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(54) **COMMUNICATION SYSTEM**

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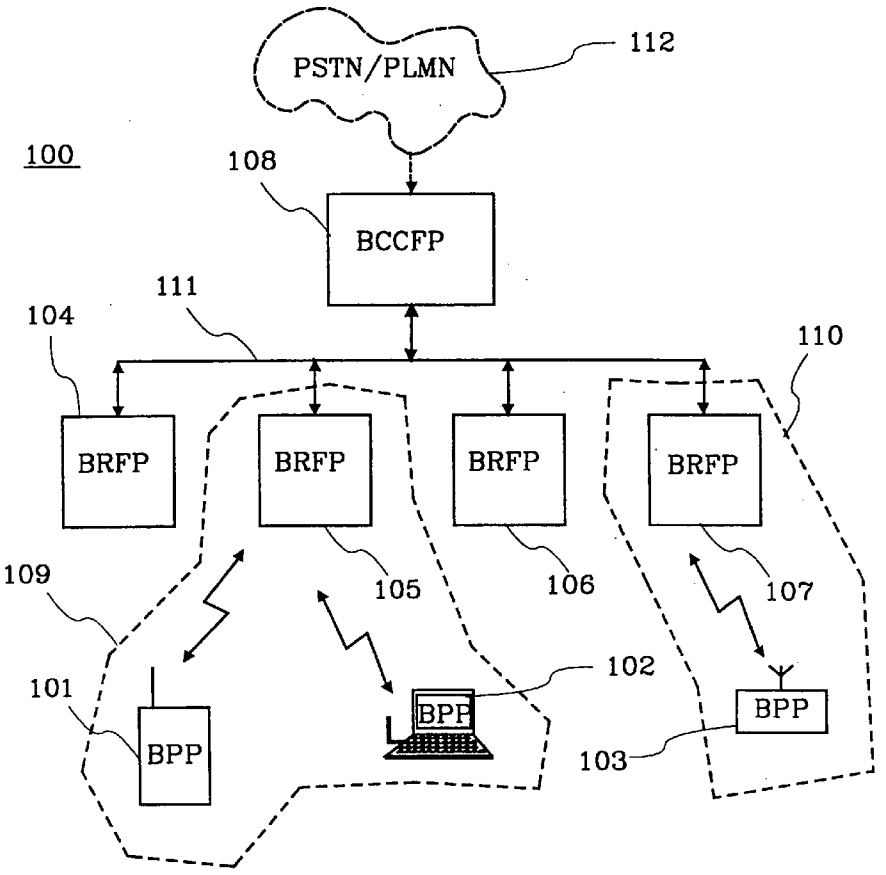
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(57) **ABSTRACT**

The present invention relates to methods and means for creating a cellular radio communication system (**100**) out of a number of local radio networks (**109, 110**), e.g. piconets. The local radio networks (**109,110**) are unsynchronised with each other and uses a radio interface that has no broadcast channel, e.g. the Bluetooth radio interface.

A control unit (**108**) is connected to each local radio network to provide the basic means and methods for a cellular radio communication system (**100**). Radio units (**101-103**) can attach and retain a connection to the control unit (**108**) via their respective radio node (**104-107**). The radio units (**101-103**) can also perform roaming, handover, measurments and fast connection set-ups in the system (**100**).



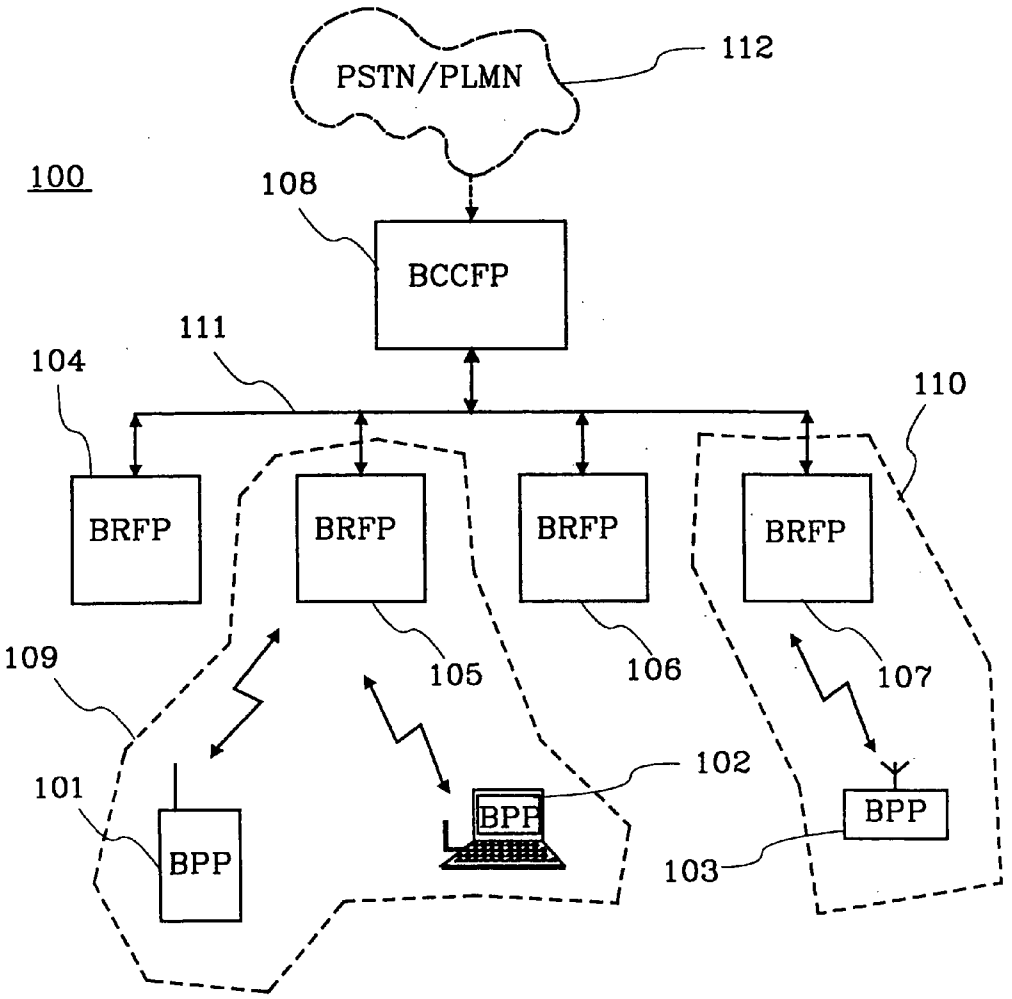

PSTN/PLMN
112
100
108
BCCFP
111
104
110
BRFP
BRFP
BRFP
BRFP
109
105
106
107
102
101
BPP
BPP
BPP
103

Fig.1

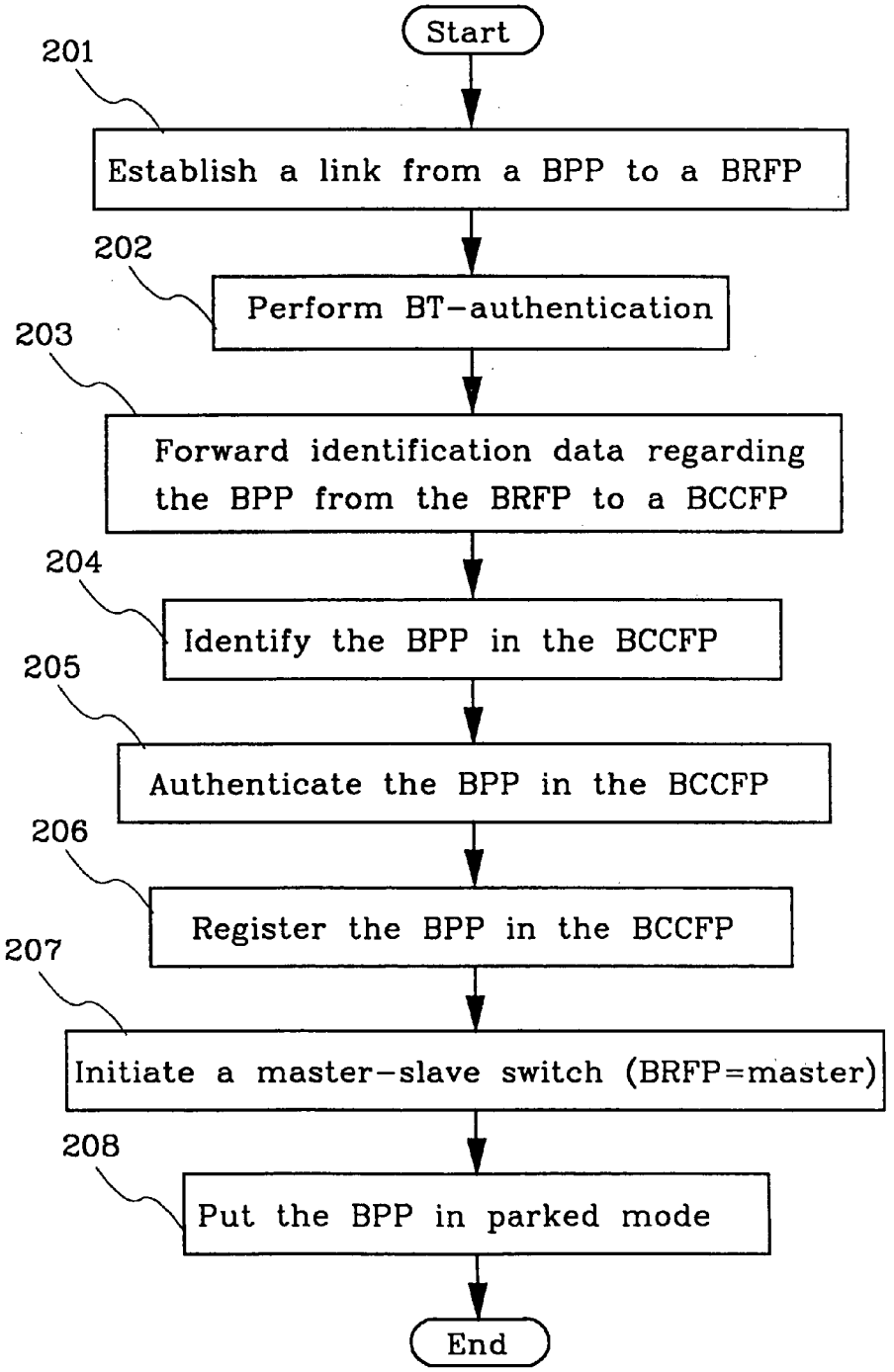

Start
201
Establish a link from a BPP to a BRFP
202
Perform BT-authentication
203
Forward identification data regarding the BPP from the BRFP to a BCCFP
204
Identify the BPP in the BCCFP
205
Authenticate the BPP in the BCCFP
206
Register the BPP in the BCCFP
207
Initiate a master-slave switch (BRFP=master)
208
Put the BPP in parked mode
End

