

Title: THE FOUR MIMOS
Duration: Half Day (3 hours)
Speaker: Lajos Hanzo
Affiliation: Chair of Telecommunications, School of ECS, Univ. of Southampton

Objectives

This light-hearted, but nonetheless research-oriented presentation is based on an amalgam of the Wiley/IEEE Press monographs [1] - [14] and provides an overview of the four basic types of multiple antenna-aided wireless systems briefly characterised in Table 1. We also argue that under realistic propagation conditions, when for example the signals associated with the MIMO elements become correlated owing to shadow fading, the predicted performance gains substantially erode. In this scenario only the combination of MIMOs with High-Speed Downlink Packet Access (HSDPA) style adaptive modulation and coding is capable of maintaining an adequate target performance. Other challenging reception scenarios are encountered in the so called rank-deficient situations, when the number of receivers is lower than the number of transmitters, which requires powerful non-linear sphere decoders or Genetic Algorithm (GA) aided detectors. This overview will conclude with the portrayal of a variety of avantgarde hybrid MIMO designs to set out a promising future research directions.

Beamforming [9]	Typically $\lambda/2$ -spaced antenna elements are used for the sake of creating a spatially selective transmitter/receiver beam. Smart antennas using beamforming have been employed for mitigating the effects of co-channel interfering signals and for providing beamforming gain.
Spatial Diversity [7] and Space-Time Spreading (STBC and STTC)	In contrast to the $\lambda/2$ -spaced phased array elements, in spatial diversity schemes, such as space-time block or trellis codes [7] the multiple antennas are positioned as far apart as possible, so that the transmitted signals of the different antennas experience independent fading, resulting in the maximum achievable diversity gain.
Space Division Multiple Access (SDMA)	SDMA exploits the unique, user-specific "spatial signature" of the individual users for differentiating amongst them. This allows the system to support multiple users within the same frequency band and/or time slot.
Space Division Multiplexing (SDM) [Foschini 1996]	MIMO systems also employ multiple antennas, but in contrast to SDMA arrangements, not for the sake of supporting multiple users. Instead, they aim for increasing the throughput of a wireless system in terms of the number of bits per symbol that can be transmitted by a given user in a given bandwidth at a given integrity.

Primary and Secondary Audience

Whilst this overview is ambitious in terms of providing a research-oriented outlook, potential attendees require only a modest background in wireless communications. The mathematical contents are kept to a minimum and a conceptual approach if adopted. Postgraduate students, researchers

and signal processing practitioners as well as managers looking for cross-pollination of their experience with other topics may find the coverage of the presentation beneficial. The participants will receive the set of slides as supporting material and they may find the detailed mathematical analysis in the above-mentioned books.

Course Notes: a copy of the slides, which are based on [1]-[14] (for sample chapters please refer to <http://www-mobile.ecs.soton.ac.uk>).

Biography of the speaker

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 14 books [1]-[11] totalling 10 000 pages on mobile radio communications, coauthored about 700 research papers, organised and chaired conference sessions, presented overview 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 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://wwwmobile.ecs.soton.ac.uk>;

Lajos presented similar 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; VTC'2006 Spring Melbourne, Australia; ICC'2006 Istanbul, Turkey; WCNC'2006, Las Vegas, USA; ISSSTA'2006, Manaus, Brazil; VTC'2006 Fall, Montreal, Canada; WCNC'2007, Hong-Kong, China; VTC'2007 Spring, Dublin, Ireland; ICC'2007, Glasgow, UK; VTC'2007, Baltimore, USA;

1. REFERENCES

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- [2] L. Hanzo, W. Webb, T. Keller: Single- and Multi-carrier Quadrature Amplitude Modulation: Principles and Applications for Personal Communications, WATM and Broadcasting; IEEE Press-John Wiley, 2nd edition, June 2000, ISBN 0-471-49239-6, 762 pages
- [3] L. Hanzo, S-X. Ng, T. Keller, W.T. Webb: Single- and From Basics to Adaptive Trellis-Coded, Turbo-Equalised and Space-Time Coded OFDM, CDMA and MC-CDMA Systems, IEEE Press - John Wiley, Sept. 2004, 1090 pages
- [4] R. Steele, L. Hanzo (Ed): Mobile Radio Communications: Second and Third Generation Cellular and WATM Systems, John Wiley-IEEE Press, 2nd edition, July 1999, ISBN 0-471-97806-x, 1060 pages
- [5] L. Hanzo, P. Cherriman, J. Streit: Wireless Video Communications: Second to Third Generation and Beyond, IEEE Press, February 2001 1, ISBN 0-7803-6032-x, 1092 pages
For detailed contents please refer to <http://wwwmobile.ecs.soton.ac.uk>
- [6] L. Hanzo, F.C.A. Somerville, J.P. Woodard: Voice Compression and Communications: Principles and Applications for Fixed and Wireless Channels; IEEE Press-John Wiley, August 2001 2, ISBN 0-471-15039-8, 672 pages
- [7] L. Hanzo, T.H. Liew, B.L. Yeap: Turbo Coding, Turbo Equalisation and Space-Time Coding, John Wiley, August 2002, ISBN 0-470-84726-3, 766 pages
- [8] L. Hanzo, C.H. Wong, M.S. Yee: Adaptive wireless transceivers: Turbo-Coded, Turbo-Equalised and Space-Time Coded TDMA, CDMA and OFDM systems, John Wiley, March 2002, ISBN 0-470-84689-5 752 pages
- [9] J.S. Blogh, L. Hanzo: Third-Generation Systems and Intelligent Wireless Networking - Smart Antennas and Adaptive Modulation, John Wiley, April 2002, ISBN 0-470-84519-8 430 pages
- [10] L. Hanzo, M. M'unster, B.J. Choi and T. Keller: OFDM and MC-CDMA for Broadband Multi-user Communications, WLANs and Broadcasting, John Wiley - IEEE Press, May 2003, 980 pages
- [11] L. Hanzo, L-L. Yang, E-L. Kuan and K. Yen: Single and Multi-Carrier CDMA: Multi-User Detection, Space-Time Spreading, Synchronisation, Standards and Networking, IEEE Press - John Wiley, June 2003, 1060 pages
- [12] L. Hanzo, T. Keller: An OFDM Primer, John Wiley – IEEE Press, May 2006, 426 pages.
- [13] L. Hanzo, F.C.A. Somerville, J.P. Woodard: Audio and Voice Compression for Wireless and Wireline Communications, John Wiley and IEEE Press, to appear
- [14] L. Hanzo, P. Cherriman, J. Streit: Video Compression and Communications: H.261, H.263, H.264, MPEG4 and Proprietary Codecs as well as HSDPA-Style Adaptive Turbo-Transceivers, John Wiley and IEEE Press, to appear
For detailed contents please refer to <http://wwwmobile.ecs.soton.ac.uk>