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1. INTRODUCTION

In this contribution, we consider methods presented previously. One is the UE channel selection method (UCSM) by GBT, another is the Channel Assignment method (CAM) by Samsung and another is suggested by Philips. We call our scheme as versatile channel assignment method (VCAM). There were some comparisons from companies in several documents. Further comparisons and explanations are presented in this paper, but first a story.

1.1 A story of two hotels

There are two hotels called UCSM and VCAM. The hotels are both situated in a busy area near the local airport and are in competition with each other for the large number of overnight guests that pass through the airport everyday. Highway 1 connects the airport to Hotel UCSM, and Highway 2 connects the airport to Hotel VCAM.

The manager of Hotel UCSM decides that in order to attract more custom, he will post information on the types and availability of given rooms, on a electronic notice board at the airport. Customers can choose their room number at the airport, and directly ask for their preferred room on arrival at the hotel. The manager is very pleased with his idea, as he has trained his dog to recognise whether a requested room is available and to respond accordingly (one bark for yes, two barks for no). The dog is also trained to retrieve the appropriate room key and hand it to the customer, so that manager can save money by not having to employ a clerk at the reception desk.

The manager of Hotel VCAM also decides to display some information at the airport. She too posts information on the types and availability of rooms, but decides that she prefers to assign that actual room numbers herself. In that way she can for example, cater for large noisy parties of guests by assigning them the top floor, or perhaps fill one floor at a time and save money by turning off the power to any that remain unoccupied.

Two tourists arrive at the airport one afternoon both requiring a room for the night. The first is impressed by large amount of information available about Hotel UCSM and the prospect of meeting a talking dog. He decides to choose a room. Preferring a double room he sees that 529 is available. He takes a taxi via Highway 1 to the Hotel. He gets stuck in traffic. The second tourist is in a hurry. He simply notes that Hotel VCAM has a selection of rooms available and jumps in a taxi and travels by highway 2 to the hotel.

On arrival at Hotel UCSM, the first tourist asks for the key to 529. The dog looks at its updated list of rooms and seeing that 529 has been recently occupied, barks twice. The tourist sighs, goes outside, gets in a another taxi, goes back to the airport (noting the large amount of traffic), chooses another room, and returns later to the hotel to have another talk with the dog.

On arrival at Hotel VCAM, the second tourist walks to reception and asks for a double room. The manager gives the tourist a key to room 105 and directs him to the elevator. The tourist decides to have a nap before coming down to dinner.

Some time later, the dog at Hotel UCSM barks once and gives the first tourist a key to room 413. The tourist goes to his room, but is unable to sleep, due to all the traffic blocking highway 1 outside.

2. COMPARISONS BETWEEN METHODS

2.1 In a view of the queuing theory

To aid the explanation, Figure 1 presents a view of Queuing theory. The box is the Queue and the circle represents the server. Since the maximum number of access preambles (AP) of CPCH is 16, the number of the Queue is 16 in the UE selection method. In Figure 1, the parameter n is 16. Furthermore, if the UE selects a specific AP, the AP number determines just one channel by the scrambling code and the channelization code. It means that one Queue corresponds to one server as is illustrated.

In Figure 2, the VCAM is represented. Since each queue is corresponding to the multiple servers, it is a reasonable assumption that a MUX is inserted in the queue and servers. In CPCH, each server is characterised by the scrambling code and the channelisation code. The MUX function is predefined, or just a simple mapping rule. Another possibility is that a mapping table will be sent by a higher layer messages. We can easily see that the VCAM has greater flexibility. In the case of CPCH, the queue corresponds to the AP number and the server corresponds to the assigned channel. Since the UTRAN and UE know both the AP number and the assigned channel number, we can increase the degree of freedom. Considering the number of signatures, the possible maximum number of CPCH is 256. Because the maximum number of queue, M, is 16 and the maximum number of the servers for each queue is 16. Then the maximum number of CPCH channels can be 256 by 16x16. This number can be restricted on only the physical resources.

When we consider flexibility and the degree of freedom from the viewpoint of queuing theory, it is clear that the VCAM is an excellent scheme.

A comparison is presented in Figures 3 and 4. In Figure 3, the UE selection method is represented for the case of failure to get a channel. Two UE's want to use CPCH and both of them select the same data rate. Then they must select an AP. For example, let us assume that they select the AP number 1 and it is corresponding to the queue number 1. Unfortunately, even though they knew the server was available a few slots ago, it is occupied just before they select. In this case, the data rate that two UE's wanted cannot be available in spite of the fact that an available channel remains.

Now, let's look at Figure 4. The situation is similar to the Figure 3, but in figure 4, the VCAM is used. The same, two UE want to use the same data rate, so they enter the same queue by selecting the AP. Even though one available channel was occupied just a few slots ago and they didn't recognise the occupancy, there is no problem for the UTRAN to assign the remaining server.

2.2 Procedures of two methods

2.2.1 The UE selection method

The UE selection method and the VCAM are represented in Figure 5 and 6, respectively. The UE selection method has specific rules. In other words, the UE must know the CPCH channel available information, then, the UE selects an available CPCH channel according to this

information, and one more rule is that the UTRAN can send only ACK or NAK. After receiving CPCH channel information in somehow, the UE requests the specific channel that the UE chooses. Then the UTRAN send the ACK if that channel is available or NAK if that channel is occupied. Since there is a possibility that two or more UE send the same AP at the same time, the collision detection (CD) is needed to prevent the collision. So, the UE send a CD preamble. In that access slot, if the UTRAN detects more than one CD preamble, the UTRAN send just one ACK to respond a specific collision preamble.

2.2.2 The VCAM

Figure 6 shows the VCAM. The similar procedures are taken to access as in the UE selection method. There are, however, obvious differences when compared to the UE selection method. One is the method of choosing an AP. The VCAM chooses an AP as the desired specific data rate. In other words, the UE requests only the data rate not a specific channel. Then the UTRAN can check the requested data rate is available or not by itself. Furthermore, if the UTRAN use the channel assignment scheme as the VCAM, the UTRAN checks only whether the total capacity will be overloaded or not when the UTRAN assign the channel to that UE. Then the UTRAN sends an ACK or NAK. Now, The UE that receives an ACK sends a CD for the collision detection. Here is the clear difference between the UE selection method and the VCAM. The UTRAN that receives a CD from the UE sends back to the UE with the CD ACK and the channel assignment message (CA). Since both the UE and the UTRAN know the AP number and CA number, they can combine two numbers. It means that they have a much greater degree of freedom, the amount is the multiplication of the number of AP's and the number of CA's which are used in the CPCH.

