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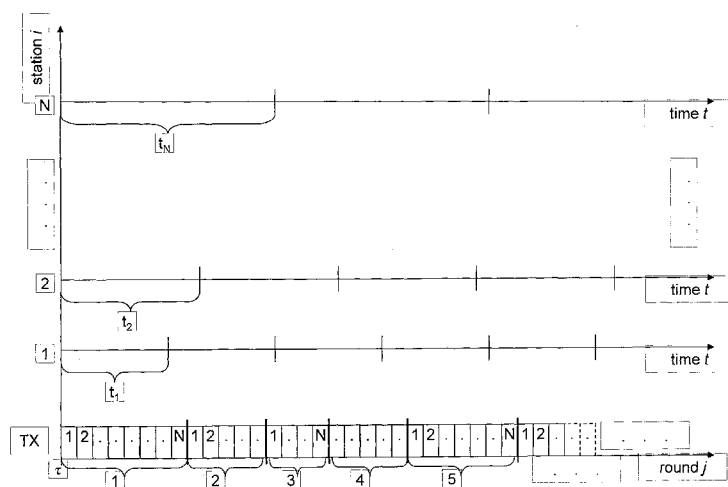
(54) Title: APPARATUS, METHOD AND COMPUTER PROGRAM FOR SCHEDULING TRANSMISSION OF SENSOR
DATA

Figure 1

(57) Abstract: There are provided measures for realising contention reduction in channels in wireless transmission scenarios. Such measures may comprise obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined channel, scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length, and transmitting the sensor data in the time slot using the predetermined radio channel.

APPARATUS, METHOD AND COMPUTER PROGRAM
FOR SCHEDULING TRANSMISSION OF SENSOR DATA

Technical Field

5 The present invention relates to apparatus, a method and a computer program for scheduling transmission of sensor data. The present invention relates generally to contention reduction in channels in wireless transmission scenarios. In specific embodiments, the present invention relates to measures (including methods, apparatus, and computer program products) for realising contention reduction in
10 channels in wireless transmission scenarios.

Background

 The following acronyms and abbreviations are used in the present specification:

15

	AP	access point
	CDMA	code division multiple access
	DCF	distributed coordinated function
	DIFS	distributed coordination function interframe spacing
20	GPRS	General Packet Radio Service
	GSM	Global Systems for Mobile Communications
	ISM	industrial, scientific and medical
	LTE	Long Term Evolution
	LTE-A	LTE-Advanced
25	PSM	power-saving mode
	STA	station
	UTC	universal time coordinated
	WLAN	wireless local area network

30 Mobile data transmission and data services are constantly making progress. The ISM (industrial, scientific, and medical) radio bands are unlicensed bands, which

were originally reserved internationally for radio applications for industrial, scientific, and medical purposes other than communications. Unlicensed bands describe a spectrum band that has rules pre-defined for both the hardware and deployment methods of devices operating on these bands in such a manner that interference is mitigated by the technical rules defined for the bands. However, in recent years these bands have also been shared with error-tolerant communications applications such as Wireless LANs (WLAN) and cordless phones in the 915 MHz, 2.450 GHz, and 5.800 GHz bands, that is, in unlicensed bands. A main usage on these ISM bands is “WiFi”.

“WiFi” is not a technical term. However, the WiFi Alliance has generally enforced its use to describe only a narrow range of connectivity technologies including wireless local area network (WLAN) based on the IEEE 802.11, which is a set of standards carrying out WLAN communication in the 2.4, 3.6, and 5 GHz frequency bands. In particular, 2.4 GHz ISM band is used for applications implementing the standards WiFi 802.11b or 802.11g/n. Furthermore, the 5GHz ISM band is used for applications implementing the standard WiFi 802.11a/n/ac.

The standard WiFi 802.11ah is an extension of the standard WiFi 802.11a for networks operating in the sub 1GHz band. For example, a working group for 802.11ah is looking at the use case of metering to pole where possibly 6000 stations (STA) are supported by a single access point (AP) (see for example document IEEE 802.11-11/0457r0 entitled “Potential Compromise for 802.11ah Use Case Document” by Rolf de Vegt, Qualcomm, March 2011).

The case of 802.11ah where an access point (AP) serves a large number of sensors is considered in the following. In such case, the sensors are sensing measurement parameters and are transmitting the sensed data to an AP.

In particular, the case where the sensors take measurements deterministically every certain amount of seconds, i.e. every certain amount of time, and forward the measured amount of information to the AP is considered.

It is to be noted that a considered scenario implementing the standard WiFi 802.11ah is a non-limiting example. The associated drawbacks can also arise in systems different from that. Thus, the following is to be understood in general in
5 view of uplink connections in networks where limited energy is a concern and where traffic is of a deterministic nature.

In such scenario, when a large number of stations is associated with an AP, it has been observed that the performance of distributed coordinated function (DCF)
10 deteriorates considerably. The principle of DCF is that a station which contends for transmission on a channel senses the channel. If sensing yields that the channel is busy, the station defers its transmission by a random period. If a transmission fails, then the colliding transmitting station defers its transmission by doubling its backoff window. Consequently, as the number of stations in this type of networks increases
15 the number of collisions will also increase, e.g. due to the hidden terminal problem, which subsequently will make the number of retransmissions and the transmission delay grow exponentially with the number of stations.

Furthermore, when a large number of stations is contending for medium
20 access, the proportion of time spent in idle state increases with the number of stations. Since power supply is a critical aspect of mobile devices, such unused idle time is undesirable. The 802.11 standard defines a power-saving mode (PSM) as a status of a power management mode, which aims for reduction of the energy consumption of mobile devices. This mechanism supports, among others, the process of
25 establishment and maintenance of the power management mode of a station. However, the PSMs specified in the standard are merely defined for the case where the buffer of the respective station storing data to be transmitted is empty.

In the context of 802.11ah, static grouping of stations was introduced in order
30 to support a large number of stations in Document IEEE 802.11-11/1255r0 (entitled "DCF Enhancements for Large Number of STAs" by Siyon Liu, CATR, September

15, 2011). The idea behind static grouping is that the stations are grouped into M groups. A station selects its group statically during the association request. An association request is sent by stations after authenticating with the AP before the station can join the network. If the AP allows the station to join the network, it will
5 send a successful association response to the station.

For each group $m = 1, 2, \dots, M$, the AP sends in the beacon two numbers, Q_m and T_m . These values can be set according to the current network utilisation rate, the number of stations in group m and other factors (e.g. the priority of each group). Q_m
10 is the contention factor that takes values in the range of $[0, 1]$. Each station, before contending for the channel, randomly and uniformly chooses a number r_m and compares it to the value Q_m . If $r_m \leq Q_m$, the station contends for the channel. Otherwise, it does not initiate the DCF procedure until time T_m has passed.

15 However, in the case that the traffic at the stations is deterministic and also in the special case where the stations are always backlogged, other alternatives may be preferable to static grouping.

From the above arises a need to provide contention reduction in channels in
20 wireless transmission scenarios while also supporting energy efficient network operation.

Summary

According to a first aspect of the present invention, there is provided a method
25 comprising: obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined radio channel; scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length; and transmitting the sensor data in the time slot using the predetermined radio channel.

According to a second aspect of the present invention, there is provided apparatus for use on a terminal side of a radio system, the apparatus comprising a processing system constructed and arranged to cause the apparatus to perform: obtaining sensor data of a certain amount in a periodical manner, at a terminal
5 associated with a predetermined radio channel; scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length; and transmitting the sensor data in the time slot using the predetermined radio channel.

The processing system described above may comprise at least one processor,
10 at least one memory including computer program code, and at least one interface configured for communication with at least another apparatus, the at least one processor, with the at least one memory and the computer program code, being arranged to cause the apparatus to perform as described above.

15 According to a third aspect of the present invention, there is provided a computer program comprising a set of instructions which, when executed on an apparatus, cause the apparatus to carry out a method comprising: obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined radio channel; scheduling transmission of the sensor data to a time slot
20 in a recurring transmission round of a variable length; and transmitting the sensor data in the time slot using the predetermined radio channel.

Such computer program may comprise or be embodied in or on or as a (tangible) computer-readable (storage) medium or the like on which the computer-
25 executable computer program code is stored, and/or the program may be directly loadable into an internal memory of the computer or a processor thereof.

Advantageous further developments or modifications of the aforementioned exemplary aspects of the present invention are set out in the following.

By virtue of any one of the aforementioned exemplary aspects of the present invention, contention reduction in channels in wireless transmission scenarios is achievable, which is effective in terms of reduction of power consumption of a terminal and in terms of reduction of contention in large number of terminals scenario.

By way of exemplary embodiments of the present invention, there is provided contention reduction in channels in wireless transmission scenarios. More specifically, by way of exemplary embodiments of the present invention, there are provided measures and mechanisms for realising contention reduction in channels in wireless transmission scenarios.

Thus, enhancements and/or improvements are achieved by methods, apparatus and computer program products capable of realising contention reduction in channels in wireless transmission scenarios, namely scenarios in which a large number of terminals are wirelessly transmitting data to an AP.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 shows a flowchart illustrating an exemplary sequence of network access of a plurality of terminals according to exemplary embodiments of the present invention;

Figure 2 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

Figure 3 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

Figure 4 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

5 Figure 5 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

Figure 6 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

10

Figure 7 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

15 Figure 8 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention;

Figure 9 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention; and

20 Figure 10 shows a schematic block diagram illustrating exemplary apparatus according to exemplary embodiments of the present invention.

