NEXT GENERATION CMTS CHARACTERISTICS INCLUDING IP MULTICAST

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Abstract

The cable industry is currently faced with upgrading from DOCSIS v1.0 CMTS equipment to DOCSIS v1.1 and PacketCable CMTS equipment. This represents the beginning of a convergence of data and voice onto a single system, what this paper calls a second generation CMTS. This paper discusses an evolutionary path for the convergence of multimedia services onto the Next Generation CMTS.

The Cable Modem Termination System (CMTS) is an integral part of the DOCSIS™ cable data network. The CMTS is essentially the "gateway" between IP services and subscribers. As the network and services change, the CMTS will continue to change too. Operators are encouraged to begin thinking now about the characteristics of a Next Generation CMTS (NG-CMTS) to enable a smooth transition to these products in the future.

The first generation CMTS offered best-effort data service for DOCSIS v1.0. The second (current) generation CMTS is designed for DOCSIS v1.1 and PacketCable™ services. This paper proposes three areas of development needed for the NG-CMTS. These areas include services, form factor, and standardized Application Programming Interfaces (APIs).

With respect to services, the first generation CMTS was designed for data. The current generation CMTS is designed for QoS (Quality of Service) and voice services. A theme of this paper is that the NG-CMTS will take on the role of multimedia processing. Not only are additional PacketCable services, that include multimedia, to be defined, the general trend in Set Top Boxes is to include a DOCSIS Cable Modem (CM) for interactive services and streaming media. With this in mind, there may be a need for multimedia services in a CMTS. This raises the question about MPEG-2 services moving through a CMTS. These MPEG services may not necessarily go onto a DOCSIS channel, but onto a digital video channel.

IP Multicast is a network capability that enhances multimedia. IP Multicast is the capability to send data from one-to-many recipients, or many-to-many recipients. This approach differs from both unicast, where data is sent from one user to one user, and broadcast, where every user is sent the data whether they want it or not. Both unicast and broadcast data transfer can put increased traffic loads on networks, whereas multicast traffic is selective in only putting traffic where it needs to be. These concepts will be explained in more detail later in the paper.

The form-factor of the NG-CMTS is taking on two distinctive flavors. One camp holds that the NG-CMTS will grow in size and port density, and be highly redundant and survivable. Another camp believes the CMTS will shrink in physical size and will be placed within a fiber node. These opposing views will be explored.

Finally, there are APIs to be supported by the NG-CMTS. APIs can be defined for such purposes as billing, QoS policy, provisioning, etc. If the same APIs are available on all CMTSs, then the operator can create networks using CMTSs from multiple suppliers. If CMTSs implement proprietary APIs, then operators may find themselves locked into a single CMTS supplier.

Vision

With respect to data, the old business was a fast web browsing service for early adopters. The new business will include moving packets, both IP and MPEG, around on networks that will support millions of every day users. The new packet-based services will require more integration and a more defined management plane. The NG-CMTS will be at the heart of this network.

DOCSIS used to be just for high-speed data. Now DOCSIS will be the platform for offering all IP services over cable, including voice and interactive television. In order to meet these needs, the CMTS must continue to evolve. As shown in Figure 1, the industry is well into the second generation CMTS development, in fact, these devices are already being tested at CableLabs in both the DOCSIS and PacketCable programs.

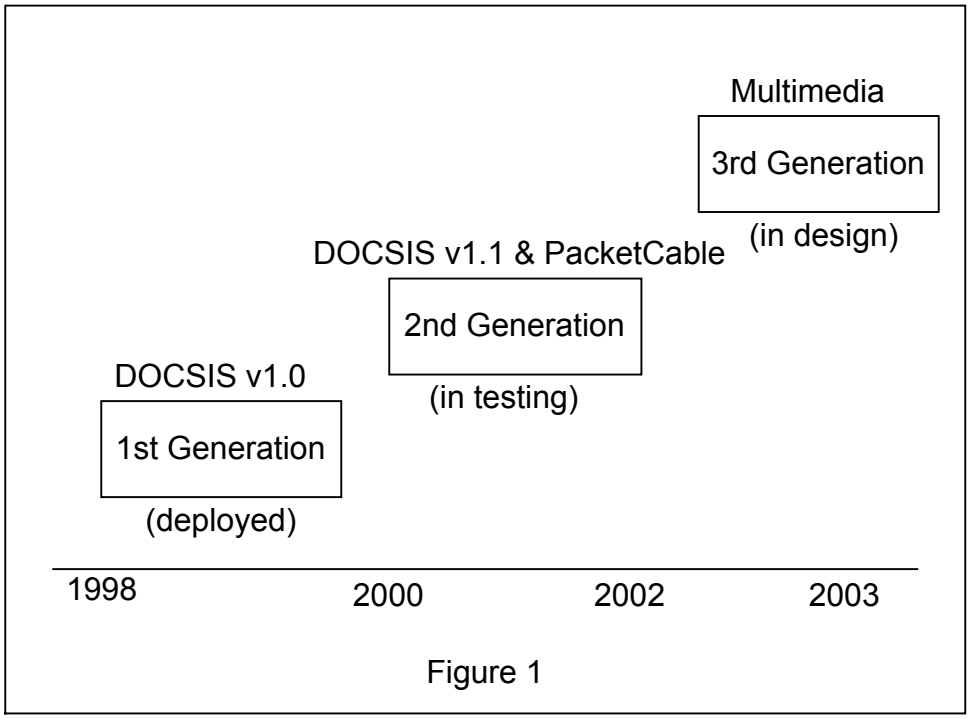

Figure 1

First Generation CMTS

The first generation CMTS products should be commended for the fine job they did in making DOCSIS an accepted world-wide standard. Without the efforts of these suppliers, DOCSIS would not be where it is right now.

