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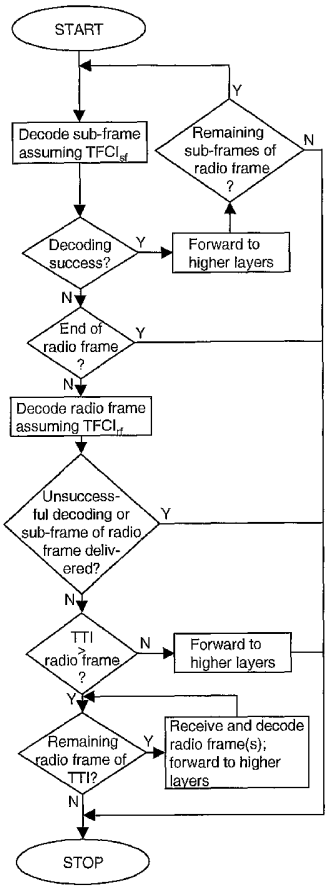
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(54) Title: METHOD AND SYSTEM OF CHANNEL ADAPTATION



(57) Abstract: The present invention relates to transmissions and retransmissions in a communications system. It reveals a method and system for backward compatible detection of an introduced channel sub-frame structure particularly well suited for data transmissions. The invention is well suited for a cellular mobile radio communications system, particularly a Universal Mobile Telecommunications System, UMTS.

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Method and system of channel adaptation

TECHNICAL FIELD OF THE INVENTION

The present invention relates to transmissions and retransmissions in a communications system, and more especially it relates to a cellular mobile radio system, particularly to a Universal Mobile Telecommunications System, UMTS or WCDMA system.

BACKGROUND AND DESCRIPTION OF RELATED ART

Transmission and retransmission of data to or from a mobile station, MS, or user equipment, UE, is previously known. It is also known to use medium access control and radio link control layers of a UMTS protocol structure in acknowledged mode for dedicated channels.

In acknowledged mode, retransmissions are undertaken in case of detected transmission errors not recovered by forward error control. This is also called automatic repeat request, ARQ. With ARQ, retransmissions can be undertaken unless a transmitted message is (positively) acknowledged or if it is negatively acknowledged. Generally there are time limits for the respective positive and negative acknowledgements to be considered.

Within this patent application, a radio network controller, RNC, is understood as a network element including a radio resource controller. Node B is a logical node responsible for radio transmission/reception in one or more cells to/from a User Equipment. A base station, BS, is a physical entity representing Node B.

Medium access control, MAC, and radio link control, RLC, is used within radio communications systems like General Packet Radio Services, GPRS, and UMTS.

With reference to figure 1, Node B 1 and Node B 2 of a radio communications system are logical nodes responsible for radio transmission/reception in one or more cells to/from the User Equipment UE. BS 1 and BS 2 are physical entities representing Node B 1 and Node B 2 respectively. Node B 1 and Node B 2 terminate the air interface, called Uu interface within UMTS, between UE and respective Node B towards the radio network controller RNC. In UMTS the interface between a Node B and an RNC is called Iub interface.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical Layer Procedures, 3G TS 25.301 v3.6.0, France, September 2000,* specifies in chapter 5 Radio Interface Protocol Architecture of a UMTS system. There are three protocol layers:

- physical layer, layer 1 or L1,
- data link layer, layer 2 or L2, and
- network layer, layer 3 or L3.

Layer 2, L2, and layer 3, L3 are divided into Control and User Planes. Layer 2 consists of two sub-layers, RLC and MAC, for the Control Plane and four sub-layers, BMC, PDCP, RLC and MAC, for the User Plane. The acronyms BMC, PDCP, RLC and MAC denote Broadcast/Multicast Control, Packet Data Convergence Protocol, Radio Link Control and Medium Access Control respectively.

Figure 2 illustrates a simplified UMTS layers 1 and 2 protocol structure for a Uu Stratum, UuS, or Radio Stratum, between a user equipment UE and a Universal Terrestrial Radio Access Network, UTRAN.

Radio Access Bearers, RABs, make available radio resources (and services) to user applications. For each mobile station there may be one or several RABs. Data flows (in the form of segments) from the RABs are passed to respective Radio Link Control, RLC, entities which amongst other tasks buffer the received data segments. There is one RLC entity for each RAB. In the RLC layer, RABs are mapped onto respective logical channels. A Medium Access Control, MAC, entity receives data transmitted in the logical channels and further maps logical channels onto a set of transport channels. In accordance with subsection 5.3.1.2 of the 3GPP technical specification, MAC should support service multiplexing e.g. for RLC services to be mapped on the same transport channel. In this case identification of multiplexing is contained in the MAC protocol control information.

Transport channels are finally mapped to a single physical channel which has a total bandwidth allocated to it by the network. In frequency division duplex mode, a physical channel is defined by code, frequency and, in the uplink, relative phase (I/Q). In time division duplex mode a physical channel is defined by code, frequency, and timeslot. The DSCH, e.g., is mapped onto one or several physical channels such that a specified part of the downlink resources is employed. As further described in subsection 5.2.2 of the 3GPP technical specification the L1 layer is responsible for error detection on transport channels and indication to higher layer, FEC encoding/decoding and interleaving/deinterleaving of transport channels.

PDCP provides mapping between Network PDUs (Protocol Data Units) of a network protocol, e.g. the Internet protocol, to an RLC entity. PDCP compresses and decompresses redun-

dant Network PDU control information (header compression and decompression).

For transmissions on point-to-multipoint logical channels, BMC stores at UTRAN-side Broadcast Messages received from an RNC, calculates the required transmission rate and requests for the appropriate channel resources. It receives scheduling information from the RNC, and generates schedule messages. For transmission, the messages are mapped on a point-to-multipoint logical channel. At the UE side, BMC evaluates the schedule messages and deliver Broadcast Messages to upper layer in the UE.

3G TS 25.301 also describes protocol termination, i.e. in which node of UTRAN the radio interface protocols are terminated, or equivalently, where within UTRAN the respective protocol services are accessible.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Physical Layer Procedures, 3G TS 25.322 v3.5.0, France, December 2000,* specifies the RLC protocol. The RLC layer provides three services to the higher layers:

- transparent data transfer service,
- unacknowledged data transfer service, and
- acknowledged data transfer service.

In subsection 4.2.1.3 an acknowledged mode entity, AM-entity, is described (see figure 4.4 of the 3GPP Technical Specification). In acknowledged mode automatic repeat request, ARQ, is used. The RLC sub-layer provides ARQ functionality closely coupled with the radio transmission technique used.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network,* Physical channels and mapping of transport channels onto physical channels (FDD), *3G TS 25.211 v4.6.0, France, September 2002,* describes characteristics of the Layer 1 transport channels and physicals channels in the FDD mode of UTRA. Chapter 4 describes dedicated and common transport channels, such as

- Dedicated Channel, DCH;
- Broadcast Channel, BCH;
- Forward Access Channel, FACH;
- Paging Channel, PCH;
- Random Access Channel, RACH;
- Common Packet Channel, CPCH; and
- Downlink Shared Channel, DSCH.

Chapter 5 defines a radio frame and a slot on the physical channel according to the 3GPP technical specification:

- A radio frame is a processing duration, which consists of 15 slots. The length of a radio frame corresponds to 38400 chips.
- A slot is a duration, which consists of fields containing bits. The length of a slot corresponds to 2560 chips.

The specification defines two uplink dedicated physical channels:

- uplink Dedicated Physical Data Channel, uplink DPDCH; and
- uplink Dedicated Physical Control Channel, uplink DPCCH.

The 3GPP technical specification explains,

> *"The uplink DPDCH is used to carry the DCH transport channel. There may be zero, one, or several uplink DPDCHs on each radio link.*
>
> *The uplink DPCCH is used to carry control information generated at Layer 1. The Layer 1 control information consists of known pilot bits to support channel estimation for coherent detection, transmit power-control (TPC) commands, feedback information (FBI), and an optional transport-format combination indicator (TFCI). The transport-format combination indicator informs the receiver about the instantaneous transport format combination of the transport channels mapped to the simultaneously transmitted uplink DPDCH radio frame. There is one and only one uplink DPCCH on each radio link."*

Figure 3 illustrates the frame structure for uplink DPDCH and DPCCH. In downlink direction DPDCH and DPCCH are time division multiplexed.

