

# Community Viewing meets Network Coding: New Strategies for Distribution, Consumption and Protection of TV Content

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*Position Paper*

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## Our Interest in the Workshop

Network coding (NC) considers data as algebraic entities not just sets of bits. As such it assumes that digital traffic can be combined by addition and multiplication by other entities. While NC has been the topic of research in the last 10 years it is now receiving a lot of attention in the technology world as one enabler of the *Internet of Information Nodes*. In particular, since network codes do not need to be end to end, NC allows tailoring coding strategies to the dynamics and topology of the network and to the features of the receiver ecosystem. This is very beneficial when transporting video traffic over heterogeneous networks to a variety of end devices.

NC provides strategies for our team to better deliver video on the Internet. We address end-to-end aspects from video codecs to rendering and social viewing. As a result, our work has recently been highlighted in MIT News (network coding) and the MIT Technology Review TR10 (the ten technologies that will shape the world, for Social Television). Of particular interest for the W3C workshop are the aspects of our research that address new delivery mechanisms beyond traditional client-server architectures such as peer to peer and distributed storage, quality of experience (QoE) with device augmentation, network combining and layered content protection that socializes TV viewing. This creates the underlying network infrastructure that will deliver the next generation of video protocols like HTML5. Hence we believe that sharing our research with the workshop community and getting the feedback of the participants will be beneficial to all.

## New Strategies for Content and Video-Centric Networking

The traditional television delivery systems are based on content being acquired and distributed to a single end device under the control of a single operator. As video moved onto the Internet and to wireless networks, this model is now obsolete. TV content is nowadays available from a variety of networks and operators and rendered via web technology on any device capable of supporting a browser. Moreover, the content is combined with ancillary content and extra features that could be inserted anywhere in the network. Because of the scarcity of wireless resources there are growing requirements for content to be shared locally without wasting bottleneck resources for digital rights management, retransmission of lost segments and other non-revenue generating traffic. In just a few years video delivery went from a linear value chain to a multidimensional one with growing complexity.

In this environment, NC allows to modify and/or store content in the network nodes, without tight controls and to add protection only where needed, thus freeing resources, and enabling peer-to-peer distribution with local features. In particular interest for peer-to-peer distribution over small community networks thus providing the “anti-cloud” is growing with the needs for greener networking and targeted and personalized services. With network coded video there is no need to know exactly where a piece of video is located: to regenerate a file there is only a need to gather “useful” combinations of content until there is enough degrees of freedom accumulated to allow decoding. These inputs can come from local as well as from remote locations and be combined with ancillary information when needed without added complexity. Hence there is a small trade between using a complex stateful implementation and some added acquisition and decoding delay. Our research, especially by using systematic coding has shown that coded approaches only incur small delays that are within the acceptable end-to-end requirements of video delivery networks.

But there are other ways to further reduce the delays. This is by “borrowing” resources from another network or from another path. In essence improving one network by using another. Our work has shown that file download durations can be greatly reduced by using a 4G network to “help” a WIFI network in times of high demands. Again, the relaxation of the tight controls on content location enables this to happen. It is important to note that other potential strategies to improve video distribution use the layered nature of video codecs but this is outside the scope of the workshop.

For the solutions highlighted above the NC is applied above the IP layer and below the TCP layer. We essentially define a layer 3 ½ of NC that does not interfere with TCP or IP operations but greatly reduces interruptions and maintains throughput (and goodput) especially over wireless networks. Simulation and implementation results will be presented at the workshop.

But getting the information to its destination is not sufficient for commercial success: content and content privacy need to be protected. We are investigating novel approaches to content protection in a social viewing perspective. Heavily encrypted approaches fail to meet the needs of both commercially produced content that needs protection when this content is shared amongst devices and “friends” and gets annotated and enhanced. One aspect of Network Coding that is yet to be fully exploited is how its algebraic structure inherently protects the encoded content. We propose an approach for distributed content verification without the need to contact a trusted authority. Our techniques build upon our earlier work on constructing homomorphic encryption. In addition since the encryption of the NC coefficients is very lightweight the decoding time is very short and significantly faster than traditional decryption. Finally in a peer-to-peer distribution networks while peers can help to disseminate NC video content they will not be able to decode it without the right key information.

## Conclusion

We believe that our work is very much aligned with the “hot topics” section of the workshop as presented in the call for papers. We address peer-to-peer, digital rights management and wireless video distribution in the social and distributed video networking that characterizes the network environment that any new web television development will face.

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## Biographies

**Prof. Muriel Médard** is a Professor in the Electrical Engineering and Computer Science at MIT. Muriel Médard is a Professor in the Electrical Engineering and Computer Science at MIT. She was previously an Assistant Professor in the Electrical and Computer Engineering Department and a member of the Coordinated Science Laboratory at the University of Illinois Urbana-Champaign. From 1995 to 1998, she was a Staff Member at MIT Lincoln Laboratory in the Optical Communications and the Advanced Networking Groups. Professor Médard received B.S. degrees in EECS and in Mathematics in 1989, a B.S. degree in Humanities in 1990, a M.S. degree in EE 1991, and a Sc D. degree in EE in 1995, all from the Massachusetts Institute of Technology (MIT), Cambridge. She has served as an Associate Editor for the Optical Communications and Networking Series of the IEEE Journal on Selected Areas in Communications, for the IEEE Transactions on Information Theory and for the OSA Journal of Optical Networking. She has served as a Guest Editor for the IEEE Journal of Lightwave Technology, for two special issues of the IEEE Transactions on Information Theory and for the IEEE Transactions on Information Forensic and Security. She serves as an associate editor for the IEEE/OSA Journal of Lightwave Technology. She is a member of the Board of Governors of the IEEE Information Theory Society. She has served as TPC co-chair of ISIT, WiOpt and CONEXT.

Professor Médard's research interests are in the areas of network coding and reliable communications, particularly for optical and wireless networks. She was awarded the 2009 Communication Society and Information Theory Society Joint Paper Award, the 2009 William R. Bennett Prize in the Field of Communications Networking , the 2002 IEEE Leon K. Kirchmayer Prize Paper and the Best Paper

Award at the Fourth International Workshop on the Design of Reliable Communication Networks (DRCN 2003). She received a NSF Career Award in 2001 and was co-winner 2004 Harold E. Edgerton Faculty Achievement Award, established in 1982 to honor junior faculty members "for distinction in research, teaching and service to the MIT community." In 2007 she was named a Gilbreth Lecturer by the National Academy of Engineering.

**Dr. Marie-José Montpetit** is research scientist at the Research Laboratory of Electronics at MIT focusing on network coding for video networking. She was previously an invited scientist at the MIT Media Laboratory where she is still involved in a class on converged video applications that got her a recent mention in the MIT Technology Review as a "TR 10" (the 10 technologies that will shape the future). Dr. Montpetit received a Ph.D. in EECS from the Ecole Polytechnique in Montreal, Canada. She is a member of the IEEE Standing Committee on DSP and a collaborator to the ETSI BSM working group on aspects of convergence. She was the recipient of the Motorola Innovation Prize in 2007 for the development of a multi-screen and multi-network video mobility system. Her work on converged video applications and multi-screen IPTV has gotten her many invited papers and keynote presentations. She is a reviewer for the European Union for proposal and projects in the wireless networking and future Internet fields as well as the editor of many journals and publications and has served on numerous conference program committees. Dr. Montpetit is a Senior Member of the IEEE.