Fig.2

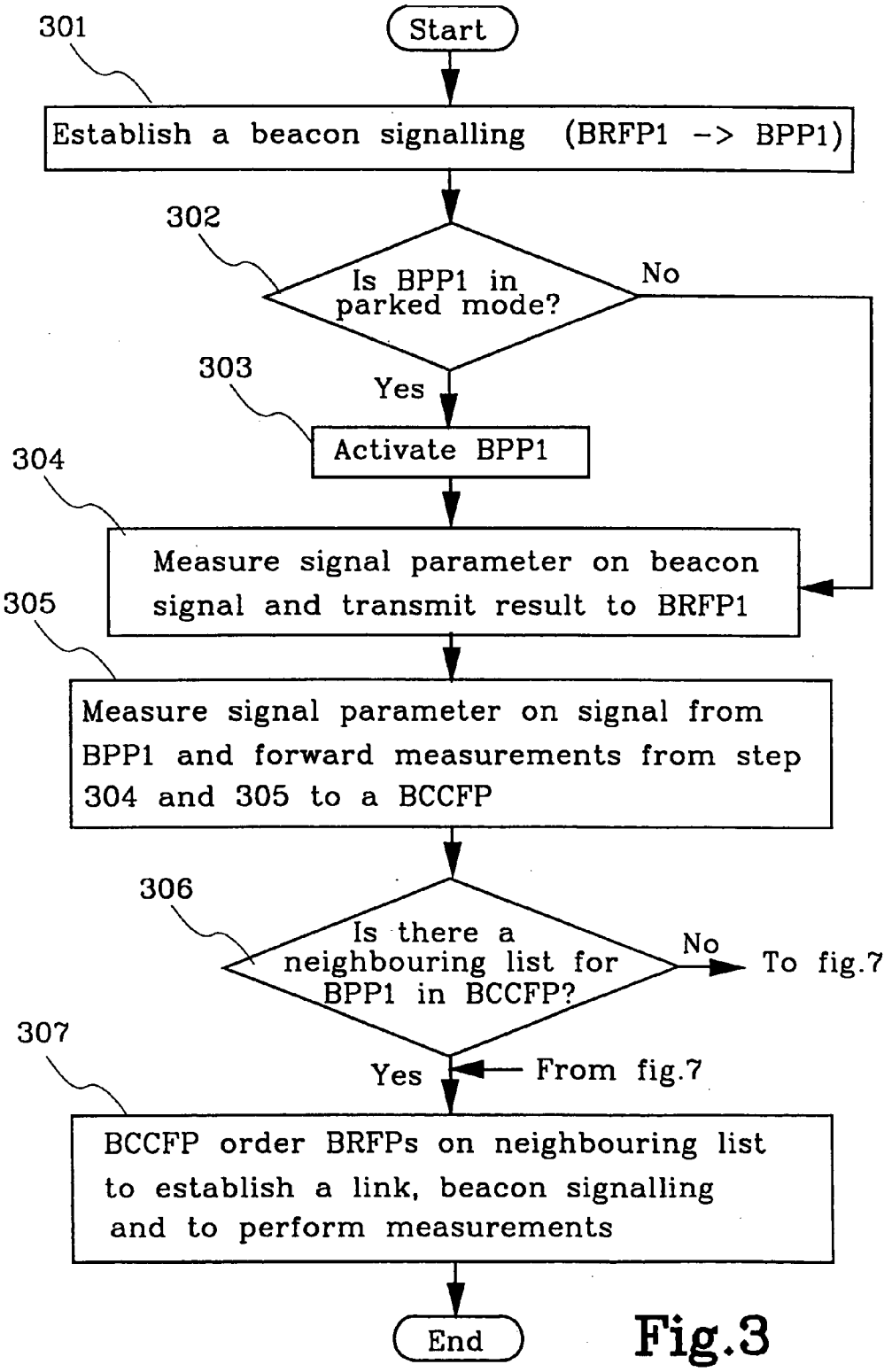

301
Start
Establish a beacon signalling (BRFP1 -> BPP1)
302
Is BPP1 in parked mode?
No
303
Yes
Activate BPP1
304
Measure signal parameter on beacon signal and transmit result to BRFP1
305
Measure signal parameter on signal from BPP1 and forward measurements from step 304 and 305 to a BCCFP
306
Is there a neighbouring list for BPP1 in BCCFP?
No
To fig.7
307
Yes
From fig.7
BCCFP order BRFPs on neighbouring list to establish a link, beacon signalling and to perform measurements
End

Fig.3

Current BPP	Candidates	Signal strength
BPP 101	BRFP 104	5
	BRFP 105	2
	BRFP 106	1

Fig.4

Current BRFP	Neighbouring BRFP
BRFP 105	BRFP 104
	BRFP 106

Fig.5

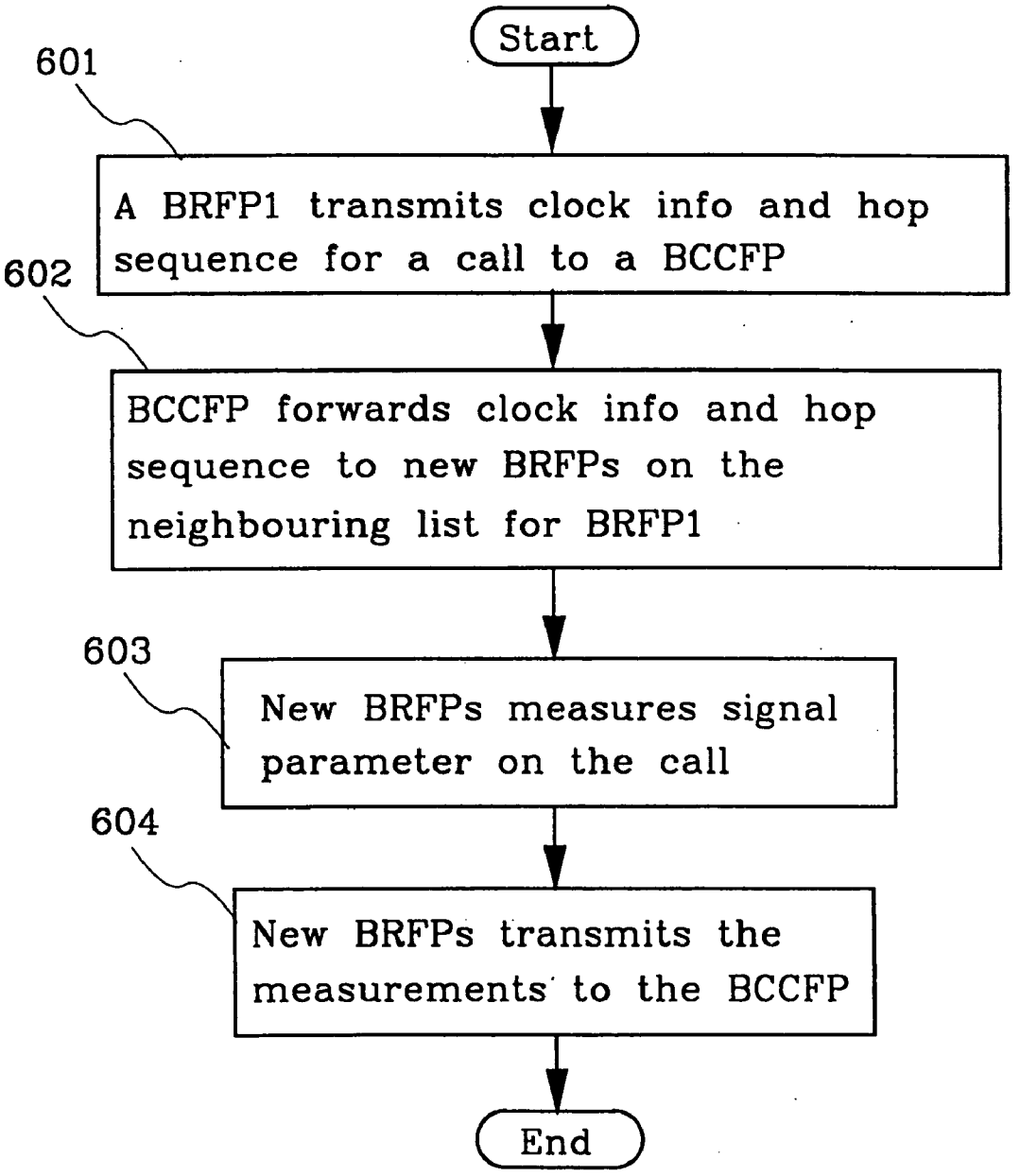

Start
601
A BRFP1 transmits clock info and hop sequence for a call to a BCCFP
602
BCCFP forwards clock info and hop sequence to new BRFPs on the neighbouring list for BRFP1
603
New BRFPs measures signal parameter on the call
604
New BRFPs transmits the measurements to the BCCFP
End

Fig.6

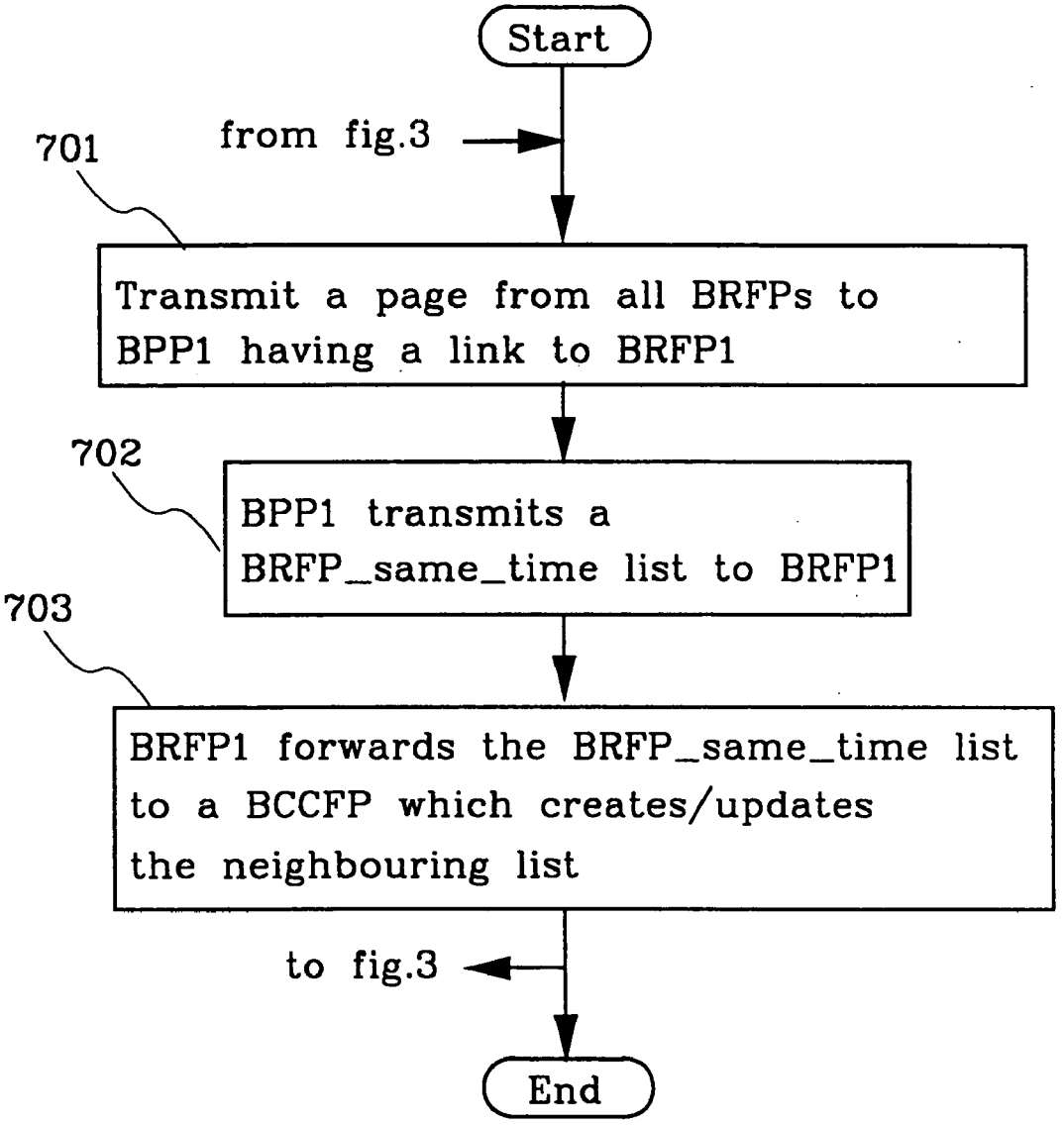

Start
from fig.3
701
Transmit a page from all BRFPs to BPP1 having a link to BRFP1
702
BPP1 transmits a BRFP_same_time list to BRFP1
703
BRFP1 forwards the BRFP_same_time list to a BCCFP which creates/updates the neighbouring list
to fig.3
End

