

CHANNEL ALLOCATION FOR CHANNEL ALLOCATION TIERING

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a channel allocation method and a channel
5 allocation system in a mobile cellular telecommunications system in which the
channel allocation tiering (CHAT) technique is used.

In particular the invention relates to a channel allocation method based upon the
interference suppression capabilities of terminals, the radio requirements of the
services in use on the individual terminals, the radio location of the terminals or some
10 combination thereof.

GENERAL BACKGROUND OF THE INVENTION

The use of mobile radio communications continues to grow rapidly and new data
services are becoming increasingly popular. Many of these new services put greater
requirements on radio quality than traditional speech services at the same time as
15 speech traffic volumes continue to rise. Given the limited radio spectrum typically
available to network operators, techniques that can increase the spectral efficiency of
cellular networks are needed. Moreover, to achieve optimal performance, systems
must be able to manage a range of services and terminals with varying radio
requirements and interference suppression capabilities in a highly efficient manner.

20 An exemplary cellular network technology is GSM whose traffic loads are currently
more intense than in any other type of system. With the non-uniformity of many
commercial networks, extreme traffic peaks can occur in certain areas at busy hour
and cells requiring close to 100% hardware load, with as many installed transceivers
as there are available frequencies, already exist. Moreover, adaptive antenna
25 products that can enable an additional doubling of spectral efficiency will soon be
available [1]. Hence, the means for handling extreme loads, including the reuse of
radio resources within cells, may not just be an issue for future networks using GSM
or other technologies; solutions could be needed for hot spot areas in existing
networks relatively soon.

30 Very high spectral efficiency and the means for handling extreme loads can be
provided by the Channel Allocation Tiering (CHAT) technique [2]. CHAT decouples

the hardware resources of a cell from the radio resources and it is possible to install a larger number of hardware resource units, e.g. transceivers, than available radio resources, e.g. frequencies, when necessary. Intra-cell co-channel interference will typically be present at peak loads in a CHAT configuration, but CHAT provides several mechanisms to manage this. Adaptive narrow-beam antennas, intra-cell interference diversity through radio resource hopping, and advanced interference suppression receivers are examples of mechanisms that may be employed.

CHAT uses fractional reuse of radio resources, that is, reuse less than one. This means that different terminals in the same cell or cell sector can use the same radio resource at the same time.

CHAT is also disclosed in [3] and may be described in the following simplified and incomplete, but illustrative manner with reference to Fig. 1 which illustrates a number of hardware resource units 1a-h, 2a-h, for example transceivers, a number of radio resources 3a-h, for example frequencies, and a cell 4 in which the resources 1-3 are available.

According to the CHAT technique the available hardware resource units are split into a number of logical groups, channel tiers 5 and 6, each of a maximum size h , where h is an integer. This maximum size h equals the number of radio resources allocated to each cell. The cell can be regarded as being comprised of two logical cells 7, 8 each corresponding to a respective tier. The fractional reuse in CHAT is achieved by sharing the radio resources among different channels in different tiers. In the example shown the available hardware resource units are split into two tiers. The two tiers utilize the same radio resources 3a-h. For example, two channels, one (1a) from tier 5 and one (2a) from tier 6, share the same radio resource 3a at this moment in time. In general, all tiers partially or fully share the same radio resources. However, sharing is very flexible. A channel may share its radio resources with other channels in different tiers, or it may use its allocated radio resources by itself without sharing. When two channels share the same radio resource, a collision occurs and intra-cell co-channel interference is generated. The effects of this should be minimized. In CHAT a number of techniques may be used to achieve the lowest possible collision rate and to minimize the effects of any collisions that do occur. Such techniques include different radio resource hopping sequences, e.g. frequency hopping

sequences, in the two tiers, different training sequences in the two tiers together with interference suppression in the receivers, and various interference avoidance techniques such as spatial separation using adaptive antennas.

CHAT is preferably used when the number of radio resources is less than the number of hardware resource units in the cell. However, CHAT may be used in cells where the number of radio resources is more than the number of required hardware resource units.

A characteristic of the CHAT technique is that the amount the channel tiers interfere with one another is dependent on the traffic load in each tier. The allocation of traffic between the tiers will therefore affect the interference levels in the other tiers. To explain this, suppose traffic load in tier 5 is high, and low in tier 6. Since traffic load in tier 5 is high, the number of terminals in tier 5 is larger than in tier 6 where the traffic load is less. Terminals that are allocated channels in tier 6 will therefore experience more intra-cell co-channel interference (from the many terminals in tier 5) than those in tier 5 which are only affected by the few terminals in tier 6. Intra-cell co-channel interference only occurs between, not within, different tiers.

