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(54) Title: METHOD AND FEMTOCELL BASE STATION FOR SUPPORTING WIRELESS CONNECTIVITY OF ONE OR MORE MOBILE STATIONS TO A CELLULAR NETWORK

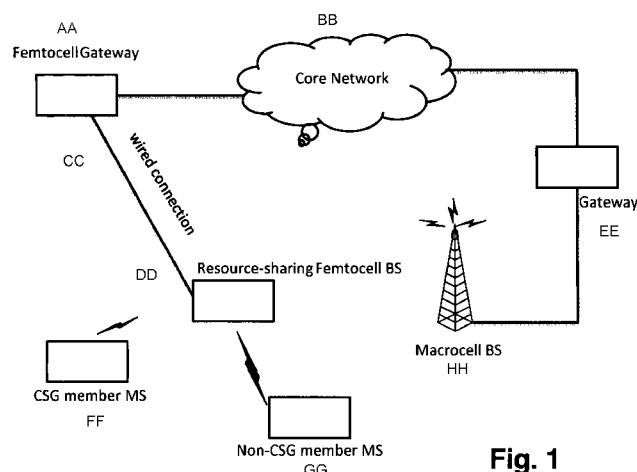


Fig. 1

(57) Abstract: Method for supporting wireless connectivity of one or more mobile stations to a cellular network, wherein said mobile stations are connected to said cellular network via a macrocell or femtocell base station - current base station -, wherein said mobile stations are located both within the coverage area of said current base station and in the coverage area of another femtocell base station - foreign femtocell base station -, wherein said foreign femtocell base station is accessible to mobile stations that are member mobile stations of said foreign femtocell base station, and wherein said mobile stations being connected to said cellular network via said current base station are non-member mobile stations of said foreign femtocell base station, is characterized in that said foreign femtocell base station reserves a basic amount of its resources - shared resources - for being utilized exclusively by mobile stations that are non-member mobile stations of said foreign femtocell base station. Furthermore, a corresponding femtocell base station is disclosed.



METHOD AND FEMTOCELL BASE STATION FOR SUPPORTING WIRELESS CONNECTIVITY OF ONE OR MORE MOBILE STATIONS TO A CELLULAR NETWORK

The present invention relates to a method for supporting wireless connectivity of one or more mobile stations to a cellular network, wherein said mobile stations are connected to said cellular network via a macrocell or femtocell base station – current base station –, wherein said mobile stations are located both within the coverage area of said current base station and in the coverage area of another femtocell base station – foreign femtocell base station –, wherein said foreign femtocell base station is accessible to mobile stations that are member mobile stations of said foreign femtocell base station, and wherein said mobile stations being connected to said cellular network via said current base station are non-member mobile stations of said foreign femtocell base station.

Furthermore, the present invention relates to a femtocell base station for supporting wireless connectivity of one or more mobile stations to a cellular network, wherein said femtocell base station is configured to be accessible to mobile stations that are member mobile stations of said femtocell base station.

In recent years there is an interest from mobile network operators to deploy femtocells (also known as home base stations, home BTS, home NBs, femto access points (FAPs), or femto radio base stations) which can be installed within the homes of the operators' customers. Such femtocells, currently being developed and standardized for both 3G and 4G networks, are scaled-down low-cost mobile base stations with low transmit power. Installation of femtocell base stations will typically be handled by the customers themselves without any technical training, therefore it has to be a simple plug-and-play procedure. Femtocell base stations are similar to a WiFi Access Point, but the radio interface is based on wide area cellular network standards such as WiMAX (Worldwide Interoperability for Microwave Access), UMTS (Universal Mobile Telecommunications System) or 3GPP LTE (Long Term Evolution). Generally, femtocell base stations are connected to the operators' network via a virtual

private network connection over a normal broadband internet connection – backhaul connection – like DSL or FTTH (Fiber to the home).

One reason for the introduction of femtocells is the increase of operator network coverage and throughput for the sake of a better user experience and therewith to make a big step towards fixed-mobile-convergence. Like Wi-Fi access points, femtocells are designed to be deployed in home and office environments in order to give full coverage in the respective area and deployment of high density is expected in areas with high population or office density. However, the deployment of femtocells comes along with drawbacks of which one is interference effects between macro and femto levels of the network. Since femtocell base stations are often deployed in the same licensed spectrum as the wide area network of the operator, it is important to configure the radio interface correctly to avoid interference with other base stations.

