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Agenda Item: **8.3**

Souce: **Motorola**

Title: **Scheduling Support for Voice Services in E-UTRA**

Document for: **Discussion**

Introduction

E-UTRA is being designed for connection to a packet domain only. Voice service will therefore necessarily be carried over the packet domain. Typically, when designing system for both packet and circuit domains special emphasis is given to ensure that the circuit domain services can be provided with the maximum spectral efficiency through the exploitation of known characteristics of the circuit switched based services. Since conversational class services will continue to be a major revenue generator for operators it is vital that control signalling mechanisms be defined that support a large number of users with minimal radio resource utilization.

E-UTRA will likely adopt a number of mechanisms that are supported for HSxPA such as link adaptation and statistical multiplexing. While the VoIP users have the same benefit of the advanced link adaptation and statistical multiplexing as the data users, the greatly increased number of users that may be served because of the smaller voice packet sizes can place a significant burden on the control and feedback mechanisms of the system. For example, based on simple bit rate calculations, it can be easily envisioned that 30x as many voice packets could be served in a given frame than data packets (1500 bytes versus 40-50bytes). However, the resource allocation and channel quality feedback and acknowledgment mechanisms are typically not designed to handle such a large peak-to-average number of allocations.

One approach is to group multiple (e.g., 2 to 4) voice packets together for transmission to the user thereby reducing the signalling required to some degree. Unfortunately, this sort of packing mechanism can adversely affect speech quality when a packet is not received, since longer periods of speech are lost or corrupted.

This contribution shows a way to group packets from multiple users instead of packets from a single user, the system to support a large number of VoIP users with good quality and reduced control overhead.

Discussion

Traditional cellular voice traffic has some distinguishing attributes –

- vocoder output at fixed intervals
- well-defined maximum and minimum rates (output can be comfort noise, full rate, sub-rate, etc.). Thus the number of potential encoder packet sizes may be limited.
- traffic with fractional activity factor

Note that similar distinguishing characteristics can be determined for streaming traffic, web-browsing, etc.

Scheduling mechanisms that incorporate statistical multiplexing should attempt to simultaneously take advantage of both VAF/DTX (e.g., 35-50%) and HARQ retransmissions (e.g., 1%-20%). It should be possible to place a HARQ retransmission in a potential transmission location not used because of VAF/DTX. Again, most VoIP users will have similar statistics, and the more users that can be considered together the better the statistical multiplexing can be. Voice traffic to a user is at a fixed relatively low data rate compared to the data traffic, and does not need to use more than a single HARQ process.

Frequency Selective scheduling is hard to apply to VoIP users because of the need for increased feedback. Thus CQI feedback rates for VoIP traffic can be significantly reduced by using frequency non-selective scheduling. However, even Frequency Non-Selective scheduling is more difficult because of the larger number of users needing to provide feedback. It may be worthwhile to restrict the MCR (modulation and coding rate) levels and/or rate of adaptation of the users to reduce feedback. In fact the low delay requirements of conversational traffic combined with the finite range of packet sizes make it possible to consider simply relying on ACK/NACK feedback in order to determine appropriate MCR settings.

One potential approach to address the need for control signalling transmission to a large number of users is to group users in similar radio conditions together. Users in similar radio conditions would be expected to require similar modulation and coding rate as well as require similar number of retransmissions.

A group of users may be defined as a sub-set of users requiring conversational service that are in similar radio conditions. The network can exploit the voice activity factor to overload the group with a user population larger than what a typical sub-frame would be able to support for voice packets. For example at 5 MHz, it is expected that 3-4 users can be supported for voice service in a 0.5 ms sub-frame. With typical voice activity factors of 0.4, it should be possible to define a group to consist of 8-10 users.

Since the vocoder outputs speech frames with a 20 ms interval, it should be possible for the scheduler to schedule two transmissions per voice packet within the 20 ms to a user assuming a 0.5 ms sub-frame (TTI). This permits the scheduler to multiplex re-transmissions as well as new transmissions within a 0.5 ms sub-frame to users within a group. On average the number of retransmissions for the different members in a group is identical. However, the scheme allows for variable number of re-transmissions given small differences in channel conditions among users of a group. In particular, the VAF and re-transmission activity, individually and together, imply the ability to use statistical multiplexing in order to serve a large number of users.

