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(54) **Titre : A method of determining network resource congestion and a system therefor.**

(57) **Abrégé :**

A system and method of determining network resource congestion includes identifying a contribution of each resource in a target cluster, which contribution is a cluster's resource contribution weight. Next, for each cell in the cluster the usage of its resources are identified. Finally, the congestion probability is determined for each cell based on the cluster's resource contribution weights and the cell's resource usage.

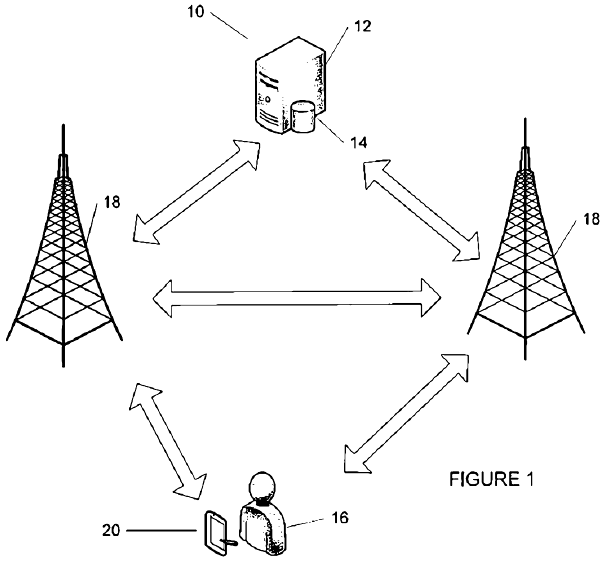


FIGURE 1

17412

ORIGINAL

« DEMANDE DE BREVET D'INVENTION »

Mobile Telephone Networks (Proprietary) Limited

A Method of Determining Network Resource Congestion and a System Therefor

COETZEE, Thinus Ruan

A METHOD OF DETERMINING NETWORK RESOURCE CONGESTION AND A SYSTEM THEREFOR

BACKGROUND OF THE INVENTION

The present application relates to a method of determining network resource congestion and a system therefor, particularly for use in a mobile communications network.

Mobile communications networks are used extensively and management of capacity on a mobile communications network is extremely important.

Networks need to be managed and upgraded constantly to ensure that congestion on the network does not reach proportions that are detrimental to users.

As upgrading of networks takes time, it is necessary to determine network resource congestion in enough advanced time to allow for necessary maintenance and/or upgrading to take place.

The present invention provides an improved method of determining network resource congestion and a system therefor.

SUMMARY OF THE INVENTION

According to one example embodiment, a method of determining network resource congestion, the method including:

> identifying a contribution of each resource in a target cluster, which contribution is a cluster's resource contribution weight;
>
> for each cell in the cluster identify the usage of its resources. ; and
>
> determine the congestion probability for each cell based on the cluster's resource contribution weights and the cell's resource usage.

The resources include one or more of Downlink Air interface Resources, Uplink Air interface Resources, User Admission and Baseband Capacity.

The contribution of each resource includes the percentage usage of each resource to the total amount of resources.

The clusters are defined as areas with the same properties such as topology, building structures, population density and consumer behaviour.

The method of determining the congestion probability includes multiplying every cell's resource utilization with its cluster's resource contribution weight and summing it all up to get the cell's congestion value.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1	is an example of an environment in which the system of the present invention operates; and
Figure 2	is a block diagram illustrating an example server in more detail.

DESCRIPTION OF EMBODIMENTS

The system and methodology described herein relate to a method of determining network resource congestion and system therefor, especially for use in a mobile communications network.

It will be appreciated that mobile communications networks use different hardware, software and firmware to operate and in addition implement various communications protocols which are continually evolving. It is envisaged that the present invention can be implement across any mobile communications network.

By way of background, Wideband Code Division Multiple Access (WCDMA) as radio access interface for Universal Mobile Telecommunication System (UMTS) consist of various services which all utilize the same resources. Services in the third Generation Partnership Project

(3GPP) Release '99, also known as R99 services, introduced Packet Switched (PS) services with practical bitrates of up to 384 kbps and Circuit Switched (CS) services with various Adaptive Multi-Rate (AMR) techniques.

The 3GPP standard introduced the High-Speed Downlink Packet Access (HSDPA) technology in Release 5 to overcome R99's low data rates, high latency and low spectral efficiency. These limitations of R99 was improved by replacing the role of power control with Adaptive Modulation and Coding (AMC), by including the ability of aggregating multiple Orthogonal Variable Spreading Factor (OVSF) 16 codes, by reducing the Transmit Time Intervals (TTI) from 10ms up to 2ms, by introducing a common channel with fixed power shared amongst HSDPA users and by introducing the Hybrid Automatic Repeat Request (HARQ) function at the Node B.