2.3 Collision detection success cases of two methods

In this section, we introduce several cases, where access is successful following the resolution of detection. In Figure 7, three UE's send the AP's at the same time with different AP numbers. Let us assume those numbers are AP #3, #7, #9. The UTRAN selects AP #3 by some criteria, e.g. the power ratio. In this example, the UTRAN sends an AP-ACK #3 and the other responses of AP's are AP-NAK. Then only the UE that sent the AP #3 sends a CD. Since the UTRAN receives only one CD numbered #4. It returns a CD-ACK #4. Now, it is the time for the UE to send messages.

We have also to consider the case that some UE's send the AP at the same time. This case is shown in Figure 8. The UE's numbered #1, #2, and #3 send the AP #3 at the same time. Then, the UTRAN sends back to an AP-ACK #3 to UE's. Now, each of the UE's can mistake that ACK as its own. At this stage, they randomly generate the CD and send it to the UTRAN. In the example, they have different numbers, namely, #1, #5, and #8. After receiving three CD's, the UTRAN knows that three UE's sent the same AP. The UTRAN can select one CD among those. Finally, it sent back CD-ACK to UE's. Since the UE that sent CD #5 is selected in Figure 8, only the UE #2 sends messages.

2.4 Getting a channel

We can easily see that the differences between the UE selection method and the VCAM in Figure 9 and 10. In Figure 9, the procedure of the UE selection method is shown. In this case, the access attempt to get a channel fails even though there is an available channel. At first, the UE knows channels numbered #1 and # 6 are available. Then it sends the AP #1 for requesting the channel numbered #1. Unfortunately, that channel has just been occupied. At that time, although the UTRAN knows the requested data rate and the #6 channel which has the same data rate is available; the UTRAN must send only

AP-NAK #1. Because the UTRAN can return only the ACK or NAK. In this case, we can see some facts. The most important fact is that the UE couldn't get a channel in spite of that there was another available channel.

By contrast, another example of the channel access method is shown in Figure 10. Once again (as in Figure 9), the UE knows that data rate #1 is available in the channels #1, #6. In case of the VCAM, the UE doesn't have to know the exact channel numbers; the UE needs only the availability of the data rate. Anyway, the UE chooses AP #1 and sends it to the UTRAN. As in the case above, channel #1 has just been occupied. The UTRAN however, knows that channel #6 is available. So, it sends an ACK to assign a channel to the UE. When the UE receives the ACK from the UTRAN, it sends a CD. At this stage, the UTRAN can give a permission to send messages and assign a channel by using CD/CA-AICH. Now, the UE can send messages successfully.

The versatile assignment rule will help UE's to get an access channel. Furthermore, the UTRAN can use all the allocated capacity for the CPCH.

2.5 Explanation of the flexibility by using OVSF

Some explanations about the flexibility will be presented in this subsection by using the OVSF tree. The Figure 11 and 12 show the OVSF tree and the channel usage of the UE selection method and the VCAM, respectively. For easy explanations, one scrambling code is used for these cases. Without loss of generality, we can assign several scrambling codes for the CPCH only if the capacity of the UTRAN is acceptable. Since the UE selection method is based on the fixed channel allocation, the channelization code is fixed as shown in the Figure 11. As in Figure 11, the UE is aware of the channel allocated by the UTRAN. Channel #1 is allocated node #1 in Figure 11, and other channels are allocated by predefined ways. In the Figure, we represent only 5 channels for to ease the explanation. The main problem of the UE selection method comes from the predefined rigidity. Let us take a look in the Figure 11 and assume that channels #2 and #3 are occupied. We can easily see that the remaining part cannot be assigned to UE's as marked in circles. At this time, if an UE requests a given data rate, the UTRAN can only send NAK although the UTRAN knows the resources are enough to assign a channel. As in Figure 11, the node #3 and node #4 cannot be assigned permanently.

Now, Figure 12 represents the flexibility of the VCAM. The AP number indicates only the data rate. In this scheme, the UTRAN can assign any channels providing that the capacity is acceptable, using the remaining part of the OVSF tree. Furthermore, since the CPCH is used for the burst data transmission, the versatile channel assignment can maintain the maximum throughput, and enables the UTRAN to schedule the capacity flexibly.

3. CONCLUSION

In this document, we have explained the superiority of the versatile channel assignment method with respect to the UE selection method. The blocking rate of the versatile channel assignment is lower than that of the UE selection method. And the UTRAN can manage resources flexibly by using the versatile channel assignment method.

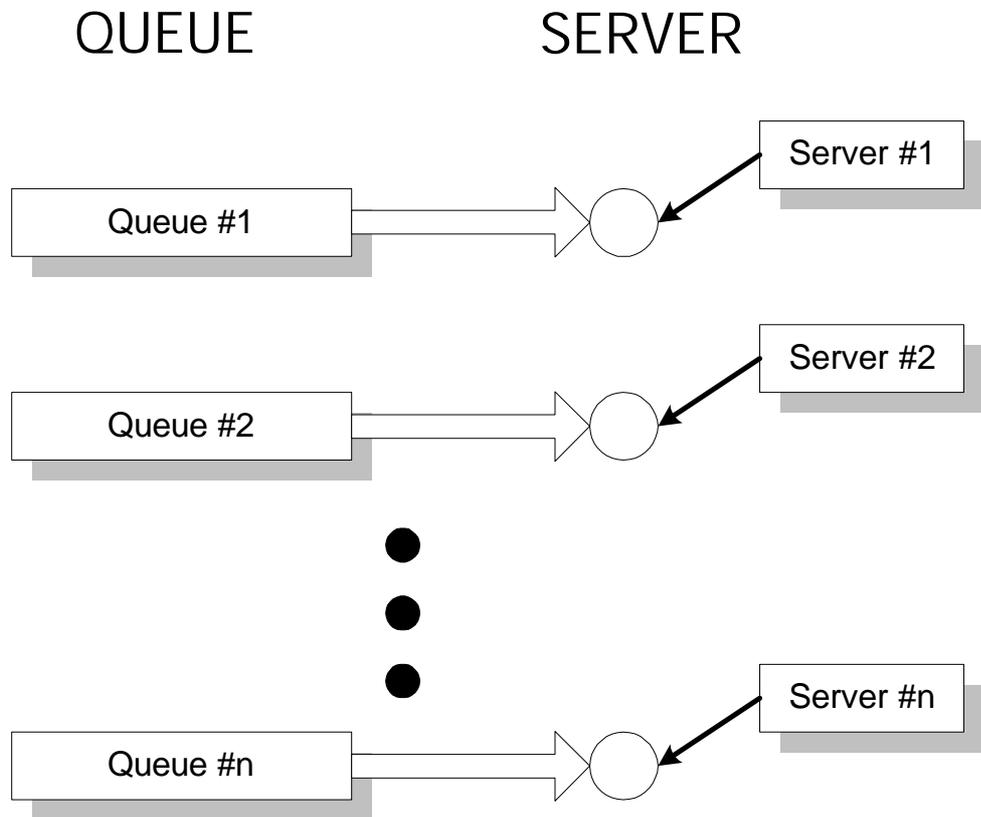**Figure 1. A Diagram for describing the UE selection method in a view of the queuing theory.**

