

Communication system and call establishment methods

Field of the Invention

5 The present invention relates to a communication system comprising a cellular mobile communication network, which includes a mobile services switching center, a base station controller and base stations, as well as a private branch exchange (PBX) system having at least one base station.

10 Background of the Invention

The conventional access technique to a fixed telephone network is a subscriber line (2-wire line) extending from a local exchange all the way to a subscriber's telephone. Presently, however, wireless access techniques are the fastest growing area within data communication. As a result, an ever increasing portion of new subscriber connections to the communication network will be wireless. The first generation of wireless subscriber connections consisted of analogue cordless phones (the CT1 system, for example), which consisted of a base station connected to a wired subscriber line of a public switched telephone network (PSTN), and a hand-held handset. The succeeding generation consisted of a digital cordless phone, known as the CT2 system. In addition to 20 the conventional cordless phone, the CT2 system offered a telepoint service and a wireless Private Automatic Branch exchange (PABX). Furthermore, a standard is being developed for a European digital wireless telephone system, known by the abbreviation DECT. To a large extent, DECT is similar to the CT2, but utilizes TDMA technique. Additionally, cordless systems based on radio interfaces of mobile communication systems, such as the NMT system, have been realized wherein a subscriber's mobility related features are limited or completely non-existent.

35 One form of wireless communication is represented

by mobile communication systems which do not provide the subscribers with a fixed access point in the network at all. Instead, the subscribers may communicate with the network via any of the base stations of the network. In order to route mobile terminating calls to a correct point at any one time, the network maintains, at the subscriber database, the location information of the subscriber. As a mobile terminating call is received by the network, the first MSC in the network carries out an enquiry to the subscriber database, and is provided with the routing address in the network.

An interesting area within wireless communication is represented by wireless PABXs. PABXs (or PBXs) are, as known, a type of office-specific private telephone exchanges that have a plurality of extensions and a smaller number of trunk lines to the local exchange. At the PABX, inexpensive (free) internal calls can be set up from an extension to another, and external calls can be set up between an extension and a PSTN trunk line. A wireless PABX is typically, as to its basic structure, a conventional "wired" PABX, but the cabling within the building is partly or entirely replaced with radio connections. The radio standards potentially applicable to PABX applications are represented for example by the aforementioned CT2 and DECT, or solutions evolving from the Pan-European digital mobile communication system GSM. The advantages of wireless PABXs are claimed to include:

- Mobility of terminal equipments. The user no longer needs to be at a specific place in the building.
- Location of the personnel. It will be easier to contact people who are outside their office buildings.
- Reduced investments in cabling inside the building.
- No costs regarding re-arranging or maintaining the cabling at the extension end of the PABX.

As noted in the above, a wireless PABX is typically implemented by using the CT2 or DECT radio interface at the extension end of the exchange. The trunk line of the PABX is in the conventional way connected to a PSTN local exchange. Consequently, the freer mobility provided by a wireless PABX is limited to the area covered by the base stations of the PABX itself, i.e. the office environment. Using phones outside the office is confined to telepoint services.

In order to extend the mobility of wireless subscriber stations several solutions have been proposed in which the wireless PABX is integrated as a part of a mobile communication system. In such a case, the trunk line end of the wireless PABX is connected to the BSC or the MSC in the place of a conventional base station. The extension end of the PABX is implemented with CT2, DECT or similar radio interfaces similarly as in wireless PABXs connected to the PSTN network. As far as location management is concerned, wireless subscribers are managed like ordinary mobile subscribers in the mobile communication network. In principal, this enables a wireless subscriber to move from a wireless PABX to another if both PABXs are connected to the mobile communication network. In addition, prior art phones may be dual-mode devices so that they can operate both via the base stations of the wireless PABX and via the base stations of the mobile communication network. Consequently, one subscriber equipment provides mobility within the entire mobile communication network and inexpensive PABX internal calls in the office. These solutions, however, utilize procedures of the mobile communication network for establishing external calls, making them more expensive. In addition, special solutions are typically required in the signalling between the elements of the mobile communication network and the

signalling used in the radio interface of the PABX. Furthermore, dual-mode subscriber equipments are required in order to be able to utilize all the features of the mobile communication network, increasing the costs of the subscriber equipments.

Disclosure of the Invention

An object of the present invention is a communication system in which a wireless private exchange can be implemented in association with a mobile communication network in a way that requires less changes than before in the PABX or the mobile communication network.

It is also an object of the invention to provide inexpensive internal and external calls at a wireless PABX connected to a mobile communication network.

Yet another object of the invention is a communication system having similar radio interfaces and similar subscriber equipments at the mobile communication network and the wireless PABX.

These objects are achieved by means of a communication system comprising a cellular mobile communication network, which includes a mobile services switching center, a base station controller and base stations, as well as a private exchange system having at least one base station. According to the invention the system is characterized in that the subscriber side of the PABX system is connected to the BSC and the trunk side is connected to another communication network; the PABX base station is connected to the base station controller; the base station controller is arranged to route subscriber calls originating from the PABX base station to the PABX system, and calls coming in via the PABX system to the PABX base station.

The invention also relates to a method for establishing an outgoing call in a communication system

comprising a cellular mobile communication network which contains a mobile services switching center, a base station controller and base stations, as well as a private branch (PABX) system having at least one base station, the method comprising the steps of transmitting a connection request from the subscriber to the base station controller via the PABX base station; activating call set-up. According to the invention, the method is characterized by checking at the base station controller whether the transmitting party of the connection request is a PABX subscriber or a standard subscriber of the mobile communication network; routing the call of the PABX subscriber from the base station controller to the PABX system, whose subscriber side is connected to the base station controller and the trunk side to another communication network; connecting the call to the mobile services switching center if the subscriber is not a PABX subscriber.