High-Speed Uplink Packet Access (HSUPA) was introduced in 3GPP Release 6 to improve the uplink limitations of R99 such as large scheduling delays, large latencies, low data rates and low cell capacity. HSUPA improved uplink R99 by introducing a smaller TTI of 2ms, fast scheduling and the HARQ functionality. HSPA, which is the combination of HSDPA and HSUPA, has been improved in 3GPP Releases 7 to 8 with the introduction of higher modulation schemes, carrier aggregation and Multi-Input-Multi-Output (MIMO).

WCDMA radio resources on the same carrier frequency are shared between R99 and HSPA. In the downlink direction resources such as Node B power, interference and OVSF codes are shared and in the uplink direction the interference is shared amongst the UEs. The 3GPP standard requires that R99 services take preference over HSDPA services as the amount of aggregated HS-PDSCH codes (OVSF 16 codes) will be reduced when an OVSF code is needed by a R99 services. The downlink power is also shared, with either a fixed power allocation to HSDPA or a variable power allocation for HSDPA as a function of power used for R99. This allocation of resources is controlled by the admission algorithms residing in the Radio Network Controller.

It is known that HSDPA's improves spectrum efficiency above R99 by up to three times in release 5 and up to six times since release 7 and 8. Interference in both the uplink and downlink direction is shared amongst the WCDMA services and limits the ability of mobiles on the edge of the cell to receive and decode signals. Due to the intertwined relationship between coverage and capacity introduced in this interference limited system, careful site planning, upgrades and optimization is required in order to optimize the WCDMA network.

The dynamic nature of the WCDMA resources increases the complexity of proactively identifying sites or areas that needs to be upgraded to maintain the desired grade of service. The present invention addresses determining the probability of congestion that can be used to proactively identify areas or cells that are congesting or will congest in the near future as well as the ability to evolve with the network, as upgrades and features are implemented to improve capacity.

Referring to the accompanying Figures, a system 10 includes a server 12 that includes a number of modules to implement the present invention and an associated memory 14.

In one example embodiment, the modules described below may be implemented by a machine-readable medium embodying instructions which, when executed by a machine, cause the machine to perform any of the methods described above.

In another example embodiment the modules may be implemented using firmware programmed specifically to execute the method described herein.

It will be appreciated that embodiments of the present invention are not limited to such architecture, and could equally well find application in a distributed, or peer-to-peer, architecture system. Thus the modules illustrated could be located on one or more servers operated by one or more institutions.

It will also be appreciated that in any of these cases the modules form a physical apparatus with physical modules specifically for executing the steps of the method described herein.

According to one example embodiment, a method of determining network resource congestion includes the steps of identifying a contribution of each resource in a target cluster, which contribution is a cluster's resource contribution weight.

Figure 1 shows a schematic example of a user 16 accessing cells 18 in a cluster by way of a mobile communications device 20.

The clusters are typically defined as areas with the same properties such as topology, building structures, population density and consumer behaviour.

In one example embodiment, the resources include one or more of Downlink Air interface Resources, Uplink Air interface Resources, User Admission and Baseband Capacity.

It will be appreciated that each cluster includes one or more of these resources.

The contribution of each resource includes the percentage usage of each resource compared to the total amount of resources.

In addition, each cluster is made up of a number of cells which can be thought of a radio transmitter and receiver which provides communications services to a customer.

Put another way, a cellular network or mobile network is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell.

When joined together these cells provide radio coverage over a wide geographic area and enable a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, via base stations, even if some of the transceivers are moving through more than one cell during transmission.

It will be appreciated that although Figure 1 only illustrates two cells in reality there will typically be any number of cells in a cluster.

Each cell in the cluster uses the same resources of the cluster with each cell using the resource more or less depending on the traffic demands of the particular cell.

The modules in server 12 illustrated in Figure 2 calculate the probability of congestion as described below.

The server includes a communications module 22 which is able to communicate with the cellular network to obtain the required information from the cellular network.

A calculation module 24 calculates the probability of congestion as follows.

The calculation module 24, for each resource, identifies what cells 18 in the cluster are using each resource the most.

Once this has been done, the congestion probability can be worked out based on the cluster's resource contribution weights and the cells resource usage.

The calculation module 24 determines the congestion probability by multiplying every cell's resource utilization with its cluster's resource contribution weight and summing it all up to get the cell's congestion value. This will be explained in more detail below.

In one example implementation of the above methodology in a Frequency-Division Duplexing Wideband Code Division Multiple Access (FDD WCDMA) network the downlink and uplink transmissions take place on two separate frequencies. In the downlink a cell's capacity is limited by the amount of available Node B power, Orthogonal Variable Spreading Factor (OVSF) codes, baseband channel elements and interference.

In the uplink the cell's capacity is limited by the interference and baseband channel elements.