In accordance with [3] the hardware resource units in prior art CHAT systems are divided into tiers when the number of needed hardware resource units is greater than the number of radio resources in that same cell. In the following this tier configuration process is referred to as slow CHAT configuration. In accordance with [3] channel allocation to the different tiers is made with consideration to the current load in the tiers. In the following we refer to channel allocation to the different tiers as fast channel allocation. Reference [3] is silent on the means and measures to be used for the fast channel allocation.

One possible way to obtain an even spread of intra-cell interference between users in a cell or cell sector would be to divide the hardware resource units into equally sized channel tiers whenever a second (or higher) tier is introduced. However, this means that intra-cell co-channel interference will occur at far lower radio resource loads than necessary, i.e. much lower than 100%, which is clearly undesirable. Another possible way to obtain an even spread of intra-cell interference between users in a cell would be to allocate channels randomly. This, however, may have the implication that a channel in a more highly interfered channel tier is allocated to a terminal on which a

service is running, that has high radio requirements in terms of the carrier-to-interference ratio (C/I), bit error rate, quality-of-service (QoS) etc., with the result that the terminal will experience excessive intra-cell co-channel interference. Another implication may be that a channel in a more highly interfered channel tier is allocated to a terminal which resides in a bad radio location, for example a terminal at the border of a cell, with the result that the terminal will experience excessive intra-cell co-channel interference. Still another implication may be that a channel in a more highly interfered channel tier is allocated to a terminal that has no or only weak interference suppression capabilities with the result that the terminal will experience excessive intra-cell co-channel interference. Intra-cell co-channel interference problems become even worse if a channel in a more highly interfered channel tier is allocated to a terminal that both has high radio requirements and a bad radio location, or is allocated to a terminal in a situation which is a combination of the listed conditions.

In [4] a radio communications system is described that utilizes multiple code sets in the downlink of a CDMA system to allow more connections in a cell. Codes are allocated to different users taking into account the interference between them.

SUMMARY OF THE INVENTION

One object of the invention is to provide a channel allocation method in a CHAT system that combines slow CHAT configuration and fast channel allocation in a manner that ensures that intra-cell co-channel interference is only introduced when absolutely necessary, i.e. a radio resource load threshold close to but less than 100% is reached, and, once introduced, has as minor an effect on user and system performance as possible.

A higher channel tier should preferably only be used when the traffic load is so high that users otherwise would be denied access to the system.

An advantage achieved thereby is that interference levels in the network are kept to a minimum at all times, thereby maximizing user and system performance, irrespective of the prevailing traffic load in the network.

Another object of the present invention is to control fast channel allocation in a CHAT scenario systematically and in accordance with the individual requirements of a

terminal. With individual requirements is meant a terminal's QoS service profile, radio location, interference suppression capabilities or combinations thereof.

An advantage achieved with the invention is that only terminals that can stand higher levels of intra-cell co-channel interference will be allocated a channel in a more highly
5 interfered channel tier.

Another advantage is that perceived service performance will be evenly spread out between all terminals in a cell to as large extent as possible, thereby maximizing system capacity.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 is a schematic view of a CHAT system in accordance with prior art,
Fig. 2 is a schematic view illustrating a CHAT system in accordance with the present invention,
Fig. 3 is a schematic view similar to Fig 2 illustrating an overlaid/underlaid cell configuration,
15 Fig. 4 is a schematic view of a CHAT system in accordance with the invention, the system using three tiers, and
Fig. 5 is a simplified block diagram of a GSM system using the channel allocation system.

DETAILED DESCRIPTION OF EMBODIMENTS

20 The invention will primarily be described with reference to the GSM system. In a GSM system the least hardware resource is a time slot on a transceiver TRX and the least radio resource is a time slot on a frequency. In GSM there are 8 time slots in each TDMA frame, so during each TDMA frame period, transmission and reception of at most 8 logical channels, e.g. traffic channels TCHs, can be performed on a
25 given TRX and a given frequency. In subsequent TDMA frames, communication can be carried out with the same set or a different set of 8 logical channels on the same or a different TRX using the same or a different frequency. Although the exact mapping of logical channels to hardware resources to radio resources may vary from time slot to time slot and from TDMA frame to TDMA frame, the principle of the
30 invention remains the same. Hence, for the sake of clarity, the invention is described below as a snap shot during a single time slot in a TDMA frame. Its generalization to

the dynamic case with multiple time slots in a TDMA frame and to multiple TDMA frames is straightforward.