The frame structure of uplink data and control parts associated with CPCH is similar to that of uplink DPDCH and uplink DPCCH respectively.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Multiplexing and channel coding (FDD), 3G TS 25.212 v5.0.0, France, March 2002,* describes the characteristics of the Layer 1 multiplexing and channel coding in the FDD mode of UTRA. Section 4.3 describes transport format detection. For a Coded Composite Transport Channel (CCTrCH), if the transport format set, TFS, of a Transport Channel, TrCH, contains more than

one transport format, the transport format can be detected either by signaling the particular transport format using the TFCI field, by blindly detecting the transport format by use of channel decoding and CRC check or using guided detection from at least one other guiding TrCH.

3rd Generation Partnership Project (3GPP): *Technical Specification Group Radio Access Network, Radio Resource Control (RRC), Protocol Specification, 3G TS 25.331 v4.7.0, France, September 2002,* specifies the RRC protocol for the UE-UTRAN interface. Section 10.3.5.11 describes in tabular format Transport Channel, TrCH, Information Elements of RRC messages related to semi-static transport format information, TFI, including transmission time interval, TTI. TTI is the duration of data over which coding and interleaving is performed for a certain transport channel. According to the 3GPP technical specification, TTI is one of 10, 20, 40 and 80 ms. Section 10.3.5.80 describes transport format combination, TFC, control duration, defining a period in multiples of 10 ms frames for which the defined TFC sub-set is to be applied. Section 10.3.6.81 describes a Transport Format Combination Indicator, TFCI, combining indicator, indicating by TRUE or FALSE whether a part of TFCI, TFCI2, should be softly combined with other TFCI2 parts of the combining set. Section 10.3.6 describes corresponding Physical Channel, PhyCH or PhCH, Information Elements as applicable.

None of the cited documents above discloses a method and system of compatibly extending an existing channel structure for the radio interface adapting a static or semi-static transmission interval such that alternating TTI could be adopted to a data channel. Further, it is not revealed a method and system such that whether or not this

extension is made use of could be blindly detected, not requiring additional signaling.

SUMMARY OF THE INVENTION

WCDMA and UMTS presently only supports TTIs of 10, 20, 40 or 80 ms. According to prior art, one TFCI is normally transmitted in each radio frame, i.e. once every 10 ms.

Delay problems have been identified for existing channel structure in some situations, e.g. communications according to TCP (Transmission Control Protocol), at high data rates, particularly in the uplink between UE and Node B.

Further, transmission power restrictions, particularly in uplink direction makes introduction of additional transport formats to be code multiplexed unfavorable, if not impossible.

Consequently, it is an object of this invention to introduce a backward compatible channel structure allowing for shorter than existing transmission time intervals without PAR (peak-to-average power ratio) increase.

A further object is to introduce a channel structure allowing for interchanging transmissions of radio frame structured data and sub-frame structured data, respectively.

It is also an object to introduce a sub-frame structure, the application of which may be detected without explicit signaling, in terms of transmission of additional symbols.

Finally it is an object to present an explicit method and system for detection of whether a sub-frame channel structure is applied or not.

Preferred embodiments of the invention, by way of examples, are described with reference to the accompanying drawings below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows communication, according to the invention, between a UE and a base station involved in a connection between an RNC and the UE.

Figure 2 displays a layered protocol structure, according to prior art, in a radio communications system.

Figure 3 illustrates the frame structure for uplink DPDCH and DPCCH, according to prior art.

Figure 4 shows a preferred frame and sub-frame channel structure for DPDCH and DPCCH, according to the invention.

Figure 5 displays a layered protocol structure, according to the invention, in a radio communication system.

Figure 6 shows a flow chart schematically illustrating detection according to a preferred embodiment of the invention.

Figure 7 shows a flow chart schematically illustrating detection according to an alternative embodiment of the invention.

Figure 8 schematically illustrates MAC and RLC protocol layers in a multilayer protocol structure.

DESCRIPTION OF PREFERRED EMBODIMENTS

WCDMA and UMTS presently only supports TTIs of 10, 20, 40 or 80 ms. Normally, one TFCI is transmitted in each radio frame, i.e. once every 10 ms. In this patent application particular radio frame TFCI is also referred to as $TFCI_{rf}$,

to distinguish from particular sub-frame TFCI, referred to as $TFCI_{sf}$. In case of TTIs being integer multiples of 10 ms, the same TFCI content is repeated in the multiple radio frames for additional redundancy to be combined for increased reliability. A plurality of transport channels are generally multiplexed and coded into a Coded Composite Transport Channel, CCTrCH, for transmission on the physical channel. There is one TFCI for each CCTrCH. According to prior art, TTI is fixed for a particular TrCH.

Excessive delay may cause problems to e.g. TCP (Transmission Control Protocol).

Consequently, a problem with substantial delays of data transmissions is identified. A solution to the problem to be applied in e.g. UMTS or a WCDMA system should be backward compatible with equipment operating according to existing specifications. Such backward compatibility will provide for soft handover possibility also between Nodes B operating according to different releases and non-increased power requirement on UE at cell border. Further, for prior art 3GPP specifications there is a restriction from e.g. existing Release'99 as there is no means to indicate different TTIs for a TrCH.

A different TTI could be achieved by setting up a new code multiplexed data channel. However, this would require use of more than one code with an inherent risk of increasing PAR (peak-to-average power ratio), which is a problem particularly in uplink direction, predominantly due to power limitation of user equipment, UE.

A further problem is RRC signaling according to prior art requiring 40 ms TTI. One rationale for this interval is strict power budgets of UE to be kept also at cell border.

According to the invention the above mentioned problems are solved by introducing an alternative transmission time interval, and a corresponding sub-frame, shorter than that existing, requiring a new structure on the physical channel. A channel structure is superimposed on an existing channel structure to allow use of shorter TTIs on existing data channels, DPDCHs, without violating existing data channel TTI structure and without increasing PAR.

The smaller block size obtained will both increase likelihood of correct transmission without retransmission, and when retransmissions are needed a reduced delay is achieved due to a combined effect of increased reliability of individual transmissions and reduced round-trip time for each (re-)transmission. A particular detection algorithm compatible to existing 3GPP specifications is proposed. Autonomous UE switching between short (according to the invention) and long (according to prior art) TTI as need be will guarantee backward compatibility and RRC signaling reception.

Figure 4 illustrates a preferred channel structure according to the invention. Compared to prior art channel structure, as illustrated in figure 3, a radio frame according to the preferred embodiment of the invention is divided into an integer number of equally sized sub-frames, each sub-frame comprising an integer number of slots. Exemplary 15 slots per frame, in accordance with 3GPP technical specifications, can be factored, giving three possible sub-frame sizes of 3 or 5 slots respectively. According to the invention a preferred sub-frame size comprises 3 slots, i.e. there are 5 sub-frames of a radio frame, each sub-frame having a duration of 10/5=2 ms. Of course, unequally sized sub-frames of a radio frame is also a possibility, however less preferred.

Both DPDCH and DPCCH are divided into the sub-frame structure. With preferred 5 sub-frames there are consequently 5 data blocks, «Data #0», «Data #1», «Data #2», «Data #3», «Data #4».

According to the preferred embodiment TFCI of the sub-frame channel structure, $TFCI_{sf}$, is included in every transmitted sub-frame of DPCCH. In an alternative embodiment, there is only needed to transmit $TFCI_{sf}$, at $TFCI_{sf}$ changes. However, as such changes may occur for every sub-frame the sub-frame channel structure allows for at least one $TFCI_{sf}$ in each sub-frame, «$TFCI_{sf}$ #0», «$TFCI_{sf}$ #1», «$TFCI_{sf}$ #2», «$TFCI_{sf}$ #3», «$TFCI_{sf}$ #4».