Versatile Channel Assignment Method

QUEUE

SERVER

Queue #1 → MUX $1 \times N_1$ →

Queue #M → MUX $1 \times N_M$ →
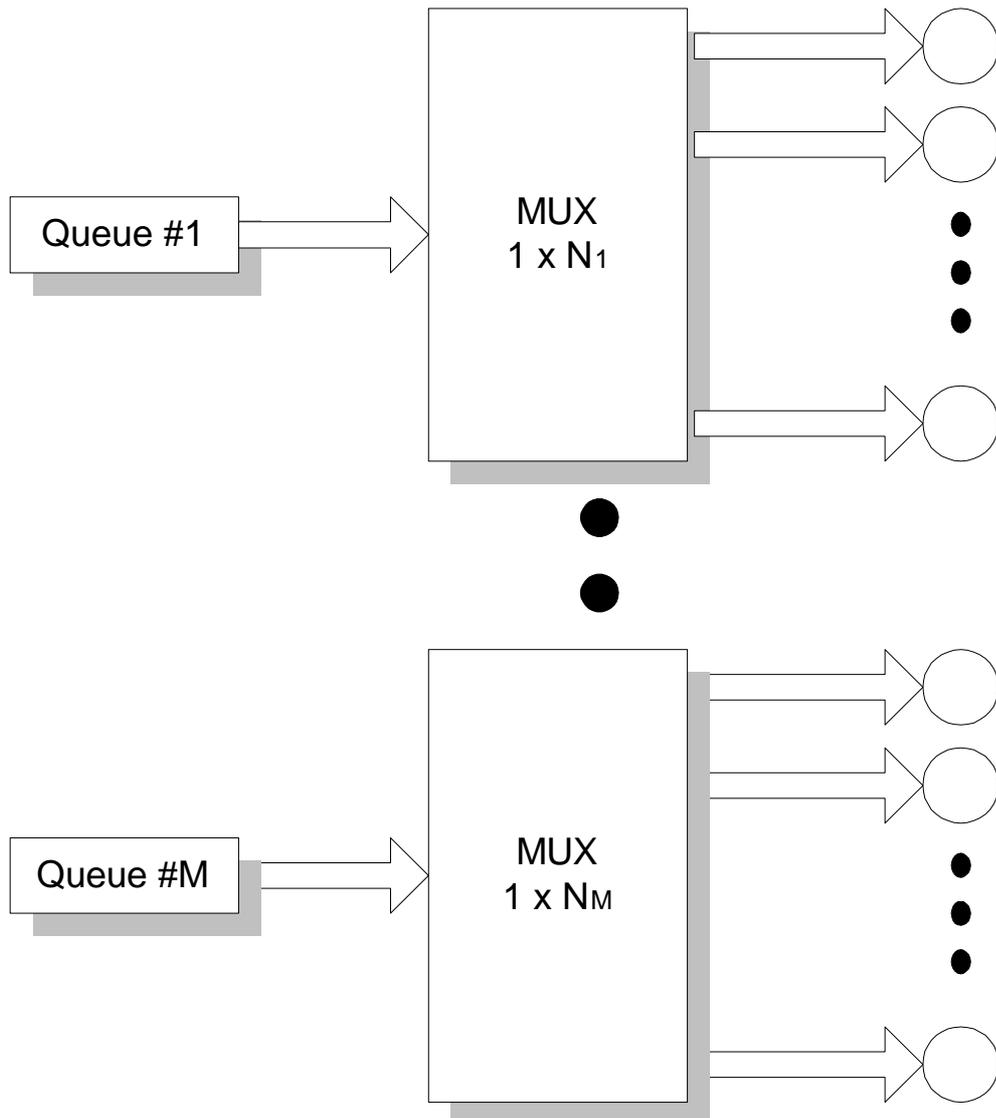
Figure 2. A Diagram for describing the VCAM in a view of the queuing theory.
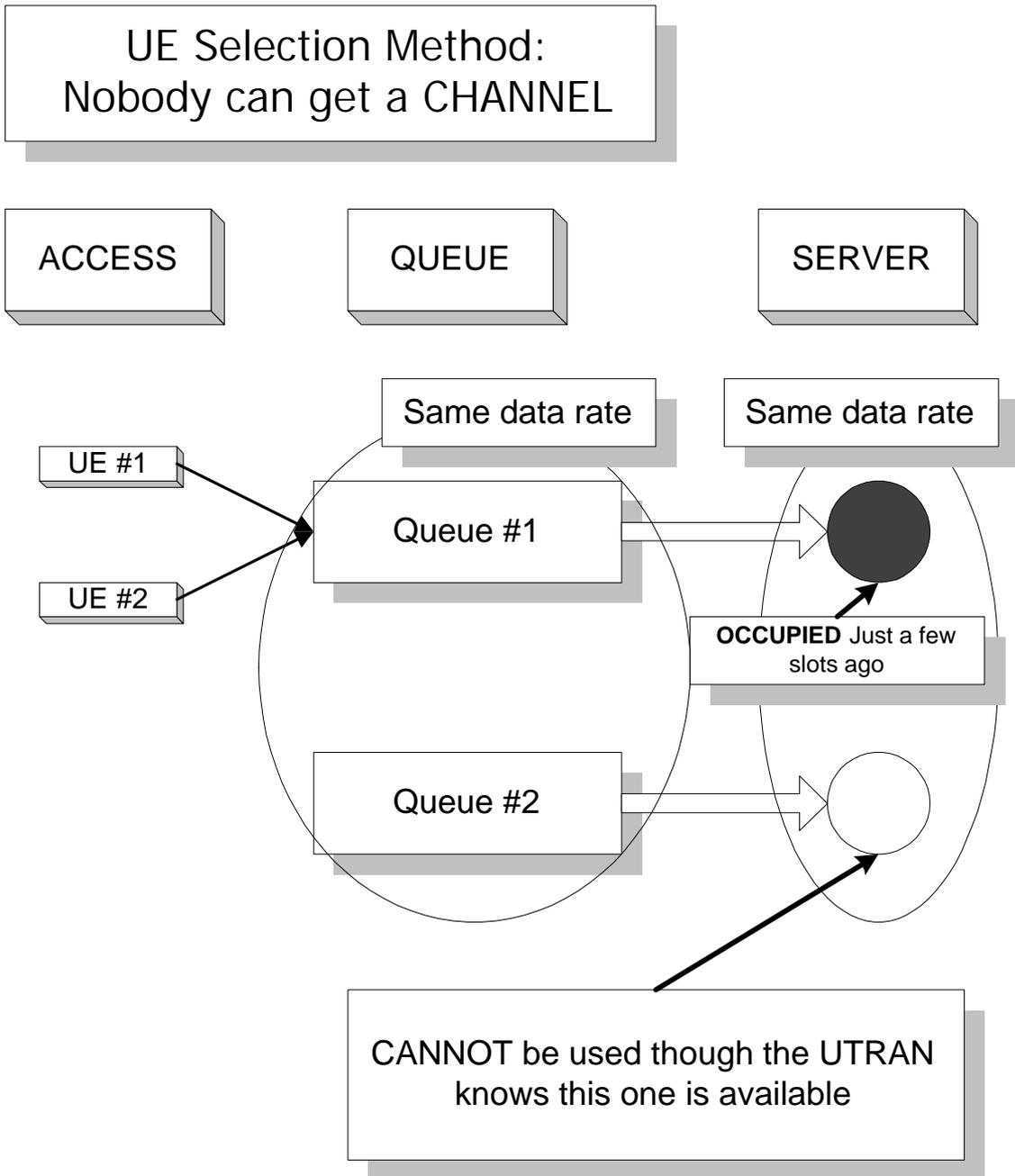
Figure 3. The UE's cannot get a channel in case of the UE selection method even though there is an available channel.

