YI C ET AL: "HYBRID ARQ SCHEME USING INTERLEAVED REED-SOLOMON CODES IN A POWER CONTROLLED DS-CDMA CELLULAR SYSTEM" PROCEEDINGS OF THE VEHICULAR TECHNOLOGY CONFERENCE, STOCKHOLM, JUNE 8 - 10, 1994, vol. VOL. 3, no. CONF. 44, 8 June 1994 (1994-06-08), pages 1402-1406, XP000497651 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS page 1402, left-hand column, paragraph 1 ---	
A	WO 95 30282 A (ERICSSON TELEFON AB L M ;JAMAL KARIM (SE); JANSSON FREDRIK (SE)) 9 November 1995 (1995-11-09) abstract ---	1,4,9, 14,17
A	EP 0 465 144 A (AMERICAN TELEPHONE & TELEGRAPH) 8 January 1992 (1992-01-08) column 2, line 8 - line 30 -----	1,4,9, 14,17



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/SE 99/00485

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0551973	A	21-07-1993	US 5392299 A	21-02-1995
			AT 160658 T	15-12-1997
			AU 665044 B	14-12-1995
			AU 3180293 A	22-07-1993
			CA 2087197 A	16-07-1993
			CN 1081296 A	26-01-1994
			DE 69315360 D	08-01-1998
			DE 69315360 T	09-04-1998
			IL 104395 A	18-06-1996
			JP 6276178 A	30-09-1994
			MX 9300195 A	29-07-1994
WO 9602100	A	25-01-1996	US 5583889 A	10-12-1996
			BR 9507201 A	16-09-1997
			CA 2181539 A	25-01-1996
			CN 1141108 A	22-01-1997
			JP 10502776 T	10-03-1998
			US 5600677 A	04-02-1997
			US 5636251 A	03-06-1997
EP 0497280	A	05-08-1992	JP 4252687 A	08-09-1992
			JP 8017485 B	21-02-1996
			KR 9509455 B	22-08-1995
			US 5276714 A	04-01-1994
WO 9530282	A	09-11-1995	SE 502244 C	25-09-1995
			SE 504396 C	27-01-1997
			AU 689893 B	09-04-1998
			AU 2422295 A	29-11-1995
			AU 670514 B	18-07-1996
			AU 7011494 A	03-01-1995
			BR 9507565 A	05-08-1997
			CA 2140364 A	22-12-1994
			CN 1110883 A	25-10-1995
			CN 1147320 A	09-04-1997
			DE 69416493 D	25-03-1999
			DE 69416493 T	24-06-1999
			EP 0655159 A	31-05-1995
			EP 0758502 A	19-02-1997
			ES 2129646 T	16-06-1999
			FI 950590 A	10-02-1995
			FI 964309 A	18-12-1996
			JP 8500233 T	09-01-1996
			JP 9512679 T	16-12-1997
			MX 9404252 A	31-01-1995
			NZ 267733 A	27-08-1996
			WO 9429849 A	22-12-1994
			SE 9401462 A	12-12-1997
			SE 9403386 A	29-10-1995
			SG 45176 A	16-01-1998
			US 5572622 A	05-11-1996
			US 5901186 A	04-05-1999
EP 0465144	A	08-01-1992	JP 4233840 A	21-08-1992