The blind TTI detection according to the invention may be used with known technologies of TFCI detection according to 3GPP technical specification.

The TFCI field of the slot structure according to 3GPP technical specifications comprises two bits per slot. For TTI being an integer multiple of a radio frame, $TFCI_{rf}$ consequently comprises $15 \cdot 2 = 30$ bits. The $TFCI_{rf}$ bits are FEC encoded such that the 30 bits represent 10 information bits. I.e., 1024 transport format combinations can be represented by $TFCI_{rf}$. For the example of sub-frames comprising three slots, $TFCI_{sf}$ would comprise 6 bits, given that two bits of each slot carry TFCI bits. Depending on FEC coding, these TFCI bits would represent at most 64 transport format combinations. With redundancy included, typically 4 or 8 transport format combinations can be represented. Circumventing need for spending TFCI bits on explicit signaling of TTI allows maximal flexibility of transport formats. Figure 6 shows a flow chart schematically illustrating detection according to a preferred embodiment of the invention.

The receiver initially anticipates received TFCI field comprises $TFCI_{sf}$ data and detects, by decoding of the first slots on DPDCH corresponding to a first sub-frame, if any, whether or not there is a sub-frame of the received transmission. Each data channel sub-frame is protected by forward error control coding. This enables the receiver to correct and/or detect transmission errors. Only some symbol combinations are valid codewords. If a symbol combination is not among the considered correct codewords after decoding a transmission error can be detected. However, if e.g. a radio frame codeword, not comprising a sub-frame codeword in its first slots, is transmitted this will appear as a transmission subject to transmission errors to a decoder assuming a sub-frame codeword being transmitted. This relationship is utilized in the preferred embodiment of the receiver operating according to the flow chart of figure 6 for determining whether or not a sub-frame structure is superimposed on the prior art radio frame structure.

If decoding is successful, it is a great probability for a superimposed sub-frame structure and the decoded sequence is accepted as a valid codeword. Data transmitted in the sub-frame on DPDCH (see figure 4) is decoded using $TFCI_{sf}$ information and forwarded to higher layers. Once a sub-frame structure is detected the decoding continues for all sub-frames of the radio frame. After the last sub-frame of the radio frame, the process is halted for that radio frame. The process is repeated for next received one or more radio frames.

However, if the initially assumed sub-frame on DPDCH is not successfully decoded and not all assumed sub-frames have been decoded, the initial assumption of a superimposed sub-frame structure on the transmission is rejected and a radio

frame structure according to prior art is assumed. This assumption is investigated by decoding entire TTI assuming received TFCI relates to $TFCI_{rf}$ data of radio frame structured transmission on DPDCH and, if DPDCH decoding is successful, decoding one or more DPDCH radio frames for a transmission time interval as indicated by TFCI. If TTI is one radio frame, once the DPDCH radio frame is decoded it is forwarded to higher layers and the decoding process halted and restarted for the next one or more radio frames. If TTI is greater than one radio frame, the entire TTI on DPDCH is decoded and forwarded to higher layers prior to halting the process and restarting for next one or more radio frames. Otherwise, no more data is passed to higher layers and the process ends to restart for next one or more radio frames.

By decoding all radio frames of a transmission time interval, when there is no sub-frame structure superimposed, prior to restarting the process for next one or more radio frames an advantage of speeding up the decoding is achieved as sub-frame decoding can then be omitted.

According to a second embodiment, the sub-frame and radio frame decoding are non-exclusive. This is illustrated in figure 7 reflected in that condition «End of radio frame?» of figure 6 is excluded and step «Decode radio frame $TFCI_{rf}$» entered unconditionally when all sub-frames of a radio frame have been candidate decoded. The outcomes of decoding sub-frames and entire radio frame, respectively, are weighted and compared and the outcome (entire radio frame or one or more sub-frames) with greatest likelihood of being correct is selected in step «Select higher layers candidates; forward to higher layers». One such comparison would be to select between whether or not a sub-frame channel structure is superimposed depending on, which of the

alternatives would correspond to the smallest number of transmission errors. In figure 7, TTI comprising a plurality of radio frames does not include candidate(s) selection for more than first radio frame. However, more radio frames of TTI could be included at the expense of increased buffering. When a radio frame is TFCI detected only one radio frame (the first) of TTI is required to be detected.

According to a third embodiment a majority vote on the sub-frame decoding attempts of a received radio frame is determined prior to any decoding attempt of an entire radio frame. If, e.g., 3-5 out of 5 sub-frames are correctly decoded, transmissions are considered according to a sub-frame structure. Depending on false alarm rate and miss rate the vote threshold may be adjusted, e.g. requiring 4-5 correctly decoded sub-frames for considering data sent according to the sub-frame structure.

The preferred, second and third embodiments described above may be referred to as blind detection. However, it should be noted that according to the invention only TTI detection is blind. Once TTI is determined, $TFCI_{rf}$ and $TFCI_{sf}$, respectively, is used to inform the receiver on control information, e.g. code rate.

On the transmitting side the terminal preferably decides whether or not to make use of the sub-frame channel structure according to needs and radio environment. The decision is based on one or more aspects such as available transmit power, transmission activity on channels requiring radio frame channel structure without sub-frame channel structure.

As an alternative to blindly detecting whether a sub-frame structure is superimposed or not, this could be signaled through differences between $TFCI_{rf}$ and $TFCI_{sf}$. To achieve

sufficiently high reliability, there a distance measure is considered. The greater the distance, the greater the reliability. The smallest distance between any TFCI and any $TFCI_{sf}$ is determined in terms of number of differing positions. Two non-exclusive alternatives for increasing the distance beyond what TFCI field according to prior art alone allows for are considered:

* The distance is increased by utilizing bits of slot FBI-field for $TFCI_{sf}$.
* The distance is increased by using different pilot sequences depending on whether or not a sub-frame structure is imposed or not.

As an alternative, the above-mentioned increase of $TFCI_{sf}$ field size could, wholly or partially, be used for allowing more transport format combinations, at the expense of a smaller distance increase.

Irrespective of which method is used for detection (blind detection or TFCI difference), each received sub-frame is preferably acknowledged (positively or negatively) by the receiver, when a sub-frame structure is superimposed. A transmitter of an earlier release will simply ignore such unknown acknowledgments.

A problem related to hybrid ARQ, combining subsequent decodings for increased reliability causes another problem related to the superimposed sub-frame structure. According to the preferred embodiment, need for dual buffers to store also a superimposed sub-frame structure, with capacity of changing the decision until all sub-frames of a radio frame is received, is eliminated. Due to great reliability of the error detecting code, and the preferred constant sub-frame size of all sub-frames of a radio frame, the decision

is made on DPDCH data from the first sub-frame. If this sub-frame is indicated to be a valid codeword, the sub-frame structure is anticipated to hold for the entire radio frame and the hybrid ARQ buffer(s) reserved for sub-frame combining. The drawback of this solution is obviously that an erroneous decision based on only one sub-frame could ruin an entire radio frame, if there is no sub-frame channel structure of the transmission.

An alternative solution to this problem is to only allow soft combining of consecutive transmissions for sub-frame TTIs, excluding TTIs being integer multiples of the duration of a radio frame for hybrid ARQ. For reasons of symmetry, buffer savings could alternatively be achieved by only allowing hybrid ARQ for TTIs being integer multiples of a radio frame. A drawback of both these alternative solutions is that if retransmission of data need to occur without possibility to retransmit using a sub-frame channel structure, retransmissions cannot be softly combined. This may be the case e.g. due to mobility (some Nodes B may not have implemented a sub-frame channel structure or UE is strictly power limited if moved close to cell border).

L2 MAC layer can request retransmission of transmission units received in error. Preferably hybrid ARQ, utilizing information available from earlier transmission(s) of a transmission unit by proper combining with the latest retransmission, is used prior to an L2 MAC layer request for retransmission.