Fig.7

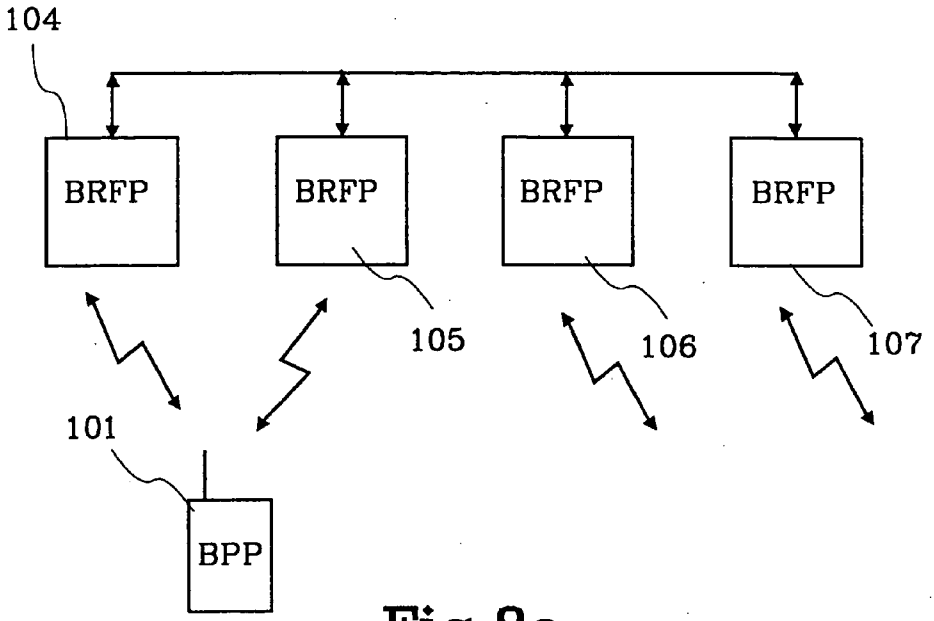

104
BRFP
BRFP
BRFP
BRFP
105
106
107
101
BPP

Fig.8a

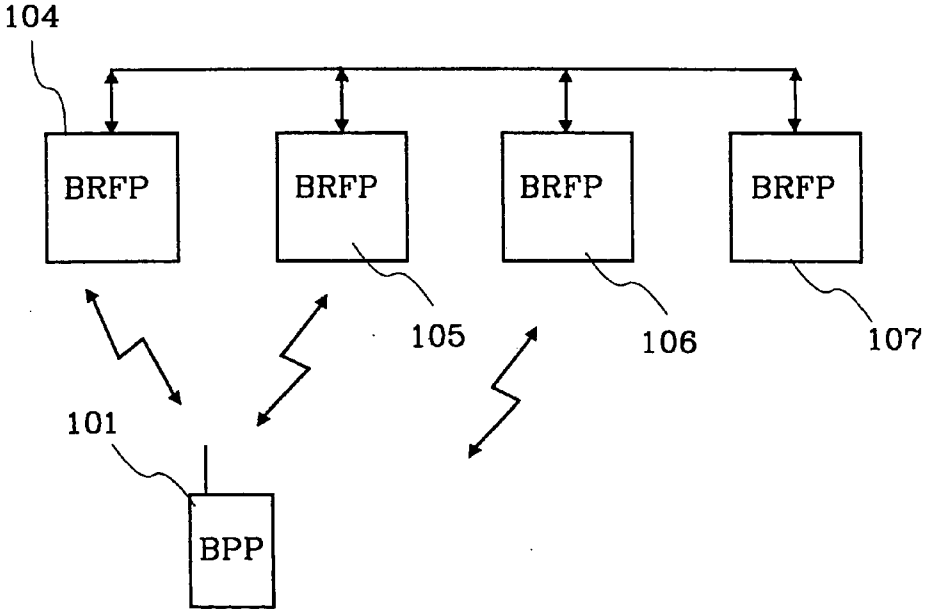

104
BRFP
BRFP
BRFP
BRFP
105
106
107
101
BPP

Fig.8b

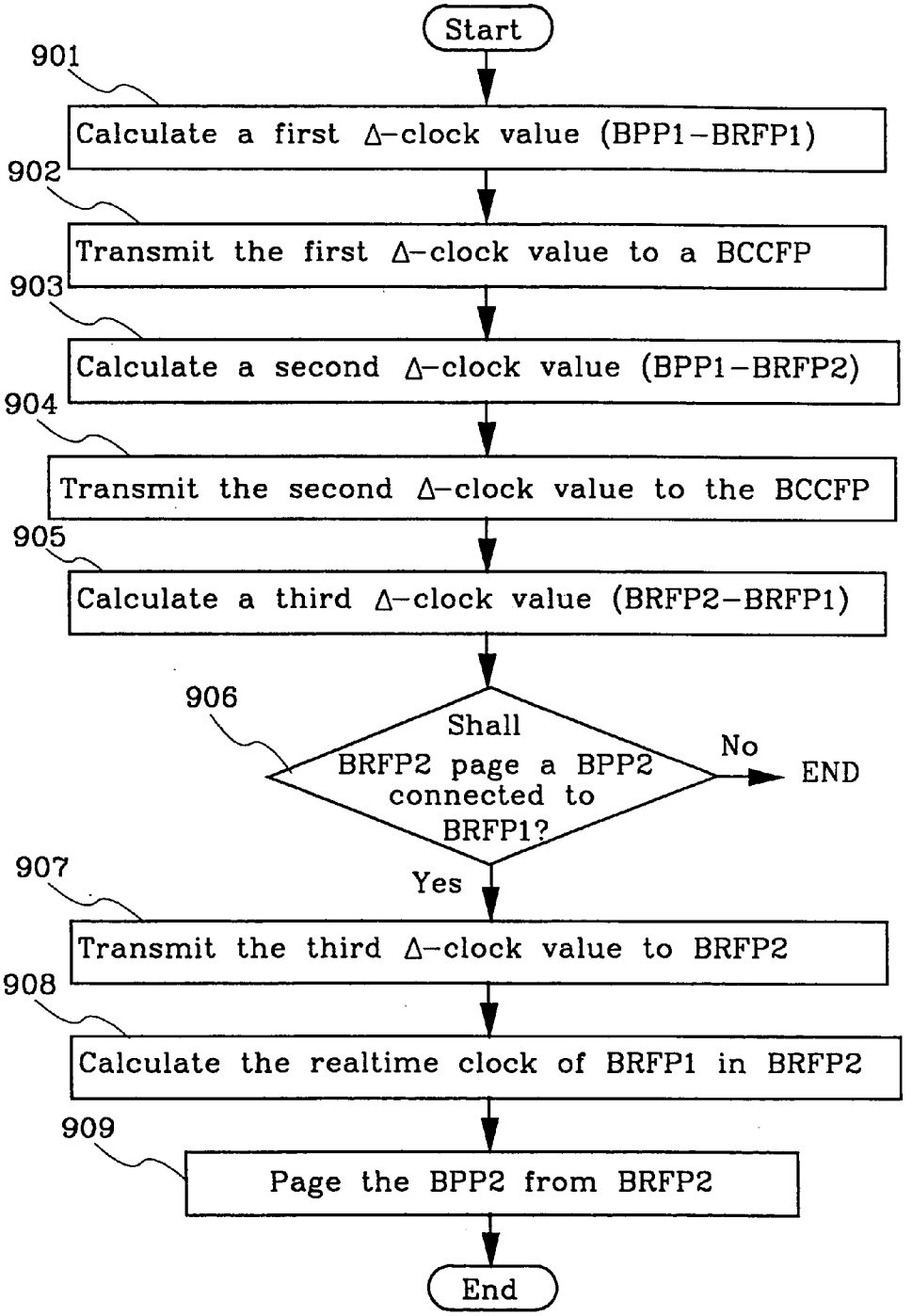

Start
901
Calculate a first Δ-clock value (BPP1-BRFP1)
902
Transmit the first Δ-clock value to a BCCFP
903
Calculate a second Δ-clock value (BPP1-BRFP2)
904
Transmit the second Δ-clock value to the BCCFP
905
Calculate a third Δ-clock value (BRFP2-BRFP1)
906
Shall BRFP2 page a BPP2 connected to BRFP1?
No
END
Yes
907
Transmit the third Δ-clock value to BRFP2
908
Calculate the realtime clock of BRFP1 in BRFP2
909
Page the BPP2 from BRFP2
End