Therefore, the amount of R99 users in the downlink that can be served by a cell is limited by the available OVSF codes and power, whereas the amount of HSDPA users is limited by system parameters.

The amount of uplink R99 users and HSUPA users that can be served is limited by the interference in the area. Another constraint on the amount of HSUPA users that can be served within a cell is set by the system parameters. The amount of HSPA users and channel elements are upgradeable constraints and need to be monitored with the resource utilization measurements.

Uplink and downlink coverage balance is essential for proper communication between the UE and the Node B cells. Unbalanced coverage between the downlink and uplink will degrade the UE's acquisition to the Universal Mobile Telecommunication System (UMTS) network. The coverage of the primary Common Pilot Channel (CPICH), used for system acquisition, and Dedicated Pilot Channel (DPCH), used for carrying the user data on the Dedicated Transport Channel (DCH) channel, has to be considered in the downlink. Both of the channels' coverage is impacted by the path loss between the Node B and the UE, interference and the antenna configuration, whereas the CPICH power and DPCH minimum and maximum power thresholds impact the primary CPICH channel and DPCH channel respectively. Uplink coverage is mainly affected by the load on the uplink frequency, as the interference introduced by the load will degrade the ability of UEs on the edge of the cell to communicate properly with the Node B cell.

WCDMA supports two modes of operation: Frequency Division Duplexing (FDD) and Time Division Duplex (TDD). In TDD mode, one 5MHz carrier frequency is time-shared between uplink and downlink, whereas in FDD, separate 5MHz carrier frequencies are used for both downlink and uplink respectively. A Node B sector can be configured with multiple carriers for capacity expansion or specific HSPA deployment strategies.

The base band hardware of a Node B is modeled by the concept of Channel Elements (CE), where one CE is defined as the amount of processing power required to serve one speech call. The CE resource is shared between all the cells in the Node B and defines a hard capacity limit on the amount of radio connections the Node B can handle at the same time in the uplink and the downlink.

The following table sets out the uplink and downlink channel element usage for various WCDMA services.

RAB	UL CE	DL CE
Speech AMR (4.75 & 5.9 kbps)	1	1
Speech AMR (7.9 & 12.2 kbps)	1	1
PS Streaming (PS 16/64 + PS 8 kbps)	2	2
CS Streaming (57.6 kbps)	4	2
CS Data (64 kbps)	4	2
CS Data (64 kbps) + PS Interactive (8 kbps)	4	2
AMR Speech (12.2 kbps) + PS Interactive (64 kbps)	4	2
PS Interactive (64 kbps)	4	2
PS Interactive (128 kbps)	8	4
PS Streaming (PS 16/128 + PS 8 kbps)	2	4
PS Interactive (384 kbps)	16	8

OVSF codes separates transmissions from a single source, i.e. dedicated physical downlink channels from the Node B cell towards different mobiles and from the mobile towards different

Node B cells. The function of the OVSF codes is to allow the spreading factor (SF) to be changed according to the requested data rate, while the orthogonality between different SFs of different lengths are maintained. Different R99 DCH data rates are achievable in both uplink and downlink directions, due to the amount of chips per symbol that's used for each OVSF code. Each OVSF code tree has a total of 512 SF codes, with the lower order SF codes having higher data rates. Using a lower order SF code will block the higher order SF codes. In the downlink these codes are shared between common channels, R99 DPCH channels and HS-PDSCH channels, with R99 DPCH channels having preference over the HS-PDSCH channels. System functions such as compressed mode also utilizes the OVSF code tree, by using half the current DCH RAB SF.

The High Speed Downlink Shared Channel (HS-DSCH) can combine up to fifteen SF 16 codes, mapped to the HS-PDSCH channel, in order to schedule higher throughput. For each HSDPA user connected to the cell there's also an associated DPCH channel. The amount of HSDPA users that can be served within one transmission of the shared HS-DSCH channel is limited by the amount of High Speed Shared Control Channels (HS-SCCH) defined in the cell. Increasing the HS-SCCH channels will lower the user throughput, but increase the overall cell throughput.

The addition of a secondary set of OVSF codes has been investigated in an attempt to increase the code capacity of a cell. The equation in (1) below can be used to determine the limit of the maximum number of simultaneous transmissions that can be supported by a cell's OVSF code tree.

$$\sum_{i=1}^{N_D}\frac{1}{SF_i} \le 1 - R_C = 1 - \sum_{j=1}^{C}\frac{1}{SF_j} \tag{1}$$

Where SF_i is the spreading factor for each of the N_D number of allocated dedicated channels, R_C is the fraction of the code tree that is reserved for total of c common and shared channels. Equation (1) can be modified as in (2) to include the OVSF code usage by compressed mode users and the reserved HS-PDSCH codes.

$$\sum_{i=1}^{N_D}\frac{1}{SF_i} \le 1 - R_C - R_H - R_{Comp} = 1 - \sum_{j=1}^{C}\frac{1}{SF_j} - \sum_{k=1}^{H}\frac{1}{SF16_k} - \sum_{l=1}^{Comp}\frac{1}{\frac{SF_l}{2}} \tag{2}$$

Where R_H is the fraction of the code tree that's reserved for the total of, H HS-PDSCH codes of spreading factor 16, SF16 and R Comp is the fraction of the code tree that's used by the compressed mode users. The table below contains the achievable bit rates for the various

OVSF codes that is mapped to the associated RAB. The table sets out the OVSF code usage for various WCDMA services.

