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Research Paper

Implications of Network Coding in Wireless Communications

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ABSTRACT: *The Concept Of Network Coding Which Basically Allows The Intermediate Relay Nodes To Combine The Received Packets For Generating Encoded Packets On The Outgoing Links. It Is A New Transmission Paradigm That Proved Its Strength In Optimizing The Usage Of Network Resources. By Using Network Coding, We Can Improve The Performance Of The File Sharing Application But Not As In Wired Networks.*

Keywords: *Partial Packet Recovery, Multi-Radio Diversity, Wireless Network Coding, Symbol level Network Coding, Software Defined Radio, Packet Delivery Ratio*

I. INTRODUCTION

A wireless local-area network (LAN) uses radio waves to connect devices such as laptops to the Internet and to your business network and its applications. When you connect a laptop to a WiFi hotspot at a cafe, hotel, airport lounge, or other public place, you're connecting to that business's wireless network.

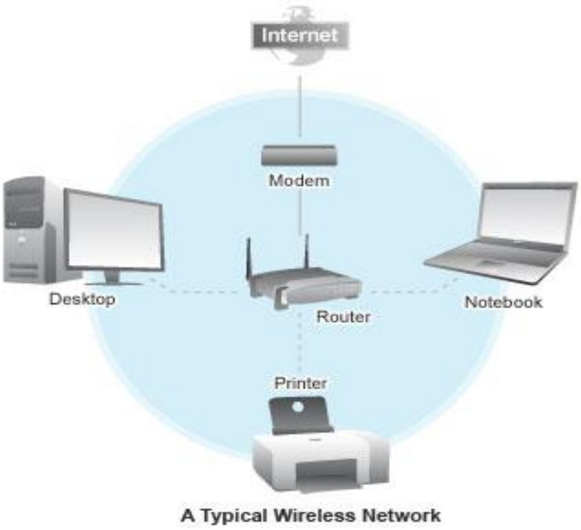

Figure – 1

Wireless communication is the transfer of information over a distance without the use of electrical conductors or wires. The distances involved may be short or very long. Whenever data has been transferred between the nodes of wireless network, there is chance of bit errors, generally for these types of problems we retransmit the data packets is done by discarding the error-inflicted packets which may some correct information and inefficiency arises and also adds the delay and throughput cost of retransmission, which has long been the primary countermeasure for the inevitable bit errors on wireless links, only recently has its efficiency begun to

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be addressed. When a sender retransmits a packet, it piggybacks a new packet. At the receiver side, once the retransmitted packet is correctly received, the receiver can use it for the decoding of the piggybacked packet. Packet losses are frequently incurred by a few bit errors. [1]

However, the majority correct bits are usually dropped together and the whole packet is retransmitted, which wastes network capacity to utilize the corrupted packet to reduce the retransmission overhead. In Partial Packet Recovery (PPR), the receiver measures confidence values for the correctness of each bit in decoding, and requests for retransmission of only those bits that are likely in error. In SOFT, the receiver stores the confidence values of the corrupted packet and combines it with the retransmitted packet, thereby improving packet reception probability. [4]

Partial Packet Recovery

Partial packet recovery is a technique by which receiver tries to recover the data from two or more versions of the original packets. These different versions of the original data are nor necessary to be correct, and there can be some error bits in each of the packets. After receiving these partially correct packets, the receiver combines the correct part of them to reconstruct the original data. If the data constructed can pass the checksum, the receiver is able to retrieve the orignal data, and it sends an ACK to the sender, otherwise the sender will retransmit the packet until the receiver can correctly decode the data, or the sender gives up sending and concludes a packet loss.Partial packet recovery may not be helpful in wired networks.[18]

There are mainly two reasons:

(1) On the one hand packet error rate in wired transmission is low, and the chance to combining partial packet is little. In fact, packet loss in wired networks is mainly due to the congestion at intermediate terminals or links, which means that the destination is not able to receive any bits of the packet.

(2) On the other hand, partial packet recovery is not free, and overheads it brings (i.e. longer waiting time) can decrease the throughput. So the penalty of using partial packets will overwhelm the benefit it brings.

Multi-Radio Diversity

Multi-Radio Diversity (MRD) system, which reduces the loss rate and improves the throughput observed by transport protocols and applications running over wireless local area networks (WLANs).

