6 Dimensioning for Single ATM-Based Iub

This chapter presents the methodologies for dimensioning a single Iub link in the UMTS Rel99 of an ATM-based UTRAN, with both simulation and analytical approaches. Novel analytical models are proposed in this chapter, which allow the dimensioning of a single Iub link for various traffic types and different QoS requirements. The traffic considered in this thesis is classified essentially into two main categories: circuit-switched traffic and elastic traffic (see Chapter 1.4). For these two traffic classes, section 6.2 and section 6.3 present two individual analytical dimensioning models at flow or connection level for their respective user-relevant QoS. Section 6.4 proposes analytical models for dimensioning the Iub link at network level to guarantee the relevant transport network QoS. The validity of the proposed analytical models is demonstrated by means of extensive simulations. Section 6.5 summarizes the main investigations of dimensioning for the ATM-based HSPA networks.

6.1 Overview and Objectives

In this chapter, the dimensioning process considers a single link, as shown in Figure 1.2 (a). It can be applied to the situations that the Node B with a direct link to the RNC or a logical Iub interface with an identifiable bottleneck. In the latter situation, other links might exist on the Iub interface but their influence on the user and network performance is considerably less than the bottleneck and therefore they can be neglected. Overall, the objective is to minimize the bandwidth costs while still meeting a desired degree of QoS. Given a certain traffic demand per traffic class, the amount of aggregated traffic carried on the Iub link need to be estimated. From this, the minimum required link bandwidth should be derived for a specific QoS target.

Every dimensioning procedure requires a model, which provides a relationship between the amount of offered load, the link bandwidth, and the achieved QoS, taking into account the characteristics of the workload and the transmission process. For the circuit-switched traffic, it is assumed that it is generated by real time services with strict QoS requirements, which need to be guaranteed by the network with a guaranteed bandwidth. The resultant analytical dimensioning model needs to consider traffic characterization at connection level and the influence of admission control function. In case of elastic traffic the packet transmission process is mainly affected by the rate-sharing features of TCP. The proposed network dimensioning methodology is based on the processor sharing model. This thesis extends the processor sharing model in order to take into account specifics of the UMTS features and...
resource management functions, and also consider the case of mixing with circuit-switched type of traffic. To dimension the Iub link for satisfying the network-relevant QoS, e.g. packet delay or packet loss ratio on the Iub interface, queuing models are proposed to estimate the network performances. In this thesis, two arrival process models are presented to capture the characteristics of the aggregated traffic at the packet level on the Iub link. By solving the closed form of delay distributions of analytical queuing models, relevant network performances can be estimated and thus can be used for dimensioning process.

6.2 Dimensioning for Circuit-Switched Traffic

For dimensioning process in the framework of this thesis, the considered relevant user QoS criterion for the circuit-switched type of traffic is call blocking probability as a result of Connection Admission Control (CAC). Each connection requires a certain bandwidth in order to achieve the desired quality of service. TNL CAC, as introduced in section 3.3.4.3, is used to decide whether there are sufficient free resources on the transport link (i.e. Iub link) to allow a new connection. A connection can only be accepted if adequate resources are available to establish the connection with the agreed QoS while the quality of service of the existing connections in the network must not be decreased by the new connection, i.e. the available bandwidth on the link needs to be larger than or equal to the requested bandwidth of the new connection. In this way, the Iub link can only carry a maximum number of simultaneous connections (trunks) each occupying a certain bandwidth which is reserved for those connections. This section discusses the feasible analytical models to dimension the Iub link capacity to satisfy a required call blocking ratio of the circuit-switched type of traffic.

6.2.1 Erlang-B Formula

The Erlang-B formula has been published by the Danish mathematician A. K. Erlang in 1917 [EHA48]. It is considered to be the classical model to evaluate the performance of a loss system which has finite capacity and limited number of channels (servers, trunks, etc.).

The Erlang-B formula can be used to estimate the probability of a call being blocked and lost in a circuit-switched network. It is used under the following assumptions:
1. The network comprises of \( n \) identical channels. A call is accepted for service if any channel is idle. Every call needs only one channel.
2. If all channels are busy, a call is blocked and lost. It is called the Erlang loss model.
3. Furthermore it is assumed that the call arrive process is a Poisson process with rate \( \lambda \) and the service times are exponentially distributed with intensity \( \mu \) (mean service time = \( 1/\mu \)).

Therefore, the Erlang loss model is denoted as M/M/n loss system.

In Erlang's loss model with Poisson arrival process, the offered traffic, denoted by \( A \), is equivalent to the average number of call attempts per mean holding time as given in (6.1).