KFUPM - COMPUTER ENGINEERING DEPARTMENT

COE-543 – Mobile Computing and Wireless Networks

Statements For Projects

Project 1: Optimal Power Control for Fourth Generation Long Term Evolution (LTE) Mobile Wireless Networks

Orthogonal multiple access schemes such as Orthogonal Frequency-Division Multiple Access (OFDMA) and its variations have been chosen in a number of next generation mobile wireless technologies including Long Term Evolution (LTE) [1][2]. The main reason for such a choice is the ability of the orthogonal multiple access schemes to considerably lessen the interference between mobiles in the same cell in the reverse link (intra-cell interference).

Previously, intra-cell interference was combated through the use of fast power control so that the mobiles transmit with the lowest power level required to meet the desired quality of service. Although the use of orthogonal multiple access schemes ideally eliminates the possibility of intra-cell interference, power control is still needed because of inter-cell interference that is generated at neighboring cells in systems that use a frequency reuse factor of 1. Another reason for the need for power control is the several factors which can cause loss of orthogonality between mobiles in the same cell, such as frequency offset, variability of the channel within the FFT integration period due to high Doppler, and imperfect timing control [1][2]. Between the two types of interference (i.e. intra-cell interference and the inter-cell interference), the inter-cell interference dominates the system performance in orthogonal multiple access schemes based mobile wireless networks. Therefore, it is important that a suitable mobile power control scheme is used by the network to reduce the amount of inter-cell interference generated.

A number of power control schemes for LTE have been proposed [3][4][5], however, such schemes are not optimal. In this project, we explore the use of optimization techniques such as H_∞ techniques to propose optimal power control methods that will reduce the interference in LTE mobile wireless networks. Such reduction in the interference will result in an enhanced capacity of the LTE mobile wireless networks and an improved quality of service for end users. Consequently, and since the dependency on mobile wireless networks is increasing every year in the Kingdom, the region, and world-wide both at the individual level and the industry and government level, then all such sectors will ultimately benefit from the results of this project.

A number of power control schemes for LTE have been proposed. For example, the 3rd Generation Partnership Project (3GPP) [3] proposed a modification of the conventional open loop power control used in the Universal Mobile Telecommunications System (UMTS), and referred to the modified proposal as fractional power control. The fractional power control allows a higher signal to interference plus noise ratio (SINR) target for mobiles that have a smaller path loss (i.e. those that are closer to the cell interior). Accordingly, higher spectral efficiency can be obtained by allowing higher transmit power levels for those mobiles. Such high spectral efficiency causes little interference to other cells. The proposed technique was studied by Castellanos et al. [6] who evaluated in detail the impact of the proposed scheme on the SINR and the interference distributions. The authors concluded that in most cases the proposed fractional power control scheme provides a gain compared to the full conventional open loop power control used in UMTS.

However, due to the fact that the variance of the other cell interference generated with the fractional power control technique can be high, the rate selection algorithms that are designed to achieve a certain target error rate become more conservative. Subsequently, Rao [4] showed that a simple modification of the fractional power control technique that takes into account the path loss of the mobile to the strongest neighbor cell, a measurement already used for the purposes of handover, reduces the variance of the inter-cell, and results in an improved system performance.

On the other hand, Gkatzikis et al. [5] studied the interaction between the relay selection where multiple source-destination pairs compete for the same pool of relay nodes and the power control process in LTE networks. The authors developed easy to implement distributed algorithms of at most polynomial complexity that are applicable to any type of relay assisted wireless systems and offer significant improvement in the sum rate performance.

As for the use of optimization techniques in power control schemes, several papers used H_∞ techniques to control the power in wireless networks. For example, Lee et al. [7] attempted to compensate for the effects of round-trip delay, channel attenuation, and uncertain interferences plus noise in the closed-loop power tracking control design for the cellular CDMA system. A robust H_∞ tracking design with state feedback control was developed. From a comparison with conventional methods, the proposed H_∞ power control can achieve better performance, especially at high velocities.