The invention also relates to a method for establishing a terminating call in a wireless communication system comprising a cellular mobile communication network which contains a mobile services switching center, a base station controller and base stations, as well as a private branch (PABX) system having at least one base station, in which method a call terminating to PABX subscriber is received in the PABX system. According to the invention, the method is characterized by the steps of initiating, from the private branch exchange system, call establishment at the base station controller to which the subscriber side of the PABX system and said PABX base station are coupled; transmitting from the base station controller a paging message to said PABX subscriber via the PABX base station; receiving an acknowledgement message from the PABX subscriber; establishing a connection according to the

mobile communication network between the base station controller and the PABX subscriber; and connecting a speech connection between the PABX subscriber and said PABX system via the base station controller and the PABX base station.

According to the invention, the BSC of the mobile communication network is provided with an interface to which the extension side of the PABX is connected. The trunk line side of the PABX is connected to a local exchange of the PSTN network. One or more of the base stations under control of the BSC is placed in that space or building which is the desired location for an office cell of the wireless PABX. In this application, such a base station will be referred to as a PABX base station. Between the BSC and the PABX base station there is a normal signalling interface of the mobile communication network, and the PABX base station has a normal radio interface of the mobile communication network. The interface between the BSC and the PABX is also a normal PABX signalling interface towards the extensions. In a preferred embodiment of the invention this interface includes the normal PABX extensions, which are connected to the BSC.

This concept makes it possible to obtain, for a PABX of a conventional fixed network, a radio interface of the mobile communication system without changing normal signalling interfaces. The only element for which the invention requires additional features is the BSC.

The capacity of the BSC is shared to serve both PABX base stations and standard base stations of a mobile communication network at the same time. Thus, the probably long transmission connections between the BSC and the MSC are avoided when making local calls in the PABX, but the standard functions of the mobile communication network, such as authentication and ciphering, are still available.

No special features are required of the subscriber stations of a wireless PABX; they may be ordinary mobile stations of a mobile communication network. As such, they can also operate via normal base stations of the mobile communication network. The mobile stations can also be treated as normal subscriber stations of the mobile communication network outside their home PABX base stations.

In the preferred embodiment of the invention, a standard subscriber of a mobile communication network will be made a PABX subscriber by also allocating to him a PABX subscriber number. This subscriber number may be a PABX extension number or any other identifier that associates the mobile station with a specific PABX extension. This way, the mobile subscriber's mobile station can serve as a cordless phone within the office building and as a normal mobile station outside. The routing of terminating calls is done in two ways. When a calling subscriber dials a PABX subscriber number, the public switched telephone network PSTN routes the call to the wireless PABX, and connecting the call to the mobile station is handled via the radio interface between the PABX and the BSC. When the calling subscriber dials a PLMN number (e.g. a MSISDN number), the PSTN routes the call directly to the PLMN where the call is terminated with the normal call establishment procedure.

Mobile originating calls coming from a home PABX base station are routed by the BSC to the PABX on the basis of the subscriber number, whereby the PABX internal calls can be switched directly without any MSC call control functions or connections via the MSC. Consequently, internal calls, and PSTN calls, via a PABX base station can be more economical than in prior art solutions.

Brief Description of the Drawings

In the following, the invention will be described in closer detail with reference to the accompanying drawings, in which

5 Figure 1 shows a wireless communication system according to the invention,

 Figure 2 is a block diagram illustration of an extended base station controller,

 Figure 3 is a signalling chart illustrating setting
10 up of a mobile terminating call, and

 Figure 4 is a signalling chart illustrating setting up of a mobile originating call.

 In practice, the present invention is applicable to almost any mobile communication system if a wireless PABX
15 or PBX is to be connected to a PABX system.

 One example is the European digital cellular mobile communication system GSM (Global System for Mobile Communications). The basic elements of the GSM system are described in the GSM Recommendations. For a closer
20 description of the GSM system, the GSM recommendations and "The GSM System for Mobile Communications", by M. Mouly & M. Pautet, Palaiseau, France, 1992, ISBN: 2-9507190-0-7 is referred to.

 The GSM and a modification thereof, DCS1800
25 (Digital Communication System) operating at the 1800 Mhz frequency range, are the primary targets for the invention, but it is not intended that the invention be restricted to these radio systems.

 Figure 1 very briefly describes the basic elements
30 of the GSM system. A mobile services switching centre MSC handles the connecting of incoming and outgoing calls. It performs functions similar to those of an exchange of a public switched telephone network (PSTN). In addition to these, it also performs functions characteristic of mobile
35 communications only, such as subscriber location

management. The mobile stations MS are connected to the center MSC by base station systems. The base station system consists of a base station controller BSC and base stations BTS. An A interface is determined for the BSC towards to MSC, and an Abis interface towards the BTS. These interfaces are specified in the GSM recommendations.

As subscriber registers, the system includes the home location register HLR and the visitor location register VLR. The HLR permanently stores the subscriber information as well as information on which VLR area the MS is located in. The visitor location register VLR, in turn, temporarily stores the subscriber information of the subscribers visiting the VLR area. In addition, the VLR stores the subscriber's more detailed location information, i.e. the so-called location area identification.

Figure 1 also shows an office system implemented as a wireless PABX. The office system 10 comprises a conventional fixed network PABX whose extension cabling has been replaced with a radio interface. Accordingly, the office system 10 comprises at least one base station PABX_BTS under control of the PABX, the PABX_BTS creating an internal cell for the office (e.g. a building). Cordless handsets can freely move within this cell and utilize the normal PABX functions, such as internal calls, calls to the public switched telephone network PSTN, etc.