Femtocell networks can improve indoor coverage and capacity. However, a femtocell base station needs to carefully balance its transmit power, which should be high enough to ensure good signal strengths for its subscribers, but not too high to avoid severe interference to other mobile stations, other femtocells and possible co-located macrocell base stations. To address this problem, according to prior art solutions femtocells for example are linked to the network's Radio Resource Management (RRM), which is a functional/logical unit that is typically located in the Radio Access Network and that is responsible e.g. for frequency allocation and controlling the transmit power.

According to the definition in the current standard IEEE P802.16m, subscribers of femtocell base stations are categorized into three main categories of subscriber types. The main categories are Open Subscriber Group (OSG), Closed Subscriber Group – Closed (CSG-Closed) and Closed Subscriber Group – Open (CSG-Open) and these categories can be described as follows:

- An Open Subscriber Group (OSG) femtocell base station is accessible to any mobile station.

- In CSG-Closed, the femtocell base station is accessible only to mobile stations which are members of this femtocell base station except for emergency services.
- A CSG-Open femtocell base station is primarily accessible to the mobile stations that belong to its Closed Subscriber Group (CSG), while other mobile stations outside the CSG – i.e. non-member mobile stations – may also access such femtocell base station, but the non-member mobile stations will be served at lower priority. The CSG-Open femtocell base station will only provide service to non-member mobile stations as long as the Quality of Service (QoS) of mobile stations in its CSG is not compromised. That means best-effort services for non-CSG mobile stations of this femtocell base station.

Generally, the owner of the backhaul connection and/or the femtocell base station may want to restrict access to the femtocell base station because he pays the expense of maintenance and the broadband connection to his premises. Thus, the categorization according to the standard IEEE P802.16m causes the problem that when a mobile station, not being a member of the nearby CSG-Closed femtocells, enters an area which is covered only by one or more CSG-Closed femtocell base stations, the communication of the mobile station with its macrocell base station may be severely interfered or even totally interrupted. Specifically, if a macro mobile station, which is a non-member of the one or more nearby CSG-Closed femtocells, enters a CSG-Closed only area or is switched on in a CSG-Closed only area, the interference from the surrounding femtocell base stations may interrupt the communication between the non-CSG mobile station and its serving macro base station or the nearest macro base station.

Furthermore, in case of deploying a CSG-Open femtocell base station, there is the problem that only a best-effort service is available for non-CSG mobile stations. That means that the femtocell base station would not provide non-CSG mobile stations any resource if its CSG members want to utilize all available resources. Thus, a minimum resource of the femtocell base station is granted for non-CSG mobile stations only when there are spare resources available.

It is therefore an object of the present invention to improve and further develop a method and a femtocell base station of the initially described type for supporting wireless connectivity of one or more mobile stations to a cellular network in such a way that, by employing mechanisms that are readily to implement, interference of the mobile stations in the coverage area of a femtocell and an overlapping macrocell is reduced.

In accordance with the invention the aforementioned object is accomplished by a method comprising the features of claim 1. According to this claim, such a method is characterized in that said foreign femtocell base station reserves a basic amount of its resources – shared resources – for being utilized exclusively by mobile stations that are non-member mobile stations of said foreign femtocell base station.

Furthermore, the aforementioned object is accomplished by a femtocell base station comprising the features of claim 14. According to this claim, such a femtocell base station is characterized in that said femtocell base station is configured to reserve a basic amount of its resources – shared resources – for being utilized exclusively by mobile stations that are non-member mobile stations of said femtocell base station.

The invention takes into consideration that a mobile station located within the coverage area of a foreign femtocell base station, having no access authorization to this foreign femtocell base station and accordingly being a non-member mobile station of this foreign femtocell base station, will suffer and/or cause strong interference from and/or to this foreign femtocell base station. In this context, according to the invention it has first being recognized that it has to be avoided that the foreign femtocell base station is inaccessible for non-member mobile stations. Specifically, it has been recognized that interference can be reduced by sharing a basic amount of resources of the foreign femtocell base station for non-member mobile stations. That means that the foreign femtocell base station reserves a basic amount of its resources – shared resources – for being utilized exclusively by mobile stations that are non-member mobile stations of the foreign

femtocell base station. By providing a basic amount of shared resources, competition between member mobile stations and non-member mobile stations for utilizing resources of the foreign femtocell base station is avoided. Thus, the current base station and the foreign femtocell base station may be used to provide access for the non-member mobile stations to the cellular network, i.e. to the mobile operator's network, and its services. Thereby, the method and the femtocell base station according to the invention increases the Quality of Service (QoS) of the non-member mobile station when the non-member mobile station enters the coverage area of the foreign femtocell base station.