Similarly, Sorooshyari et al. [8] presented an estimator based algorithm for distributed power control. The proposed power control policy is based on H_∞ techniques, and is optimal with respect to users dynamically allocating transmit power so as to minimize an objective function consisting of the user's performance degradation and the network interference. The proposed algorithm is predictive, with a user performing autonomous interference estimation and prediction prior to adapting transmit power. The authors demonstrated through simulation results that the performance of the proposed algorithm is excellent with respect to robustness to stochastic detriments caused by a time varying channel and noisy measurements.

Likewise, Zhao et al. [9] proposed a novel robust H_∞ distributed power control scheme for wireless CDMA networks. The scheme allows each user to adapt the power either in a user-centric manner or a network-centric manner according to a simple updating function. Furthermore, the scheme is robust to the channel fading, and is more suitable for practical use with severe fading than iterative algorithms.

The references below should serve as example studies and a starting point. The list is far from being comprehensive or representative. The work is to focus on very recent studies in light of the new advancements of services and applications for the Internet.

It is required to produce survey report or paper that includes, but may not be limited to, the following points:

1. Review of LTE power control function and procedure as per the standard documents.
2. A survey of power control algorithms proposed in the literature for the LTE system.
3. Comprehensive survey of studies implementing the H_∞ method to implement power control for wireless/mobile systems with focus on LTE.
4. Identify a paper with reasonable details for reproducing the work
5. Improve the performance of the algorithm in the selected paper and compare results. The papers in references [7], [8], and [9] are good candidates.
6. Experiment with Simulink/Matlab to model and evaluate the LTE power control algorithm to be studied. The studies are encourage to search for contributed models or design their own.

Expected Output: A survey (comprehensive) report/paper that includes the points outlined above.

References:

[1] R. Van Nee, R Prasad, OFDM for Wireless Multimedia Communications, Artech House, Inc. 2000.

[2] S. Sesia, I. Toufik, M. Baker, LTE – The UMTS Long Term Evolution, John Wiley & Sons, Ltd. 2009.

[3] 3GPP TR 25.814 v.7.1.0, "Physical Layer Aspects for Evolved Universal Terrestrial Radio Access" ftp://ftp.3gpp.org/specs/2006-12/Rel-7/25_series/25814-710.zip

[4] A.M. Rao, "Reverse Link Power Control for Managing Inter-Cell Interference in Orthogonal Multiple Access Systems," Proceedings of the 2007 Fall Vehicular Technology Conference (VTC), pp.1837-1841, Sept. 30-Oct. 3, 2007.

[5] L. Gkatzikis, I. Koutsopoulos, "Low complexity algorithms for relay selection and power control in interference-limited environments," Proceedings of the 8th International Symposium on Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks (WiOpt), pp.278-287, May 31-June 4, 2010

[6] C.U. Castellanos, D.L. Villa, C. Rosa, K.I. Pedersen, F.D. Calabrese, P.H. Michaelsen, J. Michel, "Performance of Uplink Fractional Power Control in UTRAN LTE," Proceedings of the 2008 Spring Vehicular Technology Conference (VTC), pp.2517-2521, May 11-14, 2008.

[7] B.K. Lee, Y.H. Chen, B.S. Chen, "Robust H_∞ Power Control for CDMA Cellular Communication Systems," IEEE Transactions on Signal Processing, VOL. 54, NO. 10, pp. 3947-3956, October 2006.

[8] S. Sorooshyari, Z. Gajic, "Autonomous Dynamic Power Control for Wireless Networks: User-Centric and Network-Centric Consideration," IEEE Transactions on Wireless Communications, vol.7, no.3, pp.1004-1015, March 2008.

[9] N. Zhao, Z. Wu, Y. Zhao, T. Quan, "Robust H_∞ Power Control for CDMA Systems in User-Centric and Network-Centric Manners," ETRI Journal, Volume 31, Number 4, pp. 399-407, August 2009.