Fig.9

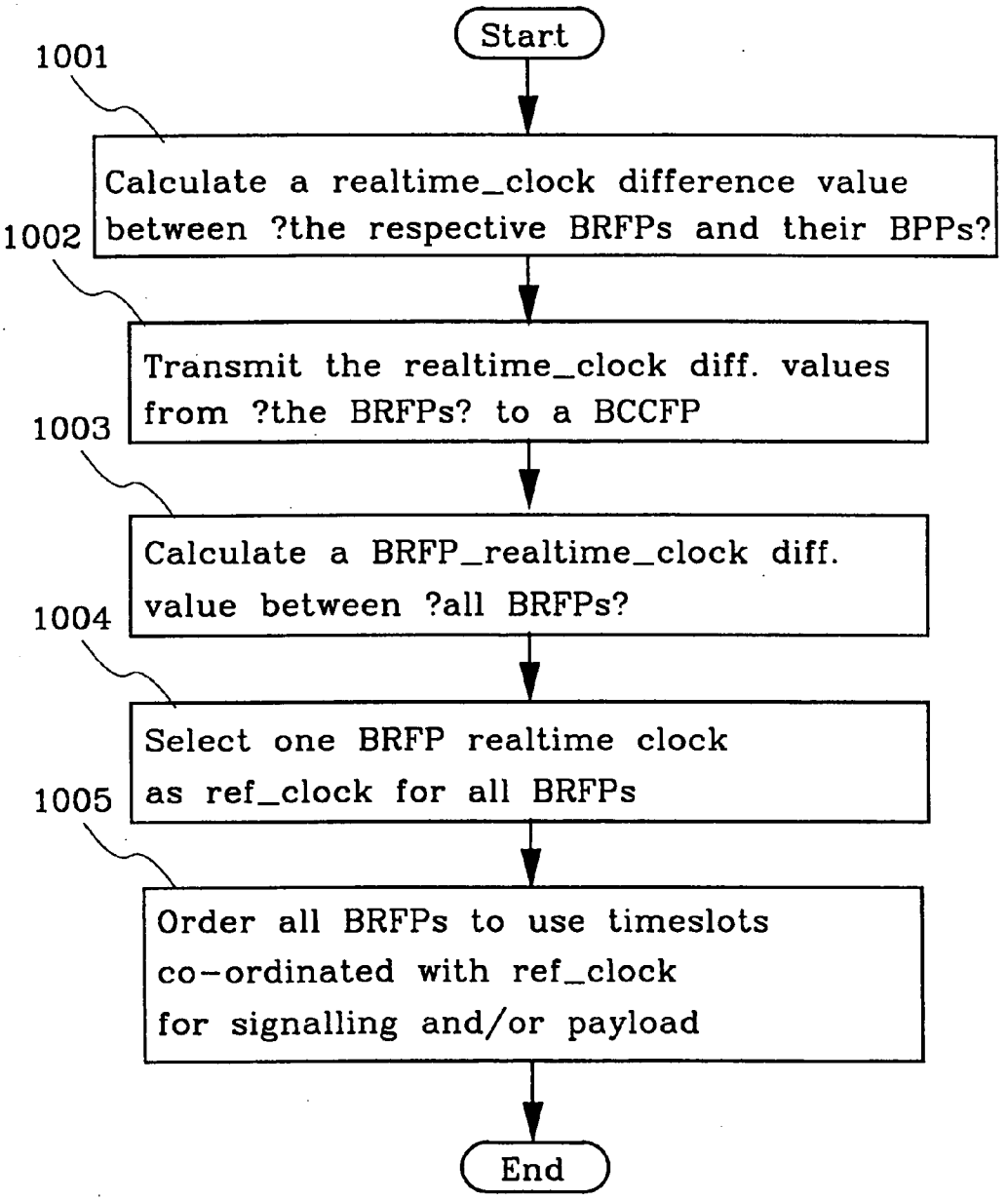

Start
1001
Calculate a realtime_clock difference value between ?the respective BRFPs and their BPPs?
1002
Transmit the realtime_clock diff. values from ?the BRFPs? to a BCCFP
1003
Calculate a BRFP_realtime_clock diff. value between ?all BRFPs?
1004
Select one BRFP realtime clock as ref_clock for all BRFPs
1005
Order all BRFPs to use timeslots co-ordinated with ref_clock for signalling and/or payload
End

Fig.10

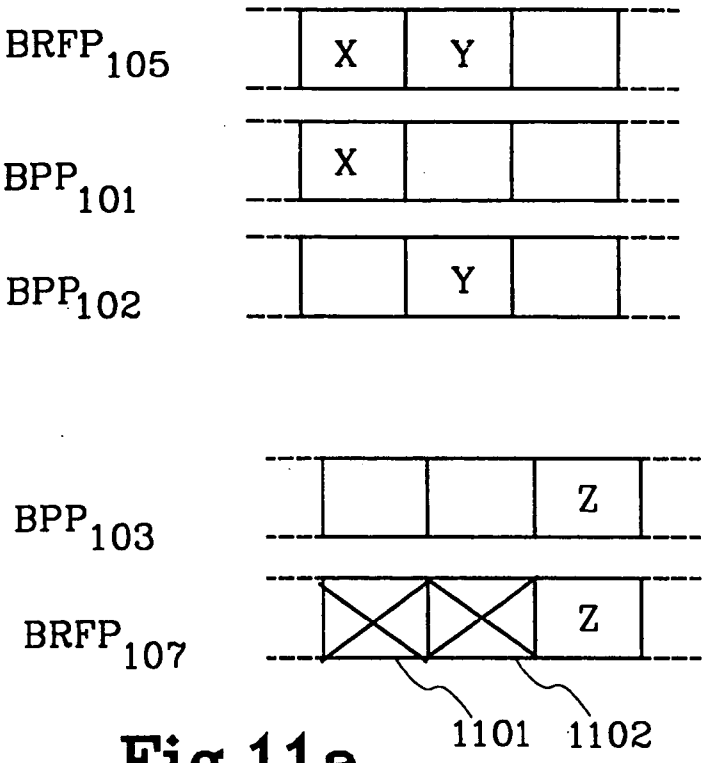


Fig.11a

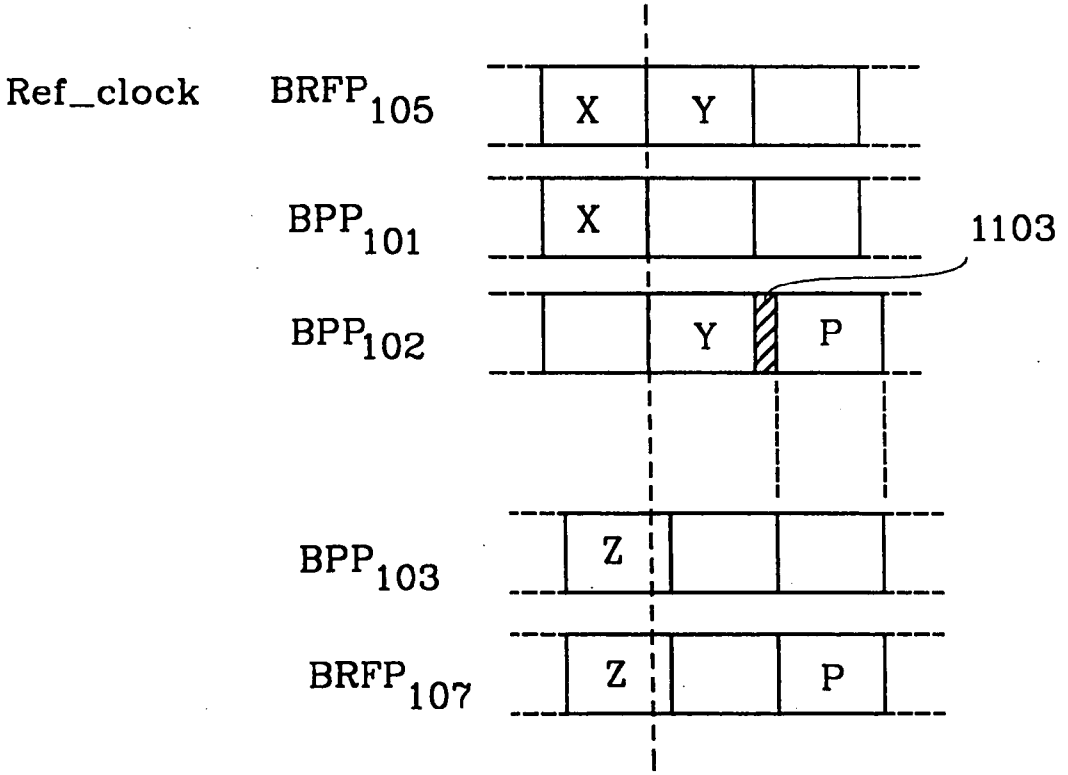


Fig.11b

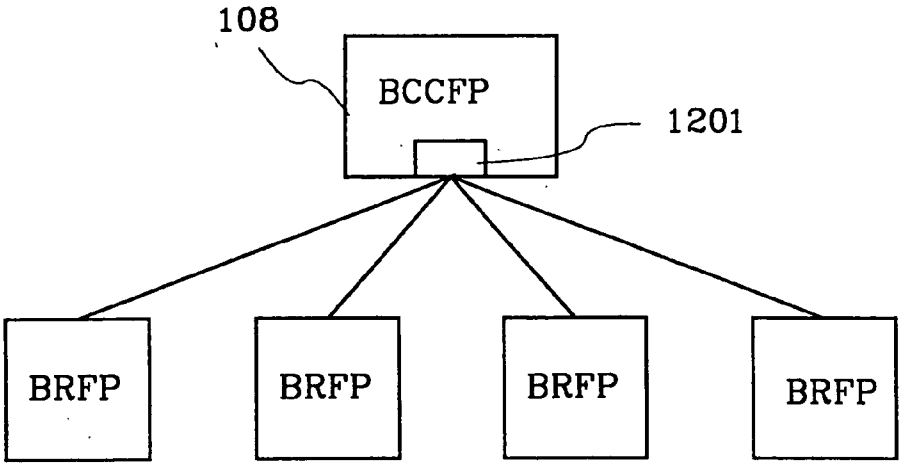


Fig.12

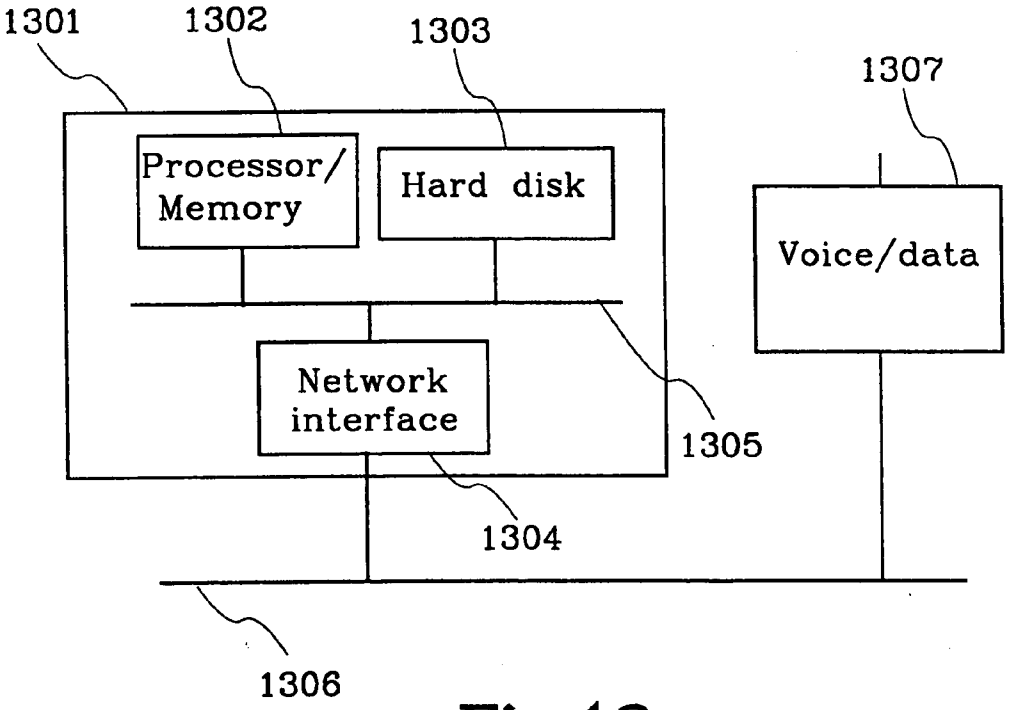


Fig.13a

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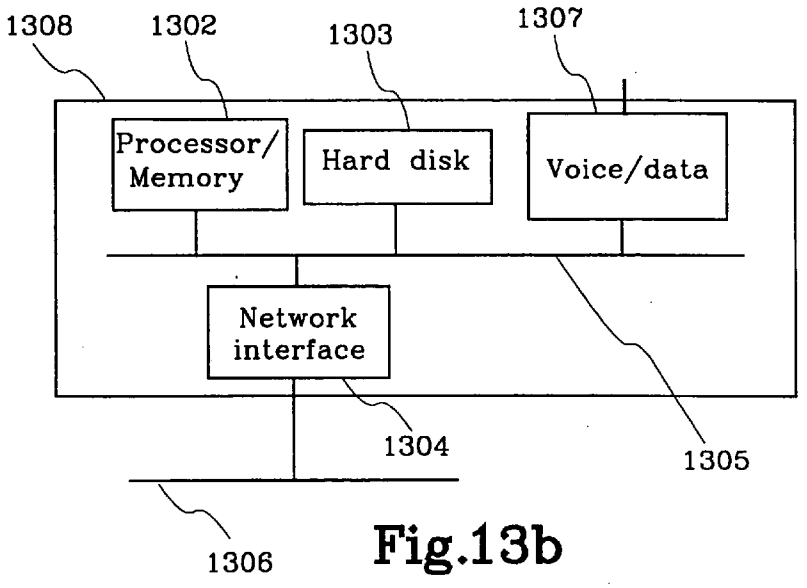