RAB	Spreading factor value	Symbol rate (ksymbol/s)	Channel bit rate (kb/s)
Speech AMR 4.75 & 5.9 kbps	256	15	30
Speech AMR 7.9 & 12.2 kbps	128	30	60
	64	60	120
PS 64 kbps & CS Data 64 kbps	32	120	240
PS 128 kbps & HS-PDSCH	16	240	480
PS 384 kbps	8	480	960

The amount of power that is available to traffic channels depends on the cell's maximum transmission power and power used for the common/control channels. The common/control channels' power values are all set relative to the primary CPICH channel power. The available traffic power is then distributed between the R99 dedicated physical channels (DPCH) and HSDPA's HS-PDSCH and HS-SCCH channels, either dynamically with R99 DPCH channels having preference over HSDPA channels or with a fixed power for the HSDPA channels.

This does not include the Node B's power margin, whereby the Node B's power fluctuates. In reality the Node B's power fluctuates due to the peak-to-average ratio of the transmit power. Fast power control is used for DPCH channels in the downlink to overcome the path loss, inter-cell interference and Rayleigh fading experienced by the served mobile. It is also used to minimize the interference introduced on the carrier. The power control's dynamic range can be adjusted by changing the minimum and maximum DPCH power thresholds. Increasing the minimum DPCH power threshold will reserve an amount of power for each DPCH channel and therefore set the maximum limit on the power left for HSDPA. Increasing the maximum DPCH power threshold increases the coverage of the DPCH channel and sets the minimum limit on the power left for HSDPA. HSDPA uses AMC instead of fast power control to compensate for the differences in path losses and the effects of fading and interference by adjusting the modulation scheme and coding.

In the downlink, the primary CPICH channel and the DPCH channel's coverage needs to be optimized for optimal performance. The primary CPICH channel's received signal strength (RSCP) and quality (Ec/No) is measured by the UE during idle mode for cell selection/reselection and in active mode for soft handover and HSDPA CQI reporting. In the soft handover areas the UE, in active mode, benefits from the DPCH channel soft handover gain as the UE will receive and combine data from the different cells that it is in soft handover with. The amount of cells that can serve the UE in the soft handover area is defined by the Active Set (AS) size. Increasing the AS size will increase the soft handover gain, but reduce the system capacity as well. Increasing the amount of primary CPICH channels beyond the AS size will increase the interference in the area and degrade the quality and coverage of the DPCH and primary CPICH signal.

The Geometry Factor (GF), defined as the wideband ratio of own-cells to other-cell plus noise interference at the mobile, can be used to combine the different aspects of coverage, capacity and quality in the downlink. It combines the relation between the cells' downlink coverage, soft handover boundaries, quality and capacity. The GF of a cell can be calculated with the equation in (3).

$$GF = \frac{I_{intra}}{I_{inter} + N_0} \qquad (3)$$

Where I_{intra} is the intra cell interference, I_{inter} is the inter cell interference and N_o is the power of the noise.

Mobiles transmitting on the same uplink frequency compete with each other and system thermal noise. Increased interference in the uplink frequency requires higher mobile transmit power in an attempt to achieve the required Eb/No at the Node B receiver for a given bit rate. This increase in power influences the achieved bit rate and coverage for other mobiles in the surrounding area as the increase in power introduces additional interference in the carrier. The equation in (4) can be used to calculate the uplink capacity for a cell in a multiple cell environment with multiple users, by expressing the uplink capacity in terms of a load factor.

$$\eta_{UL} = \left(1 + \frac{I_{inter}}{P_{RX}^{NodeB}}\right) \sum_{i=1}^{n} \frac{1}{\frac{W}{\left(\frac{E_b}{No}\right)_i \cdot R_{b,i}} + 1} < 1 \qquad (4)$$

A different approach, other than the traditional approach used for R99, is needed when analyzing the uplink capacity with the inclusion of HSUPA services. With the traditional approach, the previously assumed interference level is used when computing the received signal. This, however, is not feasible when including HSUPA's high peak data rates. Calculation of the Rise-over-Thermal is used instead, where the interference level of N + 1 users is used for the calculation of the received signal and load. Node B measurements is used for the calculation of the available headroom that is left for coverage and capacity in the uplink.