Detailed Description

Examples of embodiments of the present invention will be described below.
25 More specifically, exemplary embodiments of the present invention are described hereinafter with reference to particular non-limiting examples and to what are presently considered to be conceivable embodiments of the present invention. A person skilled in the art will appreciate that the invention is by no means limited to these examples and may be more broadly applied.

30

It is to be noted that the following description of the present invention and its embodiments mainly refers to specifications being used as non-limiting examples for certain exemplary network configurations and deployments. Namely, the present invention and its embodiments are mainly described in relation to WiFi specifications
5 being used as non-limiting examples for certain exemplary network configurations and deployments. In particular, a communication system implementing the 802.11ah standard is used as a non-limiting example for the applicability of thus described exemplary embodiments. As such, the description of exemplary embodiments given herein specifically refers to terminology which is directly related thereto. Such
10 terminology is only used in the context of the presented non-limiting examples, and naturally does not limit the invention in any way. Rather, any other network configuration or system deployment, etc. may also be utilised as long as compliant with the features described herein.

15 In particular, the present invention and its embodiments may be applicable in any wireless communication system and/or network deployment in which uplink transmission by a plurality of terminals in one channel to one AP is operable. Specifically, the present invention is also applicable for the uplink of wireless network technologies such as Long Term Evolution (LTE) networks, LTE-Advanced (LTE-A)
20 networks, Global Systems for Mobile Communications (GSM) networks, Code Division Multiple Access (CDMA) networks, General Packet Radio Service (GPRS) networks and others. The present invention and its embodiments may be applicable in the above described systems, especially in any wireless communication system and/or network deployment where the traffic at the terminals is deterministic, that is, where
25 the data to be transmitted arises in periodic intervals. It is to be noted that the periodic intervals may be arbitrary, that is, the data to be transmitted can be available with any period, as long as it is deterministic.

Hereinafter, various embodiments and implementations of the present
30 invention and its aspects or embodiments are described using several alternatives. It is generally noted that, according to certain needs and constraints, all of the described

alternatives may be provided alone or in any conceivable combination (also including combinations of individual features of the various alternatives).

According to exemplary embodiments of the present invention, in general
5 terms, there are provided mechanisms, measures and means for contention reduction in channels in wireless transmission scenarios.

In the following, exemplary embodiments of the present invention are described with reference to methods, procedures and functions, as well as with
10 reference to structural arrangements and configurations.

Generally, any procedures according to exemplary embodiments of the present invention are operable at a terminal capable of wireless transmission and/or at a base station capable of wireless transmission and/or between the same. As described
15 herein below, a terminal capable of wireless transmission may be implemented at/in/by any station-side entity of wireless communication system, such as a sensor or the like, and a base station capable of wireless transmission may be implemented at/in/by any network-side entity of a wireless communication system, such as an AP or the like.

20

Any procedures according to exemplary embodiments of the present invention or, in other words, the underlying system capable of wireless transmission comprising a terminal capable of wireless transmission and a base station capable of wireless transmission, are operable in any conceivable wireless transmission scenario where
25 the traffic at the plurality of terminals transmitting in uplink to one base station, i.e. one AP, is deterministic.

In the following, a case where N stations are associated with an AP is considered. It is assumed that each station takes periodic measurements of a certain
30 amount of bytes. In such case, it is assumed that the traffic at the terminals is deterministic, that is, at each terminal i one packet is available for transmission after

each period t_i (traffic period for station i). Using the association request with the AP, a station, that is a terminal, communicates the corresponding period t_i thereof to the AP. Consequently, after all stations have performed the association request with the AP, the traffic periods for each involved station i are available to the AP. This
5 collected traffic period information is then broadcast to all involved stations. Such broadcast may be performed via a beacon message. As a result, the traffic periods for each involved station i are available to each station.

It is further assumed that the first packet at each terminal i is available for
10 transmission at the same time τ . According to the above assumption, the subsequent packets are available for transmission at terminal i after traffic period t_i , which may be different for each station. It is to be noted that the first packet at each terminal i may also be available for transmission at different times.

15 In an exemplary scenario, a station, whenever it accesses the channel for transmission, transmits for time period T that is common among all stations. T therefore represents a length of a time slot during which the station transmits. T can depend on the transmission rate, on the measurement size, traffic load, etc. The following description considers a time period T common among all stations.
20 However, the skilled person can derive the necessary steps for the case of a time period T_i that is different with respect to the plurality of stations i .

In the above described scenario where the first packet at each terminal i is available for transmission at the same time τ , at this point in time τ , data, i.e. data of a
25 measurement, becomes available at each of the stations i . Then station $i=1$ transmits for duration T . According to the considered traffic model, station 2 already has data in its buffer in this moment. Thus, as soon as the transmission of station 1 is finished, station 2 transmits and the process continues until all N stations have accessed the channel and transmitted their data for the duration T . After traffic period t_i has
30 elapsed, a new packet is available for transmission at station i . Since the traffic periods of the stations may differ from each other, it is possible that at a station no

new packet is available for transmission when the next transmission round is executed, that is, that there may be stations without data in their buffer to be transmitted. The number of terminals $N(2)$ where a new packet is available for transmission when the next transmission round (second transmission round) is executed can be computed with the following pseudo code. It is to be noted that the number of stations that have transmitted during the first period, that is the number of active terminals during the first round, i.e. $N(1)$, must be known when executing the pseudo code. In case the first packet at each terminal i is available for transmission at the same time τ , $N(1)=N$. Otherwise, $N(1)$ is to be determined prior to executing the following pseudo code:

```

N(2) = 0;
for i = 1 to N {
    if  $t_i < N(1) \cdot T + (i - 1) \cdot T$  {
15         N(2) = N(2) + 1;
    }
}
end

```

Consequently, the number of terminals $N(j)$ at rounds $j > 1$, that is at rounds $j \geq 2$, where a new packet is available for transmission, when a transmission round j is executed, can be computed with the following pseudo code:

```

N(j) = 0;
25 for i = 1 to N {
    if
         $t_i \cdot (k(i) - 1) < \left( \sum_{n=1}^{j-1} T \cdot N(n) \right) + (i(j) - 1) \cdot T$ 
    {
        N(j) = N(j) + 1;
30     }
}

```

}
end

wherein $k(i)$ is a number indicating how many arrivals of traffic (data to be
5 transmitted) occurred at station i before the considered round j since τ , and $k(i) \leq j$.

Consequently, at each station as well as at the AP, the number of terminals
 $N(j)$ that will transmit data in a round j can be computed for each future round once
the traffic period information is broadcast.

10

Figure 1 shows a flowchart illustrating an exemplary sequence of network
access of a plurality of terminals according to exemplary embodiments of the present
invention.

15 In Figure 1, the lower axis illustrates the transmission performed by the
terminals i during the operation of the considered network. Each block on the lower
axis represents a transmission with its transmission duration performed by the
terminal i identified by a number. Blocks including a dot “.” represent transmissions
performed by terminals other than terminal 1, 2 or N .

20

The axes above illustrate the traffic periods for stations 1, 2 and N , that is, the
moments when new data to be transmitted becomes available at the stations 1, 2, and
 N . It is to be noted that there may be provided further stations other than station 1, 2,
and N , which is expressed by the three vertically arranged dots “...”.

25

In Figure 1, the relation between the different traffic periods t_i of the different
involved stations, the (variable) length of a transmission period j , the number of
terminals transmitting in a certain transmission period and the information regarding
which of the terminals i are transmitting in a certain transmission period are
30 illustrated.

The number of terminals transmitting in a transmission round j can be determined using the above stated pseudo code. As can be seen in Figure 1, the length of a transmission round depends on at which terminals data to be transmitted is available during a certain transmission round.

5

It is to be noted that in Figure 1 a case is shown where the time period T for transmitting is common among all involved stations. However, when the time periods are not common among all involved stations, the blocks on the lower axis would have different widths, and the calculation of the number of terminals transmitting in a certain transmission round and the calculation of the beginnings of a transmission would depend on every single time period T_i .

10

Figure 2 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

15

As shown in Figure 2, a corresponding procedure according to exemplary embodiments of the present invention, at the terminal side, comprises an operation of obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined channel, an operation of scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length, and an operation of transmitting the sensor data in the time slot using the predetermined radio channel.

20

According to exemplary embodiments of the present invention, the sensor data may contain an output data of a sensor. Alternatively, the sensor data may contain already processed output data of the sensor. However, the sensor data according to exemplary embodiments of the present invention is of a certain amount of bytes. Further, according to exemplary embodiments of the present invention, the predetermined radio channel is the channel at which the wireless radio transmissions of the stations take place.

25

30

Figure 3 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

The procedure according to Figure 3 represents a variation of the procedure according to Figure 2, in which exemplary details of the scheduling operation are given, which are inherently independent of each other as such.

According to Figure 3, an exemplary scheduling operation according to exemplary embodiments of the present invention comprises an operation of acquiring access parameters of the predetermined radio channel, and an operation of calculating a beginning of the time slot based on the access parameters.

The beginning of a time slot is illustrated in Figure 1 as the left edge of each of the boxes representing the corresponding time slots.

15

Figure 4 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

The procedure according to Figure 4 represents a variation of the procedure according to Figures 2 and 3, in which exemplary details of the acquiring operation and of the scheduling operation, in particular of the calculating operation, are given, which are inherently independent from each other as such.

According to Figure 4, an exemplary calculating operation according to exemplary embodiments of the present invention comprises computing a point in time (t_B) of the beginning of the time slot in a transmission round (j) using the formula:

$$t_B = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

Such computed point in time may represent a time value relative to a standard time like universal time coordinated (UTC). The computed point in time may also represent a time value relative to an internal reference time.