At the receiving end, error detection is also performed by layer L2 RLC of figure 8. If an RLC protocol data unit, PDU, is received in error or the PDU is missing, it will be requested for retransmission at a point in time when a status report is established by the RLC layer. RLC PDUs

are transferred to/from the MAC layer SDUs. The MAC SDU possibly includes a header not included in the RLC PDU. A network layer PDU or L3 PDU can comprise several RLC PDUs, as illustrated in figure 8. RLC PDUs are reassembled into RLC service data units, RLC SDU, prior to delivery to higher layer PDU. The L3 protocol can be, e.g., the Internet Protocol, IP. Upon reception from L3, RLC SDUs are segmented into RLC PDUs.

One reason for terminating the Fast Hybrid ARQ in Node B, as illustrated in figure 1 is the reduction of roundtrip delay as compared to terminating it in RNC. Another reason is that Node B is capable of using soft combining of multiply transmitted data packets, whereas RNC generally only receives hard-quantized bits.

Preferably, all Nodes B and UEs of the radio communications system operate according to the invention for outstanding performance. However, the invention can also be used in systems also including Nodes B not operating according to the invention.

A person skilled in the art readily understands that the receiver and transmitter properties of a BS or a UE are general in nature. The use of concepts such as BS, UE or RNC within this patent application is not intended to limit the invention only to devices associated with these acronyms. It concerns all devices operating correspondingly, or being obvious to adapt thereto by a person skilled in the art, in relation to the invention. As an explicit non-exclusive example the invention relates to mobile stations without a subscriber identity module, SIM, as well as user equipment including one or more SIMs. Further, protocols and layers are referred to in close relation with UMTS terminology. However, this does not exclude applicability of

the invention in other systems with other protocols and layers of similar functionality.

The invention is not intended to be limited only to the embodiments described in detail above. Changes and modifications may be made without departing from the invention. It covers all modifications within the scope of the following claims.

CLAIMS

1. A method of transmitting data according to a sub-frame channel structure, the method characterized in that for a radio frame channel structure of a data channel and a control channel

- a first transmission time interval being an integer multiple of the duration of a radio frame; and
- a second transmission time interval smaller than the first transmission interval and corresponding to the duration of a sub-frame

are defined; the sub-frame channel structure being applied with the second transmission time interval on the same data channel for which the first transmission time interval may be applied allowing the first and second transmission time intervals to interchange for different radio frames of the same data channel.

2. The method according to claim 1 characterized in that the sub-frame channel structure is superimposed on the radio frame channel structure.

3. The method according to claim 1 or 2 characterized in that transmission time interval is changed without transmitting explicit control signaling, comprising information on second time interval, on the control channel.

4. The method according to any of claims 1-3 characterized in transport format combination information according to the sub-frame channel structure is transmitted if transport format combination information has been changed since most recently transmission time interval

and is not transmitted if transport format combination information has not changed.

5. The method according to any of claims 1-3 characterized in that symbol intervals corresponding to symbol intervals of slots representing transport format combination information according to the radio frame channel structure are representing transport format combination information according to the sub-frame channel structure.

6. The method according to any of claims 1-5 characterized in that one or more symbol intervals of feedback information or pilot sequence of one or more radio frame channel structure slots are reallocated to represent transport format combination information on the sub-frame channel structure.

7. The method according to any of claims 1-6 characterized in that received sub-frames are acknowledged to data transmitter.

8. A method of detecting a sub-frame channel structure transmission time interval characterized in that for a data channel one or more slots corresponding to a transmission time interval of a sub-frame channel structure are received and for a control channel one or more transmission format control symbols of the one or more slots corresponding to those of the data channel are received; a candidate decoding of a first data channel sub-frame is performed assuming transport format control information being in accordance with the transport format control information of a corresponding control channel sub-frame of the sub-frame channel structure.

9. The method according to claim 8 characterized in that the method allows detection of inter-

change of first and second transmission time intervals for different radio frames of the same data channel, the second transmission time interval corresponding to the duration of a sub-frame and being smaller than the first transmission time interval.

10. The method according to claim 9 characterized in that sub-frame channel structure transmission time interval is detected without transmitting explicit control signaling, comprising information on second time interval, on the control channel.

11. The method according to any of claims 8-10 characterized in that candidate decoded sub-frame data is stored.

12. The method according to claim 11 characterized in that all sub-frames of a radio frame are candidate decoded.

13. The method according to any of claims 8-12 characterized in that when all one or more sub-frames of a radio frame have been candidate decoded, for the data channel the radio frame is candidate decoded assuming transport format control information being in accordance with transport format control information of a corresponding control channel radio frame of the radio frame channel structure.

14. The method according to claim 13 characterized in that depending on the outcome of the candidate one or more decodings, for the data channel a transmitted radio frame is selected according to a metric or cost function.

15. The method according to claim 14 characterized in that the metric or cost function reflects probability of selected data being transmitted.

16. The method according to claim 14 characterized in that the metric or cost function reflects probability of decoded data conditioned by received data.

17. The method according to claim 14 characterized in that the metric or cost function reflects a fraction of successfully decoded sub-frames of a radio frame.

18. The method according to claim 17 characterized in that the fractional metric or cost function is a majority vote.

19. The method according to any of claims 14-16 characterized in that if data is considered to be radio frame structured data and not being sub-frame structured, transmission time interval is determined from transport format combination information according to the radio frame structure, and if transmission time interval is greater than radio frame duration, remaining one or more radio frames of the transmission time interval are received and decoded according to the radio frame channel structure.

20. The method according to claim 19 characterized in that no candidate decoding assuming a sub-frame channel structure are undertaken for the remaining radio frames of the transmission time interval.

21. The method according to any of claims 8-10 characterized in that if the sub-frame candidate decoding of the data channel sub-frame is successful, candidate decoded sub-frame data is forwarded to higher layers.

22. The method according to claim 21 c h a r a c t e r - i z e d i n that subsequent sub-frames of a radio frame are candidate decoded until candidate decoding of a sub-frame fails or all sub-frames of received radio frame have been decoded.

23. The method according to claim 22 c h a r a c t e r - i z e d i n that failed decoding indicating candidate decoded data not being valid data of a sub-frame according to the sub-frame channel structure.

24. The method according to any of claims 8-10 c h a r - a c t e r i z e d i n that if the sub-frame candidate decoding of the data channel sub-frame is unsuccessful, for the data channel the radio frame is candidate decoded assuming transport format control information being in accordance with transport format control information of a corresponding control channel radio frame of the radio frame channel structure.

25. The method according to claim 24 c h a r a c t e r - i z e d i n that if candidate decoding of radio frame structured data and not being assumed sub-frame structured, transmission time interval is determined from transport format combination information according to the radio frame structure.

26. The method according to claim 25 c h a r a c t e r - i z e d i n that if transmission time interval is greater than radio frame duration, remaining one or more radio frames of the transmission time interval are received and decoded according to the radio frame channel structure.

27. The method according to claim 26 c h a r a c t e r - i z e d i n that no candidate decoding assuming a sub-

frame channel structure is performed for the remaining radio frames of the transmission time interval.

28. The method according to claim 26 or 27 characterized in that decoded data is forwarded to higher layers.

29. A signal format for transmission of data and control signaling characterized in that the signal format comprises a radio frame structure and a superimposed sub-frame structure, the radio frame being of a first duration and the sub-frame being of a second duration shorter than the first duration, the data part comprising information sufficient for determining whether or not transmissions are according to the superimposed sub-frame structure.

30. The signal format according to claim 29 characterized in that the sub-frame structure comprises transport format control information if the information has changed from an earlier transmission time interval, corresponding to the second duration or an integer multiple of the first duration.

31. The signal format according to claim 29 or 30 characterized in that the data and control signaling is transmitted on a data channel and control channel respectively.

32. A radio transmitter characterized in that it comprises circuitry for transmitting data according to the method in any of claims 1-7.

33. A radio transmitter characterized by transmission circuitry for transmitting data and control signaling according to the signal format in any of claims 29-31.

34. The radio transmitter according to claim 32 or 33 characterized in that the radio transmitter is included in or is a User Equipment.

35. The radio transmitter according to claim 32 or 33 characterized in that the radio transmitter is included in or is a radio base station.