UEs are assigned to a group by the network on initiation of a service request based on their channel conditions and service desired. The group attributes, for e.g. the modulation and coding rate to be used, the sub-frame number within a 20 ms super-frame the group has been assigned to, etc. can be signalled with the group assignment thus enabling both a reduction in signalling and monitoring of resource allocation by the UE. In addition, UEs may be assigned a shorter identity to be used within the group context in order to further save signalling resources for resource allocations. The group identity and UE group-specific identity in combination would uniquely identify a UE in a cell in connected mode.

Each group is associated with one or multiple sub-frames during a pre-determined time interval (e.g., 20ms). UEs within a group can be associated to one particular sub-frame of the different sub-frames the group is associated with.

Figure 1 is an illustration of resource allocation, over a 20 ms super-frame duration, for two groups of users. Users in group 1, viz. users 1, 2, 4, 7 and 9 have been assigned to sub-frame 1 and 21. Members of group 2, viz. 3, 5, 6, 8 and 10 have been assigned to sub-frame 11 and 31.

In the first sub-frame, group 1 UEs have been allocated resources and UEs 1, 4 and 7 have been assigned resources for their voice packets – only three users have been assigned resources taking into account the VAF i.e. users 2 and 9 did not have any voice packets for transmission. UEs 3, 5 and 8 of group 2 are assigned resources in sub-frame 11.

For group 1, UEs 1 and 7 required retransmission of their voice packets and are therefore assigned resources in sub-frame 21. UE 4 received the packet successfully in the first transmission. UE 2 of group 1 is sent a SID frame during sub-frame 21. UEs 3 and 5 did not require retransmissions. UEs 6, 9 and 10 have been previously sent SID frames are therefore need not be sent any transmission during the 20 ms super-frame illustrated below.

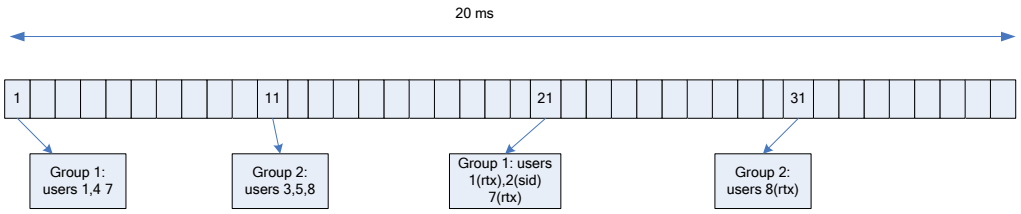

Figure 1: 20 ms Resource allocation – showing assignments for Group 1 and 2 UEs only

To allow for the case where a cell is heavily loaded a UE may be assigned to multiple groups. The terminal looks for its assignment in the expected sub-frame for the primary group it belongs to and if it does not find resources assigned to it in that sub-frame it looks for an assignment in the sub-frame corresponding to the alternate group it has been assigned to.

In order to support mobility, groups may be defined over an area covering multiple cells with the UE's group assignment being transferred to the target cell. It is also possible to re-assign the group on handover. Change of channel conditions can result in the UE being re-assigned to a more appropriate group through network signalling.

Grouping thus allows the system to exploit:

- similar resource assignments for users in similar radio conditions
- statistical multiplexing of users through voice activity factor and HARQ retransmission activity
- allows UEs to exploit fixed (semi-static) TDM based resource allocation for micro-sleep mechanisms thereby saving battery

Summary

Voice continues to be a major revenue source for operators. Since E-UTRA is aimed to support PS domain only, voice will need to be delivered as a packet service. Due to the small packet sizes involved with voice and due to the need to support a large number of users especially with the wider bandwidths expected for LTE, it is vital that efficient signaling mechanisms be defined to support voice service. This contribution proposes to use "grouping" in order to reduce the amount of signaling and feedback required in order to support voice traffic. User are grouped based on their channel conditions – the rationale being that users in similar channel conditions would be supported with similar channel attributes such as modulation, coding rate, etc. Groups are associated with particular sub-frames in order to exploit known traffic characteristics and allow for statistical multiplexing based on activity factor and retransmission requirements. The mechanism is flexible and supports cases of overloading and mixed services as well.