A first embodiment of the invention will be described with reference to Fig. 2. In the drawings like elements have the same references. Fig. 2 illustrates hardware

5 resource units 1, 2 and radio resources 3 available in a cell of a cellular mobile telecommunication system. Radio resources 3 are frequencies $f_1, f_2, \dots, f_{10}$.

Hardware resource units 1 are transceivers TRX1, TRX2, ... TRX10. Hardware resource units 2 are transceivers TRX11 and TRX12. Further there is a plurality of logical channels 9 each one associated with a respective hardware resource unit 1

10 and 2 as illustrated by arrows 10. In the illustrated example there are as many logical channels CH1, CH2, ... CH12 as there are hardware resource units 1 and 2, i.e. the hardware resources are fully utilized. Each of the hardware resource units 1 is mapped on a respective radio resource as indicated by arrows 11. There are as many hardware resource units 1 as there are radio resources, ten in the illustrated
15 example. Channel allocation is made on the logical channels.

Each of the channels CH11 and CH12 is mapped on a respective hardware resource unit that is mapped on a respective radio resource as indicated by arrows 12.

Mapping of hardware resources on radio resources is part of the slow CHAT configuration process.

20 To get a better understanding of the invention, assume a scenario wherein the cell comprises just the ten transceivers TRX1-10 and the traffic load in the cell is increasing over time. A point is reached when all time slots in all TRXes are occupied with traffic and the cell cannot take any more traffic. A state of congestion is said to exist. Since there obviously is a need to increase the capacity of the cell, two more
25 TRXes, TRX11 and TRX 12, are added to the cell. These can use any of the frequencies f_1-10 in a CHAT configuration implying a fractional reuse. The determination of the mapping between hardware resources and radio resources at this point where a CHAT configuration is introduced is a part of the slow CHAT configuration.

30 Traffic varies over the day and let us assume we start at a time when there is no traffic and all hardware resources are available. The first terminal to make or take a call is assigned channel CH1, which is allocated to TRX1. Since TRX1 is mapped on

frequency f1 at this instant, as illustrated by arrows 11, the allocation of an individual channel to a terminal results in the assignment of an individual radio resource to the terminal. The second terminal to take or make a call is assigned a channel CH2, which is allocated to TRX2, which is mapped on f2 at this instant, as illustrated by the second of arrows 11 from the top. The second terminal will thus be allocated an individual radio resource. Channel allocation in accordance with this rather conventional manner proceeds as traffic increases. When a threshold close to, but less than, 100 % of the radio resources is reached, allocation of channels in this process of fast channel allocation will take place utilizing transceivers TRX11 and TRX12.

If we for a moment consider a full TDMA frame with 8 time slots, the above-mentioned threshold may for example be reached when all 8 time slots in TRX1-9 and two time slots in TRX 10 are occupied and only six time slots in TRX 10 are free.

Slow CHAT configuration is for example made in connection with installation of transceivers in the base transceiver station (BTS) or when traffic load is zero in the BTS. Slow CHAT configuration means that the hardware resource units 1 and 2 are divided into tiers, in this case two tiers 13 and 14, the first tier 13 comprising TRX1, TRX2, ... TRX10 and the second tier 14 transceivers TRX11, TRX12. Slow CHAT configuration also comprises establishment of the threshold. The threshold and the border between the two tiers is schematically indicated with the dashed line 15. Further, slow CHAT allocation comprises the above-mentioned assignment of radio resources to each channel tier.

The slow CHAT configuration is made in order to avoid congestion problems while still keeping interference levels in the network to a minimum at all times.

The fast channel allocation scheme allocates channels to new terminals in a strictly controlled manner and on demand. Since fractional reuse of radio resources occurs the general idea is to allocate channels in a more highly interfered channel tier to terminals that can stand more intra-cell co-channel interference while terminals that are susceptible to interference are allocated channels in a less interfered tier.