According to a preferred embodiment the shared resources may be employed to send signaling information and/or data. Thus, a non-member mobile station, e.g. a macrocell mobile station, that experiences severe interference from the foreign femtocell base station can use the shared resources on the foreign femtocell base station in order to send signaling information and/or data, thereby mitigating interference while at the same time services for end-users can be maintained.

With regard to the level of resources that can be utilized by non-member mobile stations, it may be provided that the amount of the shared resources are defined statically, in particular to a predefined value.

Additionally or alternatively, it may be provided that the amount of the shared resources are defined dynamically, in particular changing over a predefined range. Thus, a dynamic resource allocation is provided.

Referring to a dynamic resource allocation, it may be provided that the amount of the shared resources is increased beyond the basic amount depending on predetermined conditions, in particular depending on the demand of member mobile stations of the foreign femtocell base station, traffic level and/or QoS (Quality of Service) requirements. For example, when there are fewer member mobile stations in the coverage of the foreign femtocell base station, the foreign femtocell base station may allocate more of its resources as shared resources and allows hence more non-member mobile stations to utilize these shared resources in order to mitigate interference.

Advantageously, in case of employing a dynamic resource allocation the amount of the shared resources may be set to change between the basic amount and an upper limit, in particular depending on predetermined conditions.

According to a specific embodiment, the foreign femtocell base station may provide integrated relay functionalities in order to be connected via an air interface to another base station, e.g. to a macrocell base station. Thus, the shared resources on the foreign femtocell base station can be used for relay purpose, and therefore the foreign femtocell base station has both femtocell and relay functionalities. It is noted that currently femtocell base stations and relay base stations are built separately.

According to a preferred embodiment the foreign femtocell base station may direct data traffic originating from member mobile stations and/or non-member mobile stations to the backhaul network via a wired connection and/or a wireless connection. In doing so the data traffic may include signaling information and/or data.

Advantageously, a routing scheme may be provided that specifies which data traffic is transferred through which link, i.e. through a wireless connection or through a wired connection or both. Furthermore, the routing scheme may consider the type of data traffic and the volume of data traffic that is to be transferred through the corresponding link.

Advantageously, it may be provided that according to a routing scheme signaling information, e.g. control signals, are transferred via the wireless connection and data are transferred via the wired connection, or vice versa.

Furthermore, according to a routing scheme data traffic (signaling and data) of non-member mobile stations of the foreign femtocell base station may be routed via the wireless connection and data traffic of member mobile stations of the foreign femtocell base station may be routed via the wired connection. Thus, in the context of CSG-Closed femtocells, it may be specified that non-CSG-Closed

member data traffic (signaling and data) goes through the wireless connection while CSG-Closed member data traffic is routed via the wired connection to the backhaul network. In this way, the definition and rules of CSG-Closed femtocells are maintained and the non-CSG-Closed members can use the shared resources as members of a relay station.

In a specific embodiment it may be provided that according to a routing scheme real-time applications related data traffic is routed via the wireless connection and non-real-time applications related data traffic is routed via the wired connection.

With respect to reliability and system stability the wireless connection may be employed as fall-back connection in case the wired connection is down and/or vice versa.

There are several ways how to design and further develop the teaching of the present invention in an advantageous way. To this end it is to be referred to the patent claims subordinate to patent claims 1 and 14 on the one hand and to the following explanation of preferred embodiments of the invention by way of example, illustrated by the figure on the other hand. In connection with the explanation of the preferred embodiments of the invention by the aid of the figure, generally preferred embodiments and further developments of the teaching will be explained. In the drawings

Fig. 1 is a schematic view of an application scenario of a method and a femtocell base station according to an embodiment of the present invention,

Fig. 2 is a schematic view of another application scenario of a method and a femtocell base station according to an embodiment of the present invention, and

Fig. 3 is a schematic view of another application scenario of a method and a femtocell base station to an embodiment of the present invention.

