

Choice of a Medium Access Control Protocol for High-Speed Hybrid Fiber/Coax Networks

Nada Golmie *Mark Corner* *David Su*

National Institute of Standards and Technology

Gaithersburg, MD 20899

Extended Abstract

Cable network operators blessed with an installed broadband architecture are in a unique position to offer high-speed access over cable modems and deliver the voice, data and video services of the future. However, despite the fact that cable operators have been using a reverse spectrum since the 1970s for pay-per-view as well status monitoring and control systems, new standards, namely specifications for a Medium Access Control (MAC) protocol are needed for the new two-way services to be deployed over hybrid fiber/coax networks to provide adequate capacity in the narrow 5 to 40 MHz reverse spectrum channel.

The first MAC interface specifications to be completed are the Data Over Cable Service Interface Specifications (DOCSIS) [2], started as a project of the Multimedia Cable Network System (MCNS) organization and later adopted as a standard by the Data Standard Subcommittee of the Society of Cable Telecommunications Engineers (SCTE). In parallel to the MCNS activities, the Project P802.14, Cable-TV Protocol Working Group of the IEEE LAN/MAN (Local Area Network/ Metropolitan Area Network) Standards Committee has been working over the past four years on producing a standard suitable for two-way transmission of multiple services over Cable-TV systems [1].

While both the IEEE and MCNS/SCTE specifications share a common goal to provide interface specifications to the same anticipated services (such as cable telephony, Internet and on-line access for Web browsing, chat rooms, interactive games, local area network emulation for work-at-home applications and desktop conferencing), the solutions offered by the two groups have little in common at the MAC layer.

802.14 chose ATM transfer as its default solution because it provides Quality of Service (QOS) required for integrated delivery of video, voice and data traffic. ATM is a long-term solution that has the flexibility to provide more than just Internet access. On the other hand, SCTE uses a scheme that favors the delivery of variable length IP packets rather than ATM in an attempt to keep cost and complexity of cable modems down.

At the physical layer, which defines, modulation formats for digital signals the IEEE and the MCNS specifications are similar. The 802.14 specification supports the International Telecommunications Union's (ITU) J.83 Annex A, B and C standard for 64/256 QAM modulation on the downstream while SCTE supports Annex B which is also the North American standard. Both 802.14 and SCTE support QPSK and 16 QAM for the upstream modulation.

In this study we compare the performance of both IEEE 802.14 and SCTE MAC specifications in terms of access delay, cell delay variation, cell loss and throughput. We focus on the efficiency of the two solutions in terms of contention resolution, ATM vs. IP transfer, and adequate QOS provision.

We use *The NIST ATM Network Simulator* platform to develop a general simulation model for HFC MAC protocols [8]. In this model, the upstream channel is divided into a sequence of minislots that are used to either send requests in contention (contention minislots) or data in reservation (several minislots are grouped together to form a data slot). When a station has data to transmit, it sends a request in a contention slot, and waits for the feedback and data grant messages from the headend. In case two or more stations send a request at the same time, a collision occurs and a contention resolution algorithm is invoked to resolve the collision. A bandwidth allocation algorithm allocates data slots on the upstream channel and varies the ratio of contention vs. data slots within each request/feedback cycle.

We present four simulation experiments that help identify the trade-offs and differentiate the performance offered by the SCTE and the IEEE 802.14 MAC protocols. In experiment 1, we look at the contention resolution algorithms used: binary exponential backoff [3] for SCTE versus enhanced ternary-tree with FIFO and priority access for 802.14 [4] (more on the performance of the ternary-tree algorithm within the HFC context can be found in [5][6][7]). In experiment 2 and 4, we study ATM and IP transfer respectively. In Experiment 4, we study jitter and end-to-end delay bound sensitive CBR applications (for example voice, telephony) in both SCTE and 802.14 environments.

The results obtained confirm our expectations. IEEE 802.14 provides a friendly ATM environment with a good support of QOS while SCTE offers a much more efficient Internet access. However the significant delay variations observed in the SCTE results provide a hostile environment for any QOS support.

Key Words: Hybrid Fiber/Coax networks, Residential Broadband Access, Medium Access Control protocol.

References

1. IEEE 802.14 Working Group, Media Access Control, IEEE Draft Std. 802.14, Draft2 R2, November 1997.
2. MCNS Holdings L.P., Data-Over-Cable Service Interface Specifications, Radio Frequency Interface Specification, SP-RFI-I02-9710008, October 1997.
3. D. Bertsekas and R. Gallager, *Data Networks*, 2nd Ed., Prentice Hall, 1992.
4. C. Bisdikian, B. McNeil, and R. Norman, "msSTART: A random access algorithm for the IEEE 802.14 HFC network," *Computer Communications*, vol. 19, no. 11, pp. 876-887, Sept. 1996.
5. C. Bisdikian, "A review of random access algorithms," International Workshop on Mobile Communications, pp. 123-127, Thessaloniki, Greece, Sept. 19-20, 1996.
6. N. Golmie, G. Pieris, S. Masson, and D. Su "Performance Evaluation of MAC Protocol Components for HFC Networks," Proceedings of the International Society for Optical Engineering, *Photonics East'96 Symposium*, 18-22 November 1996, Boston, Massachusetts.
7. N. Golmie, G. Pieris, S. Mason, and D. Su "Performance Evaluation of Contention Resolution Algorithms: Ternary-tree vs. p-Persistence," *IEEE 802.14 Working Group*, Contribution no. IEEE 802.14/06-241.
8. N. Golmie, Y. Saintillan, M. Corner, A. Koenig and D. Su "The NIST ATM/HFC Network Simulator: Operation and Programming, Version 3.0," *National Institute of Standards and Technology*, NISTIR 5703R1, March 1998.