36. A radio receiver characterized by circuitry for receiving data transmitted according to the method in any of claims 1-7.

37. A radio receiver characterized by circuitry for detection according to the method in any of claims 8-28.

38. A radio receiver characterized by receiving circuitry for receiving data and control signaling according to the signal format in any of claims 29-31.

39. The radio receiver according to any of claims 36-38 characterized in that the radio receiver is included in or is a radio base station.

40. The radio receiver according to any of claims 36-38 characterized in that the radio receiver is included in or is a User Equipment.

41. A radio communications system characterized by means for carrying out the method in any of claims 1-28.

42. A radio communications system characterized by radio transmissions according to the signal format in any of claims 29-31.

43. A radio communications system characterized by a plurality of radio transmitters according to any of claims 32-35.

44. A radio communications system characterized by a plurality of radio receivers according to any of claims 36-40.

45. The radio communication system according to any of claims 41-44 characterized in that the radio communications system is a UMTS or WCDMA system.

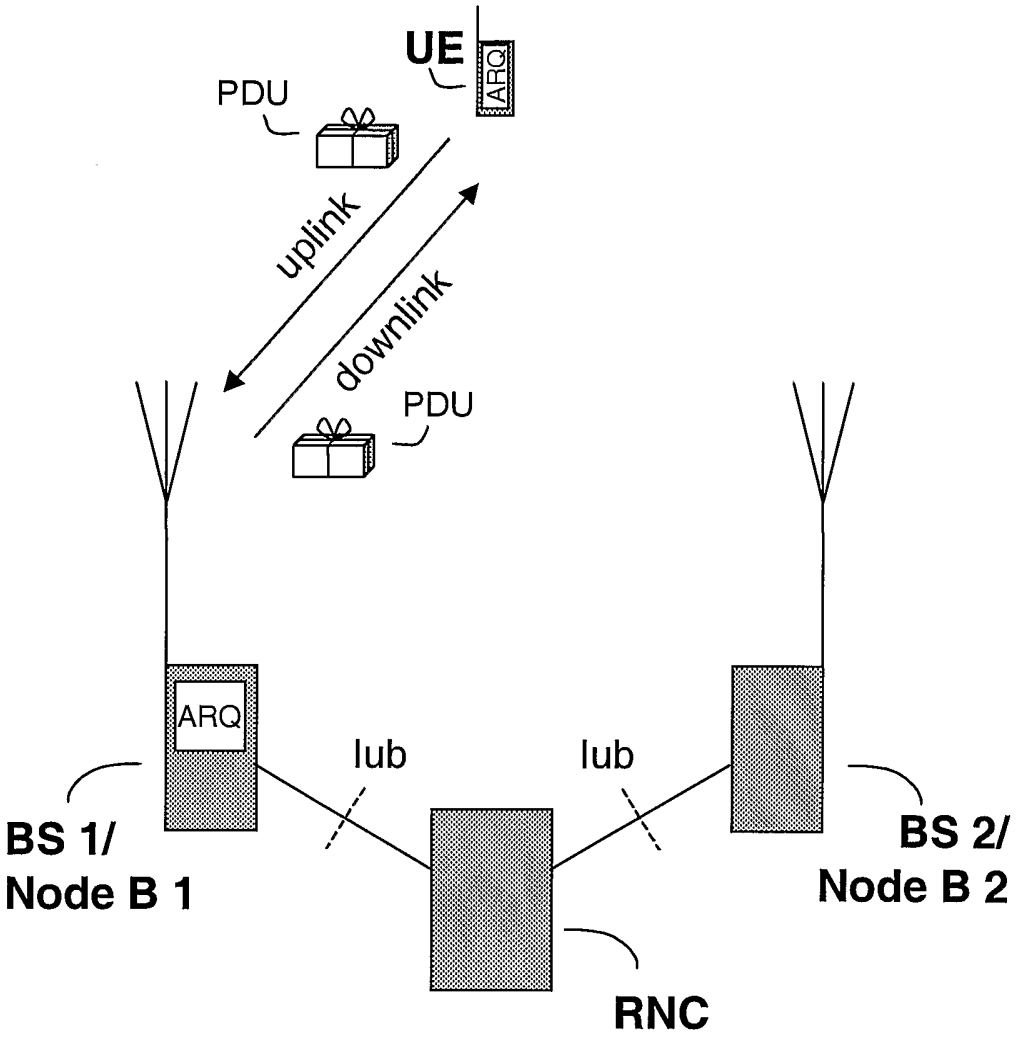

UE
ARQ
PDU
uplink
downlink
PDU
ARQ
Iub
Iub
BS 1/
Node B 1
BS 2/
Node B 2
RNC

Fig. 1

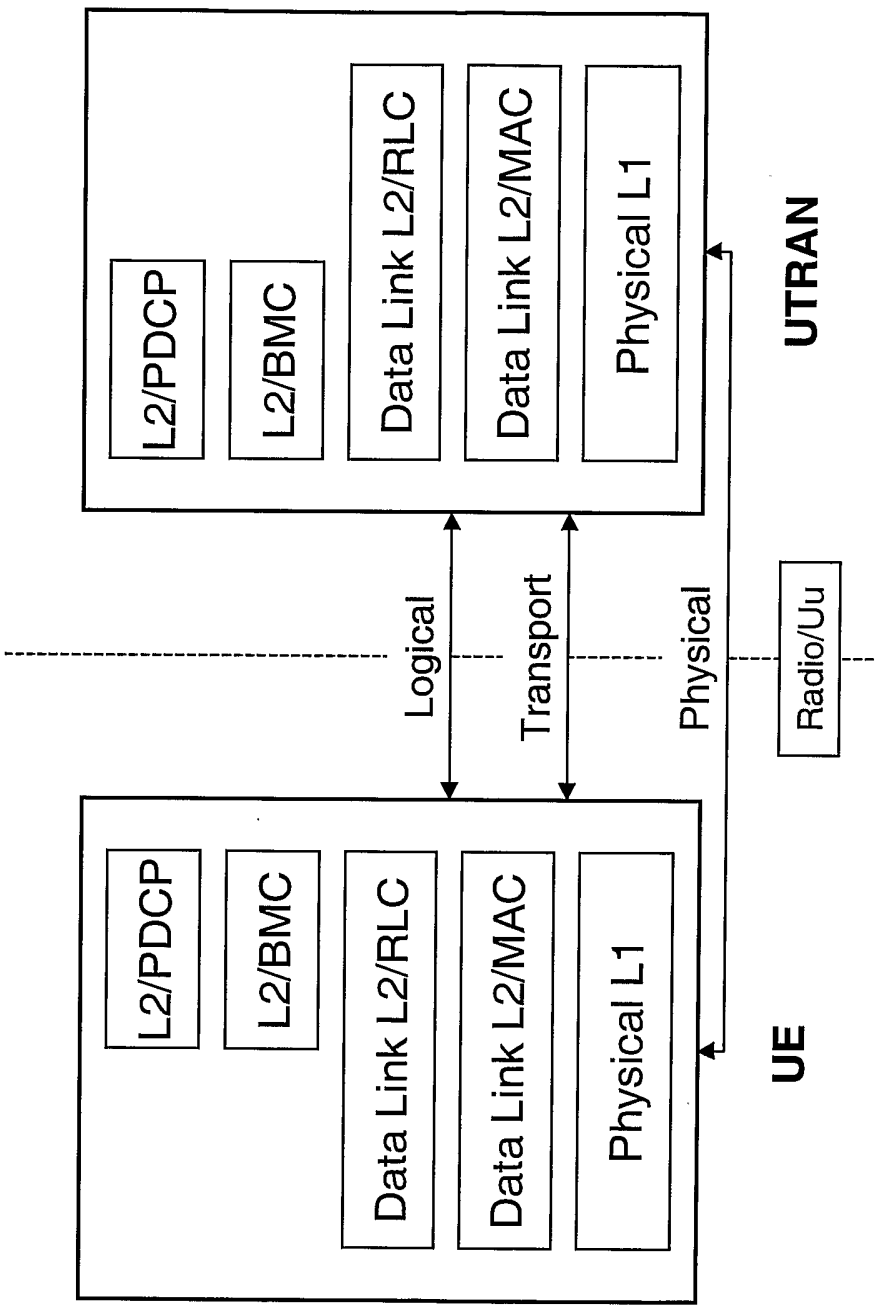

L2/PDCP
L2/BMC
Data Link L2/RLC
Data Link L2/MAC
Physical L1
UTRAN
Logical
Transport
Physical
Radio/Uu
L2/PDCP
L2/BMC
Data Link L2/RLC
Data Link L2/MAC
Physical L1
UE