Fig. 1 shows a schematic view of an application scenario of a method and a femtocell base station according to an embodiment of the present invention. Fig. 1 depicts a macrocell base station – Macrocell BS – that is connected via a gateway to the core network. Furthermore, Fig. 1 depicts a femtocell base station – Femtocell BS – using CSG (Closed Subscriber Group). According to the present invention the Femtocell BS is designed as a Resource-sharing Femtocell BS which means that it can reserve a basic amount of its resources (denoted shared resources hereinafter) for being utilized exclusively by mobile stations that are non-member mobile stations of the Resource-sharing Femtocell BS, i.e. for non-CSG member MS.

In the embodiment illustrated in Fig. 1, the Resource-sharing Femtocell BS is equipped only with a wired connection to the backhaul. More specifically, the Resource-sharing Femtocell BS is connected to a femtocell gateway via the wired connection and, thus, enables the connection to the core network. In the specific embodiment shown in Fig. 1, the Resource-sharing Femtocell BS directs all traffic originating from both its CSG member mobile stations and non-CSG member mobile stations to the backhaul network via the wired connection.

The resource level that is shared with non-CSG member mobile stations can optionally be set either statically using a pre-defined value or dynamically, changing over a pre-defined range.

Referring to dynamic resource allocation, there are several methods for implementation. For example, the amount of allocated resources can be set to change between minimum and upper limits depending on conditions such as traffic level and/or QoS requirements.

Fig. 2 shows a schematic view of another application scenario of a method and a femtocell base station according to an embodiment of the present invention. Similar to the embodiment of Fig. 1, Fig. 2 depicts a macrocell base station – Macrocell BS – that is connected via a gateway to the core network. Furthermore, Fig. 2 depicts a femtocell base station – Femtocell BS – using CSG (Closed

Subscriber Group). Again, according to the present invention the Femtocell BS is designed as a Resource-sharing Femtocell BS which means that it reserves a basic amount of its resources (denoted shared resources hereinafter) for being utilized exclusively by mobile stations that are non-member mobile stations of the Resource-sharing Femtocell BS, i.e. for non-CSG member MS.

In the embodiment illustrated in Fig. 2, the Resource-sharing Femtocell BS is equipped only with a wireless connection. Specifically, the Resource-sharing Femtocell BS has a wireless connection to the Macrocell BS. In the specific embodiment shown in Fig. 2, the Resource-sharing Femtocell BS directs all traffic originating from both its CSG member mobile stations and non-CSG member mobile stations to the backhaul network via the wireless connection.

Since only wireless connections are available, the shared resources can be used for relay purpose. Thus, the Resource-sharing Femtocell BS illustrated in the application scenario of Fig. 2 is a relay-femto Resource-sharing Femtocell BS station with integrated relay functionalities. In doing so, control signals and data traffic are transported via the air interface. Further mechanisms are similar to those mechanisms of the Resource-sharing Femtocell BS with only wired connection to backhaul that is illustrated in Fig. 1.

The gateway of the Resource-sharing Femtocell BS of Fig. 2 can be either integrated or separated with the gateway of the Macrocell BS. For a non-CSG member mobile station, e.g. a macrocell mobile station or a member of another femtocell, the non-CSG member mobile station communicates with its own macrocell gateway or femtocell gateway via the air interface.

Fig. 3 shows a schematic view of another application scenario of a method and a femtocell base station according to an embodiment of the present invention. Fig. 3 depicts a macrocell base station – Macrocell BS – that is connected via a gateway to the core network. Furthermore, Fig. 3 depicts a femtocell base station – Femtocell BS – using CSG (Closed Subscriber Group). Again, according to the present invention the Femtocell BS is designed as a Resource-sharing Femtocell BS which means that it can reserve a basic amount of its resources (denoted

shared resources hereinafter) for being utilized exclusively by mobile stations that are non-member mobile stations of the Resource-sharing Femtocell BS, i.e. for non-CSG member MS.

In the embodiment illustrated in Fig. 3, the Resource-sharing Femtocell BS is equipped with both wired and wireless connections to the backhaul. More specifically, the Resource-sharing Femtocell BS is connected to a femtocell gateway via the wired connection and therefore enables the connection to the core network. In addition, the Resource-sharing Femtocell BS of Fig. 3 has a wireless connection to the Macrocell BS. In the specific embodiment shown in Fig. 3, the Resource-sharing Femtocell BS directs all traffic originating from both its CSG member mobile stations and non-CSG member mobile stations to the backhaul network via either the wired connection or the wireless connection or both.

