CONCLUSIONS AND FUTURE ENHANCEMENTS

8.1 CONCLUSIONS

High quality multimedia applications require large network resources to meet its quality of service. In particular, the video consumes most of the bandwidth allotted for multimedia traffic. Furthermore, compressed (MPEG-4) video streams are bursty and irregular with large variations in data rate. This property is exploited in the algorithms presented here to maximize the system capacity.

The bit rate also depends on the source recording format and media. For example, in the movie “Miracle at St. Anna” on blue ray using MPEG-4 AVC, the peak rate sometimes exceeds 50 Mbps. Although the bit rate requirement for audio is relatively low, the upper bound on delay is more stringent (50ms for basic conversational service). Different ultra low delay codecs for audio are available, but the network delays are usually high and hence become a critical factor in protocol design. The resource requirements for high quality multimedia services are soaring (Also as per the IMT-advanced guideline), e.g. throughput for live streaming 2-50Mbps, that none of the existing mobile network can serve it, and this justifies the development of next generation network and protocols.

The Rayleigh channel model is used to describe the form of fading that occurs when multipath propagation exists, and, in many instances, cellular systems being used in a dense urban environment fall into this
category. Although there are many channel parameters like delay spread and coherence band width that characterize the wireless channel, the higher value of Doppler shift greatly affects the received wireless signal. In the deep fades due to Doppler shift of 10-100Hz in the Rayleigh channel at 2.4 GHz the signal strength drop by a factor of several thousands or 30-40 dB. Hence the Doppler shift becomes one of the important channel parameters while simulating a wireless mobile environment.

The higher spectral efficiency and flexible resource allocation in multi-carrier system makes its highly suitable for next generation networks. Out of the two basic multiple access scheme, i.e. MC-CDMA and OFDMA, the OFDMA shows greater flexibility and performance. Although the cyclic prefix helps in combating ISI, it is an overhead on wireless communication. In other words, part of the system capacity is wasted in carrying cyclic prefix data.

An MC-CDMA system in TDD mode was modeled and analyzed to support an adaptive resource allocation algorithm. The multi-cell environment was modeled and simulated by generalizing a two-cell model. The interference analysis has two major components: the intra cell and inter cell. Based on the traffic directions, four cases were modeled and analyzed. The proposed SSA algorithm judicially allocates the subcarrier and slot. The SINR (and hence the BER) performance highly depends upon the number of users in home and neighboring cells. Other factors like orthogonality in downlink, equally affects the MC-CDMA performance. A small change of orthogonality $\Delta \eta = 0.1$ causes BER to vary more than $1.5 \times 10^{-3}$. The observed average capacity falls around 2 bit/sec/Hz, by adopting 8-QAM modulation technique compared to the theoretical limit of 3 bits/sec/Hz.

The proposed SCA algorithm for OFDMA works on the same principles of adaptiveness as SSA in MC-CDMA, but slot management is
directly not incorporated in the SCA. The number of uplink/downlink slots in frame of OFDMA system is dynamically decided based on the present traffic requirements and not on the problem of capacity optimization. Further, in the estimation of the SINR in OFDMA system, it is assumed that intra-cell interference is absent, which is quite justifiable in system design. The MC-CDMA offers benefits like additional channel gain, but lags behind OFDMA when it comes to basic performance measures like BER and SINR. In all four cases considered here OFDMA outperforms MC-CDMA with respect to SINR and BER. The delay pattern for both of these systems is acceptable for multimedia traffic but, for a larger number of users, it rises exponentially for the MC-CDMA systems.

An adaptive and spectrally efficient novel resource allocation algorithm called TSRA was developed that meets the main QoS requirement for many real-time multimedia communications. To facilitate the TSRA algorithm system model and subchannel allocation problem in OFDMA were formulated. Four types of multimedia traffic namely CBR, rt-VBR, nrt-VBR, and ABR were considered for simulation. It is observed that, when all four types of traffic are mixed randomly, the capacity of the proposed TSRA with BWA algorithm exceeds 6 bit/sec/Hz while approaching the analytical limit in higher traffic load. On the other hand, when the number of users in each type of traffic is fixed, the average capacity does not follow the same uniform performance path.

Since the random mix of all traffic represents a more generic case of user traffic, other parameters like delay and throughput were analyzed for this case. The delay observed here corresponds to the under laying hardware and hence the processing delay of the TSRA can be scaled down to support all the major categories of multimedia services including rich (<20ms) and low delay (<10ms) conversational traffic as per IMT-advanced guideline. The
observed average BER of the system with larger number of users represents the worst case scenario and includes all traffic. A user terminal using suitable error correction technique like Turbo coding can very well afford the average BER observed here.

The water filling technique allows the resource allocation technique to follow the theoretical limit more closely (on an average gap of less 0.5 bits/sec/Hz between simulated and analytical results) than without water filling. It also reduces the processing time of a new call, but it incurs extra delay for rt-VBR traffic and also lower throughput of the system. It is concluded that the TSRA with water filling technique works well for a varying traffic load, but, when the traffic load is high and shows not much variation, the TSRA alone is capable of optimizing system capacity.

8.2 FUTURE ENHANCEMENTS

The major directions that can be followed for the improvements of the adaptive resource allocation technique in multi-carrier systems for the fourth generation system are as described below:

1. Enhancing the throughput of the system while increasing the system capacity.

2. A parallel processing approach to reduce the processing delay of resource allocation algorithm.

3. The system analysis in particular BER and throughput in presence of channel coding (e.g. Turbo coding).

4. Instead of taking an instantaneous value, a mean or variance of the multimedia traffic can be considered for the TSRA algorithm.
5. Fixing two thresholds in TSRA is based on statistics of different applications and it needs further research to incorporate into the problem formulation.

6. A real-time testing of TSRA can be a challenging but interesting work.