The trunk line side of the PABX is connected in the conventional way to the trunk lines from a local exchange or an ISDN exchange (or any other type of a communication exchange) of the PSTN. As noted in the above, in the prior art solutions the extension side of the PABX is directly connected to the base station PABX_BTS. In accordance with the invention, Figure 1 shows the extension side of the PABX being connected to the BSC of the mobile communication network PLMN. A special interface module IF

is provided in the BSC for this purpose. In this application, such a base station controller in accordance with the invention is referred to as an extended base station controller XBSC. The PABX_BTS, in turn, is connected to the extended base station controller by Abis, the normal BSC-BTS interface in the GSM system. Since the PABX_BTS is a normal GSM base station, also the radio interface of the wireless PABX in the office cell 10 is a GSM/DCS interface entirely in accordance with the recommendations. As a result, a conventional GSM/DCS mobile station can be used in the office cell 10 as a cordless handset 11. However, the invention does not prevent the base station PABX_BTS of the PABX system from having a different radio interface (e.g. DECT) than standard base stations of the mobile communication network. This results in that the subscriber stations of the PABX system must be dual-mode devices so as to be able to operate on both radio interfaces, which is a significant deterioration in comparison to the preferred embodiment.

The A interface between the MSC and the extended base station controller XBSC can be maintained as a normal GSM interface without any modifications. This way, by means of the present invention, the features of the GSM/DCS interface can be can be issued to a standard PABX without changes in the standard signalling interfaces. The only element requiring alterations in the PLMN network is the extended base station controller XBSC. The capacity of the XBSC is shared to serve both PABX_BTS base stations and normal PLMN_BTS base stations at the same time. Thus, the probably long transmission connections between the BSC and the MSC are avoided when making local (internal) calls in the PABX. In the office cell 10, the standard functions of the mobile communication network, such as authentication and ciphering, are still available.

The subscribers of the mobile communication network have each been allocated unique identities in the mobile communication network, such as IMSI (International Mobile Subscriber Identity) in the GSM system. According to the preferred embodiment, a mobile subscriber entitled to use the office cell is in addition allocated a PABX subscriber number, such a PABX subscriber number being for example a PABX extension number or some other suitable identification. A subscriber's mobile station MS provided with an IMSI and a PABX subscriber number can be used as a cordless handset within the office cell and as a standard mobile station of a mobile communication network outside the office cell. Routing mobile terminating calls is done in two ways. When a calling PSTN subscriber dials a PABX subscriber number, the PSTN routes the call to the wireless PABX, and forwarding the call to the mobile station will be handled via the interface IF between the PABX and the XBSC. When the calling subscriber dials a subscriber number (such as a MSISDN number) allocated to the subscriber in the mobile communication network, the PSTN routes the call directly to the gateway MSC of the mobile communication network. Calls made from an MS in the office cell are routed by the XBSC to the PABX. This way the PABX internal calls can be switched directly without any MSC call control functions or connections via the MSC.

Below, various call routing procedures will be described in more detail. At first, however, the structure and operation of the extended XBSC and particularly its interface module IF will be disclosed with reference to Figure 2.

The block diagram of Figure 2 is but one exemplary embodiment of the base station controller XBSC. However, it should be understood that the invention is by no means restricted thereto, but there exists several implementations depending in particular on the type and

properties of the PABX used. Generally speaking, it can be said that the interface module IF is implemented depending on the PABX features so that a standard PABX can be coupled to an extended XBSC without alterations to the signalling and subscriber connections of the PABX. In some cases the PABX may be tailored as far as its signalling interface and extensions are concerned so that it is particularly well suitable to be connected to a base station controller. All the variations, however, are characterized in that the signalling and speech connections associated with the PABX subscriber side, i.e. extensions, are connected to the XBSC and not directly to the PABX base station as in prior art systems.

The interface module IF of Figure 2 is implemented so that the extensions of a standard analog PABX can be coupled as such to the interface module IF. It is assumed that the PABX has n extensions. If that is the case, the interface module IF has N line modules, one per each PABX extension. Each line module comprises a D/A and A/D converter 21, a transcoder 22, a ring signal detector 23, a DTMF generator 30N and an OFF/ON-HOOK switch 24. The D/A converter 21 converts the analog speech signal received from a PABX extension into a digital signal to be encoded in the transcoder 22 by a speech encoding method of the mobile communication system prior to sending it to the mobile communication network. In the same manner, the encoded speech signal received from the mobile communication network is decoded in the transcoder 22, and converted in the D/A converter 21 into an analog speech signal, which is fed to a PABX extension. The ring signal detector 23 is used in case of an incoming call to detect the ringing tone fed by the PABX to the extension in question. Upon detecting the ringing tone, the detector 23 provides a signal DET as an output. The switch 24, controlled by a control signal HOOK, is in turn used to

close the subscriber loop of the PABX extension similarly as in a conventional phone with a subscriber answering the call by lifting the earpiece (OFF-HOOK) or making a call, and to open the subscriber loop similarly as in a conventional phone with the subscriber replacing (ON HOOK) the earpiece onto the hook at the end of the call. A dual-tone multi frequency (DTMF) generator 30 is used for generating the tone-frequency dialling digits to be sent via the PABX extension to the wireless extension PABX, in a similar manner as dialling is carried out in an extension with a conventional phone. The generator 30 is controlled by a control signal DIAL, which in turn is generated on the basis of GSM type of dialling signalling of the mobile stations MS.

The interface module IF in addition comprises a controller 25, which is common to all the line modules. The controller 25 comprises inputs for detection signals DET_n generated by the ringing tone detectors 23₁-23_n, and control outputs $HOOK_1$ - $HOOK_n$ for the switches 24₁-24_n and $DIAL_1$ - $DIAL_n$ for the generators 30. The controller 25 in addition has a signalling link with a control unit 28 of the BSC. The controller 28 controls a BSC internal switch 29 and handles all the call control and signalling duties assigned to the BSC.

In the extended XBSC according to the invention, the interface module IF is additionally provided with a signalling interface 28, by means of which a signalling link is created between the BSC and the visitor location register VLR. In the preferred embodiment of the invention, the interface in question is similar to a signalling interface (B interface) defined between an MSC and a VLR in the GSM system. The B interface is specified in the GSM recommendation 0902 Chapter 2.4.3, and the signalling used therein is referred to as MAP_B signalling. As far as the present invention is concerned,

it is only significant that some kind of a VLR-BSC signalling link exists for database enquiries concerning a different kind of call set-up, such as ciphering and authentication, and possibly also for location updating.
5 For this purpose, the MAP_B signalling interface 28 is used by the controller 28.

