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(54) **Title**: METHOD FOR ENHANCING THE UPLINK PERFORMANCE OF COVERAGE-LIMITED DEVICES

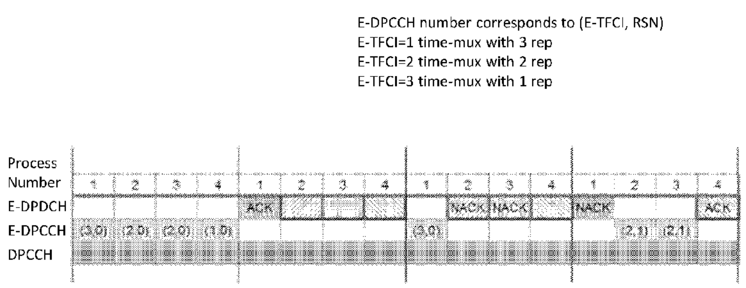

Fig. 3

(57) **Abstract**: The present disclosure pertains to a method for operating a terminal (10) for a wireless communication network, the method comprising time-multiplexing at least two uplink physical channels. The disclosure also pertains to related devices and methods.

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METHOD FOR ENHANCING THE UPLINK PERFORMANCE OF COVERAGE-LIMITED DEVICES

Technical Field

The present disclosure pertains to wireless communication technology, in particular to communication in the uplink of WCDMA systems.

Background

Small data transmission applications, for example machine-type communication (MTC) applications, are expected to be a large growth area, with the potential for billions of connected devices. In many cases, this type of traffic poses different service requirements compared to conventional traffic types. One important example is the requirement on extreme coverage rendering a need to trade data rate and latency for increased coverage.

This disclosure in particular considers solutions for increasing the UMTS (and/or WCDMA and/or HSPA) uplink coverage.

Summary

An object of the present disclosure is to provide approaches suitable in particular for Small dtat transmission scenarios or systems like MTC and/or in coverage limited scenarios.

Accordingly, there is suggested a method for operating a terminal for a wireless communication network. The method comprises time-multiplexing at least two uplink physical channels.

Moreover, a terminal for a wireless communication network is described. The terminal is adapted for time-multiplexing at least two uplink physical channels.

A method for operating a network node for a wireless communication network is also proposed. The method comprises configuring a terminal for time-multiplexing at least two uplink physical channels.

Furthermore, a network node for a wireless communication network is considered. The network node is adapted for configuring a terminal for time-multiplexing at least two uplink physical channels.

There may be considered a computer program product comprising code elements causing performance and/or control of any of the methods described herein when executed by control circuitry.

A storage medium readable by control circuitry is described, the storage medium storing a computer program product as described herein.

Time multiplexing at least two physical channels facilitates more effective use in particular in coverage limited scenarios.

Brief description of the drawings

The drawings are provided to illustrate concepts and approaches of the disclosure and are not intended as limitation. The drawings comprise:

Figure 1, showing a summary of MCL values for the agreed reference scenario;

Figure 2, showing an illustration of E-DPCCH and E-DPDCH time-multiplexed operation;

Figure 3, showing a more detailed illustration of E-DPCCH and E-DPDCH time-multiplexed operation;

Figure 4, schematically showing a terminal; and

Figure 5, schematically showing a network node.

Detailed description

Small data transmission (SDT) applications, for example machine-type communication (MTC) applications, are expected to be a large growth area, with the potential for billions of connected devices. In many cases, this type of traffic poses different service requirements compared to conventional traffic types. For an important segment of applications, the requirements on power consumption and coverage versus data rate and latency may vary. The phenomenal success of WCDMA technologies means that up to the 2020 timescale and beyond, WCDMA will be a dominant 3GPP technology with a large coverage footprint. Furthermore, WCDMA devices are already available at a cost level that is suitable for the machine oriented communication market. In order to serve the market opportunities, many operators likely need to provide enhanced support for small data applications with a coverage footprint that WCDMA can provide. The current generation of WCDMA specifications has been optimized for mobile broadband traffic. To ensure that small data applications are properly addressed, the specifications should enable requirements on coverage in challenging device locations, low device power consumption and machine type data rates to be met.

Small data transmissions for UMTS profit from new solutions in the areas of coverage, signaling optimization, support of massive deployment of devices, and power savings taking into consideration minimizing the impact on the physical layer, legacy terminals, and networks. Enhanced Uplink (EUL), also referred to as High-Speed Uplink Packet Access (HSUPA), was standardized in release 6. Compared to release 99, it provides improvements in uplink in terms of higher uplink data rates, reduced latency, and improved system capacity, and is therefore a natural complement to the downlink enhancements introduced with High-Speed Uplink Packet Access (HSDPA) in release 5. HSUPA relies on two core technologies – fast scheduling via 2 or 10 ms TTIs and fast hybrid-ARQ with soft combining. These enhancements are implemented in WCDMA through a new transport channel, the Enhanced Dedicated Channel (E-DCH), which is mapped to a set of uplink channelization codes known as E-DCH Dedicated Physical Data Channels (E-DPDCHs). To support out-band control signaling associated with E-DPDCH, the E-DCH Dedicated Physical Control Channel (E-DPCCH) is used. The E-DPCCH consists of 10 information bits (E-TFCI (7 bits), RSN (2 bits) and one happy bit) coded with a (30,10) second order Reed-Muller code and uses spreading factor 256. For 10 ms TTI, five times repetition is employed.

E-DPDCH, E-DPCCH and DPCCH are usually sent simultaneously in a code-multiplexed fashion. Among other things, DPCCH serves as the pilot channel in the uplink, meaning that detection and demodulation of other UL physical channels rely on channel estimates calculated based on pilot symbols from the DPCCH. The pilots on the DPCCH are also used for synchronization purposes and for the searcher to find channel tap delays. Since the output power of the UE is limited (typically 21-24 dBm, partly due to regulatory constraints), it is important to divide the available power efficiently between the transmitted physical channels, especially when being coverage limited and thereby transmitting at (close to) maximum power. Shannon's theory tells us that given a fixed bandwidth, the amount of information that can be reliably transmitted increases with increasing power (or, more specifically, signal-to-noise ratio). Similarly, given a fixed information rate, more power translates into better coverage.
The powers of uplink physical channels (e.g. E-DPDCH, E-DPCCH and HS-DPCCH) are set relative the power of DPCCH by means of gain factors – βed for E-DPCCH, βec for E-DPCCH and βhs for HS-DPCCH.

To reduce UE energy consumption and use of network resources, WCDMA, like most other cellular systems, has several states: URA_PCH, CELL_PCH, CELL_FACH, CELL_DCH, and idle mode. The lowest energy and resource consumption is achieved when the UE is in one of the two paging states specified for WCDMA, namely CELL_PCH and URA_PCH. In these states, the UE sleeps and only occasionally wakes up to check for paging messages. In CELL_FACH, the UE can transmit small amounts of data as part of the random-access procedure. The UE also monitors common downlink channels for small amounts of user data and RRC signalling from the network. The high transmission activity state is known as CELL_DCH. In this state, the UE can use HS-DSCH and E-DCH for exchanging data with the network. In order to provide sufficient flexibility within the specifications for handling all types of traffic, 3GPP has enhanced the functionality available to the UE when in the CELL_FACH and CELL_PCH states in several releases. Downlink operation was addressed as first priority in release 7, and was followed by uplink operation in release 8. Both downlink and uplink operations in CELL_FACH were further improved during release 11. Release 7 improved the performance by allowing HS-DSCH to be used also in CELL_FACH, and release 8 introduced E-DCH in CELL_FACH.