Pursuing the example above with a traffic load so high that only four of the 80 time slots during a TDMA frame period are free in the first channel tier, suppose a new terminal wants to make a call and therefore transmits a call request to its base station

controller BSC (comp. Fig. 5). From the call request and from other sources the BSC is able to learn the location of the terminal, its interference suppression capabilities and its requested service. If, for example, the terminal has no interference suppression capabilities, or is in a bad radio location or its requested service requires strong radio requirements or any combination of this it will be assigned one of the free time slots in the first channel tier. If it has interference suppression capabilities or has a good radio location or its requested service has weak radio requirements or any combination of the above it is assigned to the second channel tier.

This fast channel allocation process is repeated for each new terminal that wants to make or take a call.

From the above it should be understood that fast channel allocation according to the invention is based on the interference suppression capabilities of the terminal in question and/or radio requirements of the given service. More robust terminals and services are preferentially allocated to the more heavily interfered tier(s). Further the fast channel allocation is based on the "radio location" of the terminal with respect to the serving base station, the cell border, surrounding interferers, etc..

It should be understood that when a hardware resource is seized, it will be marked as occupied. When a call is finished its hardware resource will be marked as free and it will be available for a new allocation.

It should also be understood that the tier to which a terminal is allocated will depend on the terminals and services that at the channel allocation moment are present in the cell. If there are no channels free on tier 13 but free channels are available on tier 14 and a call request arrives from a terminal without interference suppression capabilities that is located near the cell border, this terminal will be assigned one of the free channels on tier 14 but a reallocation of terminals will then immediately take place in accordance with the principles of the fast channel allocation scheme described above. A reallocation may result in that terminals with interference suppression capabilities that before the reallocation were assigned channels on tier 13 will be assigned channels on the more interfered tier 14, thus making the hardware resources they occupied on the less interfered tier 13 free. Of these freed hardware resources on tier 13 one will be assigned to the terminal that caused the reallocation. Possibly, and depending on e.g. a prediction of the traffic load, also

other terminals with interference suppression capabilities are assigned hardware resources on the more interfered tier 14 during the reallocation. A similar reallocation of terminals will occur if conditions change during a service session, for example due to terminal mobility. The fast channel allocation scheme, adapted for a plurality of terminals, is preferably used for reallocation.

As traffic load decreases below the threshold or decreases below the threshold by a predefined amount only channels in tier 13 are utilized by the fast channel allocation scheme and channels in tier 14 will remain unoccupied until the predefined traffic load threshold is reached once again.

A terminal in a good radio location, for example in the cell centre, or running a service with weak radio requirements, i.e. a robust service that is not particularly sensitive to interference, or provided with interference suppression capabilities or having a combination of these conditions is assigned a channel in a more highly interfered channel tier, e.g. tier 14 in Fig. 2, whenever the traffic load is above the threshold level. A terminal in a bad radio location, for example at the border of a cell, or running a service with high radio requirements, or lacking interference suppression capabilities, or having any combination thereof is assigned a channel in a less interfered channel tier, e.g. tier 13 in Fig. 2, whenever possible.

Good radio locations are defined by radio or geographical distance to the serving base station, radio or geographical distance to the cell border, radio or geographical distance to surrounding interferers, carrier-to-interference ratio (C/I) or other link quality measures such as bit error rate (BER), block error rate (BLER) and frame erasure rate (FER), or some combination of the above.

Refer to Fig. 3 that further illustrates the embodiment shown in Fig. 2. Tier 14, which is the more heavily interfered tier, is utilising an overlaid (OL) configuration 16 while tier 13 is utilising an underlaid (UL) configuration 17. Suppose there is a mix of terminals, some with interference suppression (IS) capabilities, some without.

Assume that the total number of hardware resources are located in N_T hardware resource units 1, 2 that are mapped onto f radio resources, where $N_T > f$. Tier 14 is primarily for IS-capable terminals (IS is an acronym for interference suppression) and has N_{IS} hardware resource units run in OL. Tier 13 is for both IS and non-IS capable terminals, and comprises N_{REM} hardware resource units run in UL. At low traffic loads

all terminals should be allocated channels from N_{REM} . At loads above the radio resource load threshold 15, IS capable terminals should be allocated channels preferentially from the N_{IS} tier 14. Non-IS capable terminals should be allocated channels from the N_{REM} tier 13 whenever possible.

5 The size of the tiers should be: $N_{IS} = N_T - f$, implying that $N_{REM} = f$.

In the illustrated GSM case there are 10 frequencies ($f=10$) and 12 transceivers must be installed per cell to avoid congestion, i.e. to fulfil the blocking criteria ($N_T=12$).