Versatile Channel Assignment Method: One UE can get a SUCCESSFULLY

ACCESS

QUEUE

SERVER

Same data rate

UE #1

UE #2

Queue #1

MUX

OCCUPIED Just a few slots ago

CAN assign successfully
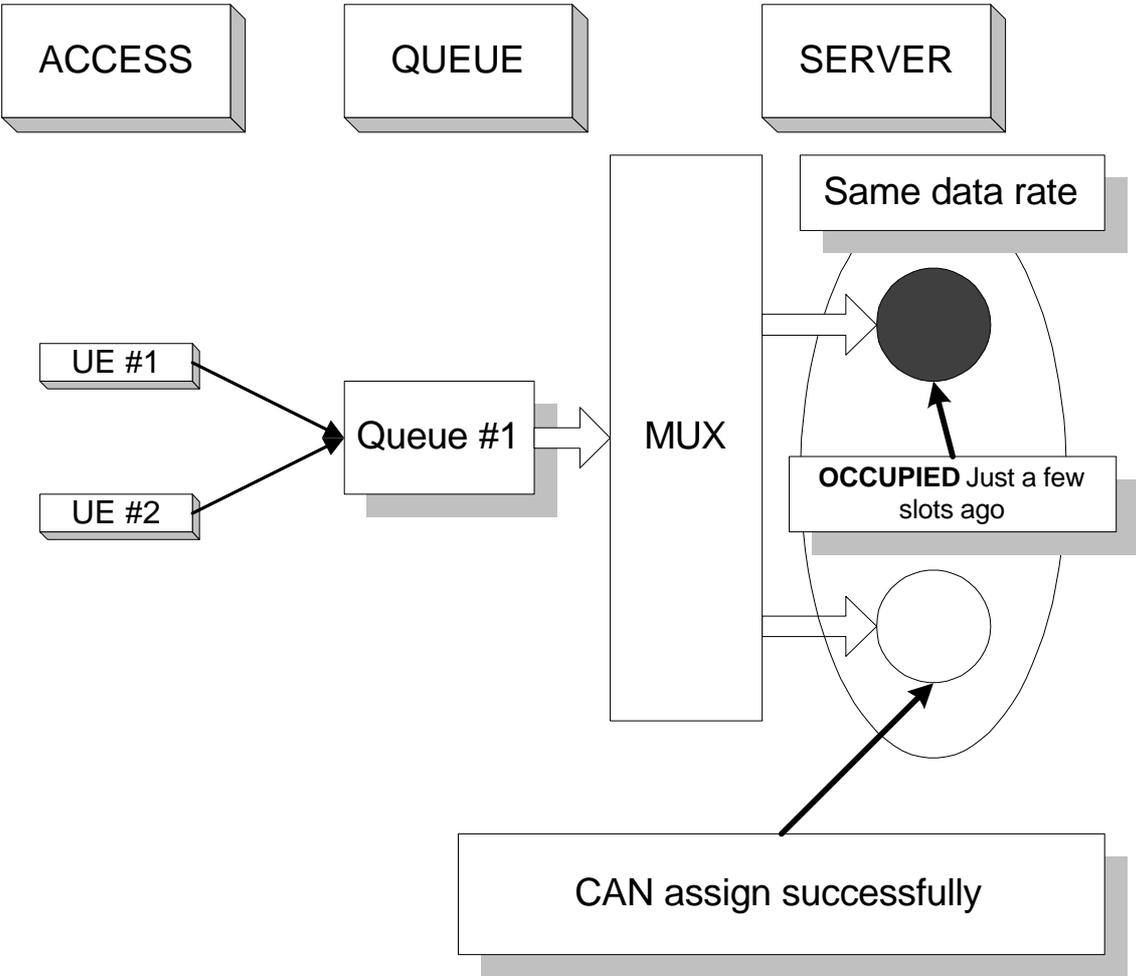
Figure 4. The UE can be assigned a CPCH channel in the VCAM. This method can be applied only if the capacity is tolerable.