Increasing the headroom with system parameters will decrease the coverage of the cell in the uplink as more interference is allowed in the area, whereas decreasing the headroom will reduce the capacity and extend the coverage of the cell in the uplink. The relation between coverage and capacity in the uplink, also referred to as the cell-breathing effect, is illustrated with the equation (5).

$$L_{p,max} = \frac{P_{T,max}}{P_N} \cdot \left(\frac{W}{\left(\frac{E_b}{N_o}\right)_i \cdot R_{b,i}} + 1 \right) \cdot (1 - \eta_{UL}) \qquad (5)$$

Where $L_{p,max}$ is the maximum expected path loss, $P_{T,max}$ is the mobile's maximum transmission power, P_N is the background noise power, $(E_b/N_o)_i$ is the i^{th} user SNR requirement, $R_{b,i}$ is the i^{th} user bit rate, W is the total bandwidth and η_{UL} is the uplink load factor.

Probability allows us to calculate the variability in the result of an event, when the exact result cannot be predicted with certainty. In a similar approach the properties of probability can be used to quantify the dynamic nature and variability of the WCDMA resource utilisation and calculate the event that a cell is congesting.

In probability theory two or more events are defined as mutually exclusive when they cannot occur at the same time. This statement is also assumed to be true for WCDMA resources, because of the dynamic properties introduced with HSPA in Rel 5 and higher. To prove this we consider the following examples of the resource utilisation on a Node B.

- Uplink and downlink baseband utilisation

  This is a shared node B resource and will also be impacted by other RAB connections in other cells on the same Node B. For this reason, it is highly unlikely that the utilisation of baseband hardware will be the same when comparing two instances in time, with one or more of the other resources having the exact utilisation values in both time instances.

- Downlink OVSF Codes

This is a dynamically shared cell resource, shared between R99 and HSDPA RABs, with R99 having preference. All of the HS-PDSCH codes can be utilized by one UE or shared between multiple UEs connected to the cell. For this reason, it is highly unlikely that the utilisation of the downlink OVSF codes will be the same when comparing two instances in time, with one or more of the other resources having the exact utilisation values in both time instances.

- Downlink Power

This is a dynamically shared cell resource, shared between R99 and HSDPA RABs, with R99 having preference. Power control is used for R99 RABs to maintain the grade of service in a changing RF environment. The remainder of the power can then be used for the HS-DSCH channel, which will vary with the scheduled throughput in the downlink. For this reason, it is highly unlikely that the utilisation of the downlink cell power will be the same when comparing two instances in time, with one or more of the other resources having the exact utilisation values in both time instances.

- Uplink Noise

Uplink noise is shared between other RABs in the own cell as well as inter-cell interference introduced by UEs which are connected to neighbouring cells on the same frequency. In the own cell the noise load will also be different for each RAB type due to the RF environment as well as scheduled throughput in the case of HSUPA. For this reason, it is highly unlikely that the utilisation of the downlink cell power will be the same when comparing two instances in time, with one or more of the other resources having the exact utilisation values in both time instances.

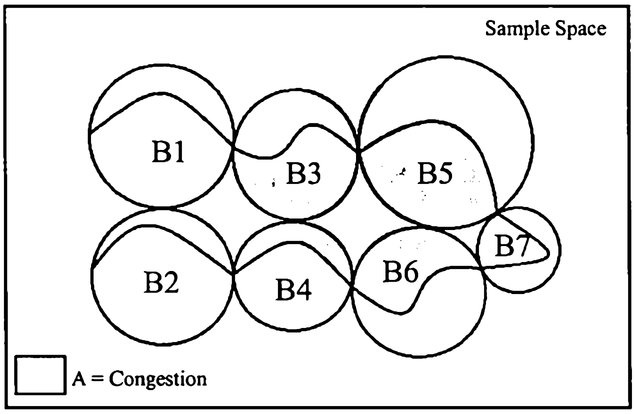
- HSPA user admission

Since the downlink power used for the HS-DSCH channel and the downlink OVSF codes used for the HS-PDSCH codes are dynamically shared between all HSDPA users, it is highly unlikely that be two instances where the same amount of HSDPA users will utilize the same amount of power or OVSF codes. The same is also valid for HSUPA users, where one or multiple users may consume the majority of the uplink noise capacity.

In the above mentioned examples it is noticeable that, due to the dynamic nature of the WCDMA resources, it is plausible to assume that the WCDMA resources are mutually exclusive.

The general rules of multiplication are useful in solving problems where the outcome of a specific event depends on the results of multiple mutual exclusive events. The rule of elimination is especially useful for calculating the probability that a WCDMA cell is congesting.