Since wireless connections are available, the shared resources can be used for relay purpose. Thus, the Resource-sharing Femtocell BS illustrated in the application scenario of Fig. 3 is a relay-femto resource-sharing femtocell base station with integrated relay functionalities.

Compared to the femtocell base station illustrated in Fig. 2 with a single connection via air interface, the embodiment illustrated in Fig. 3 is more complicated. For example, the control signals can be transferred via the air interface and data traffic can be transported via the wired connection, or vice versa. Also all the control signals and data traffic can be transported via the air interface.

The gateway of the CSG femtocell can be either integrated or separated with the gateway of the Macrocell BS. For a non-CSG member mobile station, e.g. a macro mobile station or a member of another femtocell, the non-CSG member mobile station communicates with its own macrocell gateway or femtocell gateway via either the wired connection or the wireless connection.

Referring to the application scenario illustrated in Fig. 3, a suitable scheduling or routing scheme is adopted to decide how much resources of the Resource-sharing

Femtocell BS can be used as shared resources and to specify which traffic goes through which link, i.e. wireless or wired connections. In doing so, the overall resource utilization can be significantly improved.

Similarly to the case when the Resource-sharing Femtocell BS is implemented with only wired connection or only wireless connection to the backhaul network, the portion or level of resources being shared between the Resource-sharing Femtocell BS's CSG member mobile stations and non-CSG member mobile stations can be defined either statically or dynamically.

The major difference of the implementation illustrated in Fig. 3 compared to a Resource-sharing Femtocell BS with a single connection only, i.e. either wireless or wired connection, is that with the two connections design, i.e. both wired and wireless connection, the traffic originating from mobile stations that utilize shared resources can be routed through the wired connection, the wireless connection or both to the backhaul network. In case of using both connections the portion on how much traffic goes through the wired connection and how much goes through the wireless connection can be designed flexibly and is subject to implementation preference.

Exemplary implementations for the application scenario of Fig. 3 are as follows:

1. It may be optionally specified that non-CSG member traffic go through the wireless connection while CSG member traffic is routed via the wired connection to the backhaul. In doing so, the definition and rules of CSG femtocells is maintained and non-CSG members can use the shared resource as members of a relay station.
2. It may be defined that real-time applications related traffic goes through the wireless connection while non-real-time traffic goes via the wired connection to the backhaul. This would maintain the required QoS for the various service types.

3. If the wired backhaul connection is down, the wireless connection can be used, and vice versa.

Many modifications and other embodiments of the invention set forth herein will come to mind the one skilled in the art to which the invention pertains having the benefit of the teachings presented in the foregoing description and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

Claims

1. Method for supporting wireless connectivity of one or more mobile stations to a cellular network,

wherein said mobile stations are connected to said cellular network via a macrocell or femtocell base station – current base station –,

wherein said mobile stations are located both within the coverage area of said current base station and in the coverage area of another femtocell base station – foreign femtocell base station –,

wherein said foreign femtocell base station is accessible to mobile stations that are member mobile stations of said foreign femtocell base station, and

wherein said mobile stations being connected to said cellular network via said current base station are non-member mobile stations of said foreign femtocell base station,

characterized in that said foreign femtocell base station reserves a basic amount of its resources – shared resources – for being utilized exclusively by mobile stations that are non-member mobile stations of said foreign femtocell base station.

2. Method according to claim 1, wherein said shared resources are employed to send signaling information and/or data.

3. Method according to claims 1 or 2, wherein the amount of said shared resources is set statically, in particular to a predefined value.

4. Method according to any of claims 1 to 3, wherein the amount of said shared resources is set dynamically, in particular changing over a predefined range.

5. Method according to any of claims 1 to 4, wherein the amount of said shared resources is increased beyond said basic amount depending on predetermined conditions, in particular depending on the demand of member mobile stations of said foreign femtocell base station, traffic level and/or QoS (Quality of Service) requirements.