Then, $N_{IS} = 2$ transceivers and $N_{REM} = 10$ transceivers. In this case, the probability of intra-cell co-channel interference for N_{IS} is at most 100% since $N_{REM}/f = 1$. However,

10 this situation is manageable since all terminals in that tier are IS-capable and in good radio locations. The probability of intra-cell co-channel interference for N_{REM} is at most 20% since $N_{IS}/f = 0.2$. Hence, the intra-cell co-channel interference probability for the non-IS terminals is minimised.

It should be remembered that the two tiers use frequency hopping, although with
15 different hopping sequences. The channels in tier 13 are mapped on ten frequencies, and each individual terminal (in tier 13) jumps between some or all of these. Each individual terminal in tier 14 also hops between several or all of the ten frequencies, but at any given instant at most two of the ten frequencies are used by the tier 14 terminals. This implies that the interference experienced by a tier 13 terminal on
20 average takes place at most two tenths (2/10) of the time, which is an interference that a non-IS capable terminal should stand.

It should be understood that a gradation of radio locations is enabled by using an overlaid / underlaid sub-cell configuration. If a terminal is residing in for example sub-cell 16, it is close to the base station and the system can use this information to
25 optimise communication to this terminal.

Refer to Fig. 4, which may be seen as a later version of the cell described in connection with Fig. 2 or 3. Pursuing the discussed example, assume traffic in the cell continues to rise over a long time, thus calling for insertion of additional hardware resources at the cell site. Over time ten additional transceivers TRX13-22 have been
30 inserted. Still there are only ten frequencies available. Following the same principles outlined above the slow CHAT configuration is made, now with TRX1-10 in tier 13, TRX 11-20 in tier 14 and TRX21-22 in a third tier 18 as an additional OL sub-cell 19

in the cell. Channels in tier 13 are mapped on frequencies f1-f10 as illustrated by arrows 11. Channels in tier 14 are also mapped on frequencies f1-f10 as illustrated by arrows 12, and channels on tier 18 are also mapped on frequencies f1-f10 as illustrated by arrows 21. The threshold 15 is the same and a new threshold 20 is set for the second tier 14, this threshold being so selected that it is close to but smaller than 100% of the maximum possible traffic load in tier 14, i.e. close to but smaller than 200% radio resource load in the cell. Fast channel allocation in accordance with the principles of the invention takes place in both tiers 14 and 18. The channels of tier 13 are allocated first, then the channels of tier 14 and finally the channels of tier 18. Reallocation between tiers in a fashion similar to what has been described in connection with Fig. 2 is used in Fig. 3.

Generally, the more heavily interfered tier or tiers are run in OL.

Following the principles above it is possible to add more hardware resources and perform slow CHAT configurations using several tiers. If there are f radio resources, T tiers and a total of N_T hardware resource units, the number of hardware resource units in the final tier is equal to $N_T - (T-1) f$.

Allocating Channels To Tiers

The fast channel allocation algorithm may allocate terminals to tiers in many different ways, some of which will be outlined below.

1. As already mentioned all terminals are allocated to the first tier 13 until a radio resource load close to but less than 100 % is reached.

2. Above the threshold terminals in good radio locations are allocated to the next tier 14.

3. A gradation of radio locations is enabled by using an overlaid (OL) / underlaid (UL) sub-cell configuration and each tier can be allocated to one or more radio sub-cells 16, 17, 19.

4. The steps 1-3 are repeated for higher tiers 14, 18 where the radio resource load threshold for tier N is then close to but less than $N \times 100\%$.

5. To keep terminals in good radio locations in higher tiers 14, 18, a re-allocation between tiers is performed if radio locations change sufficiently during a

service session as a result of terminal mobility or for other reasons, or if tier congestion at call setup or handover resulted in initial allocation to a less suitable tier.

6. The steps 1-5 are repeated but services with weaker radio requirements are allocated to higher tiers 14, 18 instead of, or together with, terminals in good radio locations.

7. The steps 1-5 are repeated but terminals with interference suppression capabilities are allocated to higher tiers 14, 18 instead of, or together with terminals in good radio locations and/or services with weaker radio requirements.

8. The same as in step 7, but where terminals with strong interference suppression characteristics are preferentially allocated to higher tiers than those with weaker interference capabilities, which are preferentially allocated to lower tiers.