EUL in CELL_FACH consists basically of three stages. First the UE acquires the necessary information to initiate operation of EUL in CELL_FACH via system broadcast; for example, the preamble signatures used for EUL-FACH and common E-DCH parameters. Second the UE performs random access on PRACH to gain access to the network. In this phase the UE sends preambles with increasing power until the network acknowledges that it has detected the UE by sending a response on AICH. Then, the UE can start transmitting on common E-DCH very much as in CELL_DCH.

There are a number of approaches (which may be combinable) for increasing the coverage, such as:

Transmitting the information content over a longer time, effectively reducing the data rate. Alternatives to achieve this include longer TTIs (e.g. switch from 2 ms TTI to 10 ms TTI at cell-edge) and leverage on hybrid-ARQ retransmission or repetition in general

Reducing the rate – Reducing the rate is another approach of increasing coverage. A lower data rate requires less power for reliable communication. A reduced rate can in general be achieved by several means, for example reducing the information content, employ repetitions or increasing the TTI. For EUL, two different TTIs are available (2 ms and 10 ms) and a coverage limited device typically employs 10 ms TTI.

Reducing the information content - Less information requires in general less power for reliable communication. Hence, small transport block sizes are favourable for coverage limited devices. Similarly, it is beneficial to reduce the control channel information.

Repetitions and/or HARQ retransmissions – Given the limited output power from a UE, retransmissions or repetitions are powerful means to increase EUL coverage. Each new transmission increases the received power and gives a potential diversity gain. The main cost for this is increased latency and potentially an impact on higher-layers, for example re-tuning of timers.

Favourable communication conditions – A somewhat different way of increasing uplink coverage is to aim at transmitting in favourable conditions, for example when the RoT is low in the cell or when the fading conditions are good. This has the potential to significantly increase the coverage but is obviously difficult to fully control. One example would be to steer SDT device traffic to low-load occasions, for example during off-peak hours such as night time.

Increasing the power – Power is one of the most fundamental resources when it comes to coverage and increasing the power directly translates into increased coverage. However, power is a very scarce resource in the uplink, especially for coverage limited devices that are already transmitting with full power. Hence, it is important to distribute the available power in a good way. In particular, it might be preferred to focus the available power on as few physical channels as possible each time instant instead of spreading the power over several physical channels, i.e. time-multiplexing instead of code-multiplexing.

In this disclosure there are discussed means of increasing the uplink coverage by reducing, removing or re-interpreting control channel information, and utilizing the available power in a more optimal manner.

Application of the ideas to CELL_DCH and CELL_FACH operation is possible and considered.

Herein are described different alternatives for improving the performance in coverage limited scenarios. One idea is to configure a special E-DCH transport block size table containing information not only related to the E-TFCI to transport block size mapping. More specifically, it is proposed that some E-TFCI elements should be associated with a special coverage limited operation where E-DPCCH and E-DPDCH are time-multiplexed. Parts of this disclosure will extend this idea to cover also other information elements (this will be discussed more below).

First of all, it could be possible to signal a switch between ‘normal’ operation and ‘coverage limited’ operation. Dedicated signalling could be added or some existing information elements could be used, for example a specific E-TFCI value could be used to indicate this. As an alternative one could leave it to the network to decide whether the normal of coverage limited operation should be enabled via, for example an HS-SCCH order. The ‘coverage limited’ operation (on/off) could be explicitly handled via signalling (UE and/or network), it could be determined by standardized rules (e.g. timers), or configured via network signalling (e.g. timers).

A number of potential improvement areas are discussed next:

HS-DPCCH – For coverage limited scenarios, HS-DPCCH is a very costly (in terms of power) channel. One reason being that HS-DPCCH employs a 2 ms TTI, while EUL typically operates with 10 ms TTI in a coverage limited scenario. One approach to reduce the cost of HS-DPCCH would be to use repetitions, i.e. repeat the same information element (ACK/NACK or CQI) in several consecutive TTIs. However, current specifications do not allow more than four repetitions of ACK/NACK or CQI, which most likely is not enough to reduce the power cost to resemble that of other UL physical channels. Hence, one alternative to increase coverage would be to introduce longer repetition intervals for coverage limited devices. Extending the number of repetitions might impact various system aspects, such as imposing scheduler restrictions and delays, but for a coverage limited device this might be acceptable. Considerations include, but are not limited to:

- In normal operation it is preferred to operate with small to moderate values of the repetition factors, so it is mainly when the UE becomes power limited that extending the repetition factors would be beneficial. A problem is, though, that changing the repetition factors require RRC signalling and this takes time and might be unreliable once the UE has become coverage limited.
- It could be possible to dynamically signal a change in repetition factors, e.g. to notify a change from the default repetition factor to the coverage limited value. The signalling could be based on some existing UL signalling mechanism, for example one or several specific E-TFCI value(s) could be used to change the repetition factor, or the happy bit could be reinterpreted to indicate repetition factor mode. Longer repetition factors could be part of operating in the special coverage limited mode (discussed above), i.e. changing to longer repetition factors once the UE enters the coverage limited mode. Changes could apply to all repetition factors (ACK/NACK and CQI) or a subset of them. Different messages could be used to target different repetition factor types or to jointly target all repetition factor types.

Another idea would be to completely remove the HS-DPCCH, i.e. employ HS-DPCCH DTX when operating in coverage limited scenarios. In particular, removing the HS-DPCCH could make sense if there is simultaneous EUL traffic, i.e. if E-DPCCH and/or E-DPDCH are sent at the same time as HS-DPCCH. DTXing HS-DPCCH would imply that downlink related feedback, such as ACK/NACKs and CQI cannot be signalled to the network. This can be compared to Rel-7 CELL-FACH where it is not possible for the UE to transmit the HS-DPCCH in the uplink. In this case the Node B needs to blindly decide whether to schedule a retransmission and an estimate of the supported data rate can be made from UE measured CPICH power provided by the RNC over the Iub frame protocol. Hence, a similar approach can be adopted for a coverage limited scenario, especially if EUL is configured and active simultaneously. A potential enhancement would be to include a complete or limited CQI report in another uplink physical channel. For example, some of the E-TFCI bits in the E-DPCCH can be used to signal a limited set of CQI values.

Different alternatives for how this would be done can be envisioned, including but not limited to:

- A standalone E-DPCCH can be sent (i.e. without an associated E-DPDCH) indicating that the HS-DPCCH will be DTXed. A special information element in the E-DPCCH ,e.g. a special E-TFCI can be used for this
- Info about the DTX status for HS-DPCCH can be included in an E-DPCCH associated with an E-DPDCH. Several possibilities exist, for example, some of the E-TFCIs include two information elements, i.e. HS-DPCCH DTXed and an E-TFCI. This can be combined with the E-DPCCH and E-DPDCH time-multipled operation described in [1]. A special E-TFCI is used to indicate that the HS-DPCCH will now be DTXed and a default or the last used transport block size is used for the associated E_DPDCH transmission. Yet another alternative is that the ‘happy bit’ is reinterpreted to correspond to HS-DPCCH DTX status (see reinterpretation of ‘happy bit’ below)

- The DTX time interval can be standardized or configured via the network. It can also be conditioned on the available power (i.e. is the UE power limited or not), for example current scheduling grant, power headroom, etc. It can also be toggled via some UE signalling, e.g. a special E-DPCCH information element. Similarly, the timing between signalling a change of the HS-DPCCH DTX status and when it is actually applied can be standardized or configurable. The HS-DPCCH DTX operation could be part of the special coverage limited operation.