UE Selection Method

UTRAN

AP-AICH

CD-AICH

**Accept or not
One AP-ACK**

**For Collision
detection**

One CD-ACK

Message

**Requesting
the specific channel**

UE

AP

CD
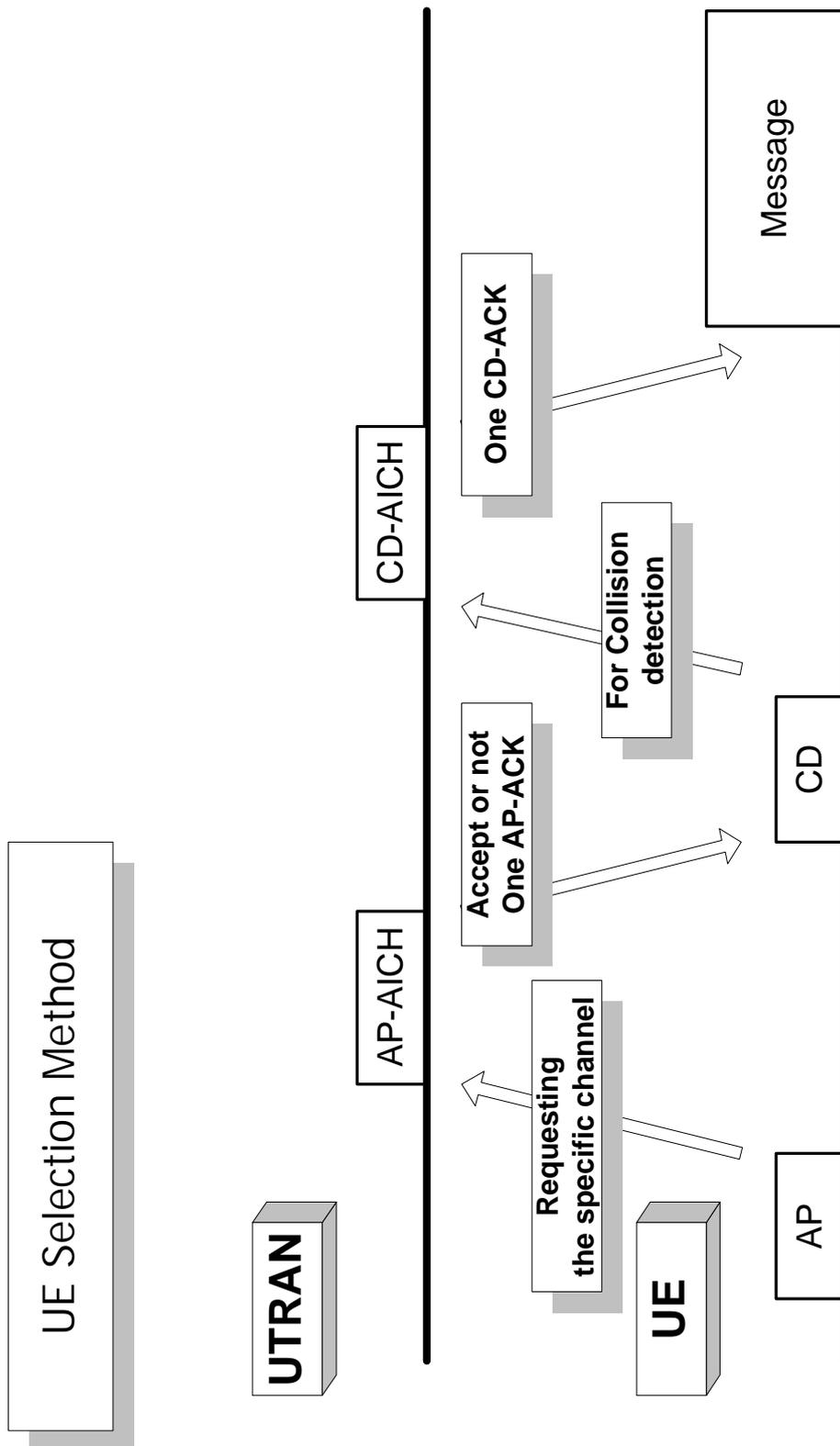
Figure 5. The procedure for the UE selection method.

Versatile Channel Assignment Method

UTRAN

AP-AICH

CD/CA-AICH

Requesting
the DATA RATE

Accept or not
One AP-ACK

For Collision
detection

One CD-ACK

Channel Assign

UE

AP

CD

Message

Figure 6. The procedure for the VCAM

Figure 7. The Collision detection procedure is shown using collision detection preamble (CD) of both methods for different access preamble case.

Collision Detection: same preamble case

UTRAN

AP-AICH · CD-AICH · CD/CA-AICH

| AP #3 | AP-ACK #3 | CD #1 CD #5 CD #8 | CD- ACK #5 |

UE #1
AP #3 → Requesting the specific channel #3 → CD #1 → CD number is generated randomly → Stop the access procedure

UE #2
AP #3 → Requesting the specific channel #3 → CD #5 → CD number is generated randomly → Message

