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Long Term Evolution of Uplink QoS Enhancement in Wireless Communication Networks

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Abstract

Wireless communication networks play an important role in anybody's life during this information age. The technology is growing at a rapid rate and it becomes essential to provide a reliable linking to the system using an appropriate uplinking channel with the required Quality of Service (QoS). The work presented here deals with important Long Term Evolution (LTE) of techniques developed over last two decades. Power optimization of the mobile unit is the most desired operation which is discussed. Towards achieving seamless transmission, Frequency Hopping Spread Spectrum (FHSS) is used in wireless communication. Multi Input Multi Output - Orthogonal Frequency Division Multiplexing (MIMO-OFDMA) techniques are also adopted for combating fading and interference. Context aware link adaptation provides intelligent networking. Reconfiguration of uplinking also discussed in wide detail to match the essential requirement of mobility. Long term evolutions in scheduling and congestion control techniques are employed in the uplinking for suitable traffic management. Error detection and correction techniques play important role in restoring the original structure of the transmitted information.

Keywords: Error Detection and Control, FHSS, MIMO-OFDM, Power Optimization, QoS, Scheduling and Congestion Control, Uplink Channel

1. Introduction

Mobility providing wireless networks grows with interest and expectations in the world of communication. In the modern wireless media, new challenges in the design of communication protocols are quite prevalent. Features of network environment like shared channel, limited bandwidth, high error rates, increased latency, mobility and security are to be handled efficiently towards required performance. In wireless communication networks, uplinking of the Mobile User (MU) plays an important role[1] as it involves the connecting of the user to the network as in Figure 1.

Free space happens to be the medium for the transmission of information where near-far problem has to be solved. Power control techniques are deployed with CDMA systems to maintain the quality of signals from far users. Recent designs employ base stations for an effective power control information transfer for uplink power control systems and methodologies are described that facilitate transmitting and receiving control data according to hopping patterns. Bandwidth capabilities of devices determine the hopping capabilities of the uplinking. This presents frequency diversity for combating fading systems and methods are provided that facilitate channel quality indicator for frequency hopping. Radio resource management in uplinking is an important effort for maintaining the quality of service. The technique is presented to provide transmitter and receiver diversity along with co-channel interference uplinking is done using MIMO-OFDMA technique. This technique can also be provided with the smart antenna techniques[2]. The uplink resource allocation has to be carried out as per its working environment. Hence a link adaptation technique

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based on context aware principle is well described. Finally scheduling and congestion control methods are covered towards the effort of error control and marinating the quality of service.

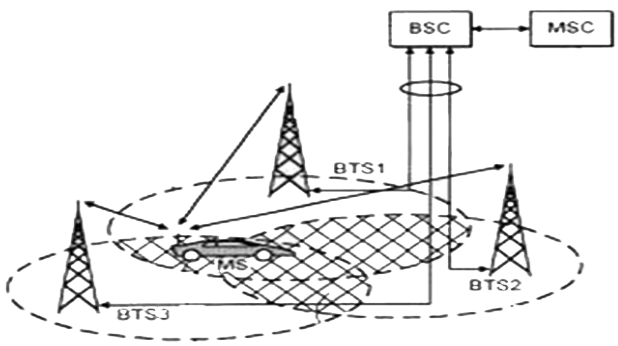

Figure 1. Uplink in wireless communication.

2. Power Control

Uplink power control works at slow varying channel conditions for reducing the interface generated towards neighboring cells. PVSCH provides full path loss compensation on PVCCH LTE advanced support component always supports carrier specific uplink power control for both contiguous and non contiguous carrier aggregation[3].

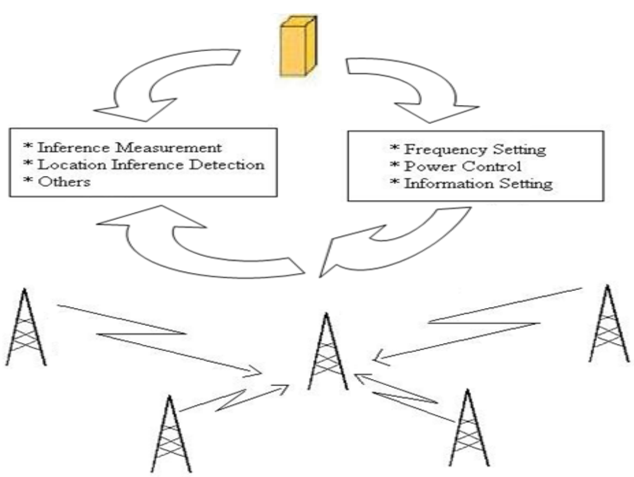

Figure 2. Concept of self organization.