5 It is shown that thus according to exemplary embodiments of the present invention, scheduled access according to Figure 1 is implemented.

According to exemplary embodiments of the present invention, it can be computed that at round j , station $i(j)$ should transmit at time:

$$10 \quad t_B = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \quad (1).$$

Thereby, $i(j)$ is the i -th station in the j -th transmission round, that is, on the i -th position in the order of transmitting. Since there may be stations that are not transmitting in round j but have transmitted in round $j-1$, the i -th station of the j -th round $i(j)$ is not necessarily the i -th station of the $(j-1)$ -th round $i(j-1)$, but it can be the same station. Hence, a position of a station in order of transmission may be different each round. For example, if at the second station of round $j-1$ no data for transmission is available in round j , the third station of round $j-1$ may be the second station of round j . Thus, only stations that will have data for transmission in round j are scheduled for transmission in round j .

It is to be noted that according to formula (1), the number of stations transmitting in rounds 1 to $(j-1)$ needs to be known in order to compute the point in time (t_B) of the beginning of the transmission of station $i(j)$ in round j . It is further to be noted that round j is a network wide variable, that is, even though a station does not transmit data in a round j , the variable j is incremented in order to only have one valid global round number which is necessary for the calculations of that station.

It is derivable from Figure 4 that according to exemplary embodiments of the present invention, the acquired access parameters may comprise at least one of a

number (N) of terminals, that is a number of stations, associated with the predetermined channel, a number ($N(j)$) of terminals having transmitted in preceding transmission round j , an own position ($i(j)$) in the considered round j in a sequence of terminals associated with the predetermined channel, a number (j_{current}) of a current
5 transmission round, a point in time (τ) of the beginning of a first transmission round, a length (T) of the time slot and traffic periods t_i (for terminals $i=1$ to N) indicative of periodic available data to be transmitted of the respective terminals (1 to N), that is, indicative of the duration between two entries of sensor data being available for transmission.

10

According to exemplary embodiments of the present invention, acquiring the number $N(j)$ may be implemented by using the pseudo code mentioned above.

15

Figure 5 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

20

The procedure according to Figure 5 represents a variation of the procedure according to Figure 2, in which exemplary additional operations are given, which are inherently independent from each other as such.

According to Figure 5, the exemplary procedure according to exemplary embodiments of the present invention may comprise an operation of activating a power save mode and an operation of de-activating the power save mode.

25

It is shown that according to exemplary embodiments of the present invention, scheduled access can be enhanced with reduction of energy consumption. Therefore, power saving mode can be provided also in the case that the buffer of the respective station is not empty. Specifically, once a station transmits, it can go to sleep (activating power save mode) and subsequently can wake up (de-activating power
30 save mode) on time to transmit its next available measurement in a subsequent round, which could e.g. be the next round $j+1$. However, if the station will not have data for

transmission in the next round $j+1$, the station does not have to wake up in round $j+1$, but only a certain interval before its next transmission time (t_B).

Figure 6 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

The procedure according to Figure 6 represents a variation of the procedure according to Figure 5, in which exemplary details of the activating operation and exemplary additional operations are given, which are inherently independent from each other as such.

According to Figure 6, the exemplary procedure according to exemplary embodiments of the present invention may comprise an operation of determining a lead time (ϵ) indicative of a minimum period when the de-activating is to be performed before the beginning of the time slot. Thus, ϵ is a constant that makes sure that the station wakes up on time to transmit its next available measurement in a subsequent round, e.g. in round $j+1$.

According to exemplary embodiments of the present invention, once a station has transmitted, it can go to sleep for a sleep time period, which is of minimum length of $(N(j+1)-2) \cdot T$ and of maximum length of $(N(j+1)-1) \cdot T - \epsilon$, before the next transmission is scheduled in the following transmission round. Thereby, ϵ is the constant that makes sure that the station wakes up on time to transmit its measurement of the next round. After the sleep time period, the station has to initiate waking up in order to be ready in time.

According to Figure 6, an exemplary activating operation according to exemplary embodiments of the present invention comprises an operation of reckoning a range in time (t_w) indicative of when de-activating (the power save mode) is to be performed for transmitting in the time slot in a transmission round (j) using the formula:

$$\tau + (i(j) - 2) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \leq T_w \leq \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) - \varepsilon$$

Such computed point in time may represent a time value relative to a standard time like UTC. The computed point in time may also represent a time value relative to an internal reference time.

For a station i to access the channel for round j at the time indicated by formula (1), the station must wake up at a time T_w which satisfies:

$$\tau + (i(j) - 2) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \leq T_w \leq \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) - \varepsilon \quad (2).$$

Figure 7 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

The procedure according to Figure 7 represents a variation of the procedure according to Figure 6, in which exemplary additional operations are given, which are inherently independent from each other as such.

According to Figure 7, the exemplary procedure according to exemplary embodiments of the present invention may comprise an operation of choosing a backoff time (t_{BO}) indicative of an idle time from the point in time an interframe spacing is sensed (T_{DIFS}) after activating (T_w) to the calculated beginning of the time slot for transmission using the formula:

$$T_w + T_{DIFS} + T_{BO} = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

The time between waking up (T_w) and transmitting (t_B) is allocated to T_{DIFS} and T_{BO} , wherein T_{DIFS} corresponds to the duration of the distributed coordination function interframe spacing (DIFS) according to the implemented specification, and T_{BO} corresponds to the duration during which the station resides in backoff. Thereby,

the backoff time is triggered by the result of sensing the channel for DIFS. Conventionally, the backoff time is determined randomly. However, this may result in the backoff time, i.e. the time the transmission of the respective station is delayed, extending beyond the point in time scheduled for transmission (t_B). Thus, according to exemplary embodiments of the present invention, T_{BO} is deterministic and chosen such that the following equation is satisfied:

$$T_W + T_{DIFS} + T_{BO} = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \quad (3).$$

Figure 8 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

The procedure according to Figure 8 represents a variation of the procedure according to Figure 6, in which exemplary details of the determining operation are given, which are inherently independent from each other as such.

According to Figure 8, an exemplary determining operation according to exemplary embodiments of the present invention comprises tuning the lead time (ϵ) based on at least one of the duration of the de-activating and the duration of obtaining.

According to exemplary embodiments of the present invention, the parameter ϵ is a parameter local at and dedicated to each station. This parameter is tuned at a station itself accordingly to capture, for example, the speed at which the station can wake up, that is, perform the de-activating of the power save mode, and take measurements, and at the same time become ready to transmit at the intended time slot instantly.

Figure 9 shows a flowchart of an example of a procedure at a terminal side according to exemplary embodiments of the present invention.

The procedure according to Figure 9 represents a variation of the procedure according to Figures 3 and 4, in which exemplary details of the acquiring operation are given, which are inherently independent from each other as such.

5 According to Figure 9, an exemplary acquiring operation according to exemplary embodiments of the present invention comprises receiving a signalling including at least one of the number (N) of terminals associated with the predetermined channel, the length (T) of the time slot, if T is constant, and the traffic periods t_i (1 to N).

10

 According to exemplary embodiments of the present invention, the AP broadcasts the number (N) of stations associated with it and/or the traffic periods t_i (1 to N) of the stations associated with it. Since a station knows at which round (j) of measurements it is and its own number (i) and by receiving the signalling including
15 the number (N) and the traffic periods t_i (1 to N), it can compute when to wake up according to formulae (2) and (3). According to exemplary embodiments of the present invention, this signalling can be sent, e.g. in a beacon message corresponding to the channel by the AP.

20 According to exemplary embodiments of the present invention, also the current round number (j) can be received via such broadcasting message from the AP to the terminals.

 According to exemplary embodiments of the present invention, the backoff of
25 the stations is deterministic such that formulae (2) and (3) are satisfied. Thus, according to exemplary embodiments of the present invention, the system can enjoy the performance benefits of a “scheduled-like” system.

 In view of the above, specific features and/or effects according to exemplary
30 embodiments of the present invention may be summarised as follows. This summary is noted to be non-exhaustive and merely illustrative/exemplary.

Exemplary embodiments of the present invention provide for contention reduction in channels in wireless transmission scenarios. That is, there is provided time slot scheduling and power saving mode performing in wireless transmission scenarios, which is effective in terms of power consumption control of a terminal and contention reduction with respect to the used channel.

Accordingly, by virtue of the contention reduction according to exemplary embodiments of the present invention, implementation synergy with existing communication systems and/or network deployments may be maximised.

Generally, the above-described procedures and functions may be implemented by respective functional elements, processors or the like, as described below.

While in the foregoing exemplary embodiments of the present invention are described mainly with reference to methods, procedures and functions, corresponding exemplary embodiments of the present invention also cover respective apparatus, network nodes and systems, including both software, algorithms, and/or hardware thereof.

Respective exemplary embodiments of the present invention are described below referring to Figure 10, while for the sake of brevity reference is made to the detailed description with regard to Figures 1 to 9.

In Figure 10, which is noted to represent a simplified block diagram, the solid line blocks are basically configured to perform respective operations as described above. The entirety of solid line blocks are basically configured to perform the methods and operations as described above, respectively. With respect to Figure 10, it is to be noted that the individual blocks are meant to illustrate respective functional blocks implementing a respective function, process or procedure, respectively. Such functional blocks are implementation-independent, i.e. may be implemented by means

of any kind of hardware or software, respectively. The arrows and lines interconnecting individual blocks are meant to illustrate an operational coupling therebetween, which may be a physical and/or logical coupling, which on the one hand is implementation-independent (e.g. wired or wireless) and on the other hand may also comprise an arbitrary number of intermediary functional entities not shown. The direction of arrow is meant to illustrate the direction in which certain operations are performed and/or the direction in which certain data is transferred.