UE #3
AP #3 → Requesting the specific channel #3 → CD #8 → CD number is generated randomly → Stop the access procedure
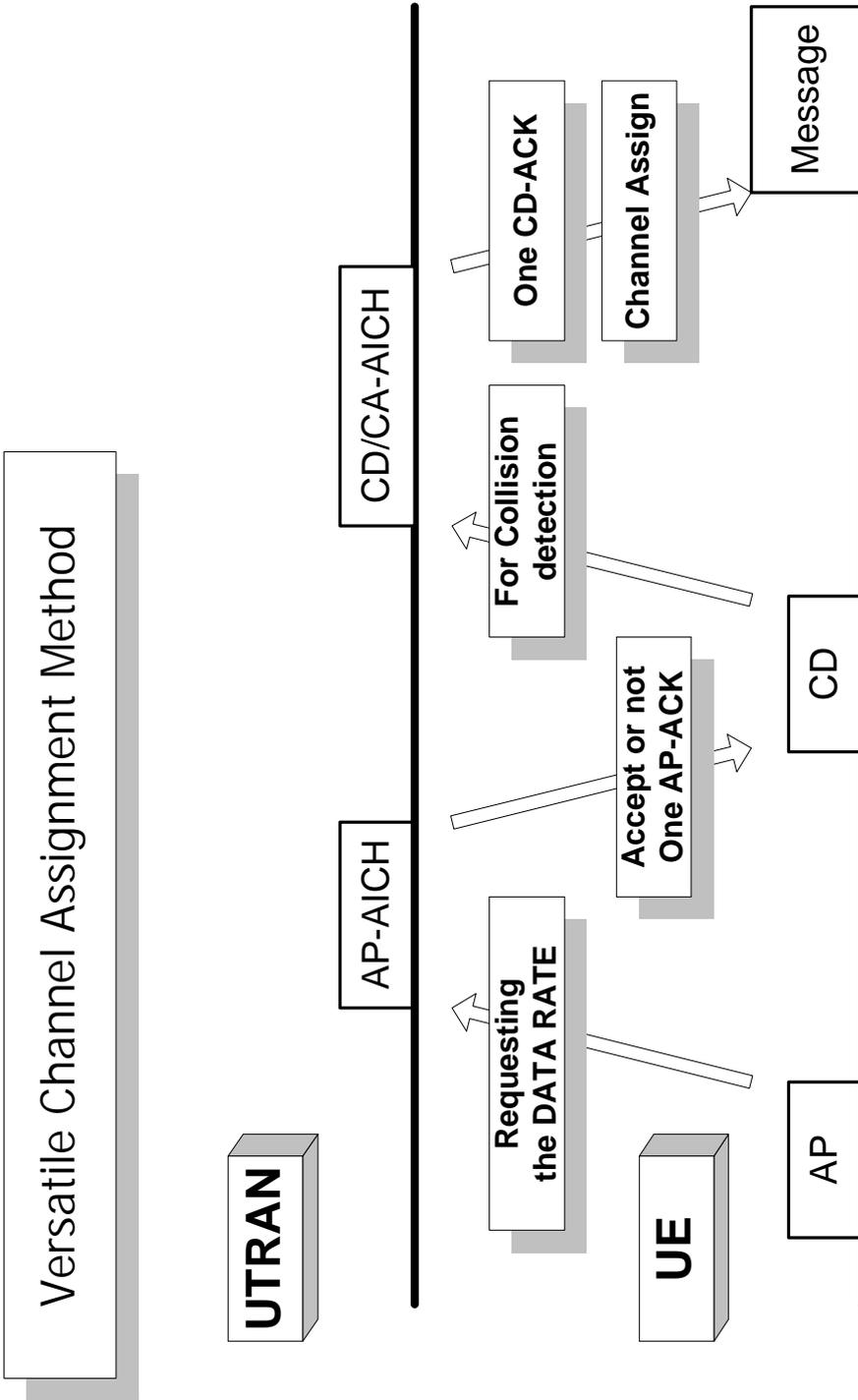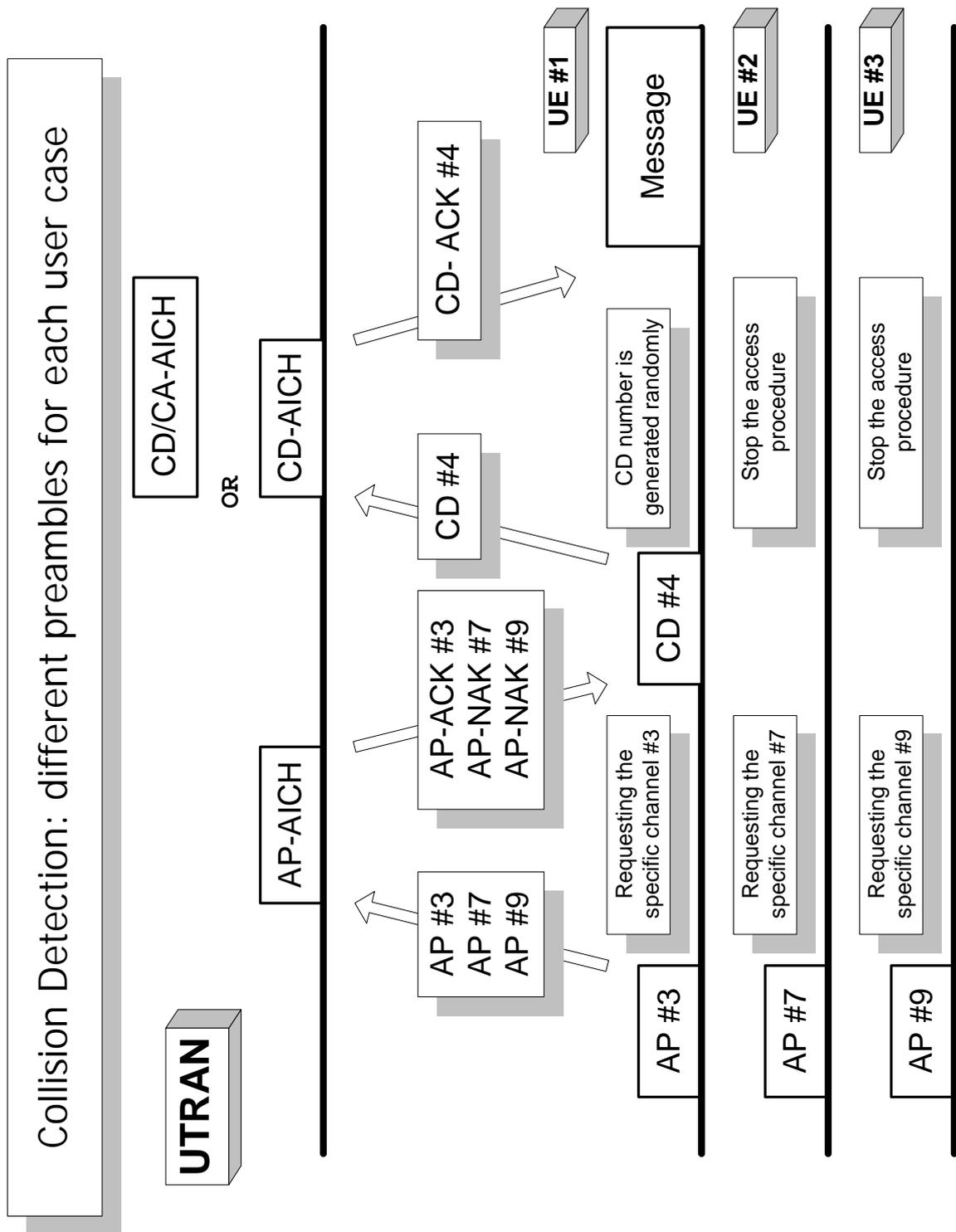
Figure 8. The Collision detection procedure is shown using collision detection preamble (CD) of both methods for the same access preamble case.