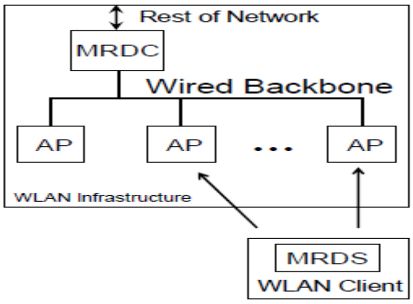

Figure 2: MRD Architecture

In MRD, different APs with overlapping coverage and listening on the same radio frequency provide alternate communication paths for each frame transmission from a given WLAN client, while multiple wireless cards on the WLAN client achieve the same result for transmissions to the client.[19]

Network Coding (NC) is a technique that could significantly improve the network throughput and the transmission reliability by allowing intermediate nodes to combine received packets. Symbol level network coding (SLNC), which combines packets at smaller symbol scale, is a more powerful technique to mitigate the impact of lossy links and packet collisions in wireless networks.

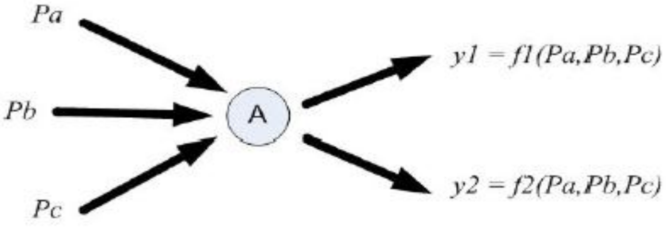

Figure 3: An Illustration of concept of network coding

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II. EXISTING SYSTEM

Network coding

Network coding is a technique where, instead of simply relaying the packets of information they receive, the nodes of a network will take several packets and combine them together for transmission. This can be used to attain the maximum possible information flow in a network. Network coding is a field of information theory and coding theory. With network coding it utilizes more battery and CPU time consumption for encoding and decoding the information. Encoding process is very easy because it is only about generating a linear combination of all information together available at each node and decoding task is more complex because it requires to run a test to check independency. [7]

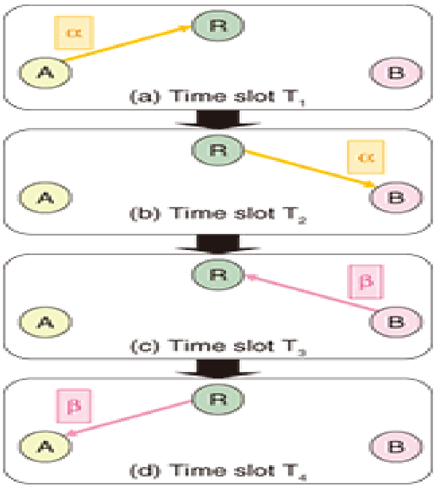

Figure 4: Transmission without network coding

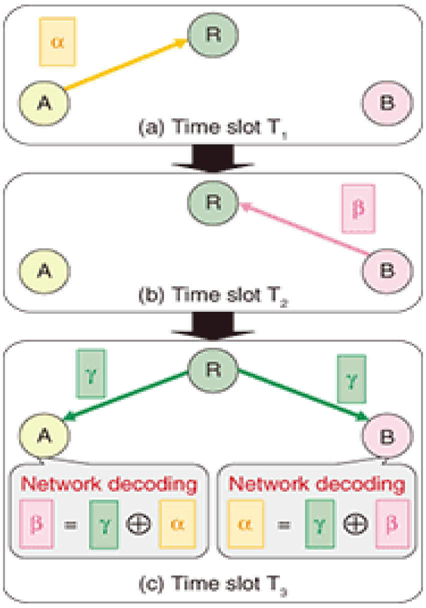

Figure 5: Transmission with network coding

The information that A and B send is denoted by α and β respectively. Without Wireless Network Coding (WNC), four time slots are necessary for communication between A and B. On the other hand, with WNC, only three time slots are necessary, In time slot T3, R encodes the received information, α and β, to generate new information γ, which it broadcasts to A and B we chose to use bitwise XOR (exclusive OR) in the study reported here. In the same time slot T3, A decodes received information γ by XORing γ using its own information α to obtain desired information β. Likewise, B processes γ received in T3 using its own information β to obtain desired information α. The function blocks for B's operations with conventional WNC.WNC can improve the system throughput by decreasing the number of time slots needed for communication. [9]

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Network coding in packet networks can be classified into two types:
(1) intra-session coding where coding is restricted to packets belonging to the same session or connection.