The Venn diagram below graphically represents the sample space and mutual exclusive events that's used in the calculation of the probability of congestion. Using a large sample space, such as a wide network area with sufficient measurements, will ensure that the results of the calculations are valid.



The Venn diagram illustrates the calculation of the probability of congestion, having events B1 to B7 for downlink cell power, downlink cell OVSF codes, uplink baseband hardware, downlink baseband hardware, HSDPA user admission, HSUPA user admission and uplink noise respectively. A is the event that the cell is congesting.

The rule of elimination in (6) is used to calculate the probability of the event that the cell is congesting given that the resources are being utilised to a certain extent.

$$P(A) = \sum_{j=1}^{7} P(A|Bj)P(Bj) \qquad (6)$$

Where P(A) is the probability that the cell is congesting, P(A|Bj) is the probability that the cell congest given that resource Bj is being utilized to a certain extent and P(Bj) is the probability that resource Bj is being utilized to a certain extent.

P(Bj) in (6) can also be seen as the contribution of congestion in the network due to that specific event and therefore the equation in (7) must always be true for P(Bj). Updating this value dynamically will ensure that the impact of network expansion will be taken into account when calculating new values for probability of congestion.

$$\sum_{j=1}^{7} P(Bj) = 1 \qquad (7)$$

P(A|Bj) in (6) can be seen as the specific resource utilisation in that instance of time. This value should be normalized to a ratio between 0 and 1 as it should indicate a probability.

To illustrate this in an example we consider the following values in the table below for a cell's resources at an instance in time.

Resource	**Event**	**Network Contribution P(Bj)**	**CELL A P(A|Bj)**
Downlink Power	B1	0.22	0.65
Downlink OVSF Codes	B2	0.12	0.55
Downlink Baseband HW	B3	0.06	0.33
Uplink Baseband HW	B4	0.09	0.45
HSDPA User Admission	B5	0.1	0.80
HSUPA User Admission	B6	0.08	0.60
Uplink Noise	B7	0.33	0.65

Using the equation in (6) the server 12 can calculate the probability of congestion for Cell A. For this example the probability of congestion works out to be 0.62.

The above example methodology was applied to a live network before and after a network wide rollout of HSPA+ upgrades. Two separate upgrades were done over a period of 30 days.

The table below contains the specific network upgrades that are of interests for this use case.

Upgrade	**Upgrade Detail**	**Notes**	**Impact noticed**	**Upgrade Step**
Uplink and downlink baseband HW	Match the license value with the installed HW	-	Reduction in UL Baseband HW utilization	Upgrade 1
Increase HS-PDSCH Codes per cell	Maximum license value loaded to 15 HS-PDSCH Codes/Cell	Node Bs need a restart for activation of this license. Not done on this date	DL Code utilization reduced as a result of the higher license value	Upgrade 1
Activating license for maximum HS-PDSCH Codes	Node Bs restarted		DL Code utilization increased due to HSDPA UEs using more HS-PDSCH Codes	Upgrade 2
Activating improved UL Baseband HW feature	Node Bs restarted	Reduce UL Baseband HW used by HSUPA services	Initial reduction seen in UL Baseband HW, but increased as soon as the activation of HSUPA 2ms TTI was completed	Upgrade 2
Activating HSUPA for 2ms TTI			Increase in UL Baseband HW	Upgrade 2

The impact of the upgrades on the probability of congestion can now be calculated, with a clear indication of what resource was impacted as well as which ones needs to be attended to next.

In a live network trial result it was found that the probability of congestion trend and the resources that impact this metric the most were able to be easily calculated. The upgrade impact of resources was clearly visible on the probability of congestion value, with a drop as high as 7%.

With the increased capacity requirements on the WCDMA network a solution is needed to proactively identify capacity upgrades on cell, site and area level. The dynamic nature of the WCDMA resource utilization together with the addition of new features in the upcoming 3GPP releases increases the complexity of this problem. Due to this complexity it is feasible to assume that the WCDMA resources are mutually exclusive. This assumption simplifies the problem and provides the possibility of using a probability algorithm based on the WCDMA resource utilization measurements, which evolves due to new features or upgrades being introduced into the network. Results from a live network trial, proves that this solution can be used to proactively identify new resource congestion in the right areas at the right time as well as quantifying the impact of introducing new capacity features in the network.

CLAIMS:

1. A method of determining network resource congestion, the method including:

   identifying a contribution of each resource in a target cluster, which contribution is a cluster's resource contribution weight;

   for each cell in the cluster identify the usage of its resources; and

   determine the congestion probability for each cell based on the cluster's resource contribution weights and the cell's resource usage.

2. A method according to claim 1 wherein the resources include one or more of Downlink Air interface Resources, Uplink Air interface Resources, User Admission and Baseband Capacity.

3. A method according to claim 1 wherein the contribution of each resource includes the percentage usage of each resource to the total amount of resources.