Fig.13b

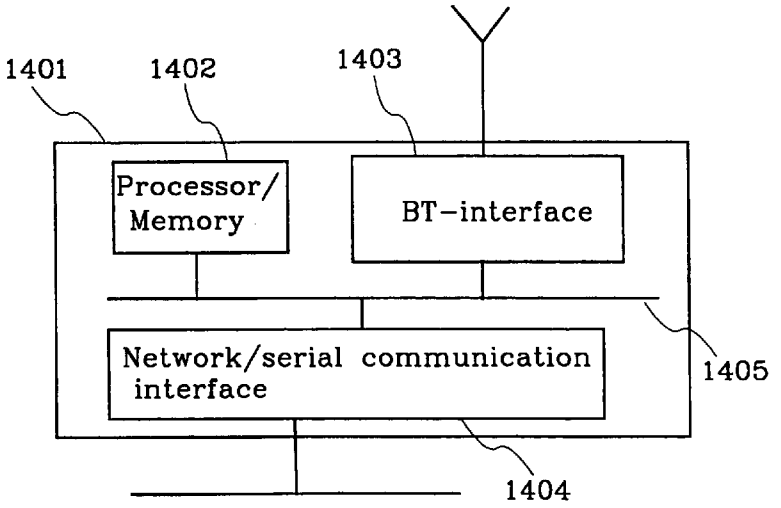


Fig.14

COMMUNICATION SYSTEM

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates in general to the field of radio communication and, in particular, to methods and means for providing a cellular radio communication system comprising a number of local radio networks utilising radio interfaces that are unsynchronised with each other and have no broadcast control channel.

DESCRIPTION OF RELATED ART

[0002] There are a number of equipments that have some sort of radio communication means. By "radio unit" is meant all portable and non-portable equipment intended for radio communication with a radio communication system. Examples of such radio units are mobile phones, cordless phones, pagers, telex, electronic notebooks, PCs and laptops with integrated radios, communicators, computers, wireless head sets, wireless printers, wireless keyboards or any other electronic equipment using a radio link as a mean of communication. These equipments can be used with any type of radio communication system, such as cellular networks, satellite or small local radio networks. They can also communicate directly with each other without using any system.

[0003] Cellular radio communication systems are commonly employed to provide voice and data communications to a plurality of radio units or subscribers.

[0004] Examples of such cellular radio communication systems are e.g. AMPS, D-AMPS, GSM, and IS-95 (CDMA). These systems generally include a number of base stations serving portable radio units, one or more base station controllers (BSC) and at least one mobile switching centre (MSC) or similar. All radio transmissions in the system are made via a specific radio interface that enables radio communication between the portable radio units and the base stations.

[0005] The cellular radio communication system covers a certain geographical area. This area is typically divided into cells or regions. A cell typically includes a base station and the radio units with which the base station is in communication. The cell associated with the particular base station with which a radio unit is communicating is commonly called the serving cell.

[0006] To each cell one or more voice/data and/or traffic/control channels are allocated. Note that "channel" may refer to a specific carrier frequency in an analogue system, e.g. AMPS, a specific carrier/slot combination in a hybrid TDMA/FDMA system, e.g. GSM or one or more assigned codes in a DS-CDMA system.

[0007] The cellular radio communication system usually provides a broadcast channel on which all radio units can listen to system information from base stations or measure signal strength and/or signal quality at regular intervals. Such a channel is called Broadcast Control Channel in GSM and Page or Access Channel in D-AMPS.

[0008] The process of changing cells during a call is often called a handover or handoff. As soon as one of the neighbouring cells is considered to have a better signal strength/quality than the serving cell, e.g. by signal measurements on the broadcast channel, a handover is made to that particular neighbouring cell.

[0009] The ability to move around, changing cells and connections over the radio interface when the radio unit is switched on or is in some kind of stand by mode but not engaged in a call is called roaming. When the radio unit is roaming it listens to the broadcast channel for information about the system e.g. in which specific area of the system the radio is presently located.

[0010] Today, a number of low-power, low-cost radio interfaces between radio units and their accessories are being developed. The intention is to replace the cables or infrared links, e.g. between a computer and a printer, with a short-range radio link (a wireless link) forming a local radio network.

[0011] A suitable frequency band for such a radio-interface is the 2,4 GHz ISM band (the Industrial-Scientific-Medical band) which ranges from 2,400-2,483 GHz in the US and Europe and from 2,471-2497 GHz in Japan. This frequency band is globally available, licence-free and open to any radio system.

[0012] There are some rules each radio system has to follow if they are to use this ISM band, e.g. in the ETSI standard ETS 300328. Synchronisation between different transmitters in a radio system using the ISM band is not allowed. Synchronisation is of course allowed between a transmitter and a receiver, e.g. when two radio units are communicating with each other. Another rule specifies that frequency spreading must be used for a radio interface using the ISM band. The IEEE 802.11 is an example of a specification utilising the ISM band.

[0013] An example of such a radio interface is called Bluetooth (see the Telecommunications Technology Journal "Ericsson Review", No. 3 1998, with the article "BLUETOOTH-The universal radio interface for ad hoc, wireless connectivity" by Jaap Haartsen). Bluetooth is an universal radio interface operating within the ISM band and enables portable electronic devices to connect and communicate wirelessly via short-range, ad hoc networks (local radio networks). Bluetooth uses a frequency-hop spread spectrum technique (FH-CDMA) where the frequency band is divided into several hop channels. During a connection, radio units with Bluetooth transceivers hop from one channel to the other in a pseudo-random fashion. Each channel is divided into a number of slots in a time division multiplexing scheme, where a different hop frequency is used for each slot.

[0014] A radio unit with Bluetooth can simultaneously communicate with up to seven other radio units in a small local radio network called a piconet. Each piconet is established by a unique frequency-hopping channel, i.e. all radio units in a specific piconet share the same frequency hopping scheme. One radio unit acts as a master, controlling the traffic in the piconet, and the other radio units in the piconet act as slaves. Any radio unit can become a master, but only one master may exist in a piconet at any time (often the one that initiates the connection). It is often the radio unit that initiates the connection that acts as a master. Any radio unit may change its role from slave to master or vice versa (a slave to master or a master to slave switch) Every radio unit

in the piconet uses the master identity and realtime clock to track the hopping channel. Hence the slaves must be informed of the identity and the clock of the master before they can communicate with the master.

[0015] Bluetooth supports both point-to-point (master to a slave) and point-to-multipoint (master to a number of slaves) connections. Two slaves can only communicate with each other through a master or by changing one of the slaves to a master with a slave to master switch.

[0016] There is no hop or time synchronisation between radio units in different piconets but all radio units participating in the same piconet are hop synchronised to one frequency-hopping channel and time synchronised so that they can transmit or receive at the right time. This does not contravene the rules of non synchronisation between transmitters in the ISM band because there is only one radio unit that is transmitting at any time instant in the piconet.

[0017] A radio unit can act as a slave in several piconets. This is achieved by using the time division multiplexing scheme of the channels where e.g. a first piconet is visited in a first time slot and a second piconet is visited in a third time slot. There are three different time slots on each channel where each time slot is split in two portions, one portion for transmitting and one portion for receiving.

[0018] There is no broadcast channel (e.g. a Broadcast Control Channel in GSM) in Bluetooth to which radio units that are not connected to or have not been connected to a Bluetooth piconet can listen to system information, "find" a base station or to measure the signal strength/quality on.

[0019] As Bluetooth is designed to replace cables or infrared links between different electronic equipments no roaming or handover support have been incorporated in the radio interface. As soon as a radio unit connected to a piconet is moved outside the radio coverage of the master, the radio unit loses its connection (the call).

SUMMARY

[0020] A number of problems occur when local radio networks, utilising radio interfaces that are unsynchronised with each other and have no broadcast control channel, are to be connected into and used as a cellular radio communication system.

[0021] A radio unit that is switched on in a local radio network can not be attached to the system with the help of a broadcast channel.

[0022] A radio unit that has established a link to one local radio network can not reach or be reached from another local radio network.

[0023] A radio unit can not roam or perform handover to a new local radio network when it is moved outside the local radio network it was first connected to.

[0024] The system can not measure the signal strength/quality from and keep track of neighbouring local radio networks to be able to perform high quality roaming and handover.

[0025] A radio node/base station from one local radio network can not establish a link with a radio unit in a neighbouring local radio network.

[0026] In light of the foregoing, a primary object of the present invention is to provide methods and means for creating a cellular radio communication system out of a number of local radio networks, where each network utilises a radio interface that has no broadcast channel and is unsynchronised compared to the other radio interfaces in the system. E.g. methods and means for attaching a radio unit to the system, retaining the connection to the system and providing measuring, roaming and handover capabilities.

[0027] According to a first aspect of the present invention there is a method for attaching a radio unit to a cellular radio communication system comprising a number of local radio networks utilising radio interfaces that are unsynchronised with each other.

[0028] According to a second aspect of the present invention there is a method for retaining a connection to a radio unit in a cellular radio communication system comprising a number of local radio networks utilising radio interfaces that are unsynchronised with each other.

[0029] According to a third aspect of the present invention there is a method for collecting data for a neighbouring list in a cellular radio communication system comprising a number of local radio networks utilising radio interfaces that are unsynchronised with each other.

[0030] According to a fourth aspect of the present invention there is a method for calculating the realtime clock of a first radio node in a second radio node in a cellular radio communication system comprising a number of local radio networks utilising radio interfaces that are unsynchronised with each other.

[0031] According to a fifth aspect of the present invention there is a method for co-ordinating the use of time slots in different local radio networks in a cellular radio communication system comprising a number of local radio networks utilising radio interfaces that are unsynchronised with each other.

[0032] A system according to the present invention comprises a control unit connected with a number of local radio networks and providing the basic means of a cellular radio communication system.