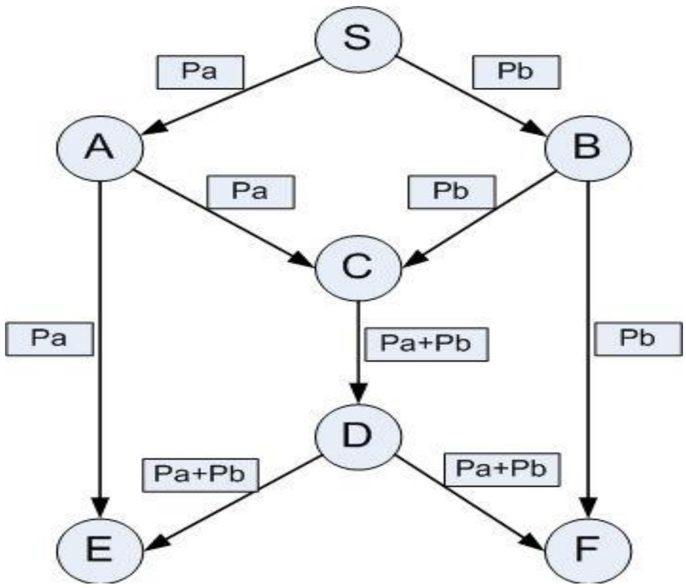

Figure 6: A simple intra-session network coding

(2) Inter-session coding where coding is allowed among packets belonging to possibly different sessions. Two nodes A and B want to exchange a packet, and due to the limited wireless communication range, an intermediate node S should play the role of relay.[11]

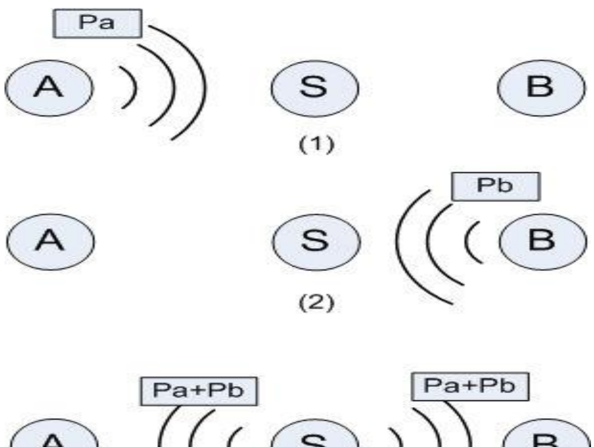

Figure 7: A simple inter-session network Coding

III. PROPOSED SYSTEM

Symbol level network coding

Symbol level network coding (SYNC), is a powerful technique which combines packets at smaller symbol scale, to mitigate the impact of lossy links and packet collisions in wireless networks, provides higher data rate and better transmission reliability for applications. It is a static wireless network based on flow network theory and queuing theory, which provides better error tolerance thus increased successful packet reception rate. SYNC is a retransmission scheme which usually does not incur any cost, as the retransmitted packet is transmitted together with another packet. If the delivery rate of the retransmitted packet and the piggybacked packet were not as good as that of a native packet both of the retransmitted packet and the piggybacked packet have at least the same decoding performance as a native packet. There are two reasons why SYNC can achieve

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this. First, it recycles the previously received corrupt packet that the traditional retransmission simply discards. Second, it uses a novel packet combining scheme that utilizes the previously decoded packet to increase the decoding probability of the remaining packet.