UE Selection Method:
channel selection FAIL even when resource is AVAILABLE

Empty channel for data rate #1: Channel #1, #6

UTRAN Knows Channel #6 is AVAILABLE

UTRAN cannot assign Channel #6

Channel #1 is OCCUPIED just a few slots ago

AP-AICH

UTRAN

AP #1

AP-NAK #1

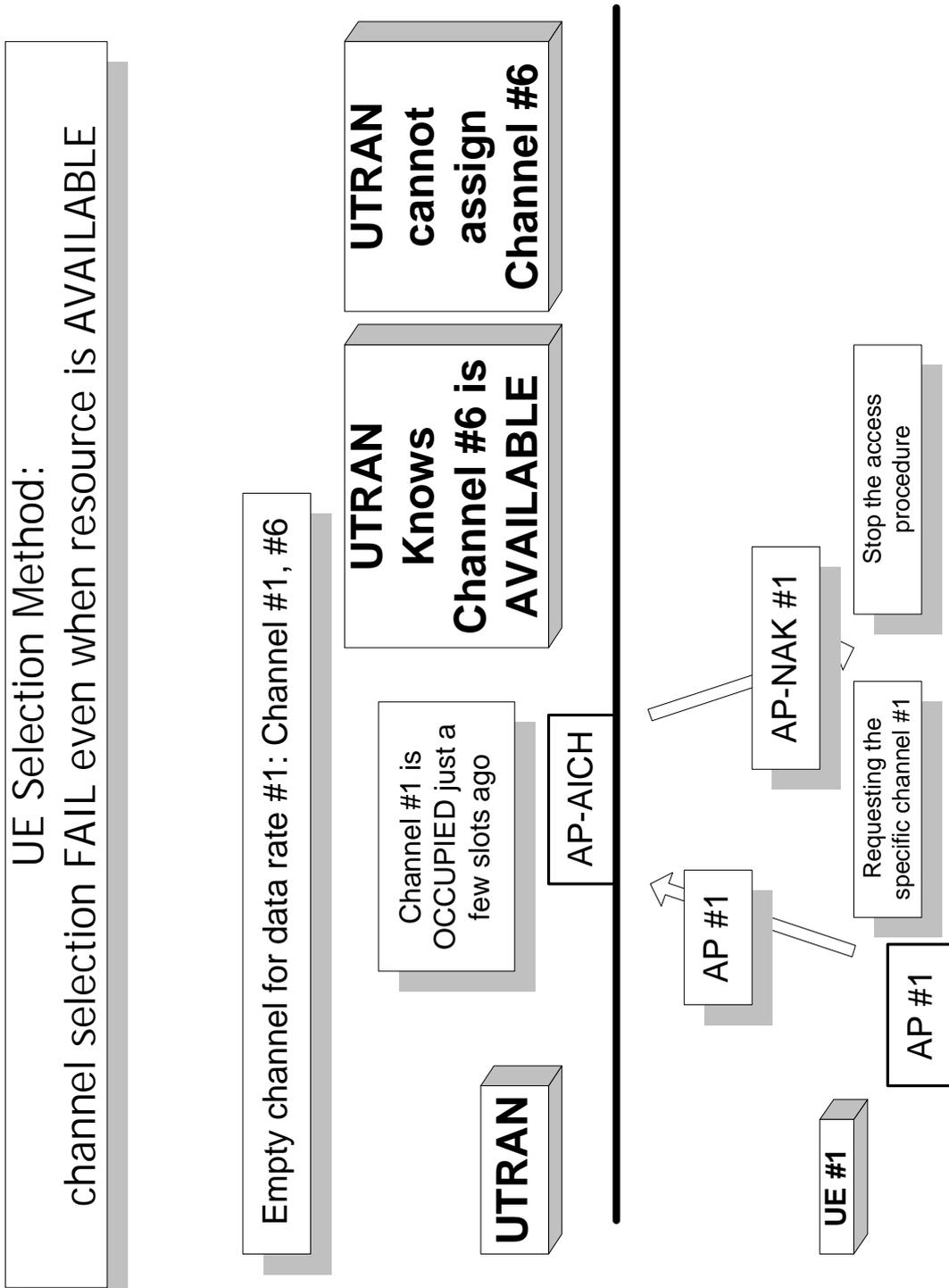Stop the access procedure

Requesting the specific channel #1

AP #1

UE #1

Figure 9. The channel selection is failed in case of the UE selection method. In this case, the resource is available.

Versatile Channel Assignment Method:
Channel Assignment SUCCESS

Empty channel for data rate #1: Channel #1, #6

UTRAN
Knows
Channel #6 is
AVAILABLE

CD/CA-AICH

CD-ACK #9
CA #6

Message

Channel #1 is
OCCUPIED just a
few slots ago

AP-AICH

CD #9

CD number is
generated randomly

AP-ACK #1

CD #9

UTRAN

AP #1

Requesting
the data rate #5

UE #1

AP #1

Figure 10. The channel assignment procedure is shown in case of
the VCAM.

OVSF allocation for the UE Selection Method

CANNOT be used these nodes even when channel #1 is NOT occupied

node #1

Channel #1 (AP #1)

Channel #2 (AP #2)

OCCUPIED

node #2

Channel #3 (AP #3)

OCCUPIED

Channel #4 (AP #4)

node #3

Channel #5 (AP #5)