[0033] A control unit according to the present invention is connected with a number of local radio networks to provide the basic means for a cellular radio communication system.

[0034] An advantage with the present invention is that it is possible to attach and retain a radio unit that is switched on in the cellular radio communication system with no broadcast channel.

[0035] Another advantage is that it is possible to provide roaming and handover between local radio networks having radio interfaces that are unsynchronised with each other.

[0036] Still another advantage is that it is possible for a radio node in one local radio network to make a contact with a radio unit in another neighbouring local radio network.

[0037] Yet another advantage is that the signalling in the respective local radio network can be coordinated to facilitate inter local radio network communication.

[0038] Still another advantage is that it is possible for the system to keep track of neighbouring local radio networks to each radio unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] **FIG. 1** is illustrating a block diagram of a first embodiment of a cellular radio communication system according to the present invention

[0040] **FIG. 2** is illustrating a flow chart of a first method according to the present invention.

[0041] **FIG. 3** is illustrating a flow chart of a first embodiment of a second method according to the present invention.

[0042] **FIG. 4** is illustrating an example of a BRFP_candidates list according to the present invention.

[0043] **FIG. 5** is illustrating an example of a neighbouring list according to the present invention.

[0044] **FIG. 6** is illustrating a flow chart of a second embodiment of the second method according to the present invention.

[0045] **FIG. 7** is illustrating a flow chart of a first embodiment of a third method according to the present invention.

[0046] **FIGS. 8***a-b* are illustrating a block diagram of a paging scenario according to the present invention.

[0047] **FIG. 9** is illustrating a flow chart of a fourth method according to the present invention.

[0048] **FIG. 10** is illustrating a flow chart of a fifth method according to the present invention.

[0049] **FIG. 11***a* is illustrating uncoordinated timeslots in two local radio networks.

[0050] **FIG. 11***b* is illustrating co-ordinated time slots in two local radio networks according to the present invention.

[0051] **FIG. 12** is illustrating a block diagram of a second embodiment of a cellular radio communication system according to the present invention

[0052] **FIG. 13***a* is illustrating a schematic block diagram of a first embodiment of a control node according to the present invention.

[0053] **FIG. 13***b* is illustrating a schematic block diagram of a second embodiment of a control node according to the present invention.

[0054] **FIG. 14** is illustrating a schematic block diagram of a radio node according to the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0055] As previously stated, the present invention relates to a cellular radio communication system comprising a number of local radio networks (piconets).

[0056] **FIG. 1** illustrates a block diagram of a first embodiment of a cellular radio communication system **100** for utilising the present invention. The system **100** comprises a control-node (BCCFP) **108** connected to four radio-nodes (BRFP) **104-107** respectively. The BRFP **105** is serving two radio units (BPP) **101**, **102** respectively and the BRFP **107** is serving a radio unit (BPP) **103**. The BRFP **105** and the two BPPs **101**, **102** respectively utilises a radio interface, to enable communication between them, and forms a first piconet **109** (a first local radio network). The BRFP **107** and the BPP **103** utilises the same radio interface and forms a second piconet **110** (a second local radio network). The radio interface used in piconet **109** is not synchronised with the radio interface used in piconet **110**.

[0057] The control-node **108** may be connected to a PSTN (Public Switched Telephone Network) and/or a PLMN (Public Land Mobile Network) as illustrated by the dashed cloud **112**. The control-node **108** can also be connected to other control-nodes so as to form a bigger cellular radio communication system than illustrated in **FIG. 1**. This system **100** will be described in more detail at the end of this description.

[0058] **FIG. 2** illustrates a flow chart of a first method according to the present invention for attaching the BPP **101** to the cellular radio communication system **100** in **FIG. 1**. Attaching a BPP means that the cellular system becomes aware of that a new radio unit is switched on in the system, where in the system the new radio unit is located, if the new radio unit is authorised to use the system and to registrate the new radio unit in the system.

[0059] According to a step **201**, the BPP **101** establishes a link with the BRFP **105** so that it becomes a part of the first piconet **109** in **FIG. 1**. The BPP scans for BRFPs within its radio coverage area, at regular intervals, by transmitting inquire signals (LC_INQUIRY) including the identity and the realtime clock of the BPP **101**. The BRFPs in radio range answers by transmitting acknowledge signals (LC_FHS_{BRFP}) including their identity and realtime clocks to the BPP **101**. The BPP **101** can then select one of these BRFPs, in this case BRFP **105**, and transmit a page signal (LC_PAGE) to the selected BRFP and establish the link. The BPP **101** assumes the role as a master and the BRFP **105** takes the role as a slave. The BRFP **105** receives identification data from BPP **101**, e.g. the IEEE-identity and/or if the radio unit **101** is equipped with a SIM-card the IMSI identity. The BRFP **105** also receives information regarding the class of service provided by the BPP **101**, authentication, and as previously stated the realtime_clock of the BPP **101** which is needed to calculate the frequency hopping sequence in the BRFP **105**.

[0060] The BPP **101** makes the first contact, by the LC_INQUIRY, with the BRFP **105** before it can detect any signal from the BRFP **105**. The BRFP **105** needs to know at least the identity of the BPP **101** (received by the LC INQUIRY) to be able to transmit a signal that the BPP **101** can detect. This is because that there is no broadcast control channel in the radio interface utilised in the system **100**.

[0061] According to a step **202**, the BRFP **105** performs a Bluetooth authentication (LMP_Bluetooth_Authentication). This is performed between the Bluetooth circuits in the BRFP **105** and the BPP **101** in a known way.

[0062] According to step **203**, the BRFP **105** forwards the information and the identification data received in step **201** to the BCCFP **108**.

[0063] According to step **204**, the BCCFP **108** identifies the BPP **101** by the identification data.

[0064] According to step **205**, the BCCFP **108** authenticates the BPP **101**. As an example, the known authentication technique used in GSM can be used for this authentication. The IEEE identity with additional authentication information can also be used.

[0065] According to step **206**, the BCCFP **108** registers the identity of the BPP **101** in the system. This means that

the BPP **101** has established a connection with the system **100** and is ready to receive incoming calls etc.

[**0066**] According to a step **207**, the BRFP **105** initiates a Master-Slave switch so that the BRFP **105** becomes the master and the BPP **101** becomes the slave.

[**0067**] According to step **208**, the BRFP **105** puts the BPP **101** in a parked mode by transmitting a park command. This means that the BPP **101** will terminate the link to the BRFP **105** but still be active and listen for signals from the BRFP **105** (the master) so that it can retain the link to the BRFP **105** again. This means that if the maximum number of BPPs in a piconet is 7 and the BPP **101** was the 7^{th} one a new BPP may not be able to connect to the piconet after the BPP **101** is put in the parked mode.

[**0068**] **FIG. 3** illustrates a flow chart of a second method according to the present invention for retaining the connection to the BPP **101** in the cellular radio communication system **100** in **FIG. 1** after the BPP **101** has been attached to the system.

[**0069**] According to a step **301**, the BRFP **105** (the master) establishes a beacon signalling to the BPP **101** (the slave) at evenly spaced time instants (beacon intervals). This means that the BPP **101** receives signals from the BRFP **105** at the beacon intervals.

[**0070**] This beacon signal can as an example comprise parameters that activates a parked slave (e.g. a channel access code for the BPP **101**), re-synchronises parked slaves or allows certain slaves to access the channel. This signal can as an alternative also include information regarding how busy the BRFP **105** is. The beacon signal is transmitted to a number of specific radio units, in this case the BPP **101**, and not to all radio units within radio range of the radio node as with a broadcast channel. The beacon signal is intended as a means for a master to retain the link to slaves that are not active in any transmissions and if needed to activate parked slaves (see step **208** above).

[**0071**] If, according to a step **302**, the BPP **101** is in a parked mode the method continues with step **303**, otherwise it **30** continues with step **304**.

[**0072**] According to a step **303**, the BRFP **105** activates the parked BPP **101** by transmitting a page with the identity of the BPP **101**. This can be made at evenly spaced time instants.

[**0073**] According to a step **304**, the BPP **101** measures a signal parameter, e.g. the signal quality or signal strength, on the beacon signal from BRFP **105**. The BPP **101** transmits this measurement to the BRFP **105** in a result signal.

[**0074**] According to a step **305**, the BRFP **105** measures the signal parameter on one or more signals from the BPP **101**, e.g. the result signal in step **304**. The BRFP **105** forwards the measurements in step **304** and **305** to the BCCFP **108** which stores them in a BRFP_candidates list. See **FIG. 4** which illustrates an example of such a list. The BRFP **105** puts the BPP **101** in parked mode again if the BPP **101** where in a parked mode in step **302**.

[**0075**] According to step **306**, the BCCFP **108** checks if there is a neighbouring list for the BRFP **105** stored in the BCCFP. If not, the method continues with step **701** according to **FIG. 7** for creating such a list. The neighbouring list for BRFP **105** comprises information of which additional BRFPs in the system that a BPP connected to BRFP **105** in piconet **109** should be able to hear. **FIG. 5** shows an example of such a neighbouring list for BRFP **105** where BRFP **104** and **106** are listed as neighbours.

[**0076**] According to step **307**, the BCCFP **108** orders the BRFPs **104** and **106** in the neighbouring list to page the BPP **101**, activate the BPP if needed, establish a beacon signalling and perform measurements according to step **301**-**305**. If a BRFP on the neighbouring list is unable to establish a link to the BPP **101** (the BPP **101** may temporarily be out of reach) it will continue to page the BPP **101** as long as the BPP **101** remains in the piconet **109** associated with the BRFP **105**. The BRFPs **104** and **106** on the neighbouring list can page (reach) the BPP **101** thanks to the BCCFP **108** which distributes the identity of the BPP **101** to the BRFPs.

[**0077**] The three BRFP **104**, **105** and **106** respectively will now have beacon signalling ongoing with the BPP **101**. The BRFP **104**, **106** respectively will measure one or more signal parameters, e.g. the signal quality and/or signal strength, from the BPP **101** whenever they have free capacity for that. As an alternative, if the BPP **101** is in a parked mode, one BRFP, e.g. BRFP **105**, can activate the BPP **101**, receive measurements from the BPP and deactivate the BPP within a short interval and the other BRFPs, e.g. BRFP **104** and **106**, can do the same but within a longer interval to reduce the signalling within the system. If this is the case, the BPP may perform measurements on the BRFPs **104** and **106** at the same time as on the BRFP **105** and transmit these measurements to the BRFP **105** at the shorter intervals.

[**0078**] **FIG. 6** illustrates a flow chart of a second embodiment of the second method where the measurements in step **304** and **305** are made during an ongoing call. This means that step **304** and **305** according to **FIG. 3** may be replaced by the following steps.

[**0079**] According to a step **601**, the BRFP **105** transmits information to the BCCFP **108** regarding the exact clock information and hop sequence used for the call/link to the BPP **101**.

[**0080**] According to a step **602**, the BCCFP **108** forwards the information received in step **601** to the BRFP **104** and **106**, i.e. to all additional BRFPs on the neighbouring list for BRFP **105**.

[**0081**] According to a step **603**, the BRFP **104** and **106** measures the signal strength and/or signal quality on the ongoing call between the BRFP **105** and the BPP **101**, e.g. in a separate receiver in the BRFPs dedicated for monitoring (e.g. measuring).