Fig. 2

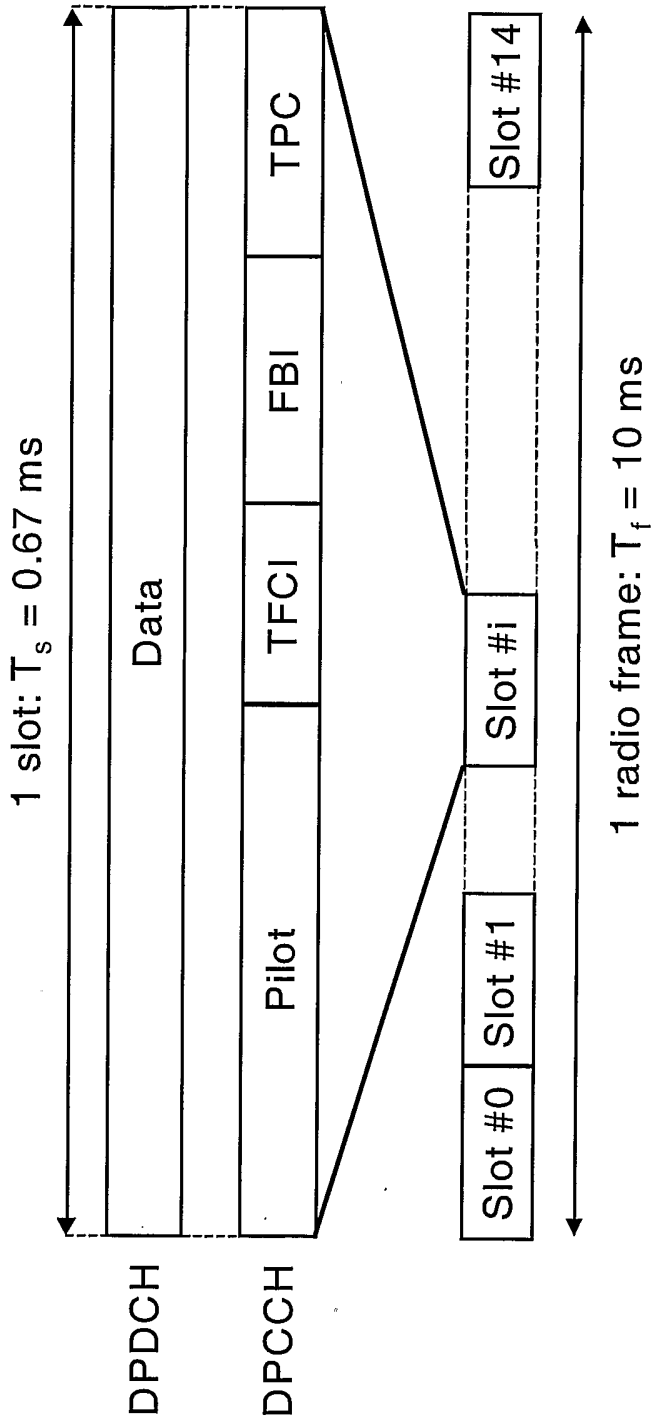

1 slot: T_s = 0.67 ms
Data
TFCI
FBI
TPC
Pilot
Slot #0
Slot #1
Slot #i
Slot #14
1 radio frame: T_f = 10 ms
DPDCH
DPCCH

Fig. 3

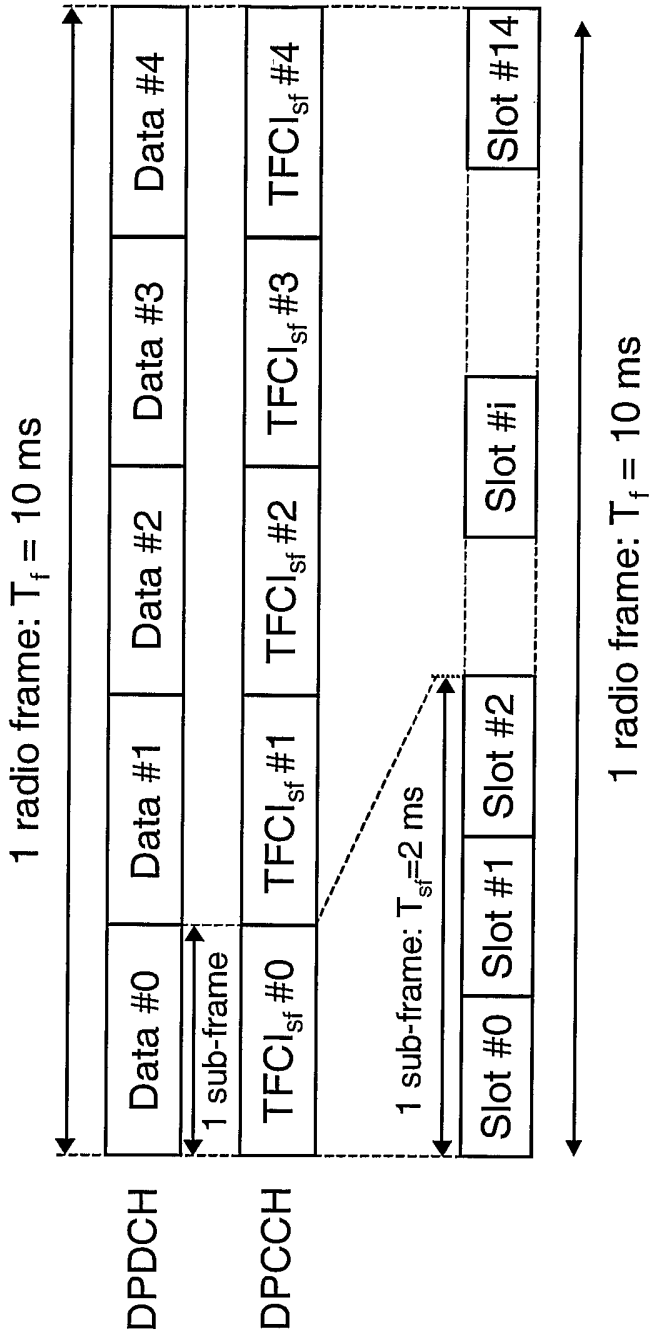

1 radio frame: T_f = 10 ms
Data #0
Data #1
Data #2
Data #3
Data #4
1 sub-frame
$TFCI_{sf}$ #0
$TFCI_{sf}$ #1
$TFCI_{sf}$ #2
$TFCI_{sf}$ #3
$TFCI_{sf}$ #4
1 sub-frame: T_{sf}=2 ms
Slot #0
Slot #1
Slot #2
Slot #i
Slot #14
1 radio frame: T_f = 10 ms
DPDCH
DPCCH