Distributed uplink power control is done with two approaches namely the target-SIR tracking scheme and the opportunistic approach. In the target-SIR-Tracking Power Control (TPC) algorithm, each user is tracking its own predefined target SIR. This causes a user to increase it's transmit power when the effective interference is increased because of heavy traffic and/or deep fading and/or far distance. In contrast to TPC, in an Opportunistic Power Control (OPC) scheme, each user increases it's transmit power as the effective interference decreases. The OPC significantly increases the aggregate throughput as compared to TPC by allocating more power to users with good channels, and very low power to users with poor channels. We shall bring the soft removal property of OPC into TPC to improve its performance in infeasible systems[16].

3. Frequency Hopping

At adverse battle conditions, military applications of wireless communication demand reliable and secured operation. Frequency hopped spread spectrum combats adverse condition and compassing fading, interference and jamming. Here the allocated bandwidth is divided into multiple frequency channels. Frequency hopping sequences are employed between transmitter and receiver in the uplink. When wireless connection using the uplink is established and time synchronization is gained, frequency hopping provides frequency diversity to minimize fading while interference rejection is also carried out[4]. By using suitable encryption key, eavesdropping can also be avoided as it provides necessary security in communication[5]. The general frequency hop spread spectrum technique is illustrated in Figure 3. The frequency hopping can be compared with channel changing in the high of error. Typical FHSS operation is shown in Figure 3.

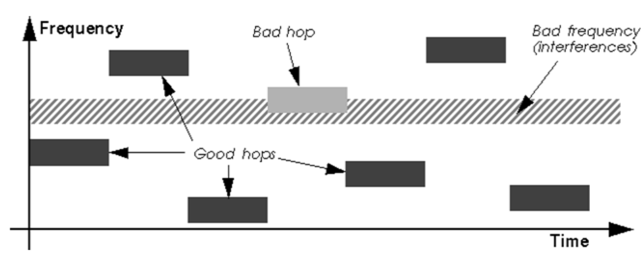

Figure 3. Principle of Frequency Hopping.

Uplinking channel control adapts FHSS, towards providing better quality of signal.

4. Radio Resource Management

In LTE, Radio Resource Management (RRM) is an essential event. This technique is quite effective in global system for mobile communication and Enhanced Data rates GSM Evolution (EDGE). The techniques developed[4] are also quite useful in Radio Access Networks (RAN)[5]. Radio link quality measurement is an important aspect in RRM. The received power in the link can be expressed as $P_r = P_t + G_{ant} - L_{pl} - L_{sf}$ in dBm, where the antenna gain G_{ant}, the average path loss L_{pl} and the shadow fading L_{sf} can be obtained based on mobile unit and base station positions. Due to the frequency use aspect of GSM, co-channel sectors share the same frequencies and generate interferences. Thus it becomes quite important to measure Signal to Interference and Noise Ratio (SINR)[1]. Voice and data services demand different traffic patterns those requiring elaborate traffic models adequate to their qualities. Opportunistic power control can bring benefits to a network where the users typically belong to two priority groups, e.g., voice (higher priority) and data (lower priority) transmission in cellular network, or in cognitive radio network[18]. Users in the higher priority group always get to maintain their SIR requirement, but due to the varying channel conditions and user mobility, users in the lower priority group get to share the channel and transmit opportunistically without violating the SIR requirement of the users with higher priority.

5. Multi Input Multi Output Diversity Systems

Currently used wireless communication systems are capacity constrained methods with issues related to quality of information handled and its transmission coverage. Multi Input Multi Output wireless systems exploit the space dimension in order to improve wireless system capacity, range and reliability. Transmission by a multipath channel (Figure 4.) is due to scattering on different obstacles. These results on two effects on propagation: 1. There will be time variations of signal strength as shown in Figure 5 which results in fading. This is the random variation of signal strength over a large diaphragm range resulting in SNR variation. 2. Time spread of received digital information which depends on frequency selectivity.

MIMO is an antenna technology that is used in both transmission and reception equipment for wireless radio communication. To illustrate the MIMO principle Figure 6 represents 2 x 2 configurations. In the place of one, two antennas are used at transmit as well as the receive range of the uplink/downlink. It can be established that[4] MIMO can persuade number of antenna elements vs. capacity as a linear relation as shown in Figure 7.

MIMO takes advantage of multipath by using multiple antennas to get multiple parallel signals from transmitter. In an urban environment these signals will beams of trees, buildings, hills etc. and continue on their way to their destination but in different direction as depicted in Figure 8. At various times, different signals arrive at the receiver through multipath. The receiving end uses a special signal processing algorithm to sort out the multiple signals to produce one signal that has the originally transmitted data[8].

