2005 IEEE Taiwan/Hong Kong Joint Workshop on Information Theory and Communications

20th – 21st January, 2005

List of Talks

Session 1, 14:10-15:40, 20th January 2005 (Registration starts at 13:30)

Session Chair: Morris M.Z. Wang, Polytechnic University of Hong Kong, Hong Kong

1. The REAL Approach - Generation of Perfect CDMA Codes for Futuristic Wireless Applications

   Hsiao-Hwa Chen, National Sun-Yat-Sen University, Taiwan

2. Theory of Linear Network Coding

   S.-Y. Robert Li, The Chinese University of Hong Kong, Hong Kong

3. Equivalent Convolutional Codes

   Mao-Chao Lin, National Taiwan University, Taiwan

* * * COFFEE BREAK * * *

Session 2, 16:10-17:40, 20th January 2005

Session Chair: Mao-Chao Lin, National Taiwan University, Taiwan

1. Blind Channel Estimation and Signal Detection for a Class of Delay Diversity Space-Time Block Code in Frequency Selective MIMO Channels

   Chi-Wah Kok, The Hong Kong University of Science and Technology, Hong Kong

2. Advanced Coding for OFDM UWB Systems with Under-Sampled Receivers

   Chi-Chao Chao, National Tsing-Hua University, Taiwan

3. Interleave-Division Multiple-Access (IDMA) for Future Wireless Systems

   Ping Li, City University of Hong Kong, Hong Kong

Session 3, 09:00-10:30, 21st January 2005

Session Chair: Char-Dir Chung, National Central University, Taiwan

1. Wavelength-Time Codes for Optical CDMA Networks

   Guuchang Yang, National Chung-Hsing University, Taiwan

2. Reliable Communication in the Absence of a Common Clock

   Raymond W. Yeung, The Chinese University of Hong Kong, Hong Kong

3. Performance Bounds for Minimum-Hamming Distance Fusion in Sensor Networks

   Po-Ning Chen, National Chiao-Tung University, Taiwan

* * * COFFEE BREAK * * *

Session 4, 11:00-12:30, 21st January 2005

Session Chair: Raymond W. Yeung, The Chinese University of Hong Kong, Hong Kong

1. Towards a Better Diversity-Multiplexing Tradeoff in MIMO Systems

   Lin DAI, The Hong Kong University of Science and Technology, Hong Kong

2. Analyzing Multi-Channel Medium Access Control Schemes with ALOHA Reservation

   Yunghsiang S. Han, Jing Deng and Zygmunt J. Haas, National Taipei University, Taiwan

3. Universal Lattice Decoding

   Wai Ho Mow, The Hong Kong University of Science and Technology, Hong Kong

The REAL Approach - Generation of Perfect CDMA Codes for Futuristic Wireless Applications

Hsiao-Hwa Chen, National Sun-Yat-Sen University

(14:10-14:40, 20th January 2005)

Abstract

This talk addresses the issues on next generation CDMA technologies for future wireless networks, which should offer much higher transmission-rate/throughput than that possible using current CDMA technologies based on unitary codes and direct sequence spreading. Our ultimate objective is to propose a CDMA architecture, whose performance will no longer be self-interference limited. This talk is to give a review of our currently on-going research on next generation CDMA technologies. In particular, we will propose a new CDMA code design methodology, Real Environment Adapted Linearization (REAL) approach, which can be used to generate orthogonal complementary codes (OCCs) with inherent immunity against multipath interference and multiple access interference for both synchronous and asynchronous transmissions. They can also offer ideal correlation properties desirable for signal detection on the edges of a packet, which is important especially to the applications in all-IP based wireless networking. Some other topics related to the OCC-CDMA architecture will also be addressed, such as system implementation issues.

Theory of Linear Network Coding

S.-Y. Robert Li, The Chinese University of Hong Kong

(14:40-15:10, 20th January 2005)

Abstract

In existing computer networks, information is transmitted from the source node to destination nodes through intermediate nodes by store-and-forward. There is no need of data processing at intermediate nodes except for data replication. In actual applications, there is always some form of data processing for such purposes as sanity, security, switching, etc. It is folklore, without technological or economical ground, that the data delivery process itself is precluded from the benefit of data processing at intermediate nodes. Surprising, this folklore was refuted only recently in a paper in 2000, where the concept of *network coding* is formally introduced.

Due to its generality and its vast application potential, the theory of network coding has generated much interest in information and coding theory, networking, switching, computer science, operations research, and matrix theory. New applications are identified frequently. This talk gives a tutorial on the basics of the theory with emphasis on achieving the best possible benefits of network coding simply with *linear* coding scheme.