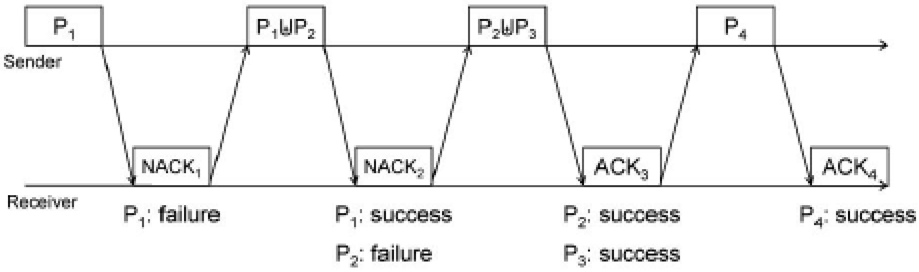

Figure 8 : A SYNC transmission Example

IV. SYSTEM WORKFLOW

Software Defined Radio

Software-defined radio (SDR) is a radio communication technology that is based on software defined wireless communication protocols instead of hardwired implementations. In other words, frequency band, air interface protocol and functionality can be upgraded with software download and update instead of a complete hardware replacement. SDR provides an efficient and secure solution to the problem of building multi-mode, multi-band and multifunctional wireless communication devices. An SDR is capable of being re-programmed or reconfigured to operate with different waveforms and protocols through dynamic loading of new waveforms and protocols. These waveforms and protocols can contain a number of different parts, including modulation techniques, security and performance characteristics defined in software as part of the waveform itself. A software-defined radio system, or SDR, is a radio communication system where components that have been typically implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on a personal computer or embedded computing devices. While the concept of SDR is not new, the rapidly evolving capabilities of digital electronics render practical many processes which used to be only theoretically possible.

SDR is a radio whose channel modulation waveforms are defined in software, waveforms are generated as sampled digital signals, converted from digital to analog via a wideband DAC and then possibly unconverted from IF to RF. The receiver, similarly, employs a wideband Analog to Digital Converter (ADC) that captures all of the channels of the software radio node. The receiver then extracts, down converts and demodulates the channel waveform using software on a general purpose processor." SDRadio is only a subset of the above definition, dealing only with the receiver part, and the ADC is not exactly wideband, but it is what is offered by the majority of today's sound cards, i.e. either 48 or 96 kHz. Nevertheless it can be considered as a first step in that direction. Software Defined Radio attempts to place much or most of the complex signal handling involved in communications receivers and transmitters into the digital (DSP) style. In its purest form, and SDR receiver might consist simply of an analog-to-digital convert chip connected to an antenna. All the filtering and signal detection can take place in the digital domain, perhaps in an ordinary personal computer.

Communication Throughput

Communication throughput defines the Packet delivery ratio (PDR) defines the total number of data packets received verses the total number of data packets originated. PDR defines the throughput of the protocols.

$$\textit{Packet Delivery Ratio} = \frac{\sum \textit{Received Packets}}{\sum \textit{Packets Originated}}$$

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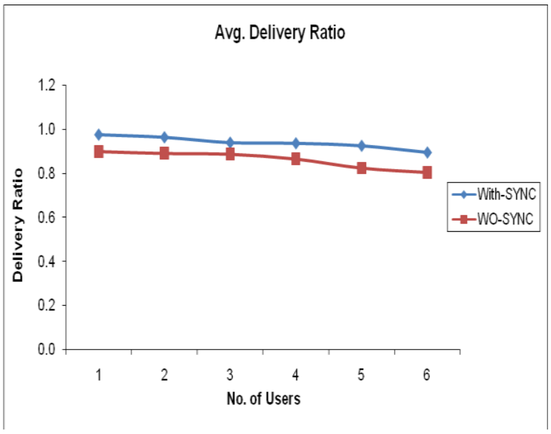

Figure 9 – Communication Throughput for 6 User Evaluations Result

Communication Delay

Communication Delay calculated as the time between the transmissions of a data packet from a source to the destination.

$$Communication\ Delay = (Delivery\ Time - Initial\ Time)$$

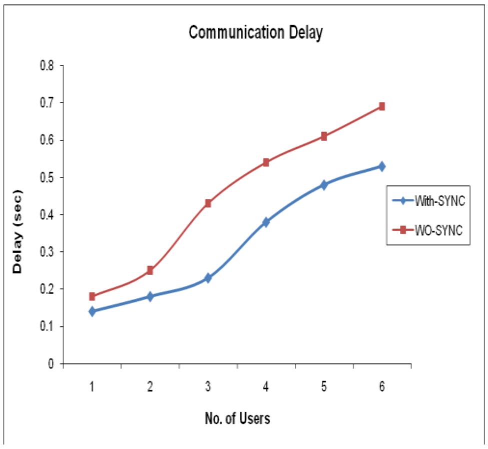

Figure 10 – Communication Delay for 6 User Evaluations Result

V. DATA INTERPRETATION & STUDY OF SYSTEM

Modules

1. Convolution Coding
2. Viterbi Coding
3. Interleaving
4. De-Interleaving
5. Symbolic network coding
6. Modulation
7. De-Modulation

1. Convolution Coding

Convolutional codes are used extensively in numerous applications in order to achieve reliable data transfer in communication. Convolution coding usually coexists with interleaving, as it is fragile to busty bit errors. These codes are often implemented in concatenation with a hard-decision code.