A similar approach could be envisioned for ACK/NACK information, but one complication is that HS-DPCCH is not time-synchronized with UL DPCCH, which could affect the DL HARQ timing. Another approach would be to condition CQI transmissions via HS-DPCH on E-DPCCH transmissions. Hence, the HS-DPCCH carrying CQIs would only be transmitted if E-DPCCH is sent. This would potentially break the existing CQI feedback cycle, but the Node B could use a detected E-DPCCH as an indication of that also a CQI report is conveyed on the HS-DPCCH. In a scenario where E-DPCCH and E-DPDCH time-multiplexing is used [1], this would increase coverage, since HS-DPCCH will never be sent together with data, i.e. E-DPDCH.

Moving E-DPCCH info to DPCCH – It is proposed to reduce the information content carried on E-DPCCH and move the remaining information to the DPCCH, thereby completely eliminating the need for sending E-DPCCH. This approach might be feasible if the information is significantly reduced. Also, there is a question about coding gains/losses if simply moving some information bits to the DPCCH.

Another approach is as follows: The E-DPCCH uses (30,10) second order Reed-Muller coding, hence the 10 information bits are coded into 30 coded bits that fit one 2 ms subframe using SF256. For 10 ms TTI, five times repetition is employed. For 10 ms TTI, one approach could be to carry the 30 coded bits over the DPCCH. In this case two symbols in each DPCCH slot would be needed to carry all 30 bits over 15 slots. Hence, a new slot format containing two E-DPCCH bits and, for example, two TPC bits and six pilot bits would be needed. Note that there already exist such slots formats that could be re-used, for example there is a slot format with 2 TPC bits, 6 pilot bits and 2 TFCI bits, and hence the TFCI bits can be re-used for E-DPCCH bits. If a slot format containing pilot bits, TFCI bits, TPC bits and E_DPCCH bits are required, a completely new slot format needs to be introduced. This kind of operation could be configured/handled in similar ways as the HS-DPCCH DTX or HS-DPCCH repetition factor. Also, this idea could be applied for HS-DPCCH information.

Reinterpreting the ‘happy bit’ – For a coverage limited scenario, it is questionable whether the happy bit is needed. Hence, it would be possible to remove or re-interpret the happy bit when entering the coverage limited operation.

Network acknowledgment of dynamic changed behaviour – For all the schemes that rely on dynamic signalling it would be beneficial to ensure that all nodes (UE and network) have the same view of the operation mode. Either one rely on that the UE signalling is reliable enough so that this is not a significant problem. Otherwise one could consider sending a reliable network acknowledgment. A natural choice would be to use an HS-SCCH order for this.
While in the above text the UE has been assumed to be a SDT device, the coverage benefits associated with the disclosure would also apply to other devices supporting this scheme, including smartphones.

The disclosure proposes approaches and alternatives for improving the performance in coverage limited scenarios. Some advantages include:

- Coverage can be significantly improved
- The available resources, e.g. power is handled in a more optimized manner.
- The impact on current UEs, networks and specifications can be made rather small.

Figure 4 schematically shows a terminal 10, which may be implemented in this example as a user equipment. Terminal 10 comprises control circuitry 20, which may comprise a controller connected to a memory. A receiving module and/or transmitting module and/or control or processing module and/or CIS receiving module and/or scheduling module, may be implemented in and/or executable by, the control circuitry 20, in particular as module in the controller. Terminal 10 also comprises radio circuitry 22 providing receiving and transmitting or transceiving functionality, the radio circuitry 22 connected or connectable to the control circuitry. An antenna circuitry 24 of the terminal 10 is connected or connectable to the radio circuitry 22 to collect or send and/or amplify signals. Radio circuitry 22 and the control circuitry 20 controlling it are configured for cellular communication with a network on a first cell /carrier and a second cell /carrier, in particular utilizing UMTS/WCDMA resources as described herein. The terminal 10 may be adapted to carry out any of the methods for operating a terminal disclosed herein; in particular, it may comprise corresponding circuitry, e.g. control circuitry. Modules of a terminal as described herein may be implemented in software and/or hardware and/or firmware in corresponding circuitry.

Figure 5 schematically show a network node or base station 100, which in particular may be an NodeB. Network node 100 comprises control circuitry 120, which may comprise a controller connected to a memory. A receiving module and/or transmitting module and/or control or processing module and/or scheduling module and/or receiving module, may be implemented in and/or executable by the control circuitry 120. The control circuitry is connected to control radio circuitry 122 of the network node 100, which provides receiver and transmitter and/or transceiver functionality. An antenna circuitry 124 may be connected or connectable to radio circuitry 122 for signal reception or transmittance and/or amplification. The network node 100 may be adapted to carry out any of the methods for operating a network node disclosed herein; in particular, it may comprise corresponding circuitry, e.g. control circuitry. Modules of a network node as described herein may be implemented in software and/or hardware and/or firmware in corresponding circuitry.

A wireless communication network may comprise at least one network node, in particular a network node as described herein. A terminal connected or communicating with a network may be considered to be connected or communicating with at least one network node, in particular any one of the network nodes described herein.

In the context of this description, wireless communication may be communication, in particular transmission and/or reception of data, via electromagnetic waves and/or an air interface, in particular radio waves, e.g. in a wireless communication network and/or utilizing a radio access technology (RAT). The communication may involve one or more than one terminal connected to a wireless communication network and/or more than one node of a wireless communication network and/or in a wireless communication network. It may be envisioned that a node in or for communication, and/or in, of or for a wireless communication network is adapted for communication utilizing one or more RATs, in particular UMTS/HSPA/WCDMA.

A communication may generally involve transmitting and/or receiving messages, in particular in the form of packet data. A message or packet may comprise control and/or configuration data and/or payload data and/or represent and/or comprise a batch of physical layer transmissions. Control and/or configuration data may refer to data pertaining to the process of communication and/or nodes and/or terminals of the communication. It may, e.g., include address data referring to a node or terminal of the communication and/or data pertaining to the transmission mode and/or spectral configuration and/or frequency and/or coding and/or timing and/or bandwidth as data pertaining to the process of communication or transmission, e.g. in a header. Each node or terminal involved in communication may comprise radio circuitry and/or control circuitry and/or antenna circuitry, which may be arranged to utilize and/or implement one or more than one radio access technologies. Radio circuitry of a node or terminal may generally be adapted for the transmission and/or reception of radio waves, and in particular may comprise a corresponding transmitter and/or receiver and/or transceiver, which may be connected or connectable to antenna circuitry and/or control circuitry. Control circuitry of a node or terminal may comprise a controller and/or memory arranged to be accessible for the controller for read and/or write access. The controller may be arranged to control the communication and/or the radio circuitry and/or provide additional services. Circuitry of a node or terminal, in particular control circuitry, e.g. a controller, may be programmed to provide the functionality described herein. A corresponding program code may be stored in an associated memory and/or storage medium and/or be hardwired and/or provided as firmware and/or software and/or in hardware. A controller may generally comprise a processor and/or microprocessor and/or microcontroller and/or FPGA (Field-Programmable Gate Array) device and/or ASIC (Application Specific Integrated Circuit) device. More specifically, it may be considered that control circuitry comprises and/or may be connected or connectable to memory, which may be adapted to be accessible for reading and/or writing by the controller and/or control circuitry. Radio access technology may generally comprise, e.g., Bluetooth and/or Wifi and/or WIMAX and/or cdma2000 and/or GERAN and/or UTRAN and/or in particular UMTS and/or HSPA and/or WCDMA. A communication may in particular comprise a physical layer (PHY) transmission and/or reception, onto which logical channels and/or logical transmission and/or receptions may be imprinted or layered.