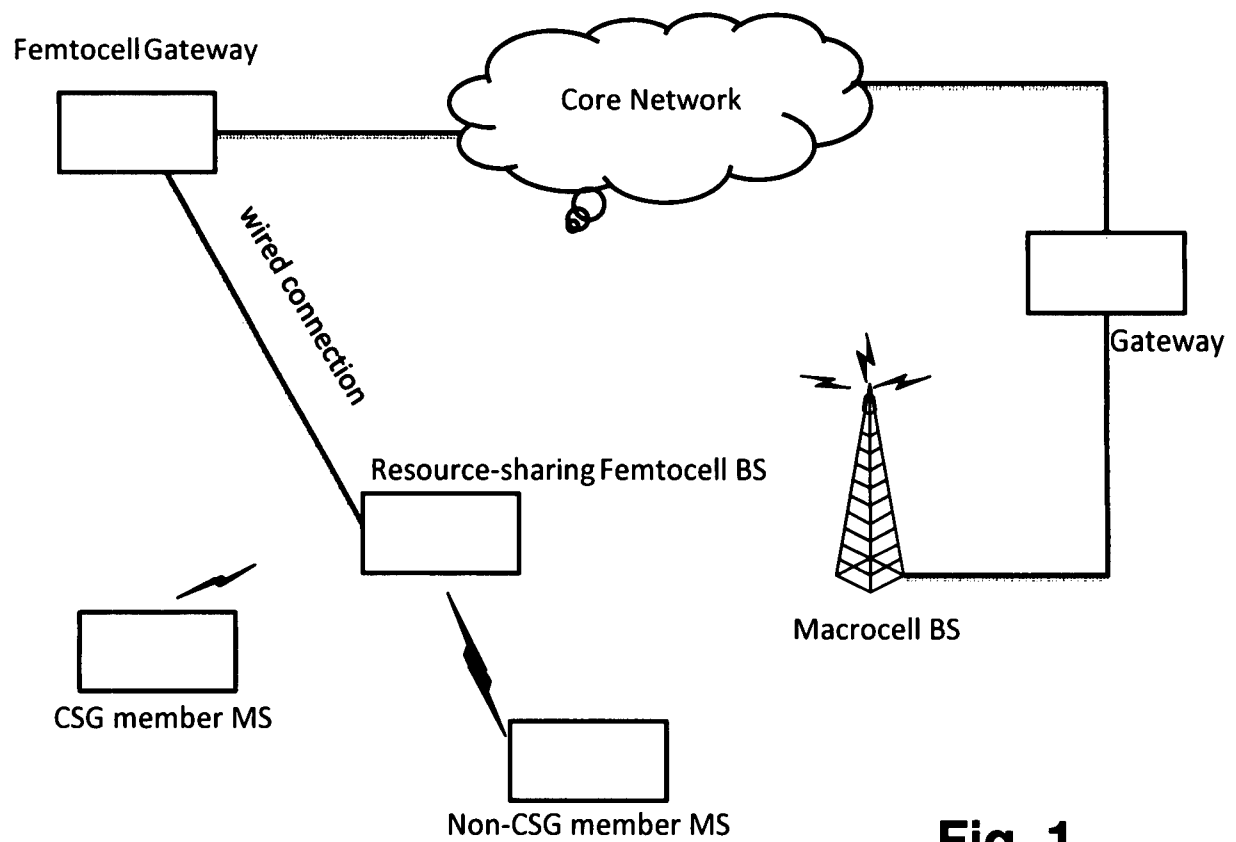
6. Method according to any of claims 1 to 5, wherein the amount of said shared resources is set to change between said basic amount and an upper limit.
7. Method according to any of claims 1 to 6, wherein said foreign femtocell base station provides integrated relay functionalities in order to be connected via an air interface to another base station, in particular a macrocell base station.
8. Method according to any of claims 1 to 7, wherein said foreign femtocell base station routes data traffic originating from member mobile stations and/or non-member mobile stations to the backhaul network via a wired connection and/or a wireless connection.
9. Method according to claim 8, wherein a routing scheme is provided that specifies which data traffic is transferred through which connection.
10. Method according to claim 9, wherein according to said routing scheme signaling information is transferred via said wireless connection and data are transferred via said wired connection, or vice versa.
11. Method according to claim 9, wherein according to said routing scheme data traffic of non-member mobile stations of said foreign femtocell base station is routed via said wireless connection and data traffic of member mobile stations of said foreign femtocell base station is routed via said wired connection.
12. Method according to claim 9, wherein according to said routing scheme real-time applications related data traffic is routed via said wireless connection and non-real-time applications related data traffic is routed via said wired connection.
13. Method according to any of claims 1 to 12, wherein said wireless connection is employed as fall-back connection in case said wired connection is down and/or vice versa.