Convolutional codes are applied in applications that require good performance with low implementation cost. They operate on data stream, not static block. Convolutional codes have memory that uses previous bits to encode or decode following bits

- It is denoted by (n,k,L), where L is code memory depth
- Code rate r is determined by input rate and output rate:

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$$r = \frac{r_{input}}{r_{output}} < 1$$

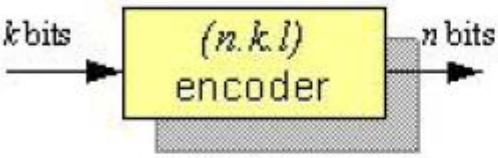

Figure 11 – Input and Output rates

2. Viterbi Coding

The Viterbi coding algorithm is a dynamic programming algorithm for finding the most likely sequence of hidden states those results in a sequence of observed events. Viterbi algorithm performs Maximum Likelihood (ML) decoding by reducing its complexity

- Eliminate least likely trellis path at each transmission stage
- Reduce decoding complexity with early rejection of unlike paths

Viterbi algorithm gets its efficiency via concentrating on survival paths of the trellis. Viterbi decoding compares the hamming distance between the branched code and the received code.

3. Interleaving

Interleaver is applied to protect *m* from burst errors. Interleaving is a technique commonly used in communication systems to overcome correlated channel noise such as burst error or fading. The Interleaver rearranges input data such that consecutive data are spaced apart.

4. De-Interleaving

At the receiver end, the interleaved data is arranged back into the original sequence by the de-Interleaver. As a result of interleaving, correlated noise introduced in the transmission channel appears to be statistically independent at the receiver and thus allows better error correction.

5. Symbolic Network Coding

SYNC is a symbol level network coding scheme that exploits corrupted packets. SYNC is used to eliminate the cost of retransmission. SYNC is independent of other PHY level performance boosting techniques such as channel coding and spatial diversity. In order to validate this, we added convolution coding in our prototype implementation and evaluated the performance with and without it. The results demonstrate that channel coding is indeed orthogonal to SYNC. Whenever a sender retransmits a packet P_i, it piggybacks the next packet P_i+1 through the means of a cleverly arranged higher modulation. Once the receiver successfully extracts P_i by combining the coded packet with the previous error-inflicted transmission $P`_i$, it is in turn used to decode P_i+1. Consequently, the bandwidth consumption by the retransmission can even be completely removed in certain channel conditions.

- Corrupt Packet Utilization Schemes

The primary challenge to utilize a corrupted packet is in determining which bits are correct and which are not.

- Network Coding

Network coding was originally proposed to mix multiple packets at routers to maximize the capacity of a wired network, and has been successfully applied to wireless context to improve the throughput of bidirectional traffic using overheard packets.

6. Modulation

Modulation is the process of varying one or more properties of a high-frequency periodic waveform, called the carrier signal, with a modulating signal which typically contains information to be transmitted. Digital modulator maps the received bit stream to symbols of length *q*, and modulates them into suitable waveforms for transmission over the wireless channel.

7. De-Modulation

Demodulation is the act of extracting the original information-bearing signal from a modulated carrier wave. A demodulator is an electronic circuit (or computer program in a software-defined radio) that is used to recover the information content from the modulated carrier wave.

VI. RESULTS & CONCLUSION

We present SYNC, a physical layer transmission scheme that drastically reduces the cost of retransmission by introducing network coding concepts to symbol level operation. It piggybacks a new packet on each retransmitted packet, and exploits the previously received packet (possibly with error) at the receiver to recover both the retransmitted packet and the piggybacked packet. The piggybacking is achieved through higher

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modulation, but it does not decrease the decodability of the mixed packets owing to the previously received packet at the receiver, which analytically shown in results.

Retransmission is a fundamental tool to fight against bit errors on wireless links, but its redundancy can significantly impair capacity of the links. Our work is a network coding-based retransmission scheme called SYNC that drastically reduces the retransmission overhead by piggybacking a new packet to the retransmitted packet, without sacrificing the information content or the decoding probability.

We implemented the proof-of-concept prototype with and without SYNC, in order to extensively evaluate the performance of the proposed idea in real-life fading channels. The performance evaluation result shows that SYNC indeed outperforms the traditional retransmission scheme.