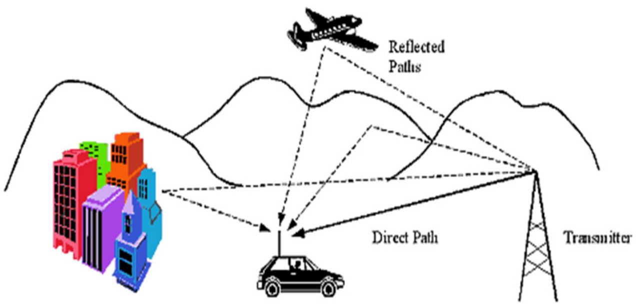

Figure 4. Multipath reception of signals.

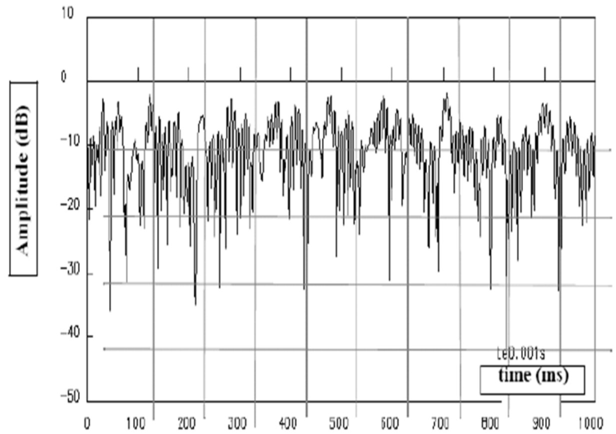

Figure 5. Signal strength variation.

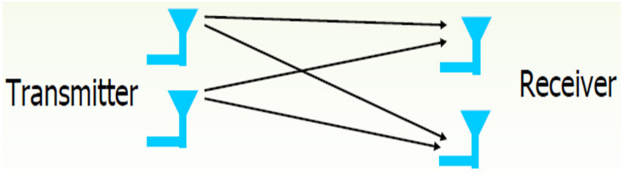

Figure 6. 2 x 2 MIMO.

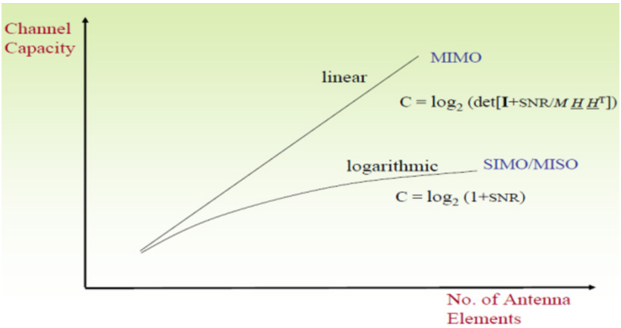

Figure 7. Linear vs. Logarithmic improvement.

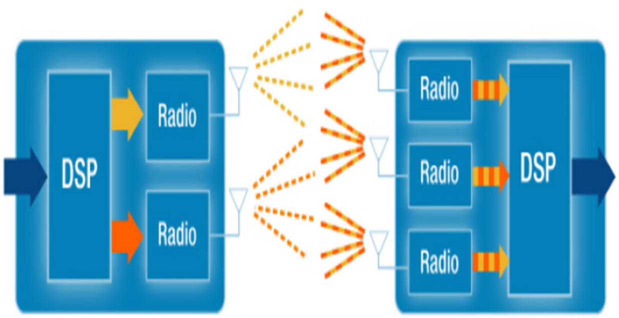

Figure 8. Multiple data streams transmitted in a single channel at the same time.

Space time diversity, spectral multiplexing and uplink collaboration are used by MIMO. The space time transmit diversity denotes the power in the channel by data through different antennas. Spatial multiplexing of MIMO gives higher capacity when RF conditions are favorable and users are close to the BTs. Uplink collaborative MIMO link leverages conventional simple Power Amplifier (PA) at device. The uplink capacity can be doubled when two devices can collaboratively transmit on the same sub-channel. The higher mathematical theory of MIMO is available in reference[7].

However MIMO performance is very sensitive to channel matrix invertibility. Small antenna spacing or small angle spread may degrade its performance[6]. MIMO conditions the multipath components well into link or right component is poorly conditioned.

6. Orthogonal Frequency Division Multiplexing

Orthogonal frequency division multiplexing has carriers separated sufficiently in frequency so that there minimal overlap to prevent crosstalk. This kind of multiplexing is designed to save bandwidth and improve spectral efficiency. In recent days MIMO and OFDMA techniques are entertained for uplink quality improvement. When OFDMA eliminates intra-cell interference and inter-symbol interference, it provides better entrance for frequency selective fading. MIMO provides diversity and hence known for better resistance against fading. Combination of MIMO and OFDMA provides better quality along with capacity. MIMO OFDMA based cellular systems are used in 3GPP LTE especially under IEEE 802.16e (WiMAX) Advanced MIMO OFDMA scheme for 100MHz bandwidth are employed by number of new projects[8].

