Network Coding in Wired and wireless Ad-hoc Networks

Niranjan Singh
M.tech* CSE
Central University of Rajasthan, Ajmer, Rajasthan

ABSTRACT:

Network coding is a relatively new concept that originated from information theory. In the recent past, a number of eye opening work have been conducted along the directions of applying this new tool for both (a) attacking classic computer science problems (e.g., Steiner trees, matrix rank computation) and (b) defining new fields of research (e.g., network error correction, optimal information network design). However, few opportunities exist for experts from the fields of information theory and computer science to meet in a common room, to involve in an in-depth dialog on the subject of profound interest to both of them --- network coding. This workshop is intended to serve as such a unique venue. Ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range. ad hoc network often refers to a mode of operation of IEEE 802.11 wireless networks. it also refers to a network device's ability to maintain link status information for any number of devices in a 1-link (aka "hop") range, and thus, this is most often a layer 2 activity.

I. Introduction:

Linear Network Coding (LNC) has received considerable attention in recent years for its potential for achieving the theoretical upper bound (max-flow) of network resource utilization via the introduction of coding concepts at the network layer. It has been shown that with simple distributed linear coding in place of the usual forwarding at intermediate nodes, system throughput can be increased in several canonical network topologies. Linear network coding is a technique which can be used to improve a network's throughput, efficiency and scalability, as well as resilience to attacks and eavesdropping, as compared to traditional methods of OSI model or TCP/IP model separation between network layers with physical layer working on principles of Shannon Information Theory. Instead of simply relaying the packets of information they receive, the nodes of a network take several packets and combine them together for transmission. This can be used to attain the maximum possible information flow in a network.

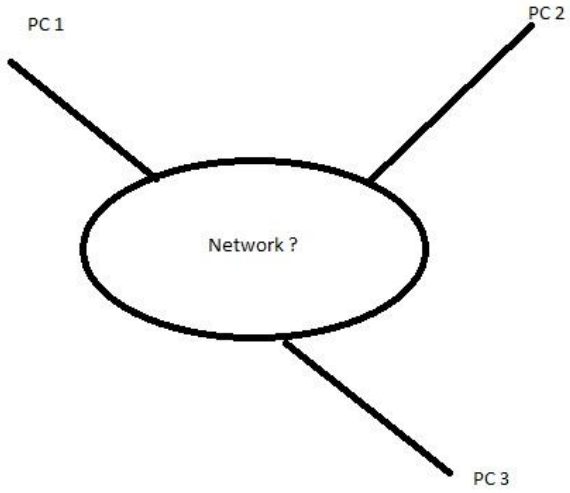


Figure Showing Linear Network Coding

It has been proven that linear coding is enough to achieve the upper bound in multicast problems with one or more sources. However linear coding is not sufficient in general (e.g. multisource, multilink with arbitrary demands), even for more general versions of linearity such as convolution coding and filter-bank coding. Finding optimal coding solutions for general network problems with arbitrary demands remains an open problem.

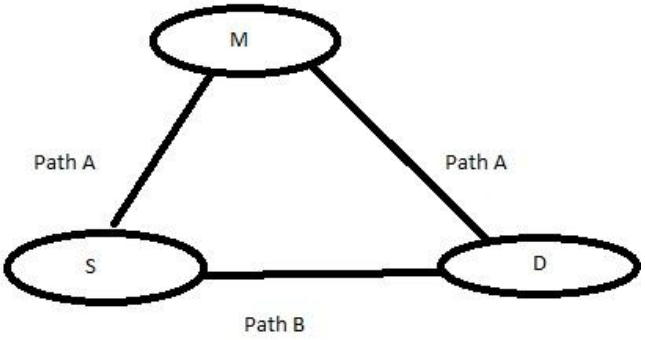
II. History of network coding in wireless networks:

- **Photophone:** The world's first wireless telephone conversation occurred in 1880, when Alexander Graham Bell and Charles Sumner Tainter invented and patented the photophone, a telephone that conducted audio conversations wirelessly over modulated light beams (which are narrow projections of electromagnetic waves)
- **Radio:** The term "wireless" came into public use to refer to a radio receiver or transceiver (a dual purpose receiver and transmitter device), establishing its usage in the field of wireless telegraphy early on; now the term is used to describe modern wireless connections such as in cellular networks and wireless broadband Internet.
- **Electromagnetic spectrum:** Light, colors, AM and FM radio, and electronic devices make use of the electromagnetic spectrum. The frequencies of the radio spectrum that are available for use for communication are treated as a public resource and are regulated by national organizations

III. Network Coding for Wireless and Wired Networks:

A wireless ad hoc network is a decentralized type of wireless network.[1] the network is ad hoc because it does not rely on a pre existing infrastructure, such as routers in wired networks or

access points in managed (infrastructure) wireless networks. instead, each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. in addition to the classic routing, ad hoc networks can use flooding for forwarding data.
An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range. ad hoc network often refers to a mode of operation of IEEE 802.11 wireless networks. it also refers to a network device's ability to maintain link status information for any number of devices in a 1-link (aka "hop") range, and thus, this is most often a layer 2 activity. Because this is only a layer 2 activity, ad hoc networks alone may not support a routable ip network environment without additional layer 2 or layer 3 capabilities.



