Chapter 1

Radio Resource Management

1.1 Introduction

Radio Resource Management (RRM) is the function of a mobile communication system used for establishing, maintaining and release of radio connections. The main elements of RRM function are the mobile station and the base station. The establishment of connections is the stage to allocate time slots or blocking the incoming voice call or data sessions if necessary. Maintaining a connection requires dealing with handovers and power control, as well as reassignment of resources and transmission scheduling for GPRS.

In this chapter we present the play scenarios of existing RRM strategies first, and then describe in more detail the ”Best Effort” policy and our proposed RRM strategy, to investigate how we can improve the GSM/GPRS system performance comparing to ”Best Effort”.

1.2 Existing RRM Technic

There are many RRM policies to improve the radio resource utilization, while we only present some existing technic related to our proposed scheme: channel dedication, channel allocation and access queue, and scheduling.

1.2.1 Channel Dedication Scheme

The most general assumption for the channel allocation is, among the N available time slots in a cell, a number p is reserved for voice, a number q is reserved for data connections, while the remaining N-p-q timeslots are shared between the two types of services [1]. The choice of p and q influences
the quality of service, in terms of the cell throughput, voice/data blocking rate, and data delay. Nowadays some operators tend to adopt the most conservative strategy, allowing all the N timeslots to be shared between voice and data users but with voice pre-emption, which is called "best effort" strategy without any QoS guarantee for data traffic. In this policy voice users will not be affected by data at all, while in the worst case all the TS will be occupied by voice and GPRS data traffic will be stopped. Some other operators reserve q timeslots to data connections, preventing their use by voice calls, and consequently guaranteeing a minimum amount of bandwidth to be shared among all the active data connection. The drawback of this choice is obviously the voice blocking rate will increase, due to the reduction of available timeslots. As a consequence, the operators maybe need to reduce the designed voice traffic load and re-dimension the cells.

In our work, we take channel dedication scheme as a configuration of a cell, or put it another way, it is fixed before any real traffic occur.

1.2.2 Channel Allocation and Access Queuing

Considering the downlink resource allocation of data alone, when a data session arrives, it may request K TS at a time while there is L channels available in the cell. There could be 2 different channel allocation mechanisms, they are: [2]

1. Fixed Resource Allocation (FRA)
   For a data request of K channels, if \( K < L \), the network assigns K channels to the GPRS packet request. Otherwise, the GPRS packet request is rejected.

2. Dynamic Resource Allocation (DRA)
   For a data request of K channels, DRA allocates at most K channels to the request. If \( K \geq L \), the network shall negotiate with the MS to allocate an acceptable number of TSs.

   It’s evident that in DRA, the idle channels will be utilized more efficiently while the control process will be more complex as compared to in FRA.

   In both cases, access queue can be introduced for those data request to wait for idle resources rather than to simply reject them. They can be served either in a First-Come-First-Serve principle or according to some kind of priority, i.e, the QoS requirement of a data session. Queuing will reduce
the blocking rate of data, though the mean access delay of the cell will be increased.

1.2.3 Scheduling Technic

In case of several data sessions sharing 1 TS, their data blocks will be waiting in transmission queue, and a schedule algorithm decides the current TS will be assigned to which TBF. There are 3 well known scheduling algorithms:

First Come First Served (FCFS): Incoming packets are scheduled according to their arrival time at the scheduler. Clearly, high volumes sources are given more chances to transmit than low volume sources.

Round Robin (RR): Here incoming packets are placed in different queues according to their TBFs; the scheduler picks 1 block form each queue in one round. This scheduler gives equal chance among these TBFs and avoid a low volume source waiting too long for a high volume source.

Earliest Deadline First (EDF): At any scheduling decision time, the packet with the earliest deadline is scheduled. Deadline is calculated as the upper bound of the tolerable end-to-end delay, and thus measures the usefulness of data packets at the destination. This algorithm depends on the QoS parameters indicated by layers higher than RLC and will not be considered in the proposed RRM model.

1.2.4 Downgrading and Upgrading

1.3 "Best effort" strategy

The RRM strategy called ”best effort” for GPRS is the one currently used by mobile operators and doesn’t take QoS or propagation conditions into account for either choosing the resources to allocate or scheduling the transmission of RLC blocks. It then considers all GPRS users equally and try to share the available bandwidth fairly between all sessions. Voice GSM users have the absolute priority, and when no resource are available, GPRS users can be downgraded to free a time slot used by the voice user (preemption). As we only consider downlink in the simulation, we will describe the downlink strategy assumed to be ”best effort".
1.3.1 Resource allocation

GSM users are allocated the first available time slot starting from the first TRX. If no time slot is available at the time of an incoming voice call, this call will be allowed to preempt a GPRS time slot, thus downgrading all GPRS users multiplexed in this TS. In the extreme case where all TS are already taken by voice calls, the incoming GSM call will be blocked.