7. Context Aware Link Adaptation

Current situations and its potentials in a wireless communication need to be analyzed and the system need to adapt to it as shown in Figure 9. Information sources and sensors will be involved in understanding the context situations towards creating adaptiveness with the uplinking. The advancement that has taken place with device capabilities results in smartness with the wireless systems due to the availability of sensors. The availability of sensor based GPS and accelerometer in the birth the link adaptation techniques which make wireless communication system smart. Innovative communication services are developed using adaptation based on observed changes in user situation. The probability of communication failure can be decreased by using context aware communication[9–11].

3GPP UTRAN long term evolution of the uplink makes use of joint detection and link adaptation[12]. Here different sectors belonging to the same site may cooperate with each other in order the system performance as in Figure 10. Coordinated Multipoint (COMP) systems are employed for cooperation among sectors. Joint detection and joint link adaptation proved to be the best alternative for significant performance gain compared to conventional system at measurable complexities. Such systems match the requirements of real world networks[13].

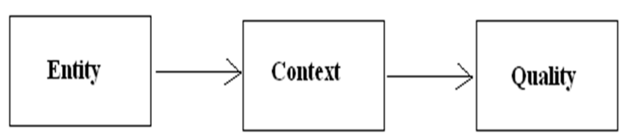

Figure 9. Context modeling.

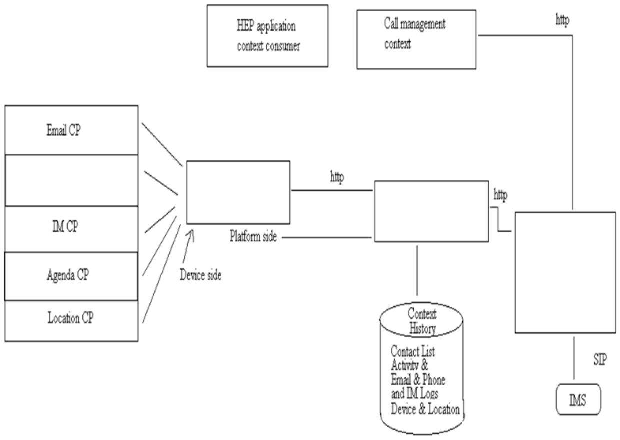

Figure 10. Call management architecture.

8. Scheduling and Congestion Control

A reliable scheduling procedure is essential to assign MSs to specific priority bands to enhance the effect of ULIP. An efficient scheduling procedure increases the effectiveness of ULIP and prevents throughput loss due to mobile station outages. Reverse link signals can be used for analysis and used for scheduling. In a fair allocation strategy cell edge mobile stations should be allocated high priority audio band so as to be able to transmit full power to achieve maximum possible Signal to Interference adverse Ratio (SINR). Low priority radio bands are used for cell centre mobile systems. In nut shell, it can be stated that least favorable SINR mobile stations need be given higher priority in scheduling[14].

In LTE, using cross layer design efficient scheduling can be achieved[14]. To assure better quality of service in heavily loaded scenario, a call admission control scheme will provide congestion control. Adaptive queue management technique in the MAC using cross layer design can optimize scheduling and congestion control in the uplinking of wireless communication networks[15].

9. Error Control in Uplinking

Joint optimization of cell sectorization, transmit power control and receiver filters will provide error control in uplinking. Directional antennas and frequency hopping also can work on error for its reduction. Optimal link adaptation achieving maximum energy efficiency can land on to lower bit error rate in wireless data transmission[16]. Precoding method with complex field coding can improve the performance of Physical Uplink Control Channel (PUCCH) format 2 control signaling. The error protection of the Control Channel Information (CCI) can be improved by using a 2 x 2 Complex Field Coding (CFC) for precoding prior to transmission, which offers significant gains on fading channels. The usage of complex field coding at transmitter and optimal detectors at receiver can improve error protection for uplink[17].

10. Summary and Conclusion

Few effective Quality of Service enhancement schemes over the past two decades were discussed here. Shared channel, limited bandwidth, high error rates, increased latency, mobility and security are the constraints for the uplink QoS. Opportunistic power control schemes are the preferable one for uplink power control as well as for the better radio resource management. Frequency hopping can be employed to overcome fading and the combination of MIMO with OFDMA assures quality as well as capacity. Context aware link adaptation suits with distinct applications, using variety of scheduling and error control techniques.

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