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The Chinese University of Hong Kong
香港中文大學

Department of Mathematics Colloquium
Jointly sponsored by: Department of Information Engineering · Institute of Network Coding

Algebraic foundation of network coding

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Nov. 18, 2011 (Friday), 3:30pm - 4:30pm
LT3, Lady Shaw Building, The Chinese University of Hong Kong

Abstract.
Network coding (NC) brings a paradigm shift in the mode of data transport from the traditional store-and-forward. Linearity in coding/decoding makes the implementation feasibly fast for engineering applications. Linear NC structures data symbols as a finite field, and the fundamental theorem guarantees the best possible throughput from the source to every receiver. While the theorem is restricted to acyclic networks, practical applications all ignore this constraint. How could that be? Well, real applications are actually in the combined space-time domain, which is always acyclic because time is unidirectional. The natural mathematical formalization of linear NC over a time-multiplexed network with possible cycles is convolutional NC, which deals with the propagation of symbol streams through nodes that perform convolutional coding. However, the symbol streams in convolutional NC do not form the ring of power series, where the dummy variable is unit time. Not the polynomial ring either. The proper structure is the ring of rational power series. Convolutional coding by a rational-power-series kernel implements algebraic inversion of everything but the dummy variable (= time). This is a form of localization in algebra, and it is implementable with a finite circuitry within finite time. It ensures causal data propagation through the network.
I shall try to translate between abstract algebra and engineering intuition, whenever possible, so that **there is essentially no prerequisite for this talk from either algebra or engineering.**

All are Welcome!

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Joint Seminar of Department of Mathematics (host) ·
Department of Information Engineering · Institute of Network Coding

Algebraic foundation of network decoding

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Nov. 18, 2011 (Friday), 4:30pm - 5:30pm
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Abstract.
This talk is a continuation from "Algebraic foundation of network coding." Convolutional NC formalizes linear NC over a time-multiplexed network with possible cycles. It deals with the propagation of symbol streams through nodes that perform convolutional coding, and the symbol streams are algebraically structured as the ring of rational power series, where the dummy variable is unit time. This ring reflects the algebraic inversion of everything but time by convolutional NC. The unidirectional characteristic of time breaks the deadlock in cyclic transmission.
However, practical application of convolutional NC is hindered by the difficulty in precise inter-node synchronization. This inspires the generalization of convolutional NC to other algebraic structures that share the key characteristics of the ring of rational power series and, at the same time, evade the synchronization problem. Generality enhances the potential of applicability.
The first key characteristics is a principal ideal domain (PID). The Invariant Factor Theorem of Free Submodules over a PID affords the notion of decoding. The second is a local ring. Together, the two make a discrete valuation ring (DVR), in which the descending-chain formation of ideals mimics the unidirectional characteristic of time. Information decodable by a receiver forms a submodule of the source information module, and the decoding delay is the highest valuation among the invariant factors of this submodule.

All are Welcome!