ADVANCED WIRELESS NETWORKING AND CROSS-LAYER OPTIMIZATION: THE MYTH OF INTERFERENCE-FREE COMMUNICATIONS

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Abstract

This research-oriented presentation is based on the Wiley/IEEE Press monographs [1] - [12] and considers the joint benefits of both adaptive physical and adaptive network-layer performance enhancement techniques, with special emphasis on the latter. More specifically, conventional systems would drop a call in progress, if the communications quality falls below the target quality of service and it cannot be improved by handing over to another physical channel. By contrast, the adaptive transceivers of the near future are expected to simply 'instantaneously drop the throughput, rather than dropping the call' by reconfiguring themselves in a more robust mode of operation. It is demonstrated that the proposed beam-forming and adaptive transmission techniques may double the expected teletraffic capacity of the system, whilst maintaining the same AVERAGE performance as their conventional fixed-mode counterparts.

Topical Highlights

1. FDD VERSUS TDD AIDED NETWORKS

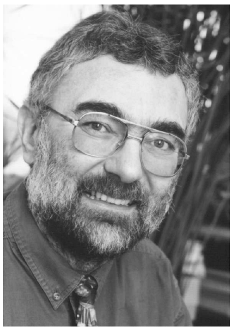
The network performance of a Frequency Division Duplex (FDD) and Time Division Duplex (TDD) Code Division Multiple Access (CDMA) based system is investigated using system parameters similar to those of the Universal Mobile Telecommunication System (UMTS) . The new call blocking and call dropping probabilities, the probability of low-quality access as well as the required average transmit power are quantified both with and without adaptive antenna arrays as well as when subjected to shadow fading. In the scenarios investigated the system's user capacity is doubled with the advent of adaptive antennas. The employment of adaptive modulation techniques in conjunction with adaptive antenna arrays resulted in further significant network capacity gains. This is particularly so in the context of TDD CDMA, where the system's capacity becomes poor without adaptive antennas and adaptive modulation owing to the high BS to BS interference inflicted as a consequence of potentially using all time-slots in both the uplink and downlink.

2. THE NETWORK-LAYER BENEFITS OF LOOSELY SYNCHRINIZED SPREADING CODES

The capacity of a UTRA-like Frquency Division Duplex (FDD) Code Division Multiple Access (CDMA) system employing Loosely Synchronized (LS) spreading codes is also discussed. Current CDMA systems are interference limited, suffering from Inter-Symbol-Interference (ISI), since the orthogonality of the spreading sequences is destroyed by the channel. They also suffer from Multiple-Access-Interference (MAI) owing to the non-zero cross- correlations of the spreading codes. LS codes exhibit a so-called Interference Free Window (IFW) , where both the auto-correlation and cross-correlation of the codes become zero. Therefore LS codes have the promise of mitigating the effects of both ISI and MAI in time dispersive channels. Hence, LS codes have the potential of increasing the capacity of CDMA networks. This contribution studies the achievable network performance by simulation and compares it to that of a UTRA-like FDD/CDMA system using Orthogonal Variable Rate Spreading Factor (OVSF) codes.

3. GENETICALLY ENHANCED PERFORMANCE OF A UTRA-LIKE TDD CDMA NETWORK

In this part of the overview a Dynamic Channel Allocation (DCA) algorithm is developed, which minimizes the amount of Multi-User Interference (MUI) experienced at the Base Stations (BSs) by employing Genetic Algorithms (GAs). A GA is utilized for finding a suboptimum, but highly beneficial Uplink (UL) or Downlink (DL) Timeslot (TS) allocation for improving the achievable performance of the third generation UTRA system's Time Division Duplex (TDD) mode. It is demonstrated that a GA-assisted UL/DL timeslot scheduling scheme may avoid the severe BS to BS inter-cell interference potentially inflicted by the UTRA TDD CDMA air interface owing to allowing all TSs to be used both in the UL and DL.



Lajos Hanzo received his first-class Master degree in electronics in 1976, his PhD in 1983 and his Doctor of Sciences (DSc) degree in 2004. He is a Fellow of the Royal Academy of Engineering (FREng). During his career in telecommunications he has held various research and academic posts in Hungary, Germany and the UK. Since 1986 he has been with the School of ECS, University of Southampton, UK, where holds the Chair in Telecommunications.
He co-authored 12 books [1]-[10] totalling 9000 pages on mobile radio communications, published in excess of 600 research papers (`http://www-mobile.ecs.soton.ac.uk`), organised and chaired IEEE/IEE conferences, such as WCNC'06, ISSSTA'06 and the IEE 3G and Beyond conference, presented keynote lectures and has been awarded a number of distinctions. Currently he heads an academic research team, working on a range of research projects in the field of wireless multimedia communications sponsored by industry, the Engineering and Physical Sciences Research Council (EPSRC) UK, the European IST Programme and the Mobile Virtual Centre of Excellence (VCE), UK. He is an enthusiastic supporter of industrial and academic liaison and he offers a range of industrial courses. Lajos is also an IEEE Distinguished Lecturer of both the IEEE Communications as well as the Vehicular Technology Society and a Fellow of both the IEE and IEEE. For further information on research in progress and associated publications please refer to http://www-mobile.ecs.soton.ac.uk;
Lajos presented short courses for example at the following IEEE conferences:
ICCS'94 in Singapore; ICUPC'95 in Tokyo; ICASSP'96 in Atlanta, USA; PIMRC'96 in Taipei, Taiwan; ICASSP'96 in Atlanta; ICCS'96 in Singapore; VTC'97 in Phoenix, USA; PIMRC'97 Helsinki, Finland; VTC'98, Ottawa, Canada; Globecom'98 Melbourne, Australia; VTC'99 Spring Houston, USA; EURASIP Conference'99, June, 1999, Krakow, Poland; VTC'99 Fall Amsterdam, The Netherlands; VTC'2000 Spring Tokyo, Japan; VTC'2001 Spring Rhodes, Greece; Globecom'2000 San Francisco, USA; Globecom'2001 San Antonio, USA; ATAMS'2001 Krakow, Poland; Eurocon'2001, Bratislava, Slovakia; VTC'2002 Spring Birmingham Alabama, USA; VTC'2002 Fall Vancouver, Canada; ICC'2002, New York, USA; Wireless'02, Calgary, Canada; WPMC'02 Honolulu, Hawaii; ATAMS'2002, Krakow, Poland; WCNC'03 New Orleans, USA; VTC'2003 Spring, Jeju Island, Korea; PIMRC'2003, Beijing, China; VTC'2003 Fall Orlando, USA; European Wireless Conference'2004, Barcelona, Spain; ICC'2004, Paris, France; EUSIPCO'2004, Vienna, Austria; VTC'2005 Spring Stockholm, Sweden; VTC'2005 Fall, Dallas, USA; WPMC'2005 Aalborg, Denmark; to be presented VTC'2006 Spring Melbourne, Australia; ICC'2006 Istanbul, Turkey; ISSSTA'2006 Manaus, Brazil; VTC'2006 Fall, Montreal, Canada. He is also the presenter of an IEEE COMSOC 'voice over powerpoint' www tutorial.

4. REFERENCES

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[1] For detailed contents please refer to http://www-mobile.ecs.soton.ac.uk