Further, in Figure 10, only those functional blocks are illustrated that relate to any one of the above-described methods, procedures and functions. A skilled person will acknowledge the presence of any other conventional functional blocks required for an operation of respective structural arrangements, such as e.g. a power supply, a central processing unit, respective memories or the like. Amongst others, memories are provided for storing programs or program instructions for controlling the individual functional entities to operate as described herein.

Figure 10 shows a schematic block diagram illustrating exemplary apparatus according to exemplary embodiments of the present invention.

In view of the above, the thus illustrated apparatus 10 and 20 are suitable for use in practising the exemplary embodiments of the present invention, as described herein.

The thus described apparatus 10 may represent a (part of a) device or terminal such as a station or a sensor or a modem (which may be installed as part of a station or sensor, but may be also a separate module, which can be attached to various devices), and may be configured to perform a procedure and/or functionality as described in conjunction with any of Figures 1 to 9. The thus described apparatus 20 may represent a (part of a) network entity, such as a base station or access point or any network-based controller, and may be configured to perform a procedure and/or functionality as indicated above, while no further details thereof are given.

As indicated in Figure 10, according to exemplary embodiments of the present invention, the apparatus 10 comprises a processor 11, a memory 12 and an interface 13, which are connected by a bus 14 or the like, and the apparatus may be connected
5 via link 30, respectively.

The processor 11 and/or the interface 13 may also include a modem or the like to facilitate communication over a (hardwire or wireless) link, respectively. The interface 13 may include a suitable transceiver coupled to one or more antennas or
10 communication means for (hardwire or wireless) communications with the linked or connected device(s), respectively. The interface 13 is generally configured to communicate with at least one other apparatus, i.e. the interface thereof.

The memory 12 may store respective programs assumed to include program
15 instructions or computer program code that, when executed by the respective processor, enables the respective electronic device or apparatus to operate in accordance with the exemplary embodiments of the present invention.

In general terms, the respective devices/apparatus (and/or parts thereof) may
20 represent means for performing respective operations and/or exhibiting respective functionalities, and/or the respective devices (and/or parts thereof) may have functions for performing respective operations and/or exhibiting respective functionalities.

When in the subsequent description it is stated that the processor (or some
25 other means) is configured to perform some function, this is to be construed to be equivalent to a description stating that at least one processor, potentially in cooperation with computer program code stored in the memory of the respective apparatus, is configured to cause the apparatus to perform at least the thus mentioned function. Also, such function is to be construed to be equivalently implementable by
30 specifically configured means for performing the respective function (i.e. the

expression “processor configured to [cause the apparatus to] perform xxx-ing” is construed to be equivalent to an expression such as “means for xxx-ing”).

According to exemplary embodiments of the present invention, an apparatus
5 representing the apparatus 10 comprises at least one processor 11, at least one
memory 12 including computer program code, and at least one interface 13
configured for communication with at least another apparatus. The apparatus 10, i.e.
the processor (namely, the at least one processor 11, with the at least one memory 12
and the computer program code), is configured to perform obtaining sensor data of a
10 certain amount in a periodical manner, at a terminal associated with a predetermined
channel, to perform scheduling transmission of the sensor data to a time slot in a
recurring transmission round of a variable length, and to perform transmitting the
sensor data in the time slot using the predetermined radio channel.

15 In its most basic form, stated in other words, the apparatus 10 may thus
comprise respective means obtaining sensor data of a certain amount in a periodical
manner, at a terminal associated with a predetermined channel, means for scheduling
transmission of the sensor data to a time slot in a recurring transmission round of a
variable length and means for transmitting the sensor data in the time slot using the
20 predetermined radio channel.

As outlined above, in enhanced forms, the apparatus 10 may comprise one or
more of respective means for acquiring access parameters of the predetermined radio
channel, means for calculating a beginning of the time slot based on the access
25 parameters, means for computing a point in time (t_B) of the beginning of the time slot
in a transmission round, means for activating a power save mode, means for de-
activating the power save mode, means for choosing a backoff time (T_{BO}), means for
determining a lead time (ϵ), means for reckoning a range in time (t_W), means for
tuning the lead time (ϵ), and means for receiving a signalling.

Thereby, the apparatus may be operable as or at a base station or access node of a wireless system or as or at a terminal, user equipment, mobile station or modem in a wireless system, and/or the apparatus may be operable in at least one of a WLAN, GSM, GPRS, 3G, LTE and a LTE-A wireless system.

5

For further details of specifics regarding functionalities according to exemplary embodiments of the present invention, reference is made to the foregoing description in conjunction with Figures 1 to 9.

10 According to exemplarily embodiments of the present invention, higher power efficiency of the terminal, in particular less power consumption, can be achieved. Further, contention in a channel can be decreased. Moreover, a system implementing exemplarily embodiments of the present invention can support large number of stations contenting for the channel.

15

According to exemplarily embodiments of the present invention, a system may comprise any conceivable combination of the thus depicted devices/apparatus and other network elements, which are configured to cooperate as described above.

20 In general, it is to be noted that respective functional blocks or elements according to above-described aspects can be implemented by any known means, either in hardware and/or software, respectively, if it is only adapted to perform the described functions of the respective parts. The mentioned method steps can be realised in individual functional blocks or by individual devices, or one or more of the
25 method steps can be realised in a single functional block or by a single device.

Generally, any structural means such as a processor or other circuitry may refer to one or more of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) combinations
30 of circuits and software (and/or firmware), such as (as applicable): (i) a combination of processor(s) or (ii) portions of processor(s)/software (including digital signal

processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present.

5 Also, it may also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware, any integrated circuit, or the like.

Generally, any procedural step or functionality is suitable to be implemented

10 as software or by hardware without changing the idea of the present invention. Such software may be software code independent and can be specified using any known or future developed programming language, such as e.g. Java, C++, C, and Assembler, as long as the functionality defined by the method steps is preserved. Such hardware may be hardware type independent and can be implemented using any known or

15 future developed hardware technology or any hybrids of these, such as MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), TTL (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD

20 (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components. A device/apparatus may be represented by a semiconductor chip, a chipset, system in package, or a (hardware) module comprising such chip or chipset. This, however, does not exclude the possibility that a functionality of a device/apparatus or module, instead of being hardware implemented, be implemented

25 as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor. A device may be regarded as a device/apparatus or as an assembly of more than one device/apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing,

30 for example.

Apparatus and/or means or parts thereof can be implemented as individual devices, but this does not exclude that they may be implemented in a distributed fashion throughout the system, as long as the functionality of the device is preserved. Such and similar principles are to be considered as known to a skilled person.

5

Software in the sense of the present description comprises software code as such comprising code means or portions or a computer program or a computer program product for performing the respective functions, as well as software (or a computer program or a computer program product) embodied on a tangible medium
10 such as a computer-readable (storage) medium having stored thereon a respective data structure or code means/portions or embodied in a signal or in a chip, potentially during processing thereof.

The present invention also covers any conceivable combination of method
15 steps and operations described above, and any conceivable combination of nodes, apparatus, modules or elements described above, as long as the above-described concepts of methodology and structural arrangement are applicable.

In view of the above, the present invention and/or exemplary embodiments
20 thereof provide measures for contention reduction in channels in wireless transmission scenarios. Such measures may exemplarily comprise obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined channel, scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length, and transmitting the sensor data in
25 the time slot using the predetermined radio channel.

The measures according to exemplary embodiments of the present invention may be applied for any kind of channel based network environment, such as for example for communication systems in accordance with any one of WiFi standards.

30

Even though the present invention and/or exemplary embodiments are described above with reference to the examples according to the accompanying drawings, it is to be understood that they are not restricted thereto. Rather, it is apparent to those skilled in the art that the present invention can be modified in many
5 ways without departing from the scope of the inventive idea as disclosed herein.

The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in
10 combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS

1. A method comprising:
 - 5 obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined radio channel;
scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length; and
transmitting the sensor data in the time slot using the predetermined radio
10 channel.
2. A method according to claim 1, wherein the scheduling comprises:
acquiring access parameters of the predetermined radio channel, and
calculating a beginning of the time slot based on the access parameters.
15
3. A method according to claim 2, wherein the access parameters include at least one of:
a number (N) of terminals associated with the predetermined channel,
a number (N(j)) of terminals having transmitted in preceding transmission
20 rounds,
an own position (i(j)) in a considered transmission round in a sequence of terminals associated with the predetermined channel,
a number (j_{current}) of a current transmission round,
a point in time (τ) of the beginning of a first transmission round,
25 a length (T) of the time slot, and
traffic periods t_i (i=1 to N) indicative of periodic available data to be transmitted by respective terminals (1 to N).
4. A method according to claim 3, wherein the calculating comprises:
30 computing a point in time (t_B) of the beginning of the time slot in a transmission round (j) using the formula:

$$t_B = \tau + (i(j)-1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

5. A method according to claim 3 or claim 4, comprising:
 activating a power save mode, and
 5 de-activating the power save mode.
6. A method according to claim 5, comprising:
 determining a lead time (ϵ) indicative of a minimum period the de-activating is
 to be performed before the beginning of the time slot,
- 10 wherein the activating comprises reckoning a range in time (t_w) indicative of
 when de-activating is to be performed for transmitting in the time slot in a
 transmission round (j) using the formula:

$$\tau + (i(j)-2) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \leq T_w \leq \tau + (i(j)-1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) - \epsilon$$

- 15 7. A method according to claim 6, comprising:
 choosing a backoff time (t_{BO}) indicative of an idle time from the point in time
 an interframe spacing is sensed (T_{DIFS}) after activating (T_w) to the calculated
 beginning of the time slot for transmission using the formula

$$T_w + T_{DIFS} + T_{BO} = \tau + (i(j)-1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

- 20 8. A method according to claim 6 or claim 7, wherein the determining comprises
 tuning the lead time (ϵ) based on at least one of the duration of the de-activating and
 the duration of obtaining.
- 25 9. A method according to any of claims 3 to 8, wherein the acquiring comprises
 receiving a signalling including at least one of:
 the number (N) of terminals associated with the predetermined channel,
 the length (T) of the time slot, and

the traffic periods t_i (1 to N).