A node of a wireless communication network may be implemented as a terminal and/or user equipment and/or base station and/or relay node and/or any device generally adapted for communication in a wireless communication network, in particular cellular communication.

A cellular network may comprise a network node, in particular a radio network node, which may be connected or connectable to a core network, e.g. a core network with a network core, e.g. according to UMTS. A network node may e.g. be a base station, for example a NodeB. The connection between the network node and the core network/network core may be at least partly based on a cable/landline connection. Operation and/or communication and/or exchange of signals involving part of the core network, in particular layers above a base station or NodeB, and/or via a predefined cell structure provided by a base station or NodeB, may be considered to be of cellular nature or be called cellular operation.

A terminal may be implemented as a user equipment. A terminal or a user equipment (UE) may generally be a device configured for wireless device-to-device communication and/or a terminal for a wireless and/or cellular network, in particular a mobile terminal, for example a mobile phone, smart phone, tablet, PDA, etc. A user equipment or terminal may be a node of or for a wireless communication network as described herein, e.g. if it takes over some control and/or relay functionality for another terminal or node. It may be envisioned that terminal or a user equipment is adapted for one or more RATs, in particular UMTS/WCDMA. It may be considered that a terminal or user equipment comprises radio circuitry and/control circuitry for wireless communication. Radio circuitry may comprise for example a receiver device and/or transmitter device and/or transceiver device. Control circuitry may include a controller, which may comprise a microprocessor and/or microcontroller and/or FPGA (Field-Programmable Gate Array) device and/or ASIC (Application Specific Integrated Circuit) device. It may be considered that control circuitry comprises or may be connected or connectable to memory, which may be adapted to be accessible for reading and/or writing by the controller and/or control circuitry. It may be considered that a terminal or user equipment is configured to be a terminal or user equipment adapted for UMTS/WCDMA.

A base station may be any kind of base station of a wireless and/or cellular network adapted to serve one or more terminals or user equipments. It may be considered that a base station is a node or network node of a wireless communication network. A network node or base station may be adapted to provide and/or define and/or to serve one or more cells of the network and/or to allocate frequency and/or time resources for communication to one or more nodes or terminals of a network. Generally, any node adapted to provide such functionality may be considered a base station. It may be considered that a base station or more generally a network node, in particular a radio network node, comprises radio circuitry and/or control circuitry for wireless communication. It may be envisioned that a base station or network node is adapted for one or more RATs, in particular UMTS/WCDMA.

Radio circuitry may for example comprise a receiver device and/or transmitter device and/or transceiver device. Control circuitry may include a controller, which may comprise a microprocessor and/or microcontroller and/or FPGA (Field-Programmable Gate Array) device and/or ASIC (Application Specific Integrated Circuit) device. It may be considered that control circuitry comprises or may be connected or connectable to memory, which may be adapted to be accessible for reading and/or writing by the controller and/or control circuitry. A base station may be arranged to be a node of a wireless communication network, in particular configured for and/or to enable and/or to facilitate and/or to participate in cellular communication, e.g. as a device directly involved or as an auxiliary and/or coordinating node.

Generally, a base station may be arranged to communicate with a core network and/or to provide services and/or control to one or more user equipments and/or to relay and/or transport communications and/or data between one or more user equipments and a core network and/or another base station and/or be Proximity Service enabled. A NodeB may be envisioned as an example of a base station, e.g. according to a UMTS/WCDMA standard. A base station may generally be proximity service enabled and/or to provide corresponding services. It may be considered that a base station is configured as or connected or connectable to a packet core and/or to provide and/or connect to corresponding functionality. The functionality and/or multiple different functions of a base station may be distributed over one or more different devices and/or physical locations and/or nodes. A base station may be considered to be a node of a wireless communication network. Generally, a base station may be considered to be configured to be a coordinating node and/or to allocate resources in particular for cellular communication between two nodes or terminals of a wireless communication network, in particular two user equipments.

It may be considered for cellular communication there is provided at least one uplink (UL) connection and/or channel and/or carrier and at least one downlink (DL) connection and/or channel and/or carrier, e.g. via and/or defining a cell, which may be provided by a network node, in particular a base station or NodeB . An uplink direction may refer to a data transfer direction from a terminal to a network node, e.g. base station and/or relay station. A downlink direction may refer to a data transfer direction from a network node, e.g. base station and/or relay node, to a terminal. UL and DL may be associated to different frequency resources, e.g. carriers and/or spectral bands. A cell may comprise at least one uplink carrier and at least one downlink carrier, which may have different frequency bands. A network node, e.g. a base station or NodeB, may be adapted to provide and/or define and/or control one or more cells.

Configuring a terminal or wireless device or node may involve instructing and/or causing the terminal or wireless device or node to change its configuration, e.g. at least one setting and/or register entry and/or operational mode. A terminal or wireless device or node may be adapted to configure itself, e.g. according to information or data in a memory of the terminal or wireless device. Configuring a node or terminal or wireless device by another device or node or a network may refer to and/or comprise transmitting information and/or data and/or instructions to the wireless device or node by the other device or node or the network, e.g. allocation data and/or scheduling data and/or scheduling grants.

A wireless communication network may comprise a radio access network (RAN), which may be adapted to perform according to one or more standards, in particular UMTS and/or radio access technologies (RAT).

A network device or node and/or a wireless device may be or comprise a software/program arrangement arranged to be executable by a hardware device, e.g. control circuitry, and/or storable in a memory, which may provide the described functionality and/or corresponding control functionality.

A cellular network or mobile or wireless communication network may comprise e.g. an LTE network (FDD or TDD), UTRA network, CDMA network, WiMAX, GSM network, any network employing any one or more radio access technologies (RATs) for cellular operation. The description herein is given for LTE, but it is not limited to the LTE RAT.

RAT (radio access technology) may generally include: e.g. LTE FDD, LTE TDD, GSM, CDMA, WCDMA, WiFi, WLAN, WiMAX, etc.

A storage medium may be adapted to store data and/or store instructions executable by control circuitry and/or a computing device, the instruction causing the control circuitry and/or computing device to carry out and/or control any one of the methods described herein when executed by the control circuitry and/or computing device. A storage medium may generally be computer-readable, e.g. an optical disc and/or magnetic memory and/or a volatile or non-volatile memory and/or flash memory and/or RAM and/or ROM and/or EPROM and/or EEPROM and/or buffer memory and/or cache memory and/or a database.