4. A method according to claim 1 wherein the clusters are defined as areas with the same properties such as topology, building structures, population density and consumer behaviour.

5. A method according to claim 1 wherein the method of determining the congestion probability includes multiplying every cell's resource utilization with its cluster's resource contribution weight and summing it all up to get the cell's congestion value.

6. A system for determining network resource congestion, the system including:
   a communications module to communicate with a cellular network to obtain required information from the cellular network; and

   a calculation module to:

      identify a contribution of each resource in a target cluster, which contribution is a cluster's resource contribution weight;

for each cell in the cluster identify the usage of its resources; and

determine the congestion probability for each cell based on the cluster's resource contribution weights and the cell's resource usage.

7. A system according to claim 6 wherein the resources include one or more of Downlink Air interface Resources, Uplink Air interface Resources, User Admission and Baseband Capacity.

8. A system according to claim 6 wherein the contribution of each resource includes the percentage usage of each resource to the total amount of resources.

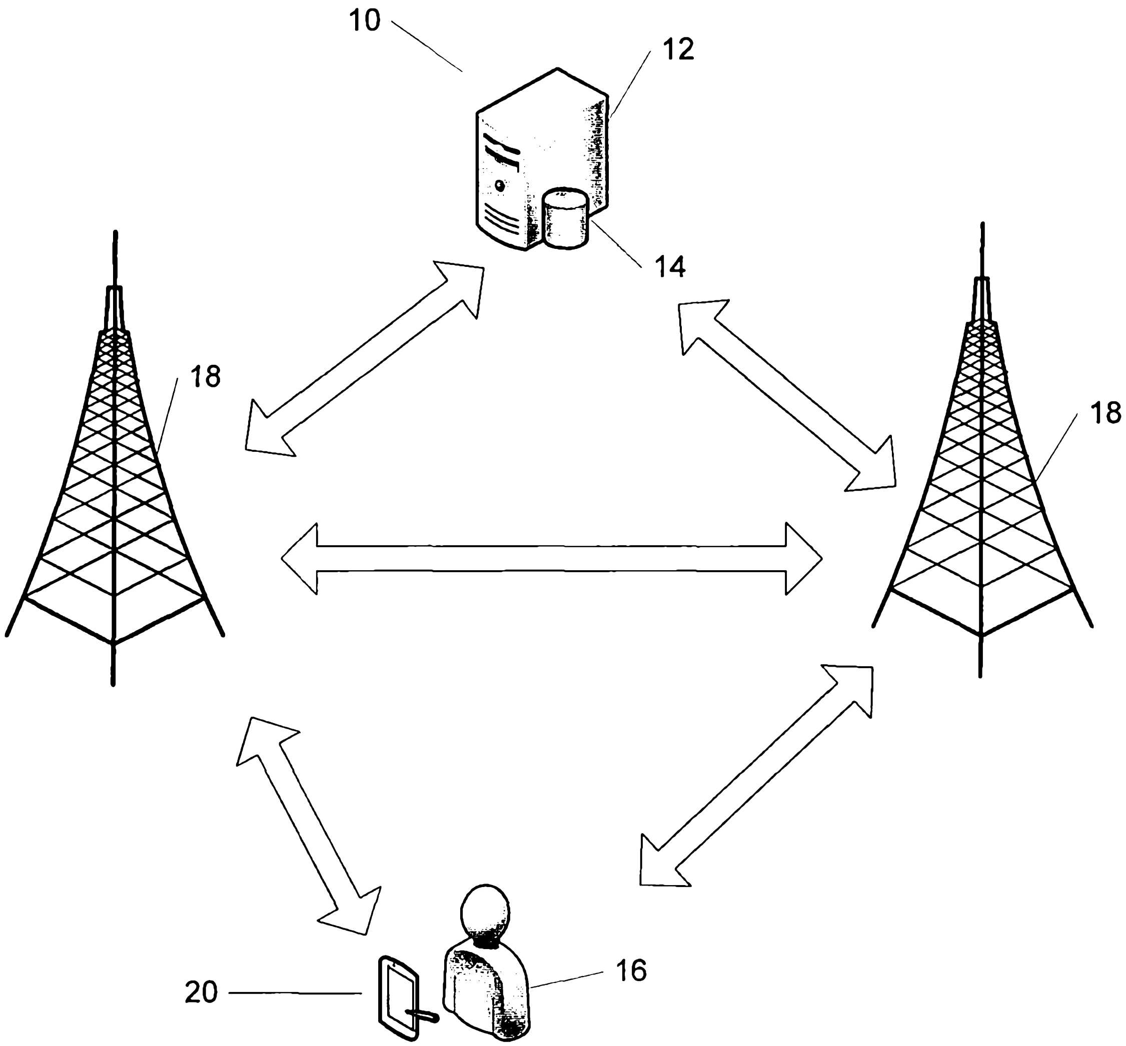
9. A system according to claim 6 wherein the clusters are defined as areas with the same properties such as topology, building structures, population density and consumer behaviour.