We implemented an even better retransmission scheme which significantly reduces the retransmission overhead. Our scheme is essentially a network coding scheme that mixes multiple packets in the retransmission. When the sender retransmits a packet, it piggybacks a new packet. At the receiver side, once the retransmitted packet is correctly received, the receiver can use it for the decoding of the piggybacked packet. As a result, the bandwidth consumption by the retransmission can even be completely removed. The efficient retransmission Symbol level Network Coding (SYNC) scheme, we attempt to drastically reduce the cost of retransmission by introducing network coding to symbol level operation. SYNC works independently of other PHY level performance boosting schemes such as channel coding and spatial diversity. The proof-of-concept SYNC prototype has been implemented on a software defined radio (SDR) platform.

REFERENCES

[1]. K. Jamieson and H. Balakrishnan, "PPR: Partial Packet Recovery for Wireless Networks," Proc. ACM SIGCOMM, 2007.

[2]. A.K. Miu, H. Balakrishnan, and C.E. Koksal, "Improving Loss Resilience with Multi-Radio Diversity in Wireless Networks," Proc. ACM MobiCom, 2005.

[3]. G.R. Woo, P. Kheradpour, D. Shen, and D. Katabi, "Beyond the Bits: Cooperative Packet Recovery Using Physical Layer Information," Proc. ACM MobiCom, 2007.

[4]. E. Blossom, GNU Software Defined Radio, http://gnuradio.org/trac/wiki, 2007.

[5]. H. Jafarkhani, Space-Time Coding: Theory and Practice. Cambridge Univ., 2005.

[6]. G. Caire and D. Tuninetti, "The Throughput of Hybrid-ARQ Protocols for The Gaussian Collision Channel," IEEE Trans.Information Theory, vol. 47, no. 5, pp. 1971-1988, July 2001.

[7]. R. Ahlswede, N. Cai, S.R. Li, and R.W. Yeung, "Network Information Flow," IEEE Trans. Information Theory, vol. 46, no. 4, pp. 1204-1216, July 2000.

[8]. S. Katti, H. Rahul, A. Goldsmith, D. Katabi, M. Medard, and J.Crowcroft, "XORs in the Air: Practical Wireless Network Coding," Proc. ACM SIGCOMM, 2006.

[9]. S. Chachulski, M. Jennings, S. Katti, and D. Katabi, "Trading Structure for Randomness in Wireless Opportunistic Routing," Proc. ACM SIGCOMM, 2007.

[10]. E. Rozner, A.P. Lyer, Y. Mehta, L. Qiu, and M. Jafry, "ER: Efficient Retransmission Scheme for Wireless LANs," Proc. ACM CoNext, 2007.

[11]. C. Chou and H. Wei, "Network Coding Based Data Distribution in WiMAX," Proc. Int'l Conf. Mobile Data Management: Systems, Services and Middleware, 2009.

[12]. J. Qureshi, C. Foh, and j. Cai, "An Efficient Network Coding Based Retransmission Algorithm for Wireless Multicast," Proc.IEEE Int'l Symp. Personal, Indoor and Mobile Radio Comm., 2009.

[13]. W. Pu, C. Luo, S. Li, and C.W. Chen, "Coutinous Network Coding in Wireless Relay Networks," Proc. IEEE INFOCOM, 2008.

[14]. S. Katti, D. Katabi, H. Balakrishnan, and M. Medard, "SymbolLevel Network Coding for Wireless Mesh Networks," Proc. ACMSIGCOMM, 2008.

[15]. A.J. Viterbi, "Error Bounds for Convolutional Codes and an Asymptotically Optimum Decoding Algorithm," IEEE Trans. Information Theory, vol. IT13 no. 2, pp. 260-269, Apr. 1967.

[16]. B. Sklar, Digital Communications, second ed. Prentice-Hall, 2001.

[17]. A. Leon-Garcia, Probability and Random Processes for Electrical Engineering, second ed. Addison Wesley, 1994.

[18]. GNU Radio Project, http://gnuradio.org/trac/wiki, 2011.

[19]. A. Kamerman and L. Monteban, "WaveLAN-II: A High-Performance Wireless LAN for the Unlicensed Band," Bell Lab Technical J., vol. 2, pp. 118-133, 1997.

[20]. IEEE 802.16 WG, IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2, IEEE, Dec. 2005.

[21]. D. Chase, "Code Combining—A Maximum-Likelihood Decoding Approach for Combining an Arbitrary Number of Noisy Packets," IEEE Trans. Comm., vol. 33, no. 5, pp. 385-393, May 1985.

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