Chapter 5

Conclusions and Future Works

In this dissertation, the essential radio resource management mechanisms are studied to support diverse QoS requirements and customized multimedia applications in CDMA cellular network, including an intelligent call admission control architecture for uplink transmission, and a CNNU-based scheduler for downlink to provide the differentiated QoS requirements and customized multimedia applications.

In chapter 2, the equivalent interference estimators are proposed to estimate the capacity required for a call connection in WCDMA cellular systems. The equivalent interference estimators for the dedicated channels and for shared channels, named EIE and RRI, respectively, associate the equivalent interference at base station side with the traffic source characteristics, several pre-claimed QoS requirements, and the radio resource. Analytical models are proposed to obtain the EIE and the RRI. The EIE and RRI can greatly reduce the complexity to develop the radio resource management mechanisms in a call level sense. However, the proposed equivalent interference estimators can only address the connections without retransmission protocols. For the non-real time connections, ARQ is an important feature to greatly reduce the block error probability in an efficient way. The equivalent interference estimator for NRT connections with ARQ can be expected to need much less power to achieve the same performance and should be further studied. Moreover, the equivalent interference based other distributed rate control schemes, ex. variable rate transmission defined in [2], should be obtained to develop the CAC schemes for practical systems.

In chapter 3, based on the equivalent interference estimator, we propose an *intelligent call admission control* architecture for wideband CDMA cellular systems to support differentiated QoS requirements such as the forced termination probability of handoffs and the outage probability for all service types, and maximize the spectrum utilization. The *fuzzy equivalent interference estimator* employs the fuzzy logic theory to mimic domain knowledge contained in the equivalent interference estimator to estimate the equivalent interference of a call request from its claimed traffic characteristics and QoS requirements. The *PRNN interference predictor* adopts a pipeline recurrent neural network [63] for accurately predicting the mean interference of existing calls. The *fuzzy call admission processor* decides whether to accept the new or handoff call based on not only the estimated equivalent interference caused by the call and the predicted mean interference generated by existing calls but also the QoS measures such as the outage probabilities of all service types and the forced termination probability as system feedbacks. In addition, the link gain of the call request, denoting a good or bad user, is further considered. Simulation results indicate that ICAC can always fulfill the multiple QoS requirements under all traffic load conditions, while these conventional CAC schemes fail in heavy traffic load condition. In particular, ICAC achieves system capacity higher than the PSIR-CAC and MCAC by more than 10% in traffic ranges where the QoS requirements are kept. ICAC is more adaptive and stable than the PSIR-CAC and MCAC. For the system with connections transmitting in both dedicated and shared channels, the joint equivalent interference estimator should be further developed to facilitate the call admission control in the practical use.

In chapter 4, we propose a CNN and utility (CNNU)-based scheduler for downlink in multimedia CDMA cellular networks. The CNNU-based scheduler contains a utility function (UF) preprocessor, a radio-resource range (RR) decision maker, and a CNN processor. Noticeably, the utility function for each connection, adopted in the UF preprocessor, jointly considers radio resource efficiency, diverse QoS requirements, and fairness. It is a radio resource function weighted by both its QoS requirement deviation function and its fairness compensation function. The utility of each connection indicates the benefits to allocate the radio resource which jointly reflects the efficiency of the allocation of the radio resource, and the extent of the need to fulfill the QoS requirement and to compensate for the difference between the received resource and the target on to achieve weighted fairness. The UF preprocessor generates a matrix of normalized utility functions of all connections. On the other hand, the RR decision maker determines a matrix showing the upper limit of radio resource assignment for each connection. The CNN processor receives the matrix of normalized utility functions and the matrix of upper limits of radio resource assignment vector as inputs. It can determine an optimal normalized radio resource assignment vector for connections in a real-time fashion, usually in a few micro seconds. The architecture of the CNN is constructed via the energy-based approach [68]-[69]. by mapping the system cost function to a proper energy function. It is designed in a two-layered configuration, which consists of a decision layer and an output layer, to reduce the number of inter-connections in the CNN. The CNN is powerful for complicated optimization problem. The simulation results show that CNNU-based scheduler has higher system throughput by the amount of over 10% than that of exponential rule scheduling algorithm. It can be found that the CNNU-based scheduler can fully utilize the radio resource and make the performance measures of QoS requirements closed but below the desired level, and therefore achieve larger QoS guaranteed region than the exponential rule does. From the results of fairness comparison, CNNU-based scheduler can get more closed to the defined weighted fairness than the exponential rule algorithm does. The CNNU-based scheduler is efficient and effective to address the diverse QoS requirements and customized traffic parameters for multimedia CDMA cellular networks. However, from the discussion of the QoS guarantee for individual connection, it is found that several connections with bad link condition, which is relative to the system load, can not be scheduled with QoS requirements guaranteed. This phenomena implies the existence of the limit of the schedulability of a specific scheduling algorithm, and the call admission control for downlink should be designed according to its underlaid scheduling scheme.

In this dissertation, we have made a study of the essential radio resource management mechanisms for CDMA systems to provide customized multimedia applications. Those control schemes make the decisions according to the user's profile at some time instance, that is, these proposed schemes determines the decision at the coming of the the call request. They cannot handle the issues resulted from the mobility of the connections when the system conditions changed. This issue is typically solved by the *Radio Bearer Control* defined in the [2] for example. The claimed QoS requirements and the required radio resource for a connection should be dynamically re-negotiated when its location has been changed and the link quality is not the same as that in the initial phase. In junction with the radio bearer control, the complete radio resource management functionality can be provided to support the customized multimedia service over the CDMA cellular networks.

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