10. A system according to claim 6 wherein the calculation module determines the congestion probability by multiplying every cell's resource utilization with its cluster's resource contribution weight and summing it all up to get the cell's congestion value.

ABSTRACT

A system and method of determining network resource congestion includes identifying a contribution of each resource in a target cluster, which contribution is a cluster's resource contribution weight. Next, for each cell in the cluster the usage of its resources are identified. Finally, the congestion probability is determined for each cell based on the cluster's resource contribution weights and the cell's resource usage.

FIGURE 1



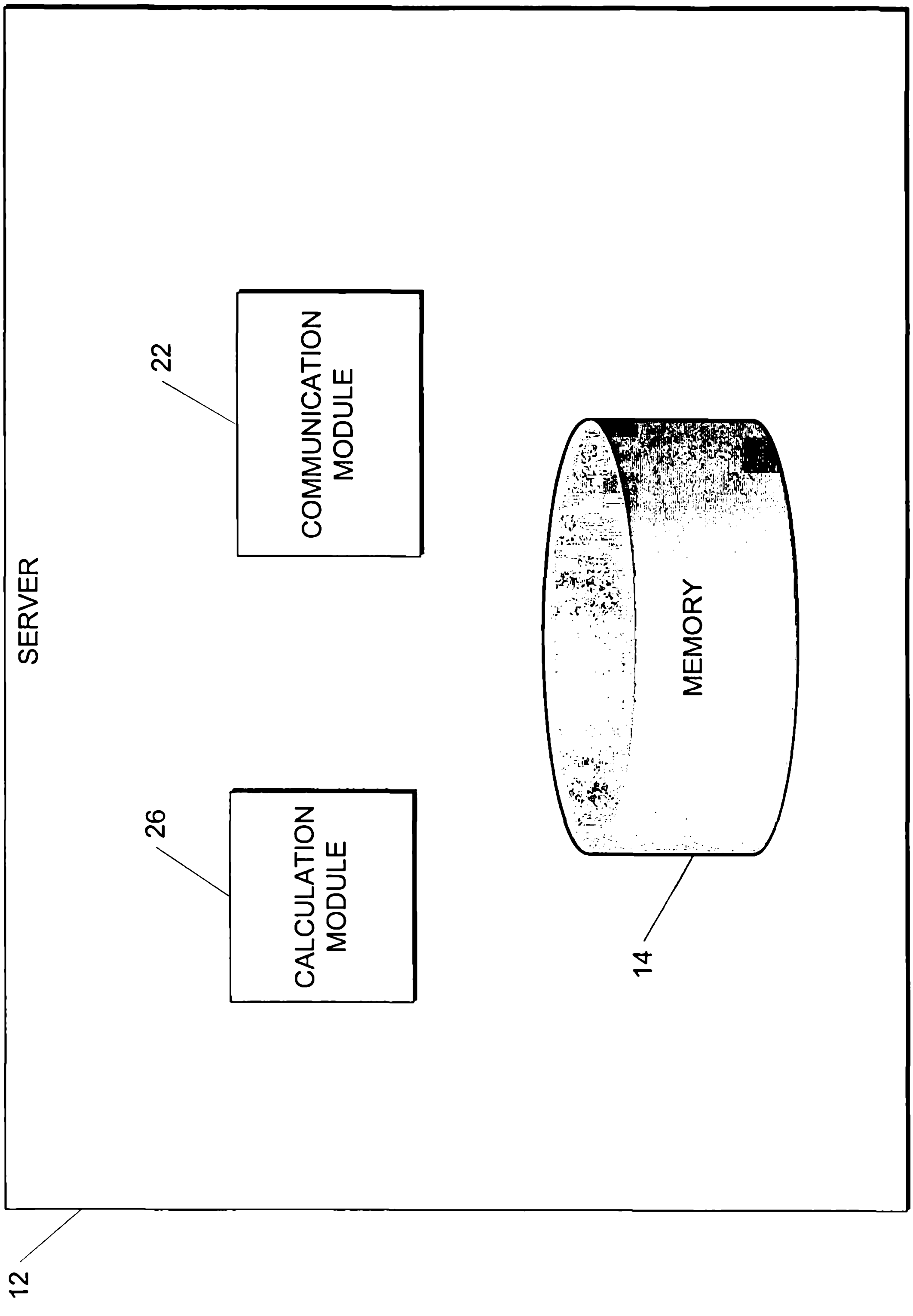

SERVER
22
COMMUNICATION MODULE
26
CALCULATION MODULE
MEMORY
14
12

FIGURE 2