For GPRS users requiring \( K \) channels (depending only the capacity of the mobile as QoS is not considered), a TRX will be chosen which will be the last least-loaded one in terms of number of TBF and GSM calls assigned. In this TRX, the \( K \) least loaded time slots will be selected and if less than \( K \) TS are available, the maximum amount possible will be allocated. The selection of Time Slots to be allocated for the TBF are illustrated in figure 1.1.

![Figure 1.1: Time Slot selection in best effort](image_url)

If no TS are available, the GPRS request will be queued in the access queue, which is a First In First Out (FIFO). If the queue is filled, the incoming GPRS request will be blocked. The resource allocation strategies described above for "best effort" are shown in figure 1.2.
1.3.2 Resource reassignment

During transmission, if a TBF possesses less than K channels due to voice preemption or lack of resources, a TBF assignment can be done to reassign some TS and upgrade the throughput.

When resources become free after a congestion period, the priority of TBF assignment goes first to the access queue to improve access delay and GPRS blocking rate, and then the TBF having the least resources to improve the user throughput.

1.3.3 Scheduling

Once a GPRS call has been allocated resources, a scheduling technique is used to choose blocks that has to be sent in TS holding multiple TBF (multiplexed time slots). In the ”best effort” strategy, in order to send blocks fairly in multiplexed time slots, the queue used is a Round Robin queue as illustrated in figure 1.2, meaning that blocks will be sent from a different TBF every block period.

Figure 1.2: Resource request
1.4 Proposed RRM strategy

In the proposed RRM strategy, different dedication policies are combined with a Dynamic Resource Allocation with Data Access Queuing (DRA-DAQ) and grading systems serve in both data access queue and scheduler, which mainly targets in improving the GPRS system throughput with a certain GSM voice blocking rate as its limitation. Comparing to ”Best Effort”, here GPRS data service is considered as important as voice, therefore a grading system was included in access control instead of voice preemption.

1.4.1 Access Control

In access control, voice request will be either accept or blocked, while data will be either accepted or put into the Data Access Queue(DAQ) if no channel available. The DAQ was arrange on a First-In-Highest-Graded-Out sense, where the grade of each TBF request was made up of two parts: a radio condition credit and a delay credit. The radio condition credit is decided by the estimation of the C/I of the user request for this TBF, and the delay credit is according to how long this request has been waiting in the DAQ. In
a word, a TBF request with higher C/I (better radio channel condition) and longer waiting time will be serve first.

Likewise a coming voice call will also be assigned a radio condition credit when it needs to compete with data request for shared channels though the credit can be higher than data given the same C/I value. Then the access control algorithm will compare the credit of coming voice call and the highest one in DAQ, and allocate TS to the one with higher credit. When a voice call failed in this contention, it will be blocked while a failed TBF request have to keep waiting in DAQ. The whole access control process is depicted in Figure 1.4.

![Access Control Process of Proposed RRM](image)

Figure 1.4: Access Control Process of Proposed RRM

A TBF request will be blocked in two cases:

1. DAQ is full;

2. The waiting time of a TBF in DAQ exceed its threshold. Here we assume a user can tolerate at most 10 seconds delay before his/her data transfer start.
1.4.2 Scheduling

Our scheduler is also based on grading, means the scheduler picks each TBF to transmit a block in a possibility according to their credit. The initial credit is assigned according to C/I, but as one TBF transmit more and more blocks, its credit will be reduced.

1.4.3 Model 1

Total Channel Number: 28
Voice Dedicated (TCH): 26
Data Dedicated (PDCH): 2
Shared Channel (TCH/PDCH): 0

1.4.4 Assumptions and Parameters used in Simulation

Several assumptions were taken in the simulation regarding the RRM strategies. The access queue size has been chosen to be of 7 sessions, which is a compromise in high loading conditions between the access delay and the blocking probability. We considered a GPRS dropping criteria on the number of consecutive retransmission of an RLC block. When this number reaches a certain threshold of 5, the GPRS transmission will be dropped (which would correspond to a packet drop in real networks). Furthermore, as we simplified the propagation model (only one Carrier to Interference ratio per transmission), and don’t consider GSM errors, no GSM dropping criteria has been used for the simulation.
Bibliography


[3] H. Bhaskar, R. Everson, M. Witwit, J. Gil, ”INTELLIGENT PACKET SCHEDULER FOR GENERAL PACKET RADIO SERVICE”, Department of Computer Science, University of Exeter, UK; Motorola, Swindon, UK