Furthermore, the controller 28 of the XBSC has access to a PABX/IMSI database 26 in the interface module IF. The database 26 contains the identities IMSI of the
10 mobile subscribers entitled to use the office cell 10 and the PABX. In addition, the database 26 informs of mapping between each IMSI and the corresponding PABX subscriber number, in this case the physical PABX extension. The database 26 is also used by the controller 25 of the
15 interface module IF itself, as will be disclosed below.

The switch of the base station controller BSC may be any MSC employed digital switch to whose ports the connections between the BSC and the MSC are coupled: i.e. those between the BSC and the PABX_BTS, those between the
20 BSC and conventional base stations, as well as connections between the BSC and the transcoders 22. Controlled by the controller 28, the switch 29 switches these connections to one another in such a manner that the calls can be routed according to standard procedures of the mobile
25 communication network and procedures of the present invention, to be disclosed below.

In the following, a more detailed description will be given of establishing a mobile terminating call and a mobile originating call with reference to the embodiments
30 of Figures 1 and 2, and the signalling charts of Figures 3 and 4.

Mobile terminating call

It should be noted that the signalling chart in Figure 4 by no means is a comprehensive description of
35 signalling associated with call establishment. The purpose

of Figure 3 is only to give a picture of information exchange related to call set-up to the extent necessary for describing the invention. Hence, in practical call set-up other signalling than the signalling described in Figure 3 is also present, but this is not essential to the invention.

It is assumed that a call is made to an extension 1 of the PABX from the PSTN or another PABX extension. As a result, the PABX must somehow inform the BSC of the incoming call in order to set up the call to the mobile station MS of the extension in question. Activating this call set-up is illustrated in the signalling chart of Figure 3 by a Set_up message transmitted by the PABX to the BSC. In some embodiments, this may be an actual message. In the preferred embodiment of the invention, in which the PABX has not been altered on account of the present invention and in which the extensions are directly connected to the interface module IF, the PABX establishes the call in a similar manner as to a conventional extension. In other words, the PABX generates a ring signal to the extension 1, the ring signal being detected by the ringing tone detector 23, of the interface module IF. The detector 23, indicates to the controller 25 of having received the ring signal by activating a signal DET₁. The active state of the signal DET₁ indicates to the controller 25 that there is an incoming call to the extension 1. The controller 25 searches from the database 26 the IMSI identifier corresponding with the PABX extension 1 and identifying the mobile subscriber of the extension 1. Following this, the controller 25 gives the controller 28 a call set-up command, which contains the retrieved IMSI. As a result, the controller 25 transmits a Paging_command paging message via the switch 28 to the base station PABX_BTS of the office cell. The base station PABX_BTS forwards the message to the mobile station MS in

the office cell. Via the PABX_BTS, the mobile station transmits a response message, Paging Response, to the BSC.

Having received the response from the mobile station, the BSC transmits an authentication request
5 MAP_pro-cess_access_request (MAP_authentication) to the VLR, to which the VLR responds with a MAP_pro-cess_request_ack message. These messages convey the same information as normally in the GSM system between the MSC and the VLR. In the preferred embodiment of the invention,
10 the controller 28 carries out this signalling via MAP_B signalling interface 28.

Having received the answer from the VLR, the controller 28 of the BSC transmits to the MS an authentication request Auth_request, according to the GSM
15 recommendations, which is responded to by the MS with an authentication message Auth_response according to the GSM recommendations. If authentication has been successful, and the mobile station MS is allowed access to the network, ciphering mode will be set. For this purpose, the
20 BSC transmits, to the VLR, a MAP_proc_acc_req (Ciph_mode) message which is responded to by the VLR with a MAP_proc_acc_req_ack message. These messages convey the same information as normally in the GSM system between the MSC and the VLR. Then, the BSC transfers the ciphering mode of
25 the MS with a Ciph_mode_cmd message, acknowledged by the MS with a Ciph_mode_com message.

When the ciphering mode has been set, a connection will be set up between the switch 29 and the MS on a traffic channel allocated to the call via the base station
30 PABX_BTS. This is illustrated with a Set_up message. The MS will be ringing, and as the subscriber answers, information on it will be conveyed to the controller 28 which commands the controller 25 to set the switch 24, to OFF_HOOK state. This will close the subscriber loop of the
35 PABX extension 1, and the PABX interprets this as the

subscriber having answered the call at the extension. This is illustrated in Figure 3 with a Call_conf message. Information on the answering by the subscriber B can naturally also be sent by other types of messages. This way a speech connection will be established between the MS and the PABX.

The BSC only establishes PABX calls within the area of the office cell 10. In the example above, no pre-checking was carried out as to whether the called MS was in the office cell 10. However, it is possible to carry out a location enquiry to the VLR prior to initiating paging in order to avoid futile paging signalling.

Mobile originating call

In the following, establishing a mobile originating PABX call will be described in the system according to the invention with reference to the signalling chart of Figure 4. The signalling chart of Figure 4 is not intended to be a full description of call set-up signalling, either. The figure only shows the signalling to the extent that is essential in order to describe the present invention. In practice, other messages can be included in the signalling, these other messages being insignificant to the present invention.

It is assumed in the following that the user of a cordless handset MS in the office cell 10 wishes to make a call. It is typical of mobile communication networks that call set-up signalling on the radio path only begins after the user has dialled the number of the called party and pressed a specific "send" button. When the user has pressed the "send" button, the MS transmits to the PABX_BTS of the office cell 10 a Channel Request message which is forwarded to the BSC. The BSC responds by transmitting an Immediate Assignment message. Both of these are messages in accordance with the GSM recommendations. The next message from the MS is a CM

Service Request which includes the reason for the transaction. This message is in accordance with the GSM recommendations as well. Due to the connection request having been received via the PABX_BTS in the office cell

5 10, the controller 28 checks in the database 26 whether the IMSI belongs to a PABX subscriber. If the IMSI in question is not included in the database 26, call establishment proceeds according to the standard procedures of the mobile communication network.