10. Apparatus for use on a terminal side of a radio system, the apparatus comprising a processing system constructed and arranged to cause the apparatus to perform:

obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined radio channel;

scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length; and

transmitting the sensor data in the time slot using the predetermined radio channel.

11. Apparatus according to claim 10, wherein the processing system is arranged to cause the apparatus to perform:

acquiring access parameters of the predetermined radio channel, and calculating a beginning of the time slot based on the access parameters.

12. Apparatus according to claim 11, wherein the access parameters include at least one of:

a number (N) of terminals associated with the predetermined channel,
a number (N(j)) of terminals having transmitted in preceding transmission rounds,

an own position (i(j)) in a considered transmission round in a sequence of terminals associated with the predetermined channel,

a number (j_{current}) of a current transmission round,

a point in time (τ) of the beginning of a first transmission round,

a length (T) of the time slot, and

traffic periods t_i (i=1 to N) indicative of periodic available data to be transmitted by the respective terminals (1 to N).

13. Apparatus according to claim 12, wherein the processing system is arranged to cause the apparatus to perform:

computing a point in time (t_B) of the beginning of the time slot in a transmission round (j) using the formula

$$t_B = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

14. Apparatus according to claim 12 or claim 13, wherein the processing system is arranged to cause the apparatus to perform:

activating a power save mode, and
de-activating the power save mode.

15. Apparatus according to claim 14, wherein the processing system is arranged to cause the apparatus to perform:

determining a lead time (ϵ) indicative of a minimum period the de-activating is to be performed before the beginning of the time slot, and

reckoning a range in time (t_w) indicative of when de-activating is to be performed for transmitting in the time slot in a transmission round (j) using the formula

$$\tau + (i(j) - 2) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \leq T_w \leq \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) - \epsilon$$

16. Apparatus according to claim 15, wherein the processing system is arranged to cause the apparatus to perform:

choosing a backoff time (t_{BO}) indicative of an idle time from the point in time an interframe spacing is sensed (T_{DIFS}) after activating (T_w) to the calculated beginning of the time slot for transmission using the formula

$$T_w + T_{DIFS} + T_{BO} = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

17. Apparatus according to any of claims 15 or 16, wherein the processing system is arranged to cause the apparatus to perform:

tuning the lead time (ϵ) based on at least one of the duration of the de-activating and the duration of obtaining.

5

18. Apparatus according to any of claims 12 to 17, wherein the processing system is arranged to cause the apparatus to perform receiving a signalling including at least one of:

the number (N) of terminals associated with the predetermined channel,
the length (T) of the time slot, and
the traffic periods t_i (1 to N).

10

19. Apparatus according to any of claims 10 to 18, wherein:

the apparatus is operable as or at a base station or access node of a wireless system or as or at a terminal, user equipment, mobile station or modem in a wireless system.

15

20. Apparatus according to any of claims 10 to 19, wherein:

the apparatus is operable in at least one of a WLAN, GSM, GPRS, 3G, LTE and a LTE-A wireless system.

20

21. A computer program comprising a set of instructions which, when executed on an apparatus, cause the apparatus to carry out a method comprising:

obtaining sensor data of a certain amount in a periodical manner, at a terminal associated with a predetermined radio channel;

25

scheduling transmission of the sensor data to a time slot in a recurring transmission round of a variable length; and

transmitting the sensor data in the time slot using the predetermined radio channel.

30

22. A computer program according to claim 21, wherein the instructions are such that the scheduling comprises:

acquiring access parameters of the predetermined radio channel, and
calculating a beginning of the time slot based on the access parameters.

5

23. A computer program according to claim 22, wherein the instructions are such that the access parameters include at least one of:

a number (N) of terminals associated with the predetermined channel,
a number (N(j)) of terminals having transmitted in preceding transmission

10 rounds,

an own position (i(j)) in a considered transmission round in a sequence of terminals associated with the predetermined channel,

a number (j_{current}) of a current transmission round,

a point in time (τ) of the beginning of a first transmission round,

15

a length (T) of the time slot, and

traffic periods t_i(i=1 to N) indicative of periodic available data to be transmitted by respective terminals (1 to N).

24. A computer program according to claim 23, wherein the instructions are such that the calculating comprises:

20

computing a point in time (t_B) of the beginning of the time slot in a transmission round (j) using the formula:

$$t_B = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

25. A computer program according to claim 23 or claim 24, wherein the instructions are such that the method comprises:

25

activating a power save mode, and

de-activating the power save mode.

26. A computer program according to claim 25, wherein the instructions are such that the method comprises:

determining a lead time (ε) indicative of a minimum period the de-activating is to be performed before the beginning of the time slot,

5 wherein the activating comprises reckoning a range in time (t_w) indicative of when de-activating is to be performed for transmitting in the time slot in a transmission round (j) using the formula:

$$\tau + (i(j) - 2) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) \leq T_w \leq \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n) - \varepsilon$$

10 27. A computer program according to claim 26, wherein the instructions are such that the method comprises:

choosing a backoff time (t_{BO}) indicative of an idle time from the point in time an interframe spacing is sensed (T_{DIFS}) after activating (T_w) to the calculated beginning of the time slot for transmission using the formula

15
$$T_w + T_{DIFS} + T_{BO} = \tau + (i(j) - 1) \cdot T + \sum_{n=1}^{j-1} T \cdot N(n)$$

28. A computer program according to claim 26 or claim 27, wherein the instructions are such that the determining comprises tuning the lead time (ε) based on at least one of the duration of the de-activating and the duration of obtaining.

20

29. A computer program according to any of claims 23 to 28, wherein the instructions are such that the acquiring comprises receiving a signalling including at least one of:

25 the number (N) of terminals associated with the predetermined channel,
the length (T) of the time slot, and
the traffic periods t_i (1 to N).

30. A computer program according to any of claims 21 to 29, embodied as a computer-readable medium.

31. A method of scheduling transmission of sensor data, substantially in accordance with any of the examples as described herein with reference to and illustrated by the accompanying drawings.

5

32. Apparatus for scheduling transmission of sensor data, substantially in accordance with any of the examples as described herein with reference to and illustrated by the accompanying drawings.