Equivalent Convolutional Codes

Mao-Chao Lin, National Taiwan University

(15:10-15:40, 20th January 2005)

Abstract

We consider two types of equivalent (n,k) convolutional codes. For the first, by permuting the n positions of each n-bit code branch in a conventional code trellis, we can have an equivalent code. We show that for an (n,n-1) code, it is easy to find an equivalent code with minimal trellis of lowest complexity. For the second, by taking a shifted version of the minimal trellis of an (n,k) convolutional code, we also have an equivalent code. It is surprising to see that some convolutional codes with distinct number of memory elements of minimal encoders are equivalent in the sense that the minimal trellis of each of these codes is a shifted version of one another. We find that a more accurate way of calculating the weight spectra of convolutional codes is to use the minimal trellis instead of the conventional trellis. We also derive bounds on the trellis complexity of convolutional codes and their equivalent codes.

Blind Channel Estimation and Signal Detection for a Class of Delay Diversity Space-Time Block Code in Frequency Selective MIMO Channels

Chi-Wah Kok, The Hong Kong University of Science and Technology

(16:10-16:40, 20th January 2005)

Abstract

A class of space-time (ST) code, known as Toeplitz ST code is developed, which can perform blind estimation on frequency selective MIMO channel. The proposed ST code is a special case of the delay diversity ST code where the code word is sent repeatedly with a fixed delay in the MIMO channel. When the delay is equal to or longer than the channel length, the proposed Toeplitz ST code will achieve maximal diversity order. Furthermore, blind channel estimation is possible with a mild requirement on the source signal which can be easily satisfied. In this paper, we further developed a maximally likelihood symbol detector which can achieve linear processing complexity at the receiver, i.e. the symbol detection can be carried out in a symbol by symbol manner. Simulation results are presented to demonstrate the performance of the proposed ST code under various communication system configurations.

Advanced Coding for OFDM UWB Systems with Under-Sampled Receivers

Chi-Chao Chao, National Tsing-Hua University

(16:40-17:10, 20th January 2005)

Abstract

In this talk, an orthogonal frequency division multiplexing (OFDM) system for ultra-wideband (UWB) applications is considered, in which the total available bandwidth is divided into *M* subbands and data are transmitted simultaneously over *M* subbands with OFDM. A key feature of the system considered is that a low-cost receiver with reduced sampling rate, only one *M*-th of the Nyquist rate, can be employed. The aliasing phenomenon in the frequency domain, arising from under-sampling, can be treated as transmit diversity. The system can hence be analogized to a multiple-input multiple-output (MIMO) system with *M* transmitters and one receiver. We will first apply space-time trellis codes to properly exploit the diversity in the considered scenario. Several good codes proposed and corresponding simulation results under IEEE 802.15.3a UWB channel models will be shown. To further improve the performance, a more complicated concatenated coding scheme with inner precoding and outer error-correction coding will then be considered. Results of several precoder designs with respect to the availability of channel state information at transmitter will be given.

Interleave-Division Multiple-Access (IDMA) for Future Wireless Systems

Ping Li, City University of Hong Kong

(17:10-17:40, 20th January 2005)

Abstract:

This talk will outline a new multiple access scheme known as interleave-division multiple-access (IDMA) that employs interleaving as the only mechanism to distinguish users. IDMA possesses many desired features for future wireless systems which are difficult to achieve simultaneously with the current technologies such as FDMA, TDMA, CDMA and OFDMA. These include

- very low receiver cost (near single-user turbo-receiver complexity),
- near optimal multi-user performance,
- de-centralized (i.e., asynchronous) control,
- simple treatment of ISI,
- cross-cell interference mitigation,
- wide-band diversity against fading,
- flexibility for multi-rate services (e.g., mixed voice and IP),
- high capacity (e.g., supporting 64 users with a spreading ratio of only 8),
- high throughput (e.g., rate > 8 bits/Hz),
- excellent power efficiency (close to limit),
- straightforward extension to multiple antenna systems.

We will provide both analytical and simulation results to confirm the features listed above.

Wavelength-Time Codes for Optical CDMA Networks

Guuchang Yang, National Chung-Hsing University
(09:00-09:30, 21st January 2005)

Abstract

In this talk, several new families of two-dimensional (2-D) wavelength-hopping time-spreading codes are introduced. Unlike the other 2-D codes, our new codes allow the number of wavelengths and code length being chosen independently and, at the same time, the code cardinality is a quadratic function of the number of wavelengths while still keeping the low maximum cross-correlation value. These codes can be found to be particularly suitable for high bit-rate optical code-division multiple-access systems with broadband mode-locked lasers, in which the number of time slots is very limited and system capacity can only be grown by increasing the number of wavelengths, rather than code length.