10 If the IMSI does belong to a PABX subscriber, the controller 28 activates the call set-up procedure of the invention, with the call being routed to the PABX. At first, the BSC authenticates the subscriber and sets the ciphering mode; similar signalling between the BSC and the

15 VLR, as well as between the BSC and the MS, is related thereto as that which was illustrated in Figure 3. When the ciphering mode has been set, the mobile station transmits, to the BSC, a call establishment message Set_up, which also contains the dialled subscriber number

20 B. In connection with the previous enquiry to the database 26, the controller 28 was provided with information on which PABX extension the IMSI of the subscriber in questions matches. Let us assume that the IMSI corresponds to the PABX extension N. Having received the Set_up message from the MS, the controller 28 commands the

25 controller 25 to set the switch 24N of the extension N to OFF_HOOK. As a result, the subscriber loop of the extension N closes. The PABX reacts to this by generating a dial tone to the extension, and awaits dialling. The

30 controller 28 now provides the controller 25 with the number of the subscriber B. The controller 25 directs the DTMF generator 30N to generate DTMF digits according to the subscriber number B. Signalling by the subscriber B to the PABX is illustrated by a B_number message in Figure 4.

35 Having received the number of the subscriber B, the PABX

proceeds with call set-up as if the dialling had been made from a standard extension.

Simultaneously with the dialling, thereafter, or prior to it the BSC establishes a connection between the switch 29 and the MS on a traffic channel allocated to the call via the PABX_BTS. This is illustrated in Figure 4 with a set_up message. As soon as the number of the subscriber B has been transferred to the PABX, the controller directs the switch 29 to connect the transcoder 22_N to said traffic channel. Thus, a connection will be established between the MS and the PABX, which is illustrated in Figure 4 with an arrow "connection".

Call release

When a mobile station requests a call release, the BSC transmits a response to the mobile station, switching it to ON-HOOK state. Information on the ON-HOOK state of the MS is simultaneously signalled to the PABX. In the preferred embodiment of the invention, this takes place by the controller 28 commanding the controller 25 to set the switch 24 of the PABX extension in question to ON-HOOK state. As a result, the subscriber loop opens and the PABX interprets the connection as having been cut off. Following this, the resources and connections reserved in the BSC for the call are released.

When the other party decides to end the call, the PABX generates a busy tone to the extension, also carried over to the mobile station MS. Normally this causes the MS user to onhook, i.e. to activate the call release described above from the MS side. In addition, the interface module IF may be provided with a busy tone detector whose activation causes the controller 28 to send a call release message in accordance with the GSM recommendations to the mobile station. In the latter case, the ON-HOOK state of the MS is signalled to the PABX by opening the subscriber loop with the switch 24.

5 Calls made to the MSISDN of the mobile station arrive in the mobile communication network in the normal manner (not via PABX), and the call set-up related thereto is normal regardless of whether the MS is in the office cell 10 or not.

 In order to save the resources of the radio network, handovers from the office cell may be restricted to minimum. In such a case, even call release can be accepted instead of a handover.

10 Furthermore, the mobile stations entitled to use the office cell 10 may have a specific access category. If that is the case, all other access categories may be prohibited from the office cell. This is how other mobile stations could be prevented from locking to the office
15 cell. In a GSM mobile station, for example, information on the subscriber's access category is located on his SIM card (Subscriber Identification Module), which means that the categorization does not require changes to the software of the mobile station.

20 Although the invention has been described with reference to specific embodiments, it should be understood that these are intended as examples only, and that changes and modifications can be made thereto without departing from the scope and spirit of the attached claims.

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Claims

1. A communication system comprising a cellular mobile communication network, which includes a mobile services switching center (MSC), a base station controller (XBSC) and base stations (BTS), as well as a private exchange system (PABX) having at least one base station (PABX_BTS), characterized in that
- 5 the subscriber side of the PABX system (PABX) is connected to the (XBSC) and the trunk side is connected to another communication network (PSTN),
- 10 the PABX base station (PABX_BTS) is connected to the base station controller (XBSC),
- 15 the base station controller (xbasc) is arranged to route subscriber calls originating from the PABX base station to the PABX system, and calls coming in via the PABX system to the PABX base station.
2. A system as claimed in claim 1, characterized in that the base station controller has a signalling link (28) to a subscriber database (VLR) of the mobile communication network, in order to, for example, authenticate the subscriber.
- 20 3. A system as claimed in claim 1 or 2, characterized in that the extensions of the PABX system (PABX) are connected to the base station controller (XBSC).
- 25 4. A system as claimed in claim 1, 2 or 3, characterized by the base station controller (XBSC) having information (26) on which identities in the mobile communication network belong to subscribers entitled to the services of the PABX system.
- 30 5. A system as claimed in claim 4, characterized by the base station controller (XBSC) having mapping information (26) between the identity of the mobile communication network and the
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corresponding PABX subscriber number or PABX extension.

6. A system as claimed in claim 1, 2, 3, 4 or 5, characterized by the base station controller having a signalling unit for signalling in the direction of the PABX system in the manner required by the PABX system, and in the direction of the mobile communication system in the manner required by the mobile communication network.

7. A system as claimed in claim 4, characterized in that terminating calls to the PABX mobile subscriber number are routed in the mobile communication network as standard terminating calls to subscribers of the mobile communication network.

8. A system as claimed in claim 1, characterized in that the PABX base stations and the mobile communication network have different radio interfaces, and that the PABX subscriber equipments are dual-mode devices capable of operating at both radio interfaces.