Fig. 4

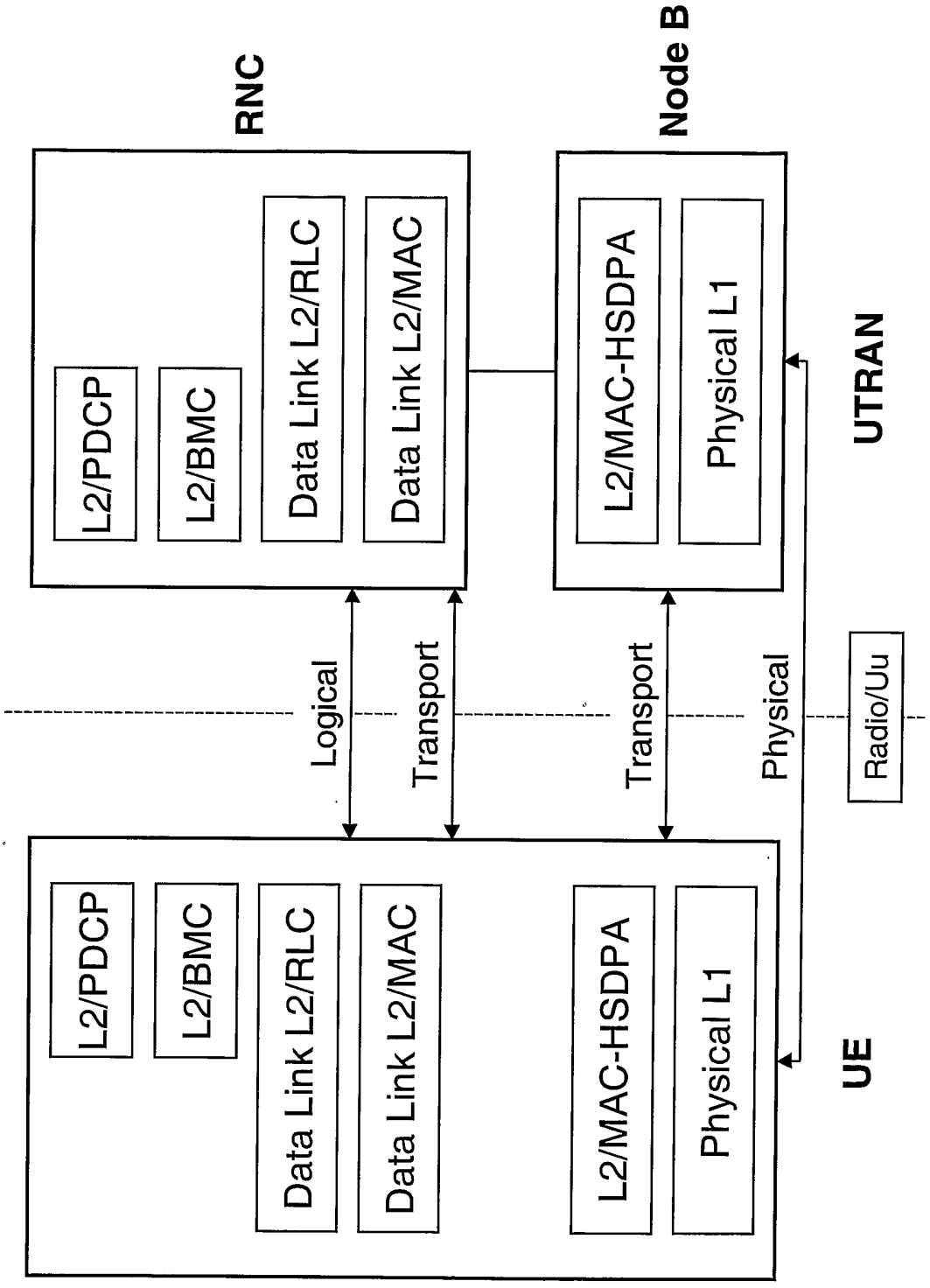

RNC
Node B
L2/PDCP
L2/BMC
Data Link L2/RLC
Data Link L2/MAC
L2/MAC-HSDPA
Physical L1
UTRAN
Logical
Transport
Transport
Physical
Radio/Uu
L2/PDCP
L2/BMC
Data Link L2/RLC
Data Link L2/MAC
L2/MAC-HSDPA
Physical L1
UE

Fig. 5

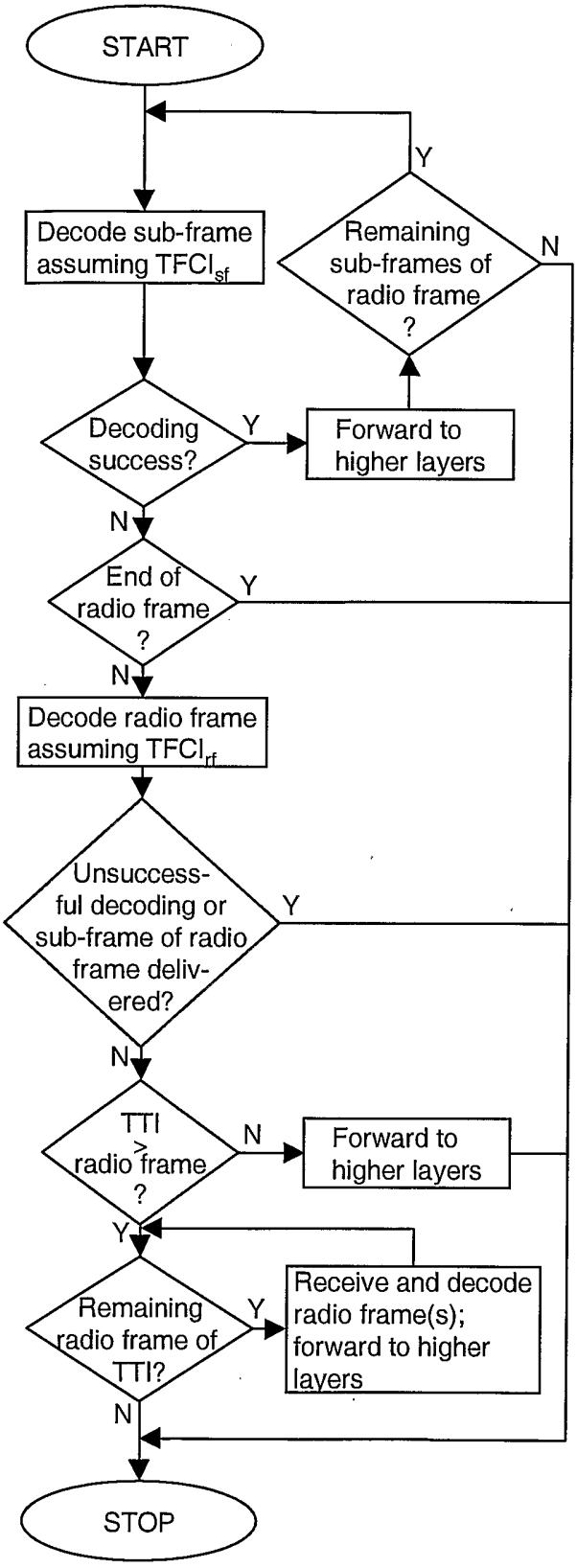

START
Decode sub-frame assuming TFCI$_{sf}$
Decoding success?
Y
Forward to higher layers
Remaining sub-frames of radio frame ?
Y
N
N
End of radio frame ?
Y
N
Decode radio frame assuming TFCI$_{rf}$
Unsuccess-ful decoding or sub-frame of radio frame deliv-ered?
Y
N
TTI > radio frame ?
N
Forward to higher layers
Y
Remaining radio frame of TTI?
Y
Receive and decode radio frame(s); forward to higher layers
N
STOP