14. Femtocell base station for supporting wireless connectivity of one or more mobile stations to a cellular network, in particular for the execution of the method according to any of claims 1 to 13,

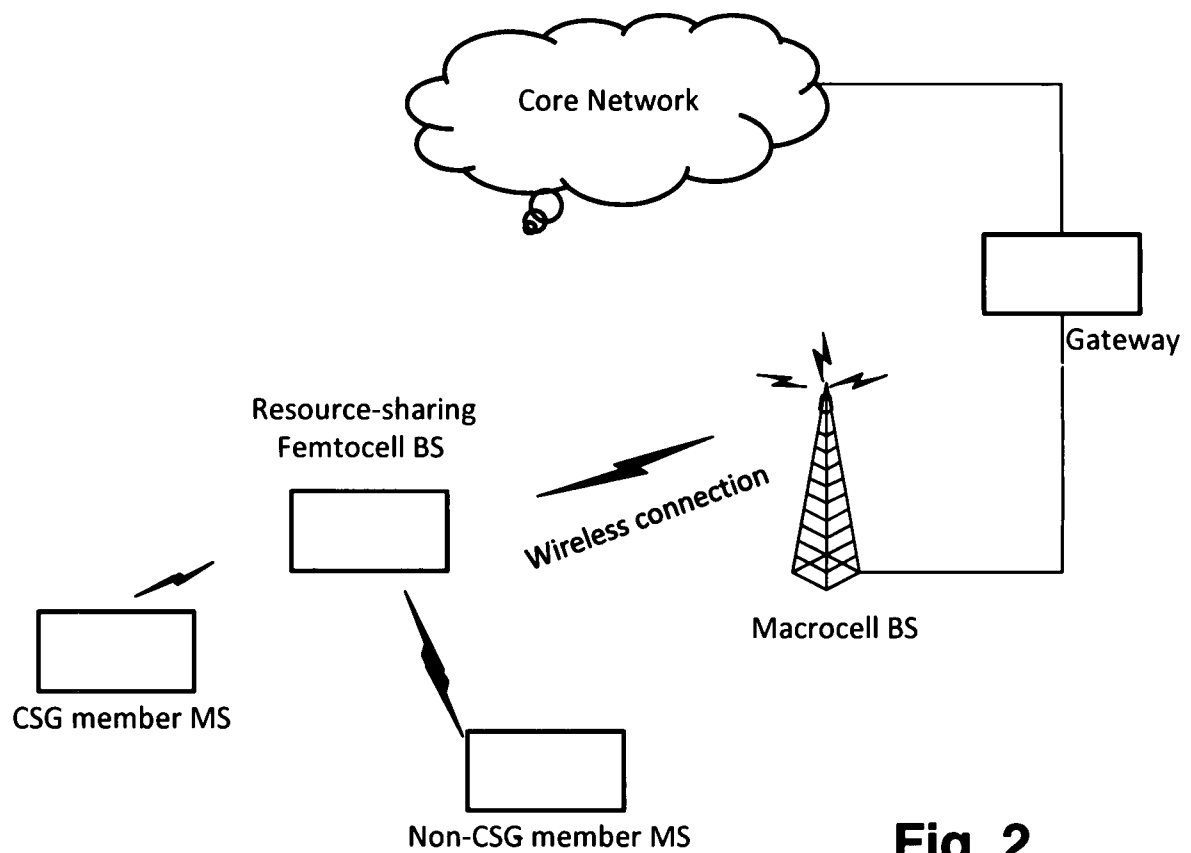
wherein said femtocell base station is configured to be accessible to mobile stations that are member mobile stations of said femtocell base station, characterized in that said femtocell base station is configured to reserve a basic amount of its resources – shared resources – for being utilized exclusively by mobile stations that are non-member mobile stations of said femtocell base station.

15. Femtocell base station according to claim 14, wherein said femtocell base station has integrated relay functionalities for being connectable via an air interface to another base station, in particular a macrocell base station.