10

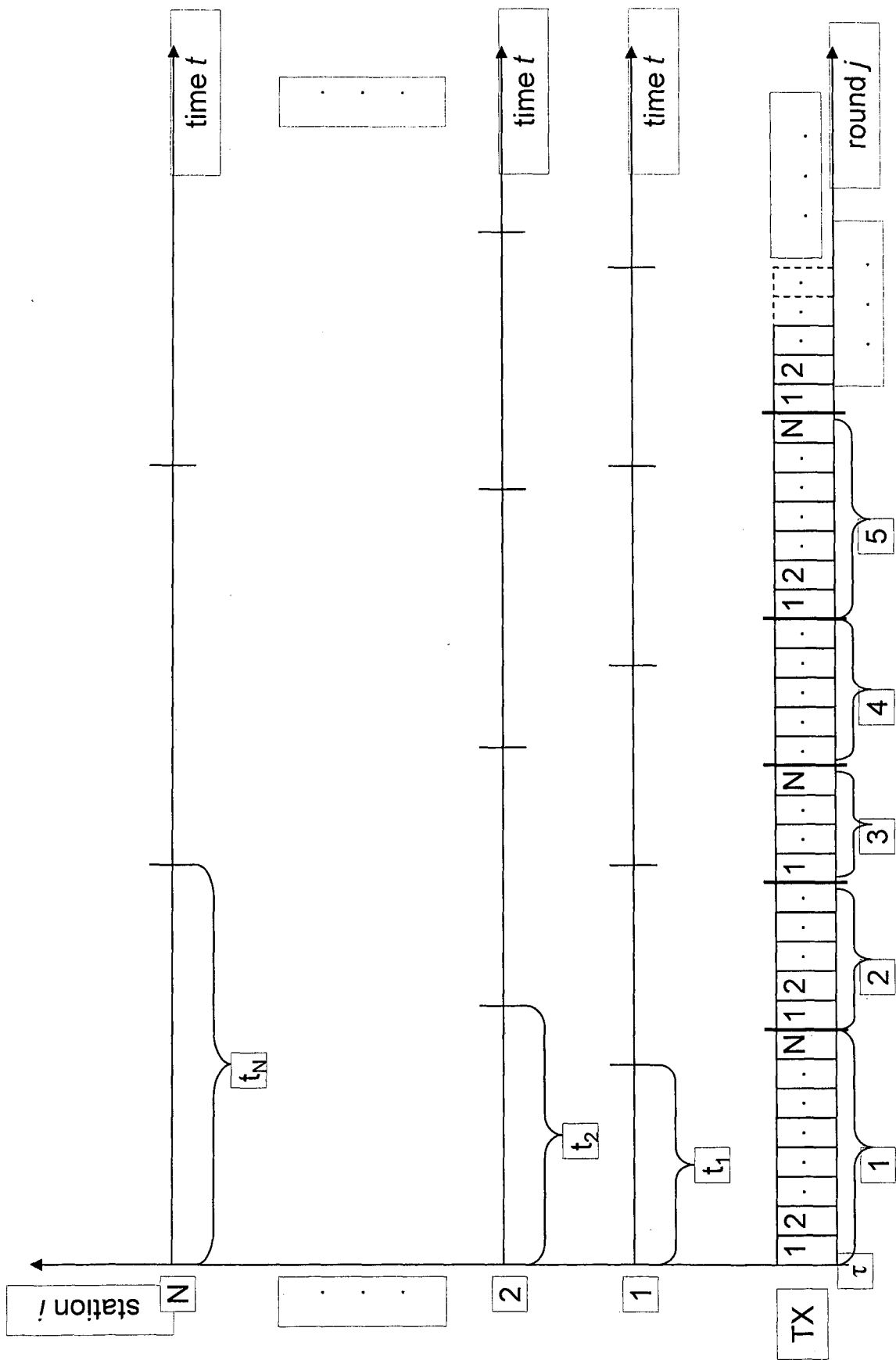


Figure 1

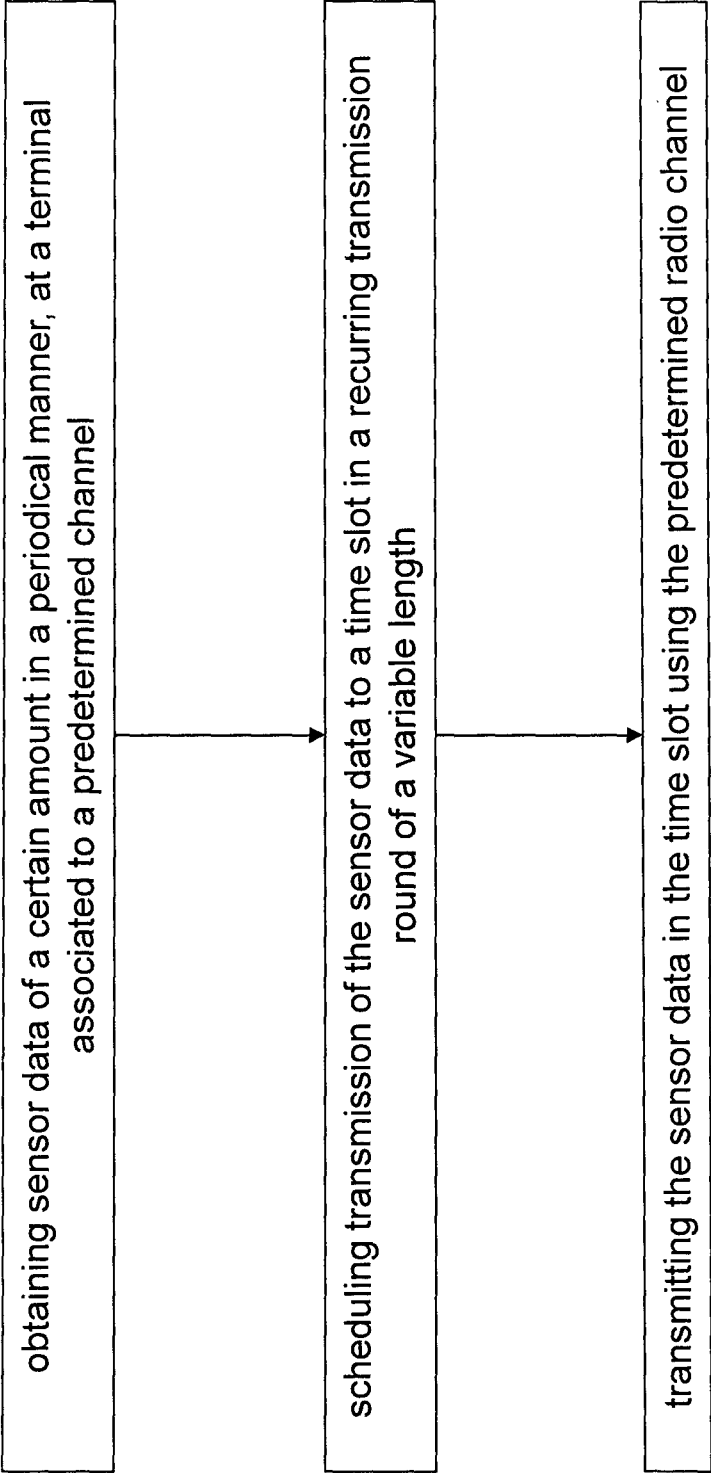


Figure 2

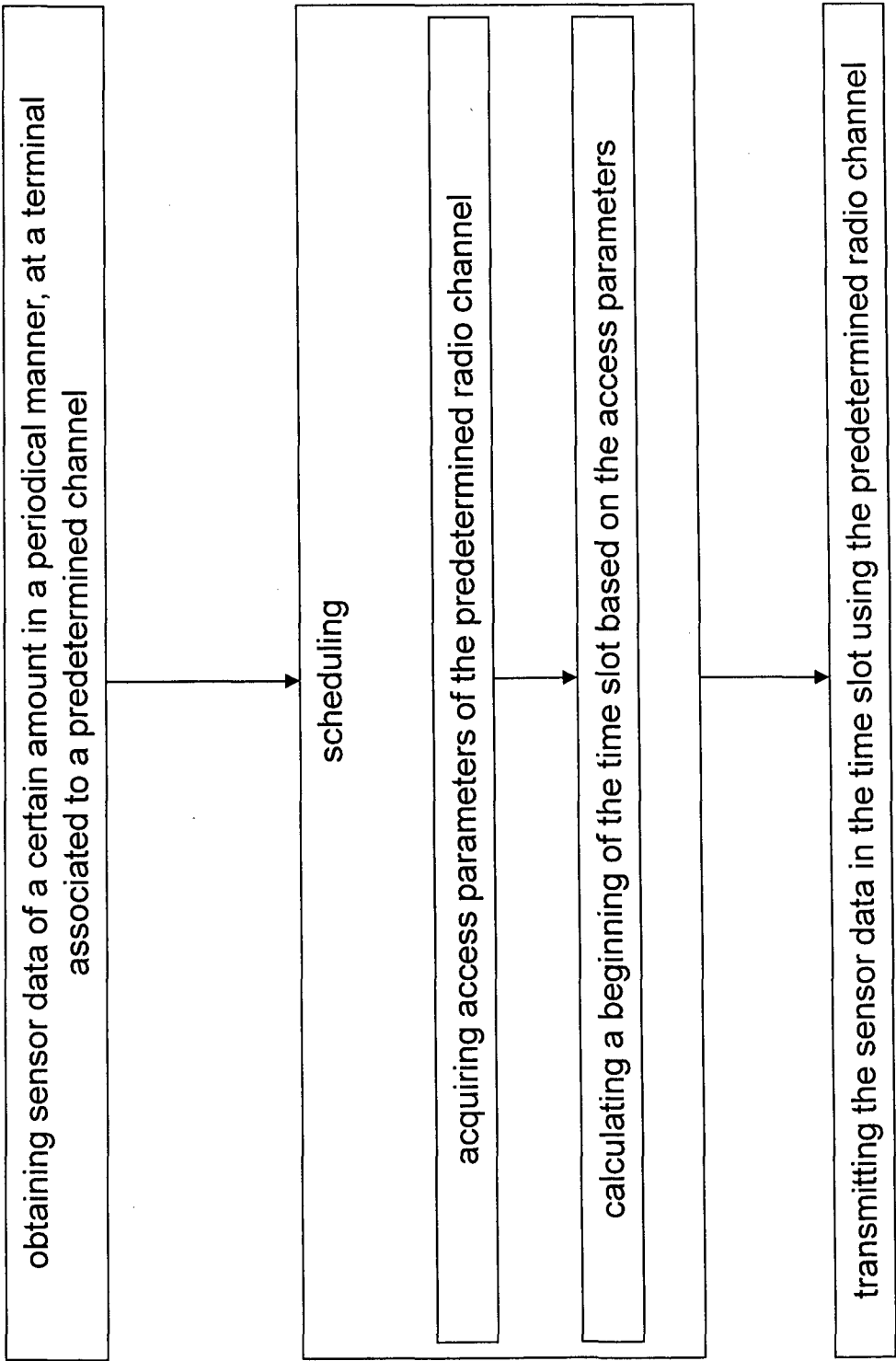


Figure 3

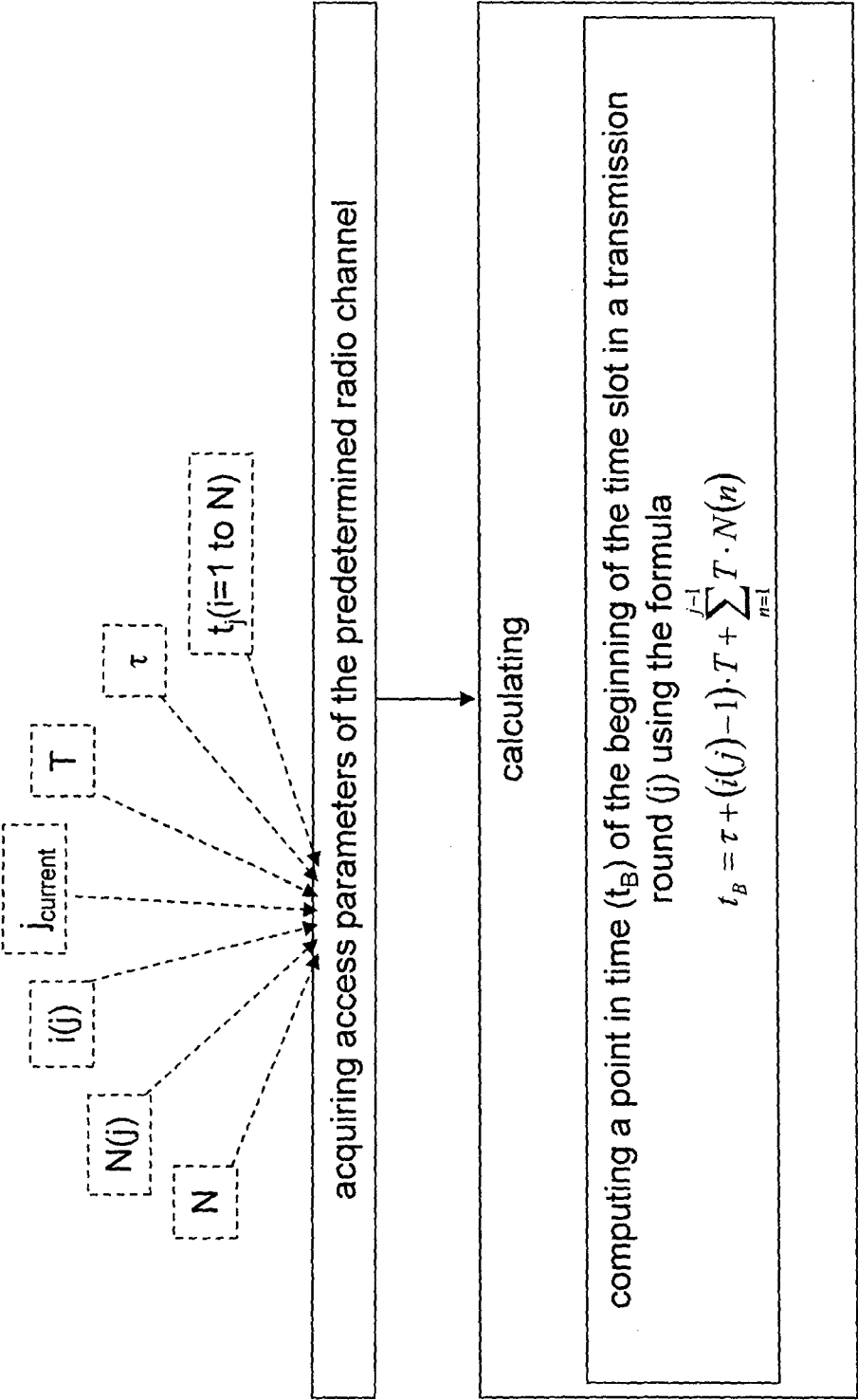


Figure 4

5/10

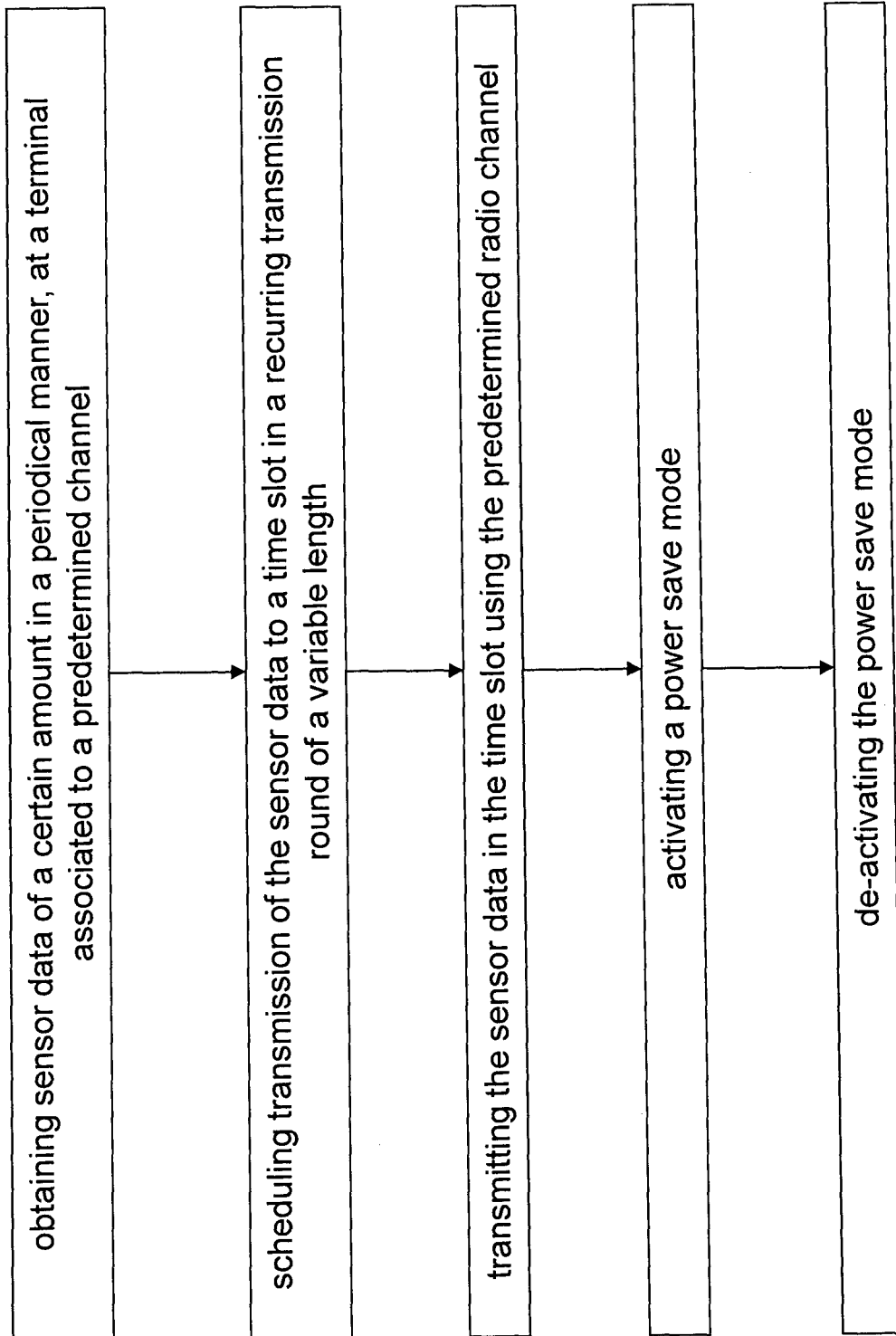


Figure 5

6/10

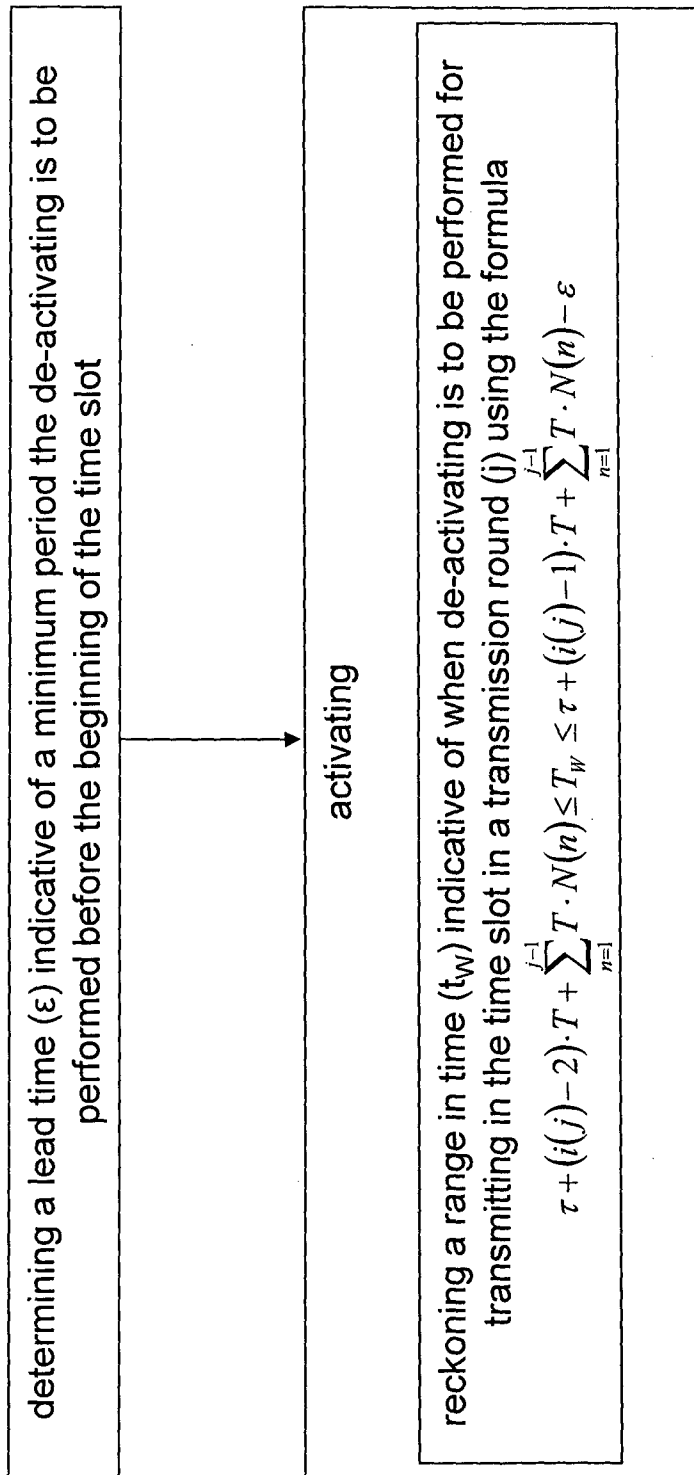


Figure 6

7/10

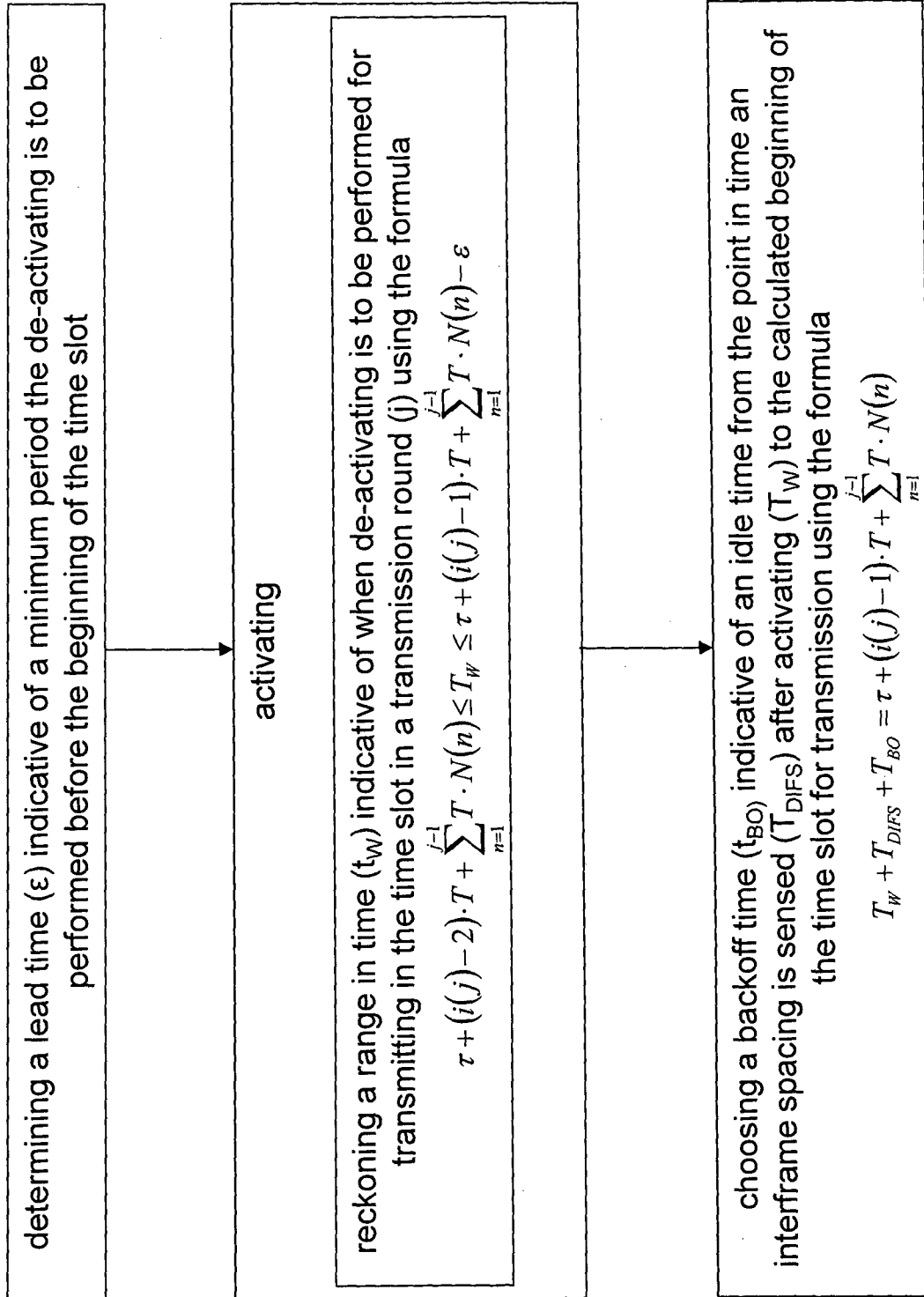


Figure 7

8/10