9. As an alternative to step 1 above, terminals are allocated directly to the worst tier they can cope with given the service profile of the service being used.

However, in most cases this would be unnecessarily conservative.

These same principles discussed above, with or without OL/UL, can be easily applied to different services, both circuit-switched and packet-switched, and to a mixture of both different types of terminals (with respect to interference suppression capabilities) and services.

System Architecture

In Fig. 5 there is shown a GSM system with a BSC (base station controller) 22 controlling a plurality of BTSs (base transceiver stations) 23 each one serving a plurality of terminals 24. A terminal in one BTS can communicate with a terminal in another via the BSC. For clarity reasons only one BTS is shown in Fig. 5. The BSC comprises conventional hard- and software and is according to the invention provided with a controller 25 for dividing the number of available hardware resource units into tiers. The controller comprises an algorithm 25A for slow CHAT configuration of the BTS. The BSC further comprises a controller 26 containing an algorithm 26A for fast channel allocation. A terminal is assigned a radio resource, for example one or more time slots 27 in a TDMA frame 28 on a frequency generated by a particular TRX 29. Information on the assigned radio resource is transmitted to the

BTS as indicated by the dashed line 30. In the case of frequency hopping, the frequency to be utilized by the terminal changes from one TDMA frame to the next. A mobile allocation index offset (MAIO) management method may be used to distribute hopping sequences among the different terminals within a tier. This will remove any co-channel interference within each tier. The parameters such as MAIO that determine the frequency hopping sequence are a part of the radio resource assignment information sent from the BSC to the BTS (30).

When a terminal wants to make or take a call it will be assigned one or more time slots 27 in an individual transceiver 29 among the transceivers 1 or 2 by the fast channel allocation algorithm 26A. A TDMA frame and its time slots are shown at an enlarged scale at the bottom part of Fig. 5.

Advantages of the Invention

The occurrence of intra-cell co-channel interference with CHAT is minimised. When intra-cell co-channel interference does occur, it affects those that are best able to cope with it, i.e. those services with weaker radio requirements and those terminals with interference suppression capabilities and/or in good radio locations. In this way the potential adverse effects caused by the intra-cell co-channel interference, e.g. near-far effects on the uplink, can be minimised and user and system performance are enhanced.

The invention also allows CHAT to easily be deployed in "migration scenarios" where only a fraction of the terminals have interference suppression capabilities, for example. The negative influence from intra-cell co-channel interference on non-interference suppression capable terminals is minimised.

Although the invention has been described with reference to a GSM system it should be understood that it is a straightforward matter for the person skilled in the art to adapt the invention to other cellular mobile telephone systems, for example those based on OFDM and CDMA. Since the radio resources in OFDM systems are divided into frequencies and time slots in a similar way to GSM, and hardware resource units like transceivers are also required, the principles of the invention that have been outlined above with reference to GSM can be directly applied to OFDM systems as well. Furthermore, DS (direct sequence) CDMA systems like WCDMA

have spreading codes as radio resources and channel elements as hardware resources and they can also make use of the invention. Higher channel tiers will then be allocated new scrambling codes, rather than frequency hopping sequences as in GSM.

- 5 The logical channels 9 shown in Fig. 2 and the accompanying text are abstract and do not have a physical existence. They have been used in order to facilitate the understanding of the term channel. A channel is physically embodied by a hardware resource, such as a transceiver. A channel may also be physically embodied by a radio resource, such as a frequency.

10 **References:**

[1] Carsten Ball et al., "Performance Analysis of a GERAN Switched Beam System by Simulations and Measurements", in *Proc of VTC'04 Spring*.

15 [2] Stephen Craig et al., "Channel Allocation Tiering (CHAT): Taking GSM/EDGE Networks Beyond One-Reuse", in *Proc of VTC'01 Spring*.