Fig. 6

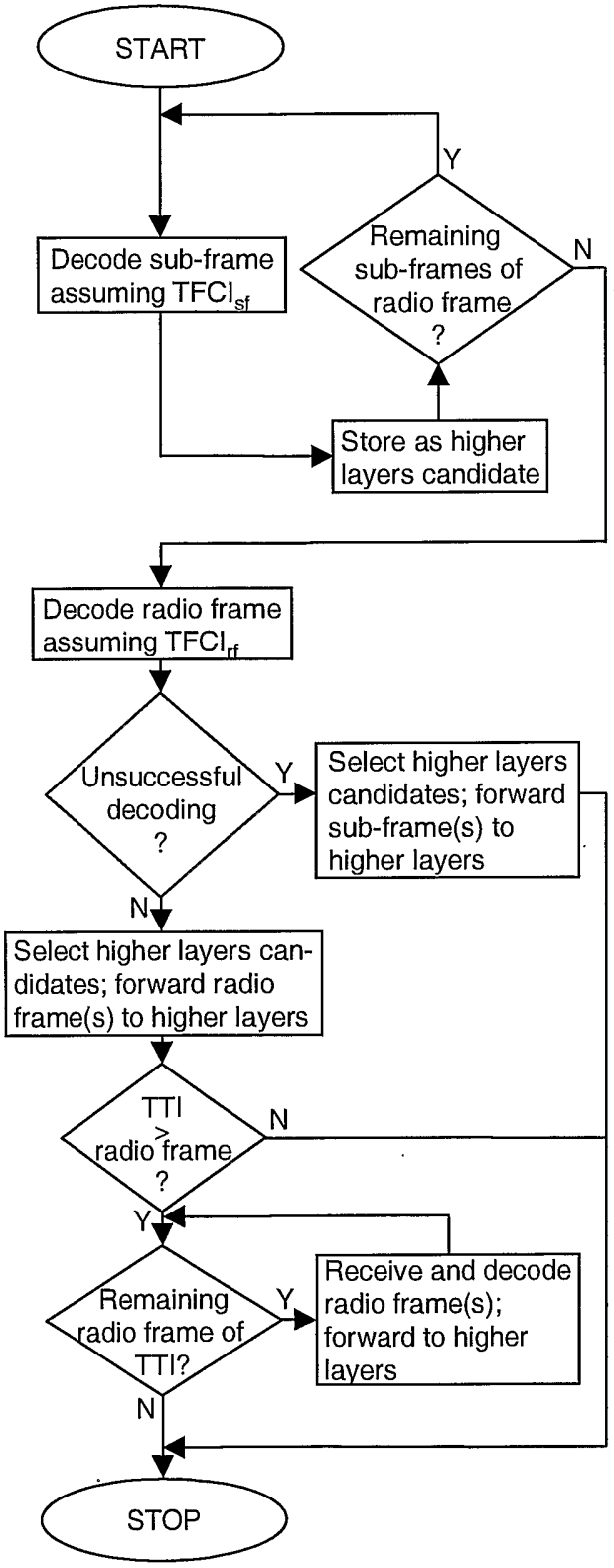

START
Y
Remaining sub-frames of radio frame ?
N
Decode sub-frame assuming TFCI$_{sf}$
Store as higher layers candidate
Decode radio frame assuming TFCI$_{rf}$
Unsuccessful decoding ?
Y
Select higher layers candidates; forward sub-frame(s) to higher layers
N
Select higher layers candidates; forward radio frame(s) to higher layers
TTI > radio frame ?
N
Y
Remaining radio frame of TTI?
Y
Receive and decode radio frame(s); forward to higher layers
N
STOP

Fig. 7

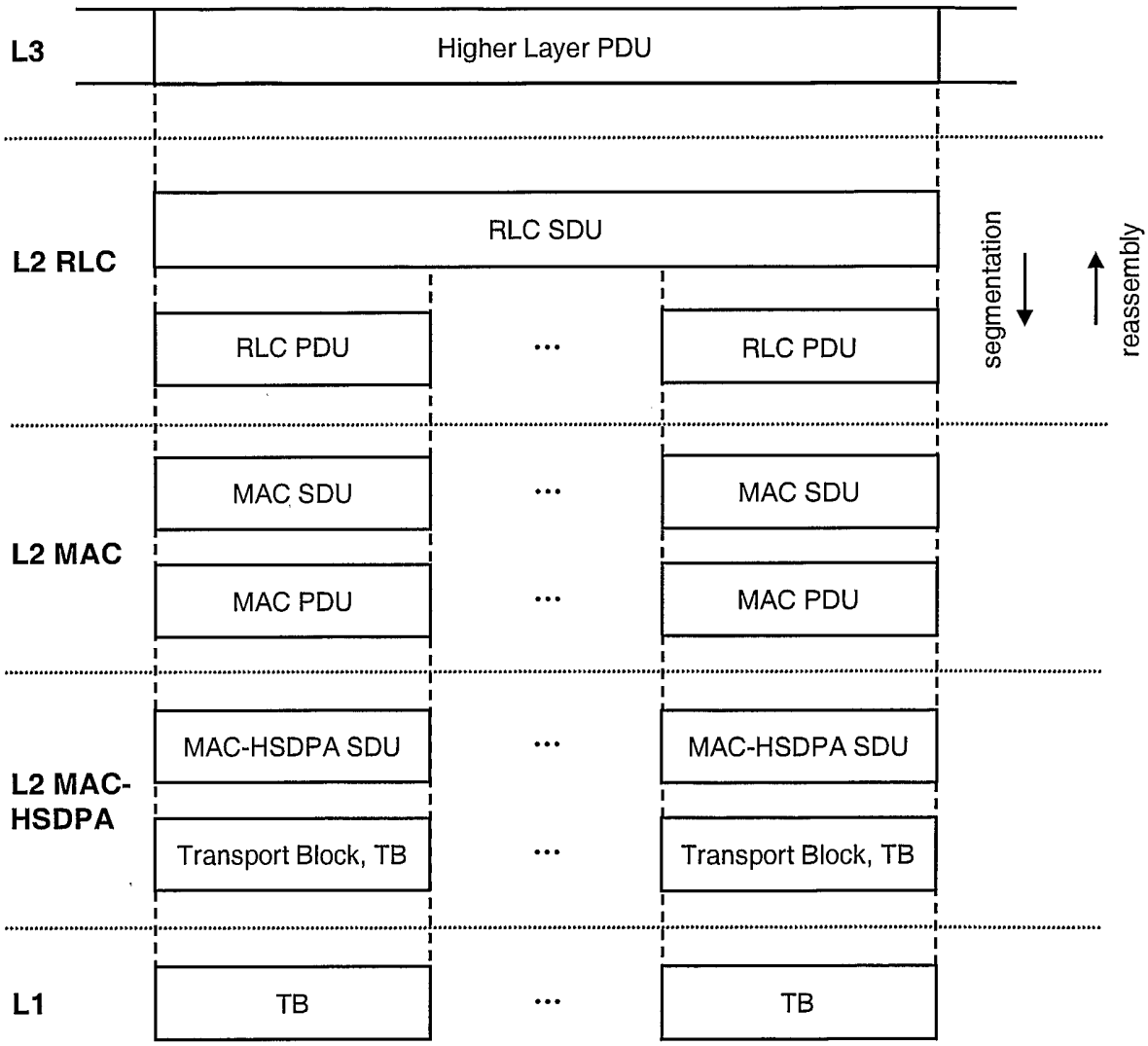

L3
Higher Layer PDU
L2 RLC
RLC SDU
RLC PDU
RLC PDU
segmentation
reassembly
L2 MAC
MAC SDU
MAC SDU
MAC PDU
MAC PDU
L2 MAC-HSDPA
MAC-HSDPA SDU
MAC-HSDPA SDU
Transport Block, TB
Transport Block, TB
L1
TB
TB

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/000159

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04L 1/18, H04B 7/26
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)

IPC7: H04L, H04B

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)

EPO-INTERNAL, WPI DATA, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PARKVALL, S. et al. "The evolution of WCDMA towards higher speed downlink packet data access". In: IEEE VTS 53RD VEHICULAR TECHNOLOGY CONFERENCE, 2001. VTC 2001 SPRING. Rhodes, Greece, 6-9 May 2001, Vol. 3, pages 2287-2291, INSPEC AN: 7183786, see abstract ---	1-45
A	EP 1286491 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 26 February 2003 (26.02.2003), abstract ---	1-45

[X] Further documents are listed in the continuation of Box C. [X] 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 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	Date of mailing of the international search report
19 May 2004	02 -06- 2004
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Åsa Rydenius /OGU Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/000159

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DAS, A. et al. "Adaptive, asynchronous incremental redundancy (A/sup 2/IR) with fixed transmission time intervals (TTI) for HSDPA". In: THE 13TH IEEE INTERNATIONAL SYMPOSIUM ON PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATIONS, 2002. 15-18 September 2002, Vol. 3, pages 1083-1087, INSPEC AN: 7678046, see abstract -- --------	1-45

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				JP	2003179581 A	27/06/2003