9. A method for establishing an outgoing call in a communication system comprising a cellular mobile communication network which contains a mobile services switching center, a base station controller and base stations, as well as a private branch (PABX) system having at least one base station, the method comprising the steps of

transmitting a connection request from the subscriber to the base station controller via the PABX base station,

activating call set-up,

characterized by

checking at the base station controller whether the transmitting party of the connection request is a PABX subscriber or a standard subscriber of the mobile communication network,



routing the call of the PABX subscriber from the base station controller to the PABX system, whose subscriber side is connected to the base station controller and the trunk side to another communication network,

connecting the call to the mobile services switching center if the subscriber is not a PABX subscriber.

10. A method as claimed in claim 9, characterized by the routing of the call from the base station controller to the PABX system comprising the steps of

signalling off-hook information to the PABX system in order to activate the extension of the subscriber equipment in the manner required by the PABX system, for example by closing the subscriber loop at the extension,

signalling the subscriber's dialling to the PABX system in the manner required by the PABX system, for example by transmitting DTMF dialling digits to the activated extension.

11. A method for establishing a terminating call in a communication system comprising a cellular mobile communication network which contains a mobile services switching center, a base station controller and base stations, as well as a private branch (PABX) system having at least one base station, in which method

a call terminating to PABX subscriber is received in the PABX system,

characterized by the steps of initiating, from the private branch exchange system, call establishment at the base station controller to which the subscriber side of the PABX system and said PABX base station are coupled,

transmitting from the base station controller a paging message to said PABX subscriber via the PABX base



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station,

receiving an acknowledgement message from the PABX subscriber,

5 establishing a connection according to the mobile communication network between the base station controller and the PABX subscriber, and

connecting a speech connection between the PABX subscriber and said PABX system via the base station controller and the PABX base station.

10 12. A method as claimed in claim 11, characterized by the base station controller maintaining, for each PABX subscriber, mapping information between the identity of the mobile communication network and the corresponding PABX subscriber number or PABX
15 extension.

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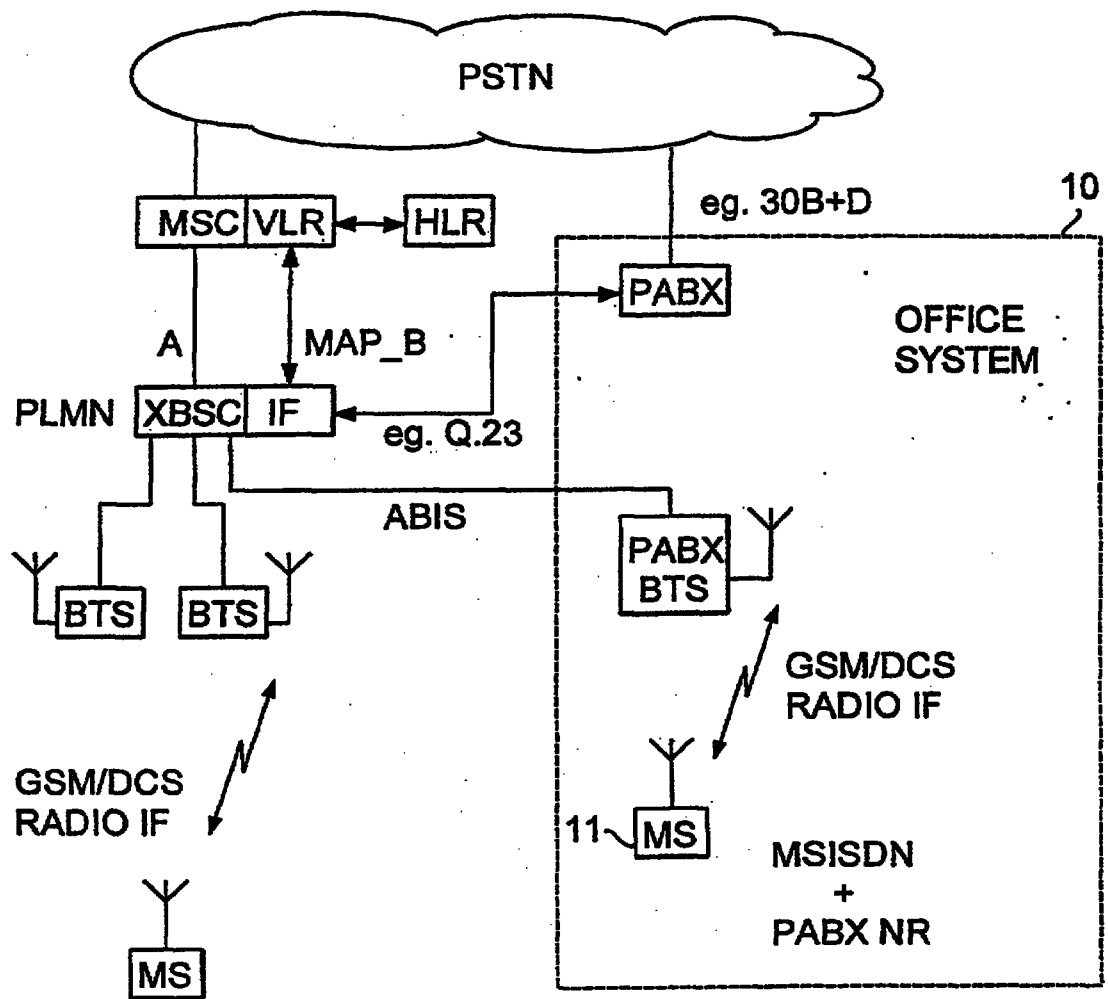
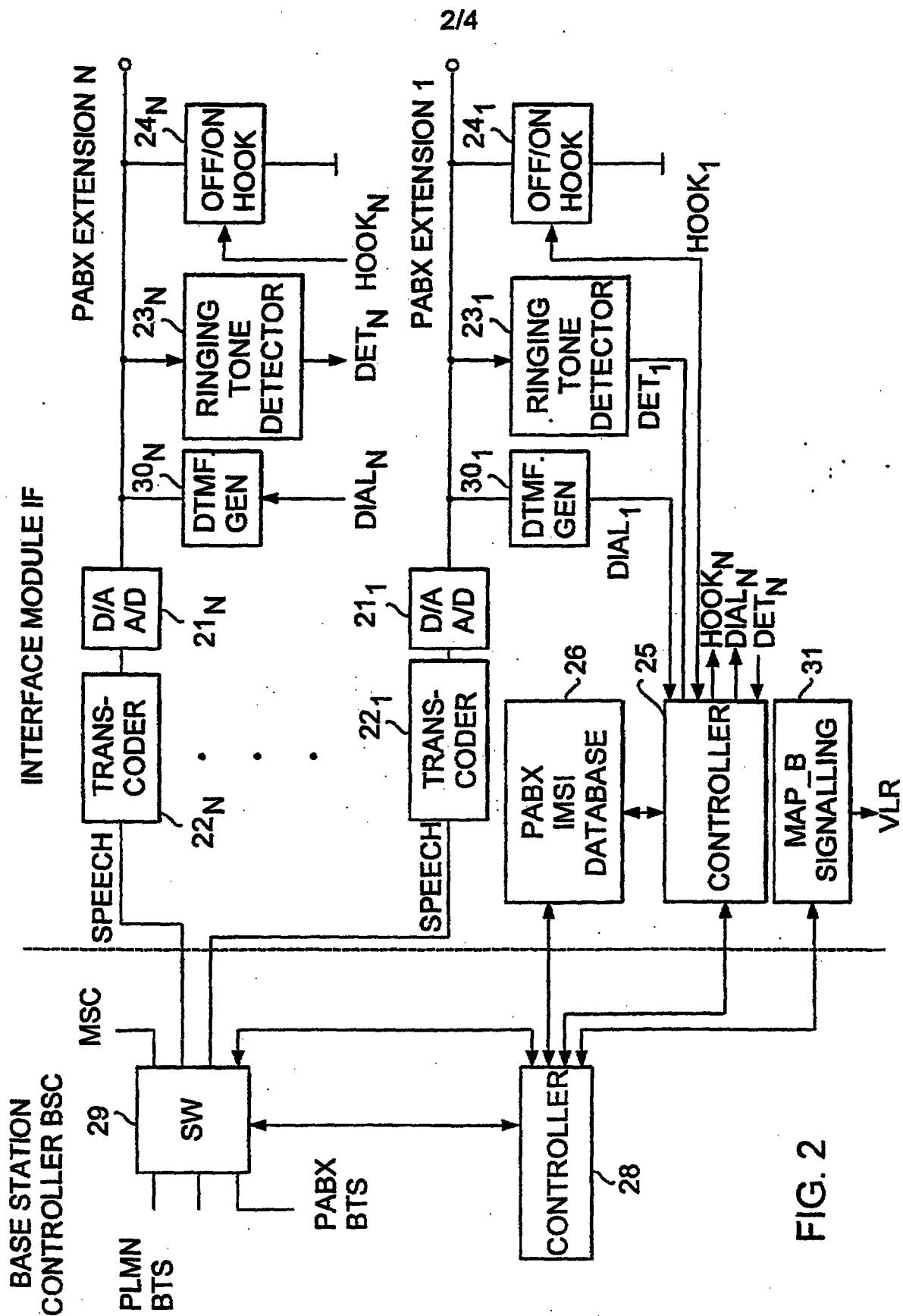