Resources or communication resources or radio resources may generally be frequency and/or time resources (which may be called time/frequency resources). Allocated or scheduled resources may comprise and/or refer to frequency-related information, in particular regarding one or more carriers and/or bandwidth and/or subcarriers and/or time-related information, in particular regarding frames and/or slots and/or subframes, and/or regarding resource blocks and/or time/frequency hopping information. Allocated resources may in particular refer to UL resources, e.g. UL resources for a first wireless device to transmit to and/or for a second wireless device. Transmitting on allocated resources and/or utilizing allocated resources may comprise transmitting data on the resources allocated, e.g. on the frequency and/or subcarrier and/or carrier and/or timeslots or subframes indicated. It may generally be considered that allocated resources may be released and/or de-allocated. A network or a node of a network, e.g. an allocation or network node, may be adapted to determine and/or transmit corresponding allocation data indicating release or de-allocation of resources to one or more wireless devices, in particular to a first wireless device.

Allocation data may be considered to be data indicating and/or granting resources allocated by the controlling or allocation node, in particular data identifying or indicating which resources are reserved or allocated for communication for a wireless device and/or which resources a wireless device may use for communication and/or data indicating a resource grant or release. A grant or resource or scheduling grant may be considered to be one example of allocation data. Allocation data may in particular comprise information and/or instruction regarding a configuration and/or for configuring a terminal. It may be considered that an allocation node or network node is adapted to transmit allocation data directly to a node or wireless device and/or indirectly, e.g. via a relay node and/or another node or base station. Allocation data may comprise control data and/or be part of or form a message, in particular according to a pre-defined format, for example a DCI format, which may be defined in a standard, e.g. LTE. Allocation data may comprise configuration data, which may comprise instruction to configure and/or set a user equipment for a specific operation mode, e.g. in regards to the use of receiver and/or transmitter and/or transceiver and/or use of transmission (e.g. TM) and/or reception mode, and/or may comprise scheduling data, e.g. granting resources and/or indicating resources to be used for transmission and/or reception. A scheduling assignment may be considered to represent scheduling data and/or be seen as an example of allocation data. A scheduling assignment may in particular refer to and/or indicate resources to be used for communication or operation.

In addition or alternative to the above, the following is disclosed. There may be considered in particular coverage of small data transmissions. Some results of an evaluation of the Maximum Coupling Loss (MCL) for different physical channels is summarized in the table of Figure 1. Three main bottleneck areas are identified from this evaluation, namely PCH over S-CCPCH, PRACH preamble and EUL. In this contribution, uplink coverage aspects associated with Enhanced Uplink (EUL) will be discussed and potential improvements will be outlined.

Figure 1 shows a summary of MCL values for the agreed reference scenario.

Ways of improving the uplink coverage can broadly be classified as:

Increasing the power – Power is one of the most fundamental resources when it comes to coverage since increasing the power directly translates into increased coverage. However, power is a very scarce resource in the uplink, especially for coverage limited devices that are already transmitting with full power. Hence, it is important to distribute the available power in a good way. In particular, it might be preferred to focus the available power on as few physical channels as possible each time instant instead of spreading the power over several physical channels, i.e. time-multiplexing instead of code-multiplexing.

Reducing the rate – Reducing the rate is another fundamental approach of increasing coverage. A lower data rate requires less power for reliable communication. A reduced rate can in general be achieved by several means, for example reducing the information content, employ repetitions or increasing the TTI. For EUL, two different TTIs are available (2 ms and 10 ms) and a coverage limited device typically employs 10 ms TTI.

Reducing the information content - Less information requires in general less power for reliable communication. Hence, small transport block sizes are favourable for coverage limited devices. Similarly, it is beneficial to reduce the control channel information.

Repetitions and/or HARQ retransmissions – Given the limited output power from a UE, retransmissions or repetitions are powerful means to increase EUL coverage. Each new transmission increases the received power and gives a potential diversity gain. The main cost for this is increased latency and potentially an impact on higher-layers, for example re-tuning of timers.

Favourable communication conditions – A somewhat different way of increasing uplink coverage is to aim at transmitting in favourable conditions, for example when the RoT is low in the cell or when the fading conditions are good. This has the potential to significantly increase the coverage but is obviously difficult to have full control on it. One example would be to steer SDT device traffic to low-load occasions, for example during off-peak hours such as night time.

EUL and HS-DPCCH have been identified as two main bottlenecks when it comes to coverage and improvements need to be considered to meet or approach the MCL range of the best physical channels. Some alternatives for increasing the coverage in the uplink that are relevant to consider in the small data transmission enhancements work are discussed below.

Repetitions and/or HARQ retransmissions are powerful means of increasing coverage. Each new transmission increases the received power and gives a potential diversity gain. The main cost for this is increased latency and potentially an impact on higher-layers, for example re-tuning of timers. It appears very likely that more than 8 E-DPDCH transmissions would be needed to achieve an MCL for EUL that is close to the MCL of other physical channels. Hence, further studies showing the impact of operating with very many physical-layer retransmissions may be advantageous. It is primarily the impact on higher-layers that is of interest, and in particular effects of combining ‘ordinary’ operation using few retransmissions with more ‘extreme’ operation with very many retransmissions. A number of questions can be envisioned. For example, what are the specification impacts of allowing very many retransmissions, is it beneficial to fix the number of repetitions rather than relying on ACK/NACK feedback, and how can the cost of allowing very many retransmissions when coverage limited be reduced if normal operation consists of few retransmissions? The latter issue include, among others, aspects related to setup/configuration of buffer sizes, timers, etc , i.e. do all configurations need to assume a worst case consisting of very many retransmissions?

Power is a very limited resource for which, in particular for coverage limited devices, requiring efficient management. The available power should be distributed in an efficient manner (gain value optimization). Operating at very low DPCCH Ec/N0 may affect the channel estimation quality resulting in poor demodulation performance. For small E-DPDCH transport block sizes the cost of control channels becomes significant. Also, increasing the number of E-DPDCH transmissions reduces the required power for E-DPDCH further and control channel overhead becomes even more dominant. Consequently, it would be beneficial to focus the available power on one or a few physical channels at the time and avoid code-multiplexing. For some examples, an MCL gain in the order of 2 dB could be achieved by putting the power spent on E-DPCCH on DPCCH and E-DPDCH instead. Hence, one approach for increasing coverage is time-multiplexing E-DPCCH and E-DPDCH .

Another way of reducing the power demand of a particular physical channel is to reduce the information content or completely remove the channel. A related approach would be to move information from one channel to another, but, in general, it is not obvious that this will save power, especially if the total information content to be transmitted in a time unit remains the same.

Physical channel structure improvements are discussed in the following.

For HSPA operation the following uplink physical channels are transmitted in a code-multiplexed manner:

- DPCCH - The DPCCH carries pilot bits and TPC bits (FBI and TFCI are considered unnecessary for an SDT device). The TPC bits are used to power control the downlink (F-DPCH) and the pilot bits are required for channel estimation purposes. Both the TPC bits and the pilot bits will be needed for coverage limited SDT applications. The pilot bits will, however, be of particular importance, since the more pilot bits, the less power needs to be spent on DPCCH for accurate enough channel estimation. Hence, maximizing the number of pilot bits in the DPCCH slot format is preferred.
- E-DPCCH - The E-DPCCH carries control information related to the E-DPDCH and consists of E-TFCI (7 bits), RSN (2 bits) and happy bit (1 bit). For coverage limited SDT application, it seems reasonable that some of this information can be restricted. For example, the number of transport block sizes (E-TFCI) can be significantly reduced or even fixed to one value and the happy bit can potentially be removed. The RSN can be used by the decoder to know the redundancy version in incremental redundancy coding, but in general this can be deduced without the RSN due to the synchronous and non-adaptive HARQ procedure used in the uplink. Hence, restricting operation to Chase combining would, from a coding point of view, mean that the RSN could be reduced to a 1 bit ‘new data indicator’. However, the main reason why the RSN consists of two bits instead of one bit is to help identifying signalling error cases in SHO operation. Hence, the RSN needs to be kept or SHO operation needs to be restricted.
- E-DPDCH - The E-DPDCH carries data and different rates are supported via code multiplexing, different coding rates, different modulation schemes, and different spreading factors. For coverage limited SDT devices, small transport block sizes (e.g. 120 bits) should be employed, and the number of possible transport block sizes can be significantly reduced or even fixed to one value.
- HS-DPCCH - The HS-DPCCH carries DL related feedback that is needed when HSPA is configured. The HS-DPCCH consists of ACK/NACK and CQI/PCI information. The HS-DPCCH can become very costly in terms of power unless very many repetitions are used. Current specifications do not allow more than four repetitions and extending the number of repetitions will impact various system aspects, such as imposing scheduler restrictions and delays. An alternative of employing repetitions could be to remove the channel completely for coverage limited operation. This can be compared to Rel-7 CELL-FACH where it is not possible for the UE to transmit the HS-DPCCH in the uplink. In this case the Node B needs to blindly decide whether to schedule a retransmission and an estimate of the supported data rate can be made

from UE measured CPICH power provided by the RNC over the Iub frame protocol. Hence, a similar approach can be adopted for a coverage limited scenario, especially if EUL is configured and active simultaneously. A potential enhancement would be to include a limited CQI report in another uplink physical channel. For example, some of the E-TFCI bits in the E-DPCCH can be used to signal a limited set of CQI values. A similar approach could be envisioned for ACK/NACK information, but one complication is that HS-DPCCH is not time-synchronized with UL DPCCH, which could affect the DL HARQ timing.

E-DPCCH and E-DPDCH time-multiplexing is discussed in the following.

One way of enabling higher power consumption per channel is to time multiplex the channels.

There is described a method for operating a terminal, the method comprising time-multiplexing at least two uplink physical channels. There may be considered a terminal, which may be adapted for such time-multiplexing and/or comprise a multiplexing module for such time-multiplexing. The uplink physical channel may be EUL-channels and/or HSA channels. The uplink physical channels may belong to the same cell and/or may be provided and/or be connected to the same base station or NodeB or connect the terminal to the same base station or NodeB. The time-multiplexing may be performed based on detection of a time-multiplexing indication (TM indication) and/or a coverage-limited condition. Detecting and/or detection of a TM indication and/or coverage-limited condition may be performed by the terminal, which may be adapted for such detection or detection, and/or may comprise a detecting module for such detecting or detection. The method may comprise transmitting, to the network and/or the network node (which may be the network node the channels connect to), a signal or message indicating that the terminal is about to perform and/or perform the time-multiplexing. It may comprise a timing indication indicating when the time-multiplexing is intended to begin.

There may generally be considered that a terminal is independently adapted to perform such time-multiplexing transmits, and/or is adapted to transmit and/or comprises a capability transmission module for transmitting, a capability indication (and/or signal and/or message) indication its capability to perform such time-multiplexing, e.g. when registering with a network or base station or NodeB, independently from actually such time-multiplexing.

There is also disclosed a (first) method for operating a network node or a network, in particular a NodeB. A network node adapted to perform such a method may be considered. The method may comprise configuring a terminal for time-multiplexing at least two uplink physical channels, in particular based on detection or detecting a TM indication and/or coverage-limited condition. The network node may be adapted for such configuring and/or comprise a configuring module for such configuring. Configuring the terminal may generally comprise transmitting a TM indication or coverage-limited condition indicating message or signal to the terminal to be configured, e.g. as part of allocation data. The method may be performed based on a corresponding capability indication (and/or signal and/or message), which may be received by the network node or the network, which in this case may provide a corresponding indication to the network node. There is also disclosed a second method for operating a network node or network, in particular a NodeB, which may be performed alternatively or additionally the (first) method described above. The second method may comprise de-multiplexing and/or decoding and/or separating at least two time-multiplexed uplink physical channels received from a terminal. The network node (which may be the network node described above or a second network node) may be adapted to perform such de-multiplexing and/or decoding and/or separating and/or comprise a corresponding channel module for such de-multiplexing and/or decoding and/or separating. The method may comprise receiving a time-multiplexing indication, from the terminal, that the terminal performs such time-multiplexing, in particular as described herein.

The at least two uplink channels may comprise E-DPCCH and E-DPDCH. It may be considered that the at least two uplink channels are two channels, which may comprise E-DPCCH and E-DPDCH.

Generally, detecting or detection of a TM indication and/or coverage-limited condition may be based on a corresponding message or signal, e.g. a TM and/or coverage indicating message or signal, which may be received, e.g. by the terminal and/or a receiving module of the terminal, or the network node and/or a receiving node of the network node, respectively. Such a message or signal may be transmitted by the network and/or a network node, in particular in the case that the message or signal is for the terminal, by a network node like a NodeB or base station, in particular the network node or base station or Node B to which the uplink channels are connected or connect to. Corresponding messages and/or signals and/or indications and/or conditions may be different for different nodes and terminals; e.g., a message to the network node indicating a coverage-limited condition may be different from a corresponding message to a terminal. It may be considered that such a message or signal comprises configuration data to configure the time-multiplexing and/or an explicit instruction for time-multiplexing. Alternatively or additionally, detecting a coverage-limited condition may comprise determining, e.g. by the terminal and/or the detecting module and/or a determining module of the terminal, or the network node and/or a corresponding module of the network node, respectively), the TM indication or coverage-limited condition (or alternatively, that no such condition is fulfilled), e.g. based on measurements performed by and/or data provided by and/or to the terminal or network node, respectively.

Moreover, there is disclosed a computer program product comprising code elements causing performance and/or control of any of the method disclosed herein when executed by control circuitry, in particular control circuitry of an associated device like a terminal and/or network node, respectively. Also, a storage medium, which may be readable by control circuitry, storing such computer program product is disclosed.

Further, there is disclosed a system comprising a network node as described herein and/or a terminal as described herein. Alternatively or additionally, the system may be adapted to perform any methods as disclosed herein, in particular any method for operating a network.

One approach for such time multiplexing is to time multiplex (e.g. by a terminal or a multiplexing module of a terminal) E-DPCCH and E-DPDCH, since E-DPCCH can have a significant power cost in scenarios where multiple E-DPDCH transmissions with small transport block sizes and soft combining are required.

A number of design criteria may be considered when designing an efficient time-multiplexing in particular of E-DPCCH and E-DPDCH time-multiplexed operation, such as:

- The impact on current terminals, UEs, networks and specifications should be minimized.
- The impact on timing relations should be minimized. For example, the HARQ timing should preferably be kept.
- The current synchronous and non-adaptive HARQ operation should be kept.
- Aim at keeping existing channel structures, e.g. keep the current slot format and coding of E-DPCCH.
- The design can take advantage of the delay tolerant nature of SDT applications.

