Abstract

In the early days of wireless communications the research community used to view multipath-induced dispersion as an undesirable propagation phenomenon, which could only be combated with the aid of complex channel equalizers. The longer the Channel Impulse Response (CIR) was, the more complex the channel equalizer became. However, provided that the complexity of a sufficiently high-memory channel equalizer was affordable, the receiver could benefit from the fact that the individual propagation paths faded independently. To elaborate a little further, even if one of the paths was experiencing a high attenuation, there was a good chance that some of the other paths were not, which led to a potential diversity gain.

However, if the channel does not exhibit several independently fading paths, techniques of artificially inducing diversity may have to be sought. A simple option is to employ a higher direct-sequence spreading factor, which results in a higher number of resolvable multipath components and hence in an increased diversity gain. Naturally, this is only possible if either the available bandwidth may be extended according to the spreading factor or the achievable bitrate is reduced by the same factor. A whole host of classic diversity combining techniques may be invoked then for recovering the original signal.

As a design alternative, we commence by classifying the different Multiple-Input Multiple-Output (MIMO) schemes while considering the attainable diversity gains, multiplexing gains and beamforming gains. Following a brief classification of different MIMO schemes, where the different MIMO schemes are categorised as diversity techniques, multiplexing schemes, multiple access arrangements and beamforming techniques, we introduce the family of multi-functional MIMOs. These multi-functional MIMOs are capable of combining the benefits of several MIMO schemes and hence attaining an improved performance in terms of both their Bit Error Ratio (BER) as well as throughput. The multi-functional MIMOs family combines the benefits of space-time coding, Bell Labs Layered Space-Time scheme as well as beamforming. We also introduce the idea of Layered Steered Space-Time Spreading that combines the benefits of Space-Time Spreading, V-BLAST and beamforming with those of the...
generalised Multi-Carrier Direct Sequence Code Division Multiple Access. Additionally, we compare the attainable diversity, multiplexing and beamforming gains of the different MIMO schemes in order to document the advantages of the multi-functional MIMOs over conventional MIMO schemes.

However, in the presence of shadow-fading the now classic co-located MIMO elements are incapable of providing multiple independently faded replicas of the transmitted signal. This problem may be circumvented by employing relaying, distributed space-time coding or some other cooperation-aided procedure, which is the subject of this lecture. One could also view the benefits of decode-and-forward based relaying as receiving and then flawlessly regenerating and re-transmitting the original transmitted signal from a relay - provided of course that the relay succeeded in error-freely detecting the original transmitted signal.

This lecture reviews the current state-of-the-art and proposes a number of novel relaying and cooperation techniques. An important related issue is the availability or the absence accurate channel information, which leads to the concept of coherent versus non-coherent detection at the realsys and at the destination. Similarly, the related initial synchronization issues also have to be considered.

Naturally, when using hard-decisions in the transmission chain, we discard valuable soft-information, which results in an eroded performance, albeit also reduces the complexity imposed. Hence the hard-versus soft-decoding performance trade-off will also be explored in the lecture, along with the benefits of interleaved random space-time coding invoked for multi-source cooperation.

Biography
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). He co-authored 17 IEEE Press - John Wiley books totalling in excess of 10 000 pages on mobile radio communications, published in excess of 800 research papers, organised and chaired major IEEE conferences, and has been awarded a number of distinctions. Lajos is also an IEEE Distinguished Lecturer and a Fellow of both the IEE and IEEE. He is the Editor-in-Chief of the IEEE Press. For further information on research in progress and associated publications please refer to http://www-mobile.ecs.soton.ac.uk.

Lajos presented research overviews 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; VTC 2007 Spring, Dublin; ICC 2007, Glasgow; IST' 2007, Budapest, Hungary; VTC 2007 Fall, Baltimore, USA; CoCom'2007, Bogota, Colombia; ICSPC'2007, Dubai; WCNC'2007, Hong-Kong, China; ICC'2008, Beijing, China; VTC'2008 Spring Singapore; WCNC'2008, Las Vegas; VTC'2008 Fall, Calgary, Canada; Globecom'2008, New Orleans, USA; Pending: VTC'2009 Spring, Barcelona, Spain; ICC'2009, Dresden, Germany; VTC'2009 Fall, Anchorage; Globecom 2009 Hawaii.