Source node transmit to destination node

A network without a network, a MANET is based on wireless user devices, rather than being set up or managed by an external service provider,"Ideally self-organising, such a network allows people with laptops, mobile phones and personal digital assistants (PDAs) to set up their own networks and run software on top.

If people are carrying suitable devices, such an ad hoc wireless network can be created anywhere within minutes. This has obvious benefits when coping with natural disasters or emergency situations, when existing communications infrastructures are often damaged or destroyed.

Such networks can also be used to establish links to the outside world from geographically remote areas. Best of all, wireless technologies such as Bluetooth or WiFi allow virtually cost-free communication between devices.

Wireless ad hoc sensor network consists of a number of sensors spread across a geographical area. Each sensor has wireless communication capability and some level of intelligence for signal processing and networking of the data.

IV. Computer interface devices:

Computer interface devices such as a keyboard or mouse are powered by a battery and send signals to a receiver through a USB port by way of a radio frequency (RF) receiver. The RF design makes it possible for signals to be transmitted wirelessly. They keyboard allows for a larger range of use (usually up to about 10 feet), However, the further away the keyboard is from its receiver, the slower**.** An interface device (IDF) is a hardware component or system of components that allows a human being to interact with a computer, a telephone system, or other electronic information system. The term is often encountered in the mobile communication industry where designers are challenged to build the proper combination of portability, capability, and ease of use into the interface device. The overall set of characteristics provided by an interface device is often referred to as the user interface (and, for computers - at least, in more academic discussions - the human-computer interface or HCI). Today's desktop and notebook computers have what has come to be called a graphical user interface (GUI) to distinguish it from earlier, more limited interfaces such as the command line interface (CLI).

An interface device generally must include some form or forms of output interface, such as a display screen or audio signals, and some form or forms of input interface, such as buttons to push, a keyboard, a voice receiver, or a handwriting tablet.

V. Examples of wireless ad hoc sensor networks are the following:

- Military sensor networks to detect and gain as much information as possible about enemy movements, explosions, and other phenomena of interest.
- Sensor networks to detect and characterize Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) attacks and material.
- Sensor networks to detect and monitor environmental changes in plains, forests, oceans, etc.
- Wireless traffic sensor networks to monitor vehicle traffic on highways or in congested parts of a city.
- Wireless surveillance sensor networks for providing security in shopping malls, parking garages, and other facilities.
- Wireless parking lot sensor networks to determine which spots are occupied and which are free.

VI. Reference:

[1] S. Li, R. Yeung, and N. Cai, "Linear Network Coding"(PDF), in IEEE Transactions on Information Theory, Vol 49, No. 2, pp. 371–381, 2003

[2]R. Dougherty, C. Freiling, and K. Zeger, "Insufficiency of Linear Coding in Network Information Flow" (PDF), in IEEE Transactions on Information Theory, Vol. 51, No. 8, pp. 2745-2759, August 2005 (erratum)

[3]Ahlswede, Rudolf; N. Cai, Shuo-Yen Robert Li, and Raymond Wai-Ho Yeung (2000). "Network Information Flow". IEEE Transactions on Information Theory, IT-46 46 (4): 1204–1216. doi:10.1109/18.850663.

[4] T. Ho, R. Koetter, M. Medard, D. R. Karger and M. Effros, "The Benefits of Coding over Routing in a Randomized Setting" in 2003 IEEE International Symposium on Information Theory.

[5]http://arxiv.org/abs/1212.2291

[6] http://www.ericsson.com/technology/research_papers/wireless_access/doc/Multi-User%20ARQ.pdf

[7] http://securenetworkcoding.wikidot.com/

[8] http://home.eng.iastate.edu/~yuzhen/publications/ZhenYu_INFOCOM_2008.pdf

[9] http://netcod.org/papers/11AcedanskiDMK-final.pdf

[10] http://www-bcf.usc.edu/~dimakis/RC_Journal.pdf [12] en.wikipedia.org/wiki/Linear_network_coding.

[11] Chai Keong Toh, Ad Hoc Mobile Wireless Networks, Prentice Hall Publishers , 2002.

[12]P. Gupta and P.R. Kumar. Capacity of wireless networks. IEEE Transactions on Information Theory, Volume 46, Issue 2, March 2000, doi:10.1109/18.825799

[13]Jinyang Li, Charles Blake, Douglas S. J. De Couto, Hu Imm Lee, and Robert Morris, Capacity of Ad Hoc Wireless Networks, in the proceedings of the 7th ACM International Conference on Mobile Computing and Networking, Rome, Italy, July 2001

[14] ee.washington.edu/research/funlab/network_coding

[15]antd.nist.gov/wahn_ssn.shtml

[16] birs.ca/events/2013/2-day-workshops/13w2169

[17] Paventi, jared. “How does a Wireless Keyboard Work.” Ehow. Web. 26 Oct. 2013.

[18] en.wikipedia.org/wiki/Wireless

[19] whatis.techtarget.com/definition/interface-device-IDF