One possible E-DPDCH and E-DPCCH time-multiplexing design is outlined in 2. One proposed idea is that for each HARQ process, the E-DPCCH is first transmitted in one subframe, followed by one or more bundled associated E-DPDCH transmissions in subsequent subframes (corresponding to the specific HARQ process). Some further details include:

- Each bundled transmission is acknowledged (via E-HICH) according to existing mechanisms. Hence, bundled transmissions are combined with legacy retransmission procedures. As an example, if the maximum number of transmissions is set to 4 and 3 E-DPDCH transmissions are bundled, then a maximum of 12 E_DPDCH transmissions can be performed. One question is whether intermediate transmissions also should be acknowledged. This would not affect the overall transmission structure (i.e. the network would always assume that all bundled E-DPDCH transmissions occur before the next E-DPCCH), but could allow the terminal or UE to DTX parts of the E-DPDCH transmissions and thereby saving power. A related question is whether E-DPCCH transmissions also should be acknowledged. This could potentially help identifying signalling error cases.
- The current HARQ process structure and HARQ timing (round trip time) are kept. The MAC protocol may need, however, to keep track of whether the transmission is an E-DPCCH or an E-DPDCH and whether transmission info should be updated or not, e.g. E-HICH feedback, RSN, etc.
- The E-DPCCH structure can be kept, but the information could potentially be re-interpreted somewhat. For example, a new E-TFCI table can be introduced, where a subset of the E-TFCIs relates to the special coverage limited operation with time-multiplexing of E-DPCCH and E-DPDCH. This subset of E-TFCIs can carry different information, for example, how many consecutive E-DPDCH transmissions that are bundled. One example is shown in Figure , where E-TFCIs 1 to 3 correspond to a coverage limited scenario using the default coverage limited TBS (e.g. 120) and three, two or one bundled E-DPDCH transmissions, respectively. For example, HARQ process one uses E-TFCI 1 meaning that each E-DPCCH is associated with three E-DPDCH transmissions, HARQ processes two and three use E-TFCI 2 meaning that each E-DPCCH is associated with two E-DPDCH transmissions and HARQ process four uses E-TFCI 3 meaning that each E-DPCCH is associated with one E-DPDCH transmission.
- The number of bundled E-DPDCH associated with one E-DPCCH is a trade-off between latency, control channel overhead, and flexibility. Different processes can potentially use different bundling patterns.

- The time-multiplexed scheme can co-exist with normal code-multiplexed operation. For example, consider Figure 3, where E-TFCIs 1 to 3 are associated with time-multiplexed operation. Then all other E-TFCIs can be associated with ordinary code-multiplexed operation. Hence, if the terminal or UE, for example, choses E-TFCI=15, then ordinary code-multiplexing is used, while if E-TFCI 2 is chosen, then time-multiplexed operation with two bundled E-DPDCHs is employed. A SDT device would then be configured with the special E-TFCI table and depending on the currently used E-TFCI, either code or time multiplexing is used. This would enable support for the special coverage extension for the UEs that need it, while other UEs in more favourable conditions could still reach high bitrates and reduced latency by using higher E-TFCIs (possibly all the way up to what existing TB size tables support).
- Alternatively or additionally, time-multiplexing may be reconfigured when becoming coverage limited and rely on ordinary code-multiplexing otherwise. However, it is very difficult (non-robust) to dynamically re-configure when the UE becomes power limited since the reliability of signalling decreases significantly resulting in an unpredictable behaviour.

Figure 2 shows an illustration of E-DPCCH and E-DPDCH time-multiplexed operation. In this example HARQ processes one, two, three and four use a bundle length of 1, 2, 2, and 3, respectively. The TTI length is 10 ms.

Figure 3 shows a more detailed illustration of E-DPCCH and E-DPDCH time-multiplexed operation. The TTI length is 10 ms.

This disclosure has discussed some alternatives for improving uplink coverage. In particular, an E-DPDCH and E-DPCCH time-multiplexed operation for EUL has been outlined, and ideas for how to handle the HS-DPCCH have been considered. These suggestions can improve the overall uplink HSPA MCL value by several dBs.

There is disclosed a terminal adapted to perform any one or any combination of the methods for operating a terminal and/or uplink transmission disclosed herein.

A terminal generally may be a user equipment and/or a terminal for and/or in a wireless communication network, in particular a UMTS/WCDMA network. It may be considered that a terminal is a SDT device, for example a MTC device.

There is also disclosed a network node adapted to perform any one or any combination of the methods for operating a network node disclosed herein and/or adapted to configure a terminal for uplink transmission as disclosed herein. Also, a network node receiving and/or decoding and/or demultiplexing and/or adapted to receive and/or de-multiplex and/or decode the uplink transmissions of a terminal as described herein is described. A network node generally may be a NodeB and/or may be a network node, in particular a radio network node, for and/or in a wireless communication network.

Generally, a cover-limited condition may be detected/determined, if the network and/or network node has sufficient capacity to handle its traffic, but its performance is limited by the maximum cell size. Such a condition may for example be determined by the network, e.g. a network node like a base station and/or RNC or a higher level layer, and be communicated by transmitting a corresponding coverage indication message or signal.

Time-multiplexing of at least two uplink physical channels may comprise time-sharing of a common signal and/or carrier and/or cell (for uplink) between the channels, such that a channel occupies the signal/carrier/cell for a fraction of the time before another channel occupies it also for a fraction of the time. E.g., between data blocks from a first channel there may be arranged data blocks from a second channel. Time multiplexing at least two uplink physical channels may comprise transmitting data of the channels and/or on the channels, in particular in a time-alternated pattern. It may be considered that time-multiplexing at least two uplink physical channels comprises removing a third channel, in particular removing the HS-DPCCH. Time-multiplexing may comprise using a 10ms TTI and/or changing from a given TTI length to another, longer TTI length for the time-multiplexing.

A physical channel may be considered to connect a terminal with a network node if data can be transmitted on/via the channel between the terminal and the network node, such that a radio transmission between these devices is provided. The channel may be determined and/or configured by the network node it connects to and/or is connected to.

A TM indication may be determined/detected based for example on traffic conditions, amount of data transfer or data transfer rate of one or more terminals, time/s of inactivity (in particular, no transmission) of one or more terminals, etc.

A coverage limited scenario or operation mode may be defined by a network node like a NodeB receiving (and/or expecting to receive, e.g. due to resource allocation/scheduling either by the Node B, e.g. for E-UL channels, or a RNC) 90% or more of the reception power limit and/or maximum power for the node or cell. This may be dependent on a time threshold, e.g. a minimum time interval for which the 90% are exceeded and/or expected to be exceeded. A corresponding signal may be transmitted to the terminal/s, indicating the coverage limit operating mode.

Some useful abbreviations include:

ACK	Positive acknowledgement
AICH	Acquisition Indicator Channel
CCCH	Common Control Channel
CLTD	Closed-Loop Transmit Diversity
CQI	Channel Quality Indicator
CPICH	Common Pilot Channel
CIO	Cell Individual Offset
DL	Downlink
DPCCH	Dedicated Physical Control Channel
DCCH	Dedicated Control Channel
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
E-RGCH	E-DCH Relative Grant Channel
EUL	Enhanced Uplink
E-DCH	Enhanced Dedicated Channel, an UL channel
E-DPDCH	E-DCH Dedicated Physical Data Channel, an UL channel
E-DPCCH	E-DCH Dedicated Physical Control Channel, an UL channel
E-RNTI	E-DCH Radio Network Temporary Identifier, an UL channel
E-TFCI	E-DCH Transport Format Combination Indicator, an UL channel
E-AGCH	E-DCH Absolute Grant Channel, an UL channel
FDD	Frequency Division Duplex
F-DPCH	Fractional Dedicated Physical Channel
HSPA	High Speed Packet Access
HSDPA	High Speed Downlink Packet Access