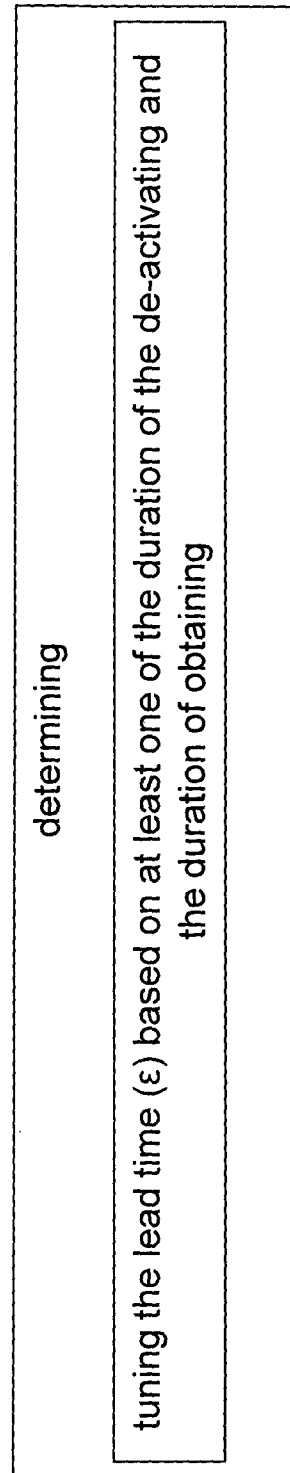


Figure 8

9/10

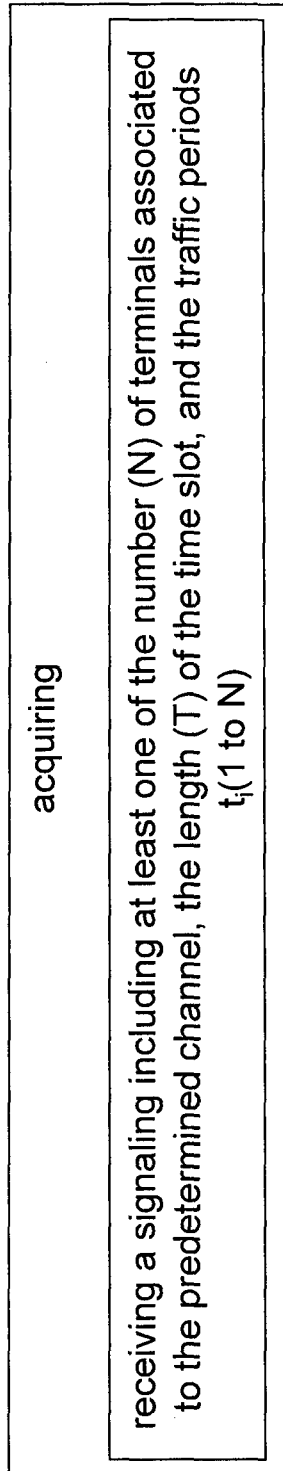


Figure 9

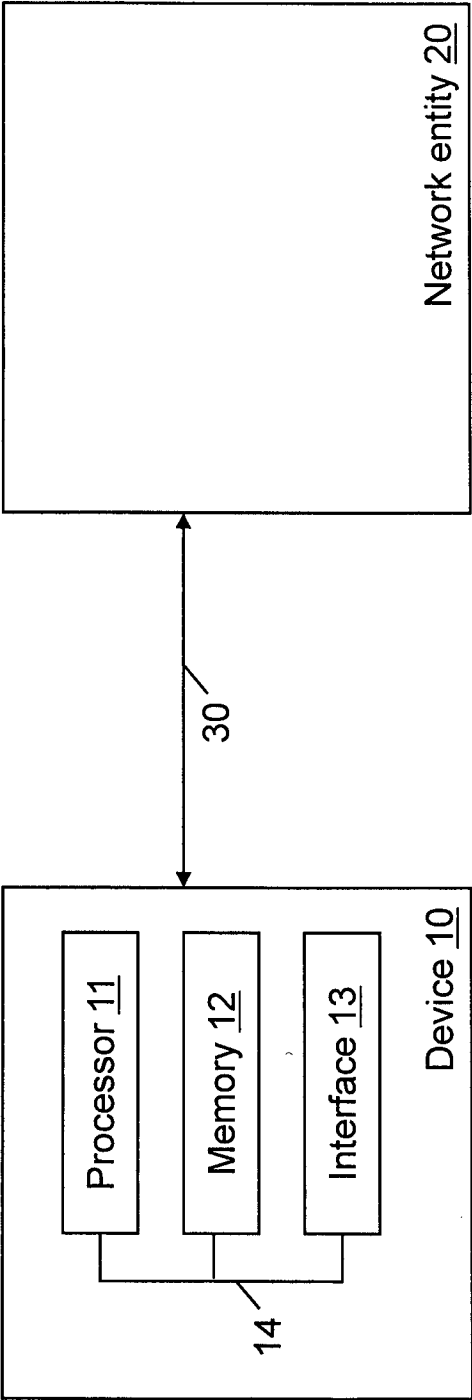


Figure 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/000365

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L12/70
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

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 735 630 B1 (GELVIN DAVID C [US] ET AL) 11 May 2004 (2004-05-11) abstract paragraph [0004] - paragraph [0030] paragraph [0102] - paragraph [0103] paragraph [0170] - paragraph [0172] paragraph [0284] paragraph [0358] - paragraph [0359] paragraph [0392] paragraph [0414] claims 1,6-8,26 figures 1-10,15-18 ----- -/-	1-32

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2013/000365

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