Reliable Communication in the Absence of a Common Clock

Raymond W. Yeung, The Chinese University of Hong Kong
(09:30-10:00, 21st January 2005)

Abstract

In this talk, we introduce the continuous time *asynchronous channel* as a model for time jitter in a communication system with no common clock between the transmitter and the receiver. We have obtained a simple characterization for an optimal zero-error self-synchronizable code for the *noiseless* asynchronous channel. By solving a related combinatorial problem, we have determined the capacity of this channel. Our results reveal that in the absence of noise, it is not necessary for the receiver clock to re-synchronize with the transmitter clock from time to time in order to achieve reliable communication. In particular, no upper limit should be imposed on the runlengths of the self-synchronization code as in the case of runlength limited (RLL) codes which are commonly used magnetic recording.

Performance Bounds for Minimum-Hamming Distance Fusion in Sensor Networks

Po-Ning Chen, National Chiao-Tung University

(10:00-10:30, 21st January 2005)

Abstract

Distributed M-ary detection and fault-tolerance have been considered as two fundamental functions in the context of large-scale sensor networks. Distributed multiclass classification fusion using error correcting codes (DCFECC) has been proposed to provide good fault-tolerance capability in wireless sensor networks. Minimum Hamming distance fusion is an essential part of the DCFECC approach. In this work, we study the asymptotic performance of minimum Hamming distance fusion for both fault-free and faulty situations when the number of sensors tends to infinity. We conclude that the error probability vanishes asymptotically as long as the minimum Hamming distance $d_{\min}$ of the DCFECC code approaches infinity, and the probabilities of correct local classification for all hypotheses are greater than one half. In case $d_{\min}/2$, normalized by the number of sensors, can be made larger than the largest local classification error, an explicit expression for the error exponent of the DCFECC system in terms of the Kullback-Leibler divergence can be established. A converse where the DCFECC decoding error is bounded away from zero is also addressed.

Towards a Better Diversity-Multiplexing Tradeoff in MIMO Systems

Lin DAI, The Hong Kong University of Science and Technology

(11:00-11:30, 21st January 2005)

Abstract

Multiple-Input Multiple-Output (MIMO) systems can provide two kinds of gain: diversity gain and multiplexing gain. Most existing MIMO schemes, including space-time coding and layered space-time, aim at maximizing either of them. Recently, a tradeoff function of these two gains has been derived for a point-to-point MIMO system when optimal detection is used. In this talk, we will further present the optimal diversity-multiplexing tradeoff function for group detector. We will show that with group transmission and detection, a good diversity-multiplexing tradeoff can be achieved. The detailed tradeoff functions of 3 schemes based on group transmission and detection, Quasi-Orthogonal Group Space-Time (QoGST), Group Layered Space-Time (GLST) and Layered space-time block codes (LSTBC), will be provided and a vivid comparison among them demonstrates that the proposed QoGST and GLST can achieve much better diversity-multiplexing tradeoff than LSTBC.

Analyzing Multi-Channel Medium Access Control Schemes with ALOHA Reservation

Yunghsiang S. Han, Jing Deng and Zygmunt J. Haas, National Taipei University

(11:30-12:00, 21st January 2005)

Abstract

In order to improve the throughput performance of Medium Access Control (MAC) schemes in wireless communication networks, some researchers proposed to divide a single shared channel into several sub-channels: one as control sub-channel and the others as data sub-channels. In this talk, we analyze and evaluate the maximum achievable throughput of a class of generic multi-channel MAC schemes that are based on the RTS/CTS (Ready-To-Send/Clear-To-Send) dialogue and pure ALOHA contention resolution technique. We study these multi-channel MAC schemes under two channel split scenarios: the fixed-total-bandwidth scenario and the fixed-channel-bandwidth scenario. In the fixed-total-bandwidth scenario, we show that the throughput of the multi-channel MAC schemes is inferior to that of the corresponding single-channel MAC scheme, which sends the RTS/CTS dialogues and DATA packets on the single shared channel. In the fixed-channel-bandwidth scenario, where CDMA or similar techniques are applied, the optimal number of the data sub-channels that maximizes the throughput is determined. Our analytical framework applies to any contention resolution technique whose average contention period is known.

Universal Lattice Decoding

Wai Ho Mow, The Hong Kong University of Science and Technology
(12:00-12:30, 21st January 2005)

Abstract

The idea of formulating the detection of a lattice-type modulation, such as M-PAM and M-QAM, transmitted over a linear channel as the so-called universal lattice decoding (or sphere decoding) problem dates back to at least the early 1990s. The applications of such lattice decoders have proliferated in the last few years because of the growing importance of some linear channel models, such as multiple-antenna fading channels and multi-user CDMA channels. The principle of universal lattice decoding can trace its roots back to the theory and algorithms developed for solving the shortest/closest lattice vector problem for integer programming and cryptanalysis applications. In this presentation, we shall review such a decoding principle and discuss some of its interesting new developments.