HS-DPCCH	High Speed Downlink Packet Access
HARQ	Hybrid automatic repeat request
ID	Identity
IP	Internet Protocol
ILPC	Inner-loop power control
LCH	Logical Channel Identifier
LPN	Low-power node
MAC	Medium Access Control
MIMO	Multiple input multiple output
MTC	Machine-Type Communication
NBAP	Node B Application Part
NACK	Negative acknowledgement
OLPC	Outer-loop power control
PDU	Protocol Data Unit
RAB	Radio Access Bearer
RNC	Radio Network Controller
RRC	Radio Resource Control
RRU	Remote Radio Unit
HS-SCCH	Shared Control Channel for HS-DSCH
RLC	Radio Link Control
RSN	Retransmission Sequence Number
RSCP	Received Signal Code Power
Rx	Receive
PRACH	Physical Random Access Channel
SDT	Small Data Transmission
SI	Scheduling Information
SS	Segmentation Status
SIR	Signal-to-interference ratio
SHO	Soft handover
SNR	Signal-to-noise ratio
SINR	Signal-to-interference-and-noise ratio
TCP	Transmission Control Protocol
TSN	Transmission Sequence Number
Tx	Transmit

TBS	Transport block size
TTI	Transmission Time Interval
TPC	Transmit power control
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRAN	UMTS Terrestrial Radio Access Network
WCDMA	Wideband Code Division Multiple Access

These abbreviations may be used according to UMTS Standard definitions, where appropriate.

CLAIMS

1. A method for operating a terminal (10) for a wireless communication network, the method comprising time-multiplexing at least two uplink physical channels.

2. The method according to claim 1, wherein the uplink physical channels are EUL-channels and/or HSA channels.

3. The method according to claim 1 or 2, wherein the time-multiplexing is performed based on detection of a time-multiplexing indication (TM indication) and/or a coverage-limited condition.

4. A terminal (10) for a wireless communication network, the terminal (10) being adapted for time-multiplexing at least two uplink physical channels.

5. The terminal according to claim 4, wherein the uplink physical channels are EUL-channels and/or HSA channels.

6. The terminal according to claim 4 or 5, wherein the time-multiplexing is performed based on detection of a time-multiplexing indication (TM indication) and/or a coverage-limited condition.

7. A method for operating a network node (100) for a wireless communication network, the method comprising configuring a terminal (10) for time-multiplexing at least two uplink physical channels.

8. A network node (100) for a wireless communication network, the network node (100) being adapted for configuring a terminal (10) for time-multiplexing at least two uplink physical channels.

9. A computer program product comprising code elements causing performance and/or control of any of the methods according to claims 1 to 3 or 7 when executed by control circuitry-

10. A storage medium readable by control circuitry, the storage medium storing a computer program product according to claim 9.

	Cell search (P-SCH, S-SCH)	BCH (S-CCPCH)	Paging (PICH, S-CCPCH)	PRACH preamble	AICH	EUL (DPCCH, E-DPCCH, E-DPDCH)	HS-SCCH	HS-PDSCH
MCL [dB], Ped A 1 Hz	154	150	143		145	141	144	160
MCL [dB], AWGN	153	152	149	143	152	146	150	158

Fig. 1

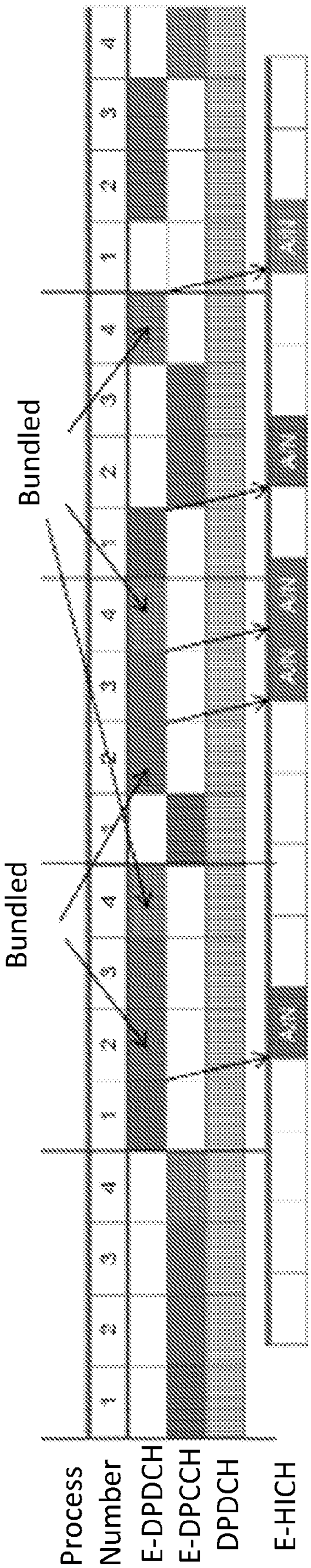
Process
Number
E-DPDCH
E-DPCCH
DPDCH
E-HICH
Bundled
Bundled
1
2
3
4

Fig. 2

E-DPCCH number corresponds to (E-TFCI, RSN)
E-TFCI=1 time-mux with 3 rep
E-TFCI=2 time-mux with 2 rep
E-TFCI=3 time-mux with 1 rep

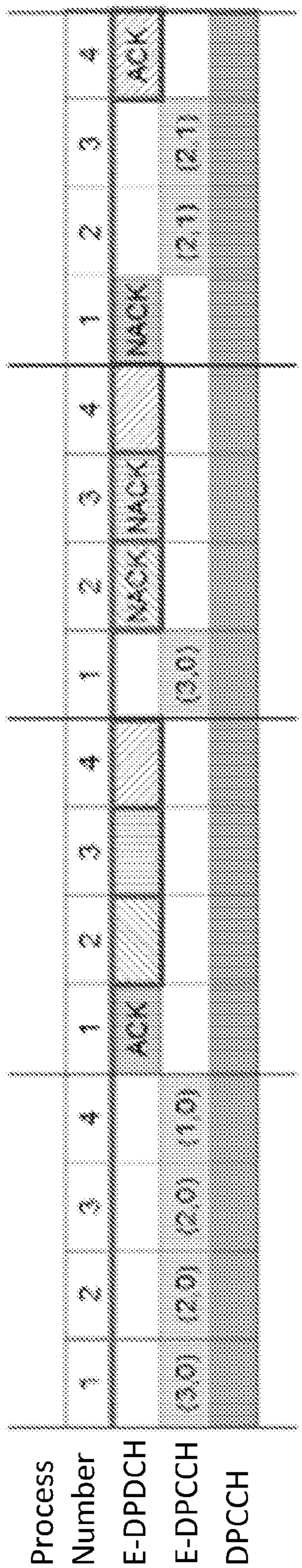

Fig. 3

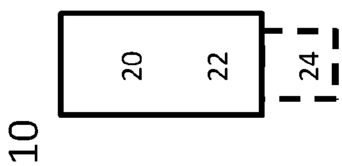

Fig. 4

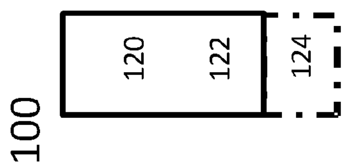

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2016/050069

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04L1/18 H04W72/12
ADD.

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)
H04L H04W

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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"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
5 April 2016	14/04/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Koukourlis, Sotirios

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2016/050069

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/SE2016/050069

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