[3] WO-A2-0197537

[4] US-A-6,542,484

CLAIMS

1. A method of allocating channels to terminals within a cell of a cellular mobile telecommunication system, the method using the channel allocation tiering (CHAT) technique in accordance with which the number (N_T) of available hardware resource units (1, 2) exceeds the number (f) of radio resources (3), and the number of
5 available hardware resource units are divided into at least two tiers (13, 14, 18), a first tier (13) and at least a second higher tier (14, 18), hardware resource units of said at least second higher tier sharing radio resources with some or all hardware resource units of the first tier,
10 some of the terminals being capable of interference suppression,
characterized by
allocating channels in said tiers (13, 14, 18) to an individual terminal based upon its interference suppression capabilities, the radio requirements of the service used, its radio location, or some combination of the above.
- 15 2. A method in accordance with claim 1, **characterized by** mapping the set of hardware resource units in the first tier on a set of radio resources such that there are as many hardware resource units as there are radio resources (f).
3. A method in accordance with claim 2, **characterized by** that the number of hardware resource units in each higher tier (14), but the last (18), is f , where f is the
20 number of radio resources, and that the number of hardware resource units in the last tier is $N_T - (T-1)f$, where N_T is the total number of hardware resource units, T is the number of tiers and f is the number of radio resources.
4. A method in accordance with claim 3, **characterized by** allocating channels in the first tier (13) to terminals until a radio resource load threshold (15) close to, but less
25 than, 100% is reached.
5. A method in accordance with claim 4, **characterized by** allocating terminals in good radio locations to channels on said at least second higher (14, 18) tier when the radio resource load is above the threshold (15, 20).
6. A method in accordance with claim 5, characterized by allocating each tier one or
30 more sub-cells in an overlaid/underlaid sub-cell (16, 17, 19) configuration.

7. A method in accordance with claim 6, **characterized by** repeating the method steps of claims 4-6 for said at least second tier (14, 18), where the radio resource load threshold for a tier (N) is then close to but less than $N \times 100\%$.

8. A method in accordance with any of claims 1-7, **characterized by** re-allocation of terminals between tiers if radio conditions change as a result of terminal (24) mobility or for other reasons so as to keep terminals in good radio locations in higher tiers.

9. A method in accordance with any of claims 1-8 **characterized by** re-allocation of terminals between tiers when the radio resource load changes from below the threshold to above the threshold.

10. A method in accordance with claim 9 **characterized by** performing the re-allocation in connection with a call set-up or in connection with a handover.

11. A method in accordance with any of claims 3-6, **characterized by** repeating the method steps in claims 4 to 10 but allocating terminals (24) using services with weaker radio requirements to said at least second higher tier instead of or together with terminals in good radio locations.

12. A method in accordance with claim 1 or 8, **characterized in** that good radio locations are defined by radio or geographical distance to the serving base station, radio or geographical distance to the cell border, radio or geographical distance to surrounding interferers, carrier-to-interference ratio (C/I) or other link quality measures such as bit error rate (BER), block error rate (BLER) and frame erasure rate (FER), or some combination of the above.

13. A method in accordance with any of claims 3-6, **characterized by** repeating the method steps in claims 4 to 10 but allocating terminals having interference suppression capabilities to higher tiers (14, 18) instead of or together with terminals in good radio locations and/or services with weaker radio requirements.

14. A method in accordance with claim 13, **characterized by** allocating terminals (24) with stronger interference suppression capabilities to a higher tier than terminals with weaker interference suppression capabilities.

15. A method in accordance with claim 1, **characterized by** allocating terminals directly to the worst tier they can cope with given their quality-of-service requirements, assuming all remaining tiers are heavily loaded.

16. A system for allocating channels to terminals within a cell of a cellular mobile telecommunication system, some terminals (24) being capable of interference suppression,

- the allocation system using the channel allocation tiering (CHAT) technique in

accordance with which the number (N_T) of available hardware resource units (1, 2) exceeds the number (f) of radio resources (3),

- the allocation system comprising

- a controller (25) for dividing the number of available hardware resource units into at least two tiers, a first tier (13) and at least a second higher tier (14, 18),

- an algorithm (25A) for mapping the tiers onto a plurality of radio resources such that the hardware resource units of said at least second higher tier share radio resources with some or all hardware resource units of the first tier,

characterized by

- an algorithm (26A) for allocating channels in said tiers to terminals based upon their interference suppression capabilities, the radio requirements of the services in use on a respective terminal, their radio location, or some combination of the above.

17. A system in accordance with claim 16, **characterized in** that the controller (25) is adapted to set thresholds (15, 20) relating to radio resource utilization of a respective tier (13, 14), said threshold being close to but less than 100%.

18. A system in accordance with claim 16, **characterized in** that the number of hardware resource units in each of said higher tiers, but the last, is f , where f is the number of radio resources, and that the number of hardware resource units in the last tier is $N_T - (T-1)f$, where N_T is the total number of hardware resource units, T is the number of tiers and f is the number of radio resources.

o-0-o