node #4

CANNOT be used these nodes even when channel #4 and #5 are NOT occupied
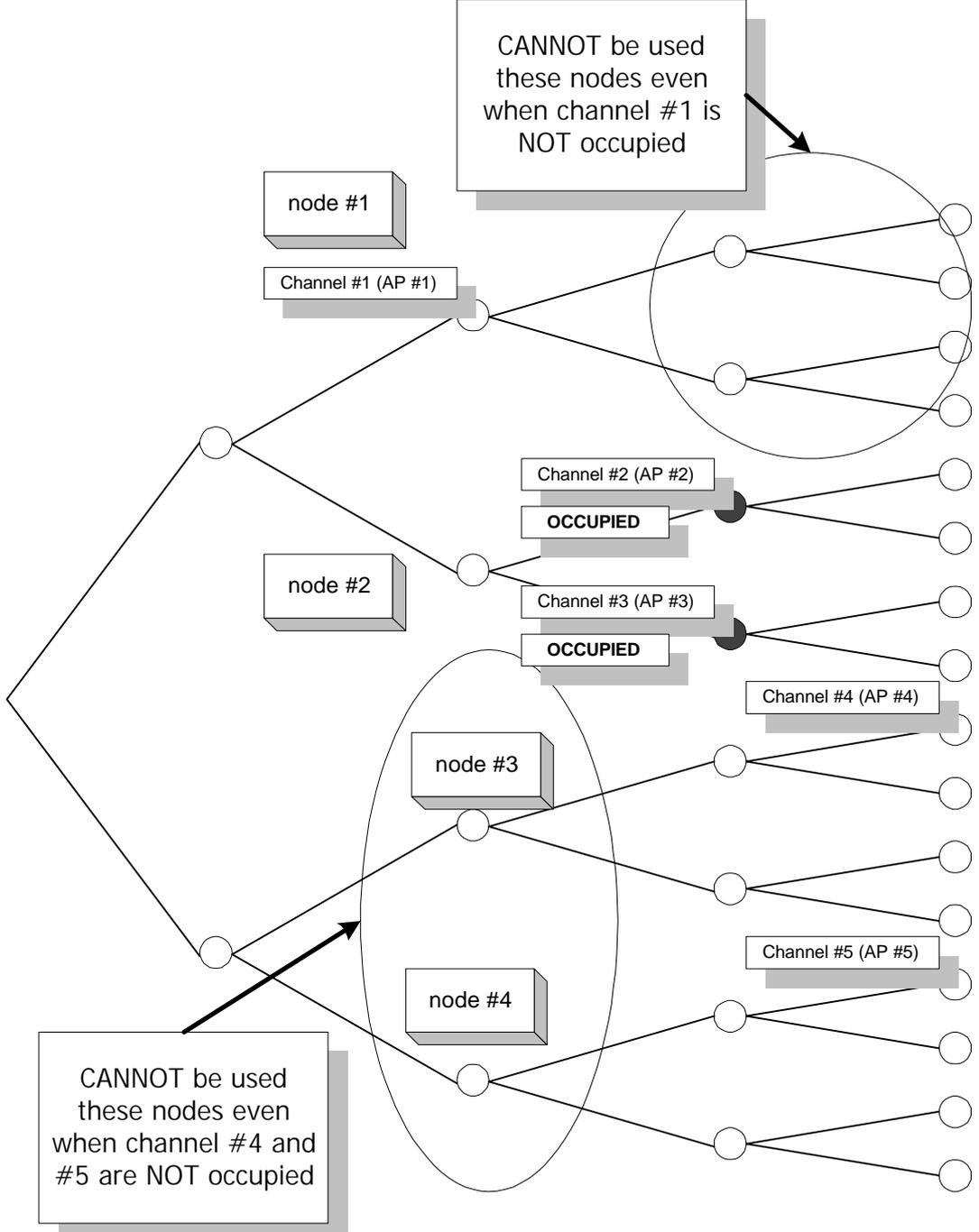
Figure 11. The OVSF tree explanation is illustrated for the UE selection method.

OVSF allocation for Versatile Channel Assignment Method

AP #6, #7, and 8

AP #3, #4, and 5

AP #1 and #2

node #1

OCCUPIED

node #2

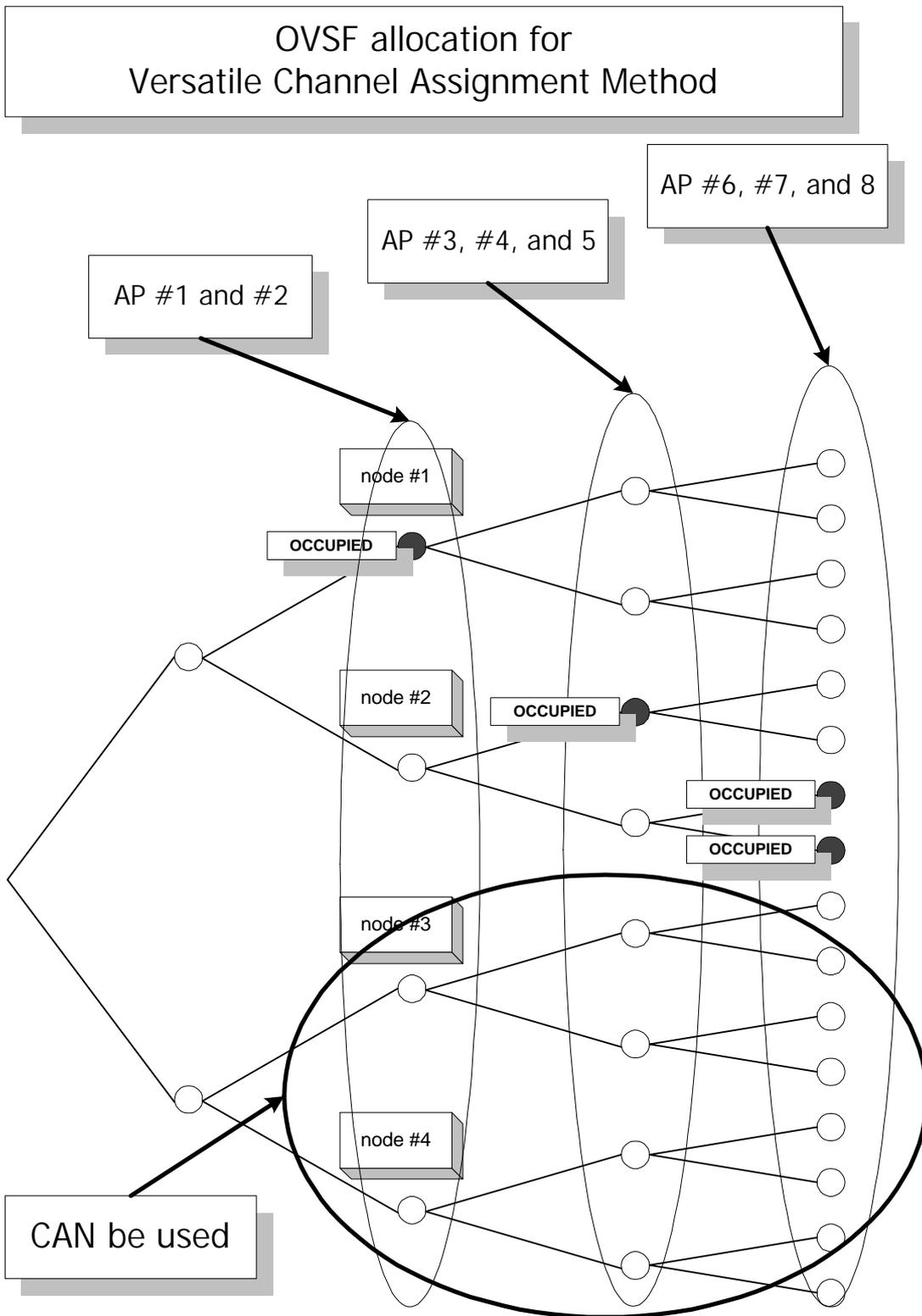OCCUPIED

OCCUPIED

OCCUPIED

node #3

node #4

CAN be used

Figure 12. The OVSF tree explanation is illustrated for the VCAM.