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**Fig. 1**

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**Fig. 2**

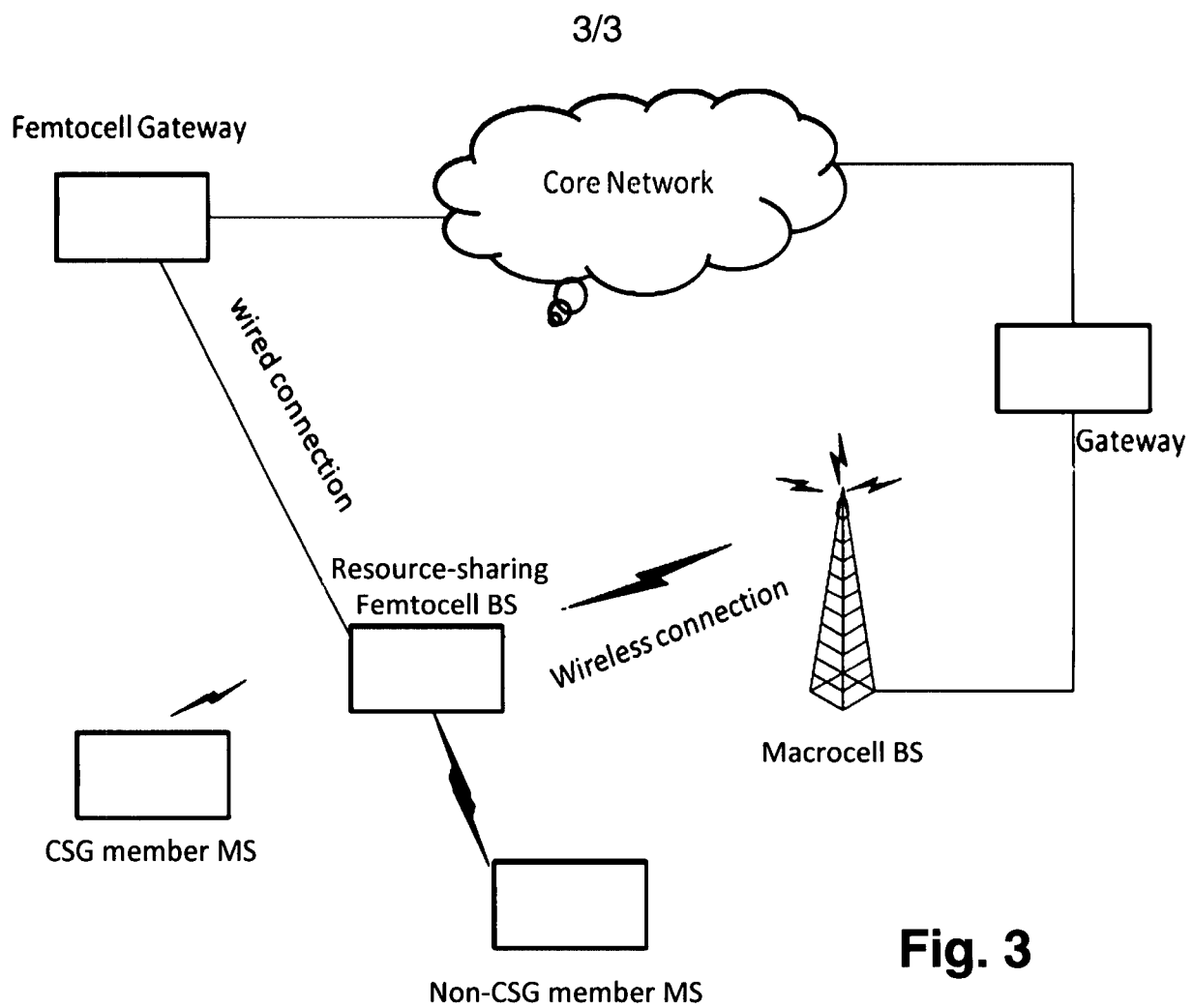


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2011/000598

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W72/04

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/132929 A1 (INFINEON TECHNOLOGIES AG [DE]; BIENAS MAIK [DE]; LUFT ACHIM [DE]; SCHM) 5 November 2009 (2009-11-05)	1-6,13,14
Y	page 15, paragraph 50 - page 17, paragraph 53; figure 3 page 25, paragraph 92 - page 26, paragraph 95 page 27, paragraph 99 - page 29, paragraph 102 ----- -/--	7-12,15

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

☒ See patent family annex.

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

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search

2 May 2011

Date of mailing of the international search report

10/05/2011

Name and mailing address of the ISA/

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Authorized officer

López García, J

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2011/000598

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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