FIG. 1



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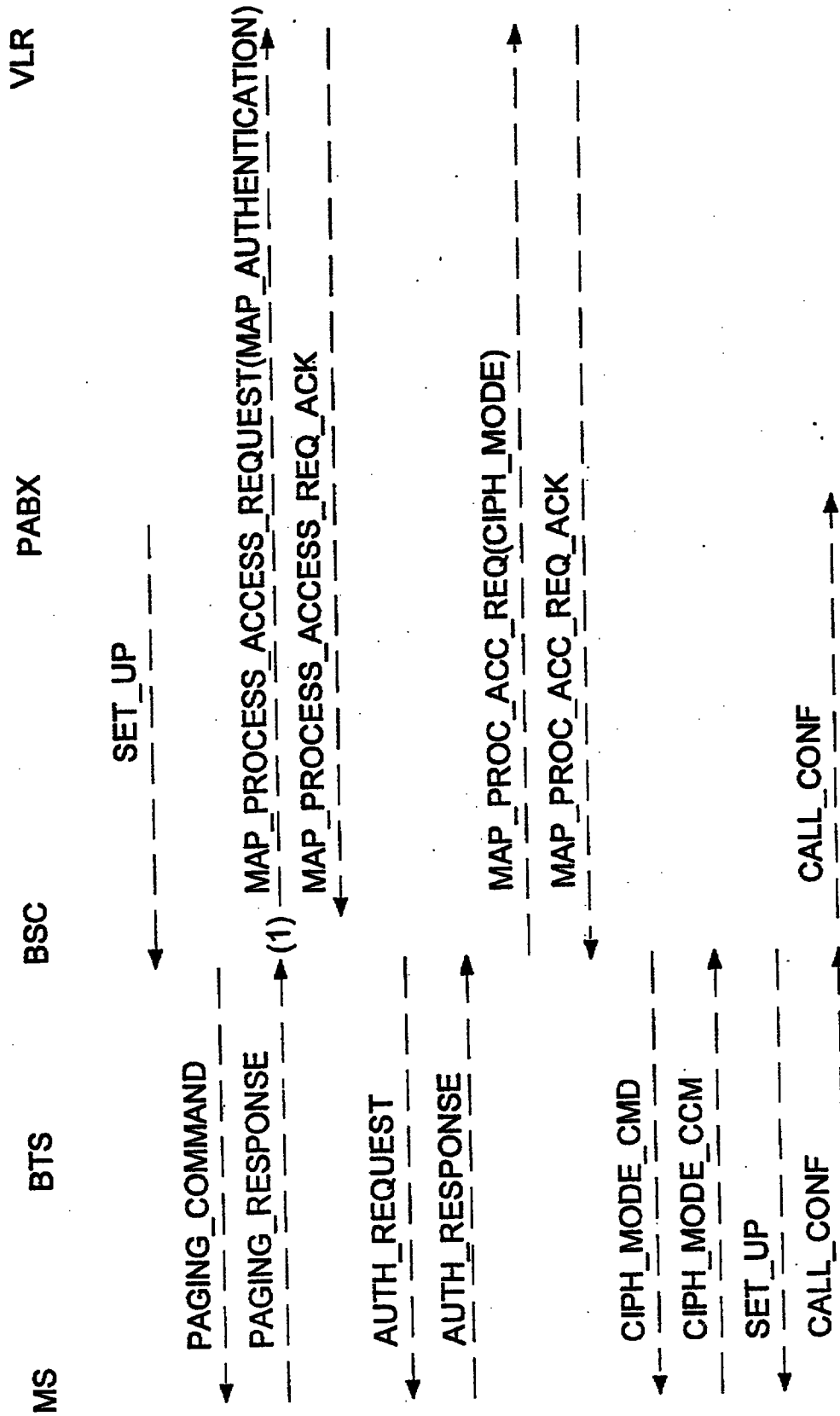