[**0082**] According to a step **604**, the BRFP **104** and **106** transmits the measured signal strength and/or signal quality to the BCCFP **108** which stores these measurements in the BRFP_candidates list for the BRFP **105**.

[**0083**] The steps **601**-**604** may in a third embodiment of the second method (not illustrated) be used as a complement to step **304** and **305** instead of replacing them. This means that steps **601**-**604** are performed after step **607** in **FIG. 3**.

[**0084**] If the link between the BPP **101** and the BRFP **105** becomes bad the second method may continue to perform roaming as the described below (not illustrated in any flow charts).

[0085] The link roams from BRFP **105** to BRFP **104** that, according to the BRFP_candidates list for BRFP **105**, has the best signal strength and/or signal quality for the moment (see **FIG. 4**). This means that the BCCFP **108** selects the new BRFP for roaming with the help of the BRFP_candidates list. This selection may as an alternative or as a complement be made on free capacity in the neighbouring BRFPs.

[0086] If the BPP **101** does not respond to any signalling from the BRFP **104**, e.g. a page signal, the second method may end by unregister the BPP **101** as described below (not illustrated in any flow chart).

[0087] The BRFP **104** transmits an unregistered message (UNREG) to the BCCFP **108** regarding a link loss to the BPP **101**.

[0088] The BCCFP **108** controls if any other BRFP, e.g. BRFP **105** and **106**, have an ongoing beacon signalling to the BPP **101**. This is made e.g. by checking the BRFPs on the neighbouring list. The BCCFP **108** unregisters the BPP **101** in the system (all links lost to BPP **101**) if no BRFP in the system has an ongoing beacon signalling to the BPP **101**.

[0089] If a system initiated handover is to be performed, the second method may continue with a handover as described below (not illustrated).

[0090] The BCCFP **108** selects a new BRFP from the neighbouring list of the BRFP **104** and orders the selected BRFP, e.g. the BRFP **105**, to initiate a handover.

[0091] If a BPP initiated handover is to be performed, the second method may continue with a handover as described below (not illustrated).

[0092] The BPP **101** establishes a new link with the BRFP **105** which, according to the BRFP_candidates list for BPP **101**, has the highest signal strength and/or signal quality.

[0093] The BRFP **105** orders the BCCFP **108** to route the call to the BRFP **105**. Hence both BRFP **104**, **105** respectively are connected to the BPP **101** for a short moment.

[0094] The BRFP **105** initiates a termination of the link from the BRFP **104** to the BPP **101** when the new link is established. This is made via the BCCFP **108**.

[0095] **FIG. 7** illustrates a flow chart of a third method according to the present invention for collecting data for a neighbouring list for the respective BRFP in the system used e.g. in the second method above. The collected data is used for creating and updating the neighbouring lists for the respective BRFP. As previously been stated, the neighbouring list for the BRFP **105** comprises information of which additional BRFPs in the system that the BPP **101** in piconet **109** can hear. This can e.g. be performed when a new system is run for the first time, when new BRFPs are added to the system, at specified intervals, or when one or several BRFPs are moved to a new location within the system.

[0096] According to a step **701**, all BRFPs in the system **100** transmits a page signal (LC_PAGE) to the BPP **101**, see **FIG. 8***a*. The BRFPs have been given the identity of the BPP **101** from the BCCFP **108** which also may initiate this step.

[0097] According to a step **702**, the BPP **101** transmits a response-signal (BRFP_same_time list) to the BRFP **105**. The response-signal comprises information regarding which BRFP the BPP **101** can hear (e.g. detected a page signal from) at the same time and, as an alternative, also the signal strength on the detected page signal (LC_PAGE). This response signal may be transmitted each time a new BRFP has established beacon signalling with the BPP **101** (e.g. in step **307**).

[0098] According to a step **703**, the BRFP **105** forwards the information received in step **702** to the BCCFP **108**. The BCCPF **108** collects this information and creates the neighbouring list for the BRFP **105** by registrating the BRFPs (except the BRFP **105**) that the BPP **101** have heard in step **702** as neighbours to the BRFP **105** or if such a list already exists updates the neighbouring list accordingly. This can as an. example be made by adding "new" neighbouring BRFPs, included in the response signal (BRFP_same_time list) but not registrated in the neighbouring list, and deleting "old" neighbouring BRFPs, registrated in the neighbouring list but not included in the response signal. A delay may be used for the deletion of BRFPs in the neighbouring list to avoid deletion of BRFPs that are just temporarily out of reach for the page. As an example, a certain BRFP on the list must be excluded from two or more consecutive response signals received according to step **702** before being removed from the neighbouring list.

[0099] The BCCFP **108** can now direct signals to the BRFP serving a specific BPP in the system and its neighbouring BRFPs, e.g. for page signals, with the help of the neighbouring list which reduce the signalling within the system as seen in **FIG. 8***b*. This improves the performance of the system.

[0100] **FIG. 9** illustrates a flow chart of a fourth method according to the present invention where the realtime clock of a BRFP in one piconet is calculated by a BRFP in another piconet, e.g. the realtime clock of BRFP **105** is calculated by the BRFP. **106**, see **FIG. 1**. This method is preferably performed when more than one BRFP (from different piconets) have established a link with one and the same BPP. In the steps below both the BRFP **105** and the BRFP **106** in the system **100** have established a link with the BPP **102**.

[0101] According to a step **901**, the BRFP **105** calculates a first realtime_clock difference value (Δ**1**_CLOCK) between the BPP **102** and its own realtime_clock (clock_BPP_{102}−clock_$BRFP_{105}$).

[0102] According to a step **902**, the BRFP **105** transmits the calculated Δ**1**_CLOCK value to the BCCFP **108** which stores it in a sync-list or as an alternative in the neighbouring list.

[0103] According to a step **903**, the BRFP **106** calculates a second realtime_clock difference value (Δ**2**_CLOCK) between the BPP **102** and its own clock (Clock_BPP_{102}−Clock_$BRFP_{106}$).

[0104] According to a step **904**, the BRFP **106** transmits the calculated Δ**2**_CLOCK value to the BCCFP **108** which stores it in the sync-list. As an alternative, the BCCFP **108** can distribute Δ**1**_CLOCK and Δ**2**_CLOCK values to the BRFPs **104**, **106** and **107**.

[0105] According to step **905**, the BCCFP **108** calculates the BRFP_realtime_clock difference value (Δ**3**_CLOCK) between the BRFP **106** and the BRFP **105** (Clock-

$_BRFP_{106}$−Clock_$BRFP_{105}$) according to the following equation:

$$\Delta 3_CLOCK=\Delta 1_CLOCK-\Delta 2_CLOCK=[Clock_BPP_{102}-Clock_BRFP_{105}]-[Clock_BPP_{102}-Clock_BRFP_{106}]=-Clock_BRFP_{105}+Clock_BRFP_{106}=Clock_BRFP_{106}-Clock_BRFP_{105}$$

[0106] The Δ3_CLOCK value is stored in the sync-list.

[0107] If, according to a step **906**, the BCCFP wants the BRFP **106** to establish a link to the BPP **101** in the neighbouring piconet **109**, e.g. establish beacon signalling according to step **305**, the method continues with step **907** below, otherwise it ends.

[0108] According to step **907**, the BCCFP **108** transmits the Δ3_CLOCK value to the BRFP **106** and orders the BRFP **106** to transmit an LC_PAGE to the BPP **101**.

[0109] According to a step **908**, the BRFP **106** calculates the realtime clock of the BRFP **105** (Clock_$BRFP_{105}$) to which the BPP **101** is listening, e.g. during park or active mode.

[0110] Every BPP in a piconet uses the master clock (e.g. a BRFP clock) to track the common hopping channel in the piconet when the BPPs have assumed the roles as slaves. Hence if the master clock in a current piconet is known, the BPP in the current piconet can be easily reached from other BRFPs or BPPs outside the current piconet as long as they are within radio reach. The Clock_$BRFP_{105}$ is calculated according to the following equation:

$$Clock_BRFP_{105}=\Delta 3_CLOCK-Clock_BRFP_{106}=Clock_BRFP_{106}-Clock_BRFP_{105}-Clock_BRFP_{106}=Clock_BRFP_{105}$$

[0111] According to step **909**, the BRFP **106** transmits an LC_PAGE to the BPP **101** and establishes a new link and a new piconet with the BPP **101**.

[0112] The calculation in step **905** can as an alternative be made in the BRFP **106** as well as the calculation in step **908** if the BCCFP **108** transmits the information regarding the BRFP_realtime differences that is stored in the sync-list to the BRFP **106**.

[0113] In short, all the BRFPs in the cellular radio communication system calculates the realtime_clock differences between the BPPs they are connected to and their own realtime clocks. The BRFPs transmits the realtime_clock differences to the BCCFP **108** where they are used for calculating the BRFP_realtime_clock differences between each BRFP in the system. A first BRFP associated with a first piconet can then page a second BPP in a second piconet (e.g. to establish a new piconet) very accurately and quickly with the help of the BRFP realtime_clock difference as described in step **908**.

[0114] **FIG. 10** illustrates a flow chart of a fifth method according to the present invention for co-ordinating the use of timeslots in -each piconet associated with the cellular radio communication system. This method is preferably performed when a call is in progress on a link in a piconet and hence one available time slot is occupied.

[0115] According to a step **1001**, the BRFPs **104-107** in the system **100** calculates the realtime_clock differences between the BPPs they are connected to and their own realtime clocks as in step **901** and **903** according to **FIG. 9**.

[0116] According to a step **1002**, the BRFPs **104-107** transmits the calculated realtime_clock differences to the BCCFP **108**, as in step **902** and **904** according to **FIG. 9**.

[0117] According to a step **1003**, the BCCFP **108** calculates the BRFP_realtime_clock differences between the BRFP **104-107**, as in step **905** according to **FIG. 9**, from the realtime_clock differences received in step **1002**.

[0118] According to a step **1004**, the BCCFP **108** selects the realtime_clock of BRFP **104** as a reference clock (ref_clock) for all piconets in the system **100**. This can as an example be made by giving the first slot from BRFP **104** the time value 0 whereby the other BRFPs are given an offset value according to their BRFP_realtime_clock difference with BRFP **104** which are e.g. added to or subtracted from their own realtime clocks.

[0119] According to a step **1005**, the BCCFP **108** orders all BRFPs in the system **100** to use, as long as possible, a time slot co-ordinated with the ref_clock for signalling and payload to their respective BPP.

[0120] This means that the signalling in the system **100** can be made more effective by increasing the probabilities of a fast connection set-up between BPPs and BRFP in different piconets, since blocked time slots (blind_spots) will be more rare. Further on the total system capacity will increase.

[0121] **FIG. 11***a* illustrates uncoordinated traffic and signalling in piconet **109** and **107** in system **100**. There are three timeslots, each with a transmit portion and a receive portion, on the hopping channel in each piconet that the BPPs and BRFPs can use. BRFP **105** and BPP **101** communicates on the first timeslot and BRFP **105** and BPP **102** communicates on the second timeslot in piconet **109**, which means that the third timeslot in piconet **109** is free. BRFP **107** and BPP **103** communicates on the third timeslot in piconet **110**, which means that the first and second timeslot in piconet **110** are free. If BRFP **107** wants to page BPP **102** in piconet **109**, the BRFP **107** has to use the first or second timeslot in piconet **110** (the free ones) but the corresponding timeslots in piconet **109** are not free. This means that the BRFP **107** can not reach the BPP **102** right know and have to wait until the communication on the first or second timeslot in piconet **109** stops. Hence two blind_spots **1101** and **1102** have occurred.