FIG. 3

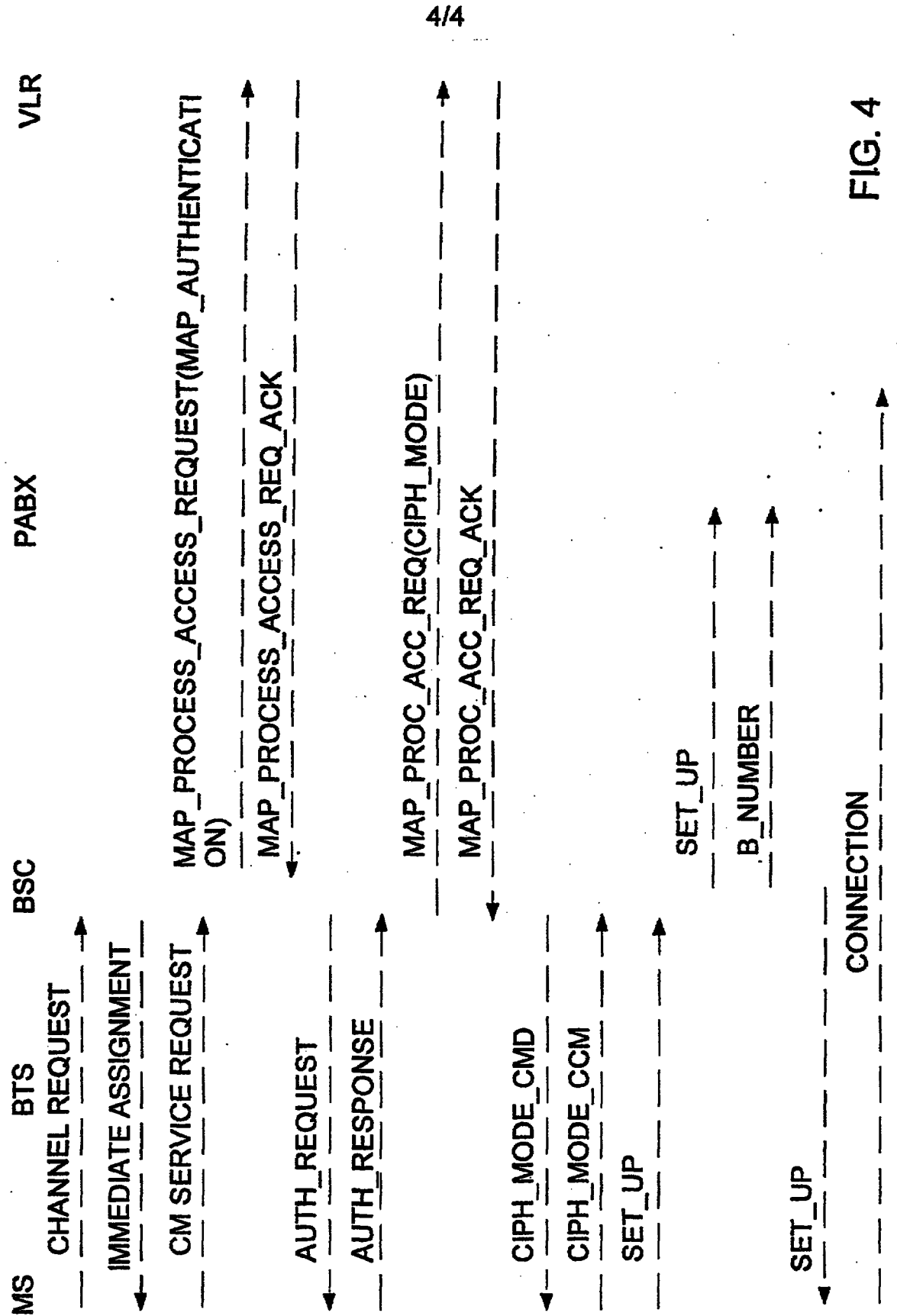


FIG. 4

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(57) Abstract

The invention relates to a communication system and call establishment methods. A communication system comprising a cellular mobile communication network, which includes a mobile services switching center (MSC), a base station controller (XBSC) and base stations (BTS), as well as a private branch exchange system (PABX) having at least one base station (PABX_BTS). In the invention, the base station controller of the mobile communication network is provided with an interface to which the extension side of the PABX is coupled. The interface between the base station controller and the PABX is a standard PABX signalling interface towards the extensions. The trunk line side of the PABX is connected e.g. to a PSTN local exchange. The base station (PABX_BTS) under control of the base station controller is placed in that space or building which is the desired location for an office cell of the wireless PABX. Between the base station controller and the base stations there exists a standard signalling interface of the mobile communication network, and the base station of the office cell (10) has a standard interface of the mobile communication network. This concept makes it possible to provide a radio interface of the mobile communication system for a standard PABX of the fixed network.