[0122] **FIG. 11***b* illustrates the same traffic and signalling as in **FIG. 11***a* but co-ordinated according to the fifth method (**FIG. 10**). The realtime clock of the BRFP **105** is selected as the ref_clock and the BRFP **107** has co-ordinated its traffic to BPP **103** accordingly so that the BPP **102** can be reach by a page P from the BRFP **107** in the third timeslot. The third timeslot in BPP **102** is synchronised with the third timeslot in BRFP **107** by introducing a small pause **1103** between the second and third timeslot in BPP **102**. This means that a part of the space where the next timeslot in BPP **102** (the first one due to the three time slot scheme) where to be put is used for the third timeslot. The first timeslot can therefore not be used for the moment. As seen in **FIG. 11***b* the BRFPs in the respective piconet are still not synchronised to each other.

[0123] The inventive methods according to **FIGS. 2, 3, 6, 7, 9** and **10** can be completely or partially implemented as software in at least one microprocessor.

[0124] As previously been described, **FIG. 1** illustrates a block diagram of a first embodiment of a cellular radio

communication system **100** for utilising the present invention. The BRFPs in **FIG. 1** are connected to the BCCFP **108** via a local area network (LAN) **111**.

[**0125**] **FIG. 12** illustrates an alternative connection where each BRFP is circuit switched connected to a switch **1201**, preferably arranged in the BCCFP **108**, via dedicated transmission lines. The BRFPs can as another alternative be connected to the BCCFP **108** via one or more radio links, e.g. a radio-LAN or wireless-LAN (WLAN).

[**0126**] Each BRFP and BPP comprises at least one Bluetooth circuit/chip for utilising the radio communication over the Bluetooth radio interface. The Bluetooth radio interface is one example of a radio interface utilised in small short range local radio network. Other radio interfaces with similar characteristics may also be used.

[**0127**] The system **100** can as an example be an indoor cellular radio communication system where the first piconet **109** is situated in a first room and the second piconet **110** is situated in a second room. The BRFPs **1.05** and **107** can as an example be personal computers (PCs) with means for radio communication and connected to the LAN **111**. The BPP **101** can as an example be a cordless phone, the BPP **102** a laptop with means for radio communication and the BPP **103** a printer with means for radio communication. The BRFP **106** may be a phone situated in a third room and connected to the LAN by wire. If the BPP **101** is moved to the third room the BRFP **106** and the BPP **101** establishes a connection and hence forms a new (third) piconet.

[**0128**] A complete cellular radio communication system needs to have some basic functionality's to work and reach an acceptable system behaviour. Those are described in the methods according to **FIGS. 2, 3, 6, 7, 9** and **10**.

[**0129**] All these basic functionality's are provided in the cellular radio communication system **100** according to the present invention. This is achieved by the BCCFP **108** (the control node) connected to all BRFPs in the system **100**.

[**0130**] **FIG. 13***a* illustrates a schematic block diagram of a first embodiment of a BCCFP **1301** (control node) according to the present-invention. The BCCFP **1301** comprises a processor with a memory **1302**, a hard disk **1303** and a network interface **1304** connected to each other by a computer bus **1305**. The processor with the memory is e.g. used for creating and updating the neighbouring lists and calculating realtime clock differences. The hard disk is e.g. used for storing the neighbouring lists, realtime clock and identity information. The network interface **1304** is used for connecting the BCCFP to the BRFPs via a LAN **1306**. All voice and data traffic is separated from the BCCFP in this embodiment and hence processed by a separate voice/data unit **1307** connected to the LAN **1306**.

[**0131**] **FIG. 13***b* illustrates a schematic block diagram of a second embodiment of a BCCFP **1308** according to the present invention where the voice/data unit **1307** is integrated in the BCCFP **1308**. The voice/data unit **1307** comprises a voice codec and means for conversion between circuit switched and packet switched information.

[**0132**] **FIG. 14** illustrates a schematic block diagram of a BRFP **1401** (radio node) according to the present invention. The BRFP comprises a processor with a RAM memory and a flash memory **1402**, a bluetooth radio interface chip/unit **1403** and a network or serial communication interface **1404** connected to each other by a computer bus **1405**. The processor with the RAM memory and flash memory is e.g. used for processing and distributing realtime clock information. The bluetooth radio interface chip/unit has previously been described. The network interface is used for connecting the BRFP to a LAN according to **FIG. 1** and the serial communication interface is used if the BRFP is circuit switched connected according to **FIG. 12**.

1-13. (Canceled)

14. A method for calculating the realtime clock of a first radio node in a second radio node in a cellular radio communication system comprising a number of local radio networks utilizing radio interfaces which, between said local radio networks are unsynchronized with each other, where each of said local radio networks comprises a radio node arranged to communicate with a plurality of radio units comprising:

establishing a link between a first radio unit and both of said first and second radio nodes:

generating a first BRFP realtime clock difference between the realtime clocks of said first radio node and said second radio node in a control node associated with said radio nodes;

transmitting said first BRFP realtime clock difference to said second radio node; and

calculating the real time clock of said first radio node in said second radio node by adding said first BRFP realtime clock difference to the realtime clock of said second radio node.

15. The method as claimed in claim 14, wherein said step of generating a first BRFP realtime clock difference comprises the steps of:

calculating a first realtime clock difference between said first radio unit and said first radio node in said first radio node;

transmitting said first realtime clock difference to said control node;

calculating a second realtime clock difference between said first radio unit and said second radio node in said second radio node;

transmitting said second realtime clock difference to said control node;

calculating said first BRFP realtime clock difference in said control unit from said first and second realtime clock difference.

16. The method as claimed in claim 14, wherein said step of calculating the realtime clock of said first radio node in said second radio node is followed by the step of:

paging a second radio unit from said second radio node, where said second radio unit has established a link to said first radio node.

17. A method for co-ordinating the use of time slots in different local radio networks in a cellular radio communication system comprising a number of local radio networks utilizing radio interfaces which, between said local radio networks, are unsynchronized with each other and having at least three timeslots, and where each of said local radio

networks comprises a radio node arranged to communicate with a plurality of radio units the method comprising:

generating a BRFP realtime clock difference between all the realtime clocks of said radio nodes in said system in a control node associated with said radio nodes;

selecting the realtime clock of a first one of said radio nodes as a reference clock for all radio nodes in said system;

ordering all radio nodes in said system to use timeslots co-ordinated with said reference clock of said first radio node for signalling and payload by using said BRFP realtime clock differences.

18. The method as claimed in claim 17, wherein said step of generating a BRFP realtime clock difference between all the realtime clocks of said radio nodes comprises the steps of:

calculating realtime clock differences in all radio nodes between their own realtime clocks and said radio units which they are connected too;

transmitting said realtime clock differences to said control node;

calculating said BRFP realtime clock difference from said calculated realtime clock difference in said control node.

19-24. (Canceled)

25. A control node in a cellular radio communication system comprising a number of local radio networks utilizing radio interfaces which, between said local radio networks are unsynchronized with each other, and where each of said local radio networks comprises a radio node arranged to communicate with a plurality of radio units, characterised in that said control node is connected to at least one radio node in each local radio network in said system so as to create a cellular radio communication system out of said local radio networks, and where said control node is arranged to control the communication in each of said local radio networks.

26. The control node as claimed in claim 25, wherein said control node comprises means for establishing a connection from each one of said radio nodes to said control-node.

27. The control node as claimed in claim 25, wherein said control node comprises means for identifying, authenticating and registrating each one of said radio units so that said control node can direct calls to and from said radio units.

28. The control node as claimed in claim 25, wherein said control node comprises means for roaming links to radio units between said radio nodes in said system.

29. The control node as claimed in claim 25, wherein said control node comprises means for performing handovers of connections to said radio units between said radio nodes in said system.

30. The control node as claimed in claim 25, wherein said control node comprises means for generating a BRFP realtime clock difference between all the realtime clocks of said radio nodes in said system.

31. The control node as claimed in claim 25, wherein said control node comprises:

means for selecting the realtime clock of a first one of said radio nodes as a reference clock for all radio nodes in the system; and

means for ordering all radio nodes in said system to use timeslots coordinated with said reference clock of said first radio node for signalling and payload.

32. The control node as claimed in claim 25, wherein said control node comprises:

means for creating a neighbouring list by registrating said radio nodes from which said first radio unit can detect a signal as neighbours to said first radio node.

33. A control node, comprising:

a processor,

a memory in communication with the processor, wherein the memory includes instructions for calculating the realtime clock of a first radio node in a second radio node in a cellular radio communication system comprising a number of local radio networks utilizing radio interfaces which, between said local radio networks, are unsynchronized with each other, where each of said local radio networks comprises a radio node arranged to communicate with a plurality of radio units,

wherein the calculating instructions comprise instructions for:

establishing a link between a first radio unit and both of said first and second radio nodes:

generating a first BRFP realtime clock difference between the realtime clocks of said first radio node and said second radio node in a control node associated with said radio nodes;

transmitting said first BRFP realtime clock difference to said second radio node; and

calculating the real time clock of said first radio node in said second radio node by adding said first BRFP realtime clock difference to the realtime clock of said second radio node.

34. The node of claim 33, wherein the instructions for generating a first BRFP realtime clock difference further comprises instructions for:

calculating a first realtime clock difference between said first radio unit and said first radio node in said first radio node;

transmitting said first realtime clock difference to said control node;

calculating a second realtime clock difference between said first radio unit and said second radio node in said second radio node;

transmitting said second realtime clock difference to said control node; and

calculating said first BRFP realtime clock difference in said control unit from said first and second realtime clock difference.

35. The node of claim 33, wherein the instructions for calculating the realtime clock of said first radio node in said second radio node also contains instructions for paging a second radio unit from said second radio node, where said second radio unit has established a link to said first radio node.

36. A control node comprising:

a processor,

a memory in communication with the processor, wherein the memory includes instructions coordinating the use of time slots in different local radio networks in a cellular radio communication system comprising a number of local radio networks utilizing radio interfaces which, between said local radio networks, are unsynchronized with each other and having at least three timeslots, and where each of said local radio networks comprises a radio node arranged to communicate with a plurality of radio units, wherein the instructions for coordinating comprise instructions for:

generating a BRFP realtime clock difference between all the realtime clocks of said radio nodes in said system in a control node associated with said radio nodes;

selecting the realtime clock of a first one of said radio nodes as a reference clock for all radio nodes in said system; and

ordering all radio nodes in said system to use timeslots coordinated with said reference clock of said first radio node for signaling and payload by using said BRFP realtime clock differences.

37. The node of claim 36, wherein the instructions for generating a BRFP realtime clock difference between all the realtime clocks of said radio nodes comprises instructions for:

calculating realtime clock differences in all radio nodes between their own realtime clocks and said radio units which they are connected too;

transmitting said realtime clock differences to said control node; and

calculating said BRFP realtime clock difference from said calculated realtime clock difference in said control node.

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