These products were designed to quickly enable a standard high speed data market. The primary service was best-effort data for email and web surfing. These devices have proven to be robust and scalable, supporting interoperability of CMs from many suppliers. These first generation products have proven the concept that mass-deployed cable data service is a reality.

Second Generation CMTS

The second generation CMTS products offer several design advances over the first generation products. One of the largest drivers of this has been the success of the first generation products; there are 4 times as many suppliers in the second generation market and this drives competition and innovation. In addition, PacketCable has defined services that require higher reliability and stringent Quality of Service (QoS), both of which have contributed to new capabilities on the CMTS. Finally, the DOCSIS v1.1 specification has defined new features and

functions for the second generation CMTS, including dynamic services, account management, IP Multicast, SNMPv3, certificate-based authentication, etc. In addition to the features already mentioned, these second generation CMTSs will differ in their power consumption, port density, foot print, cabling options, etc.

Due to these new guidelines, the second generation CMTS is more sophisticated and feature rich than the first generation CMTS. With the large number of suppliers in the market, operators have many new choices to consider. With the second generation CMTS, operators should be realizing just how central the CMTS is to their services plans.

forward with real market offerings using IP Multicast.

Potential services include streaming headlines, stock tickers, and digital audio. While these are low bit rate services, if many subscribers access them with unicast service flows, then the amount of bandwidth consumed grows with each new user. However, if the services are multicast, then the IGMP support in a second generation CMTS ensures that the content only flows along network segments where necessary. Multicast users on a segment each "tune" into the single flow that is present on that segment.

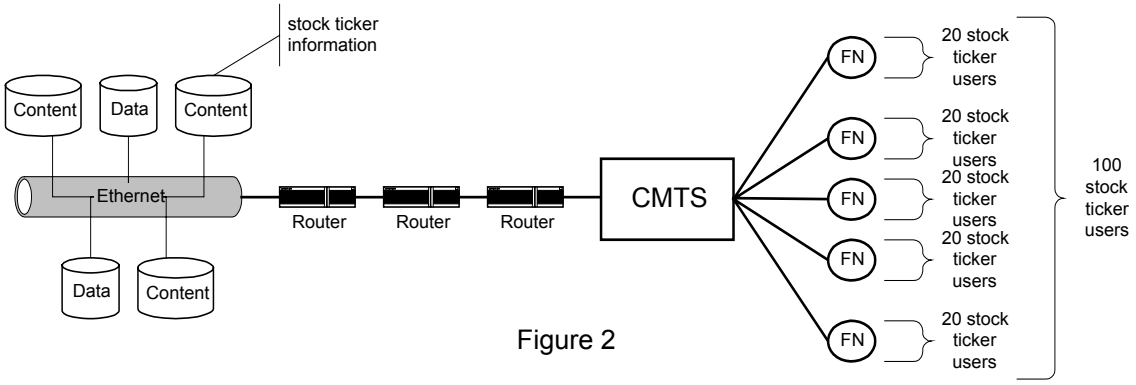

Figure 2

Second Generation CMTS - IP Multicast

The second generation CMTS, as part of the DOCSIS v1.1 specification, must implement defined rules for IP Multicast support. Specifically, DOCSIS v1.1 places rules on the CMTS for implementing the Internet Group Membership Protocol (IGMP). IGMP is the underlying protocol that allows IP Multicast services to work.

In DOCSIS v1.0, several operators experimented with IP Multicast services. However, without defined IGMP support in the CMTS, these initial attempts at IP Multicast service were technically successful, but not scalable. Having defined rules in the CMTS will allow operators to now push

With a unicast model, if one user on every fiber node subscribes to the service, then there is one instance of that data on each node. If 20 subscribers on each node want that service, then there are 20 instances of that data on each node. The difference with multicast implemented is that if 20 subscribers on each node want the service, there is will only be one instance of that data on each node, and each user can access it. In a sense, that data is shared by all the users. This is a powerful tool that will conserve bandwidth not only on the backend network, but on both the forward and return paths as well. In order for IP Multicast to be most efficient, each router in the network, from the content source to the CMTS, must be IGMP enabled.

Figure 2 can be used to illustrate the benefit of IP Multicast. In Figure 2 with unicast IP traffic, the server farm would need to source 100 individual streams to feed the 100 users. This traffic would burden every LAN segment, switch, router, and CMTS between the data and the end user. Since there is only a single source for the stock ticker, the individual unicast streams would all contain the same information; hence, there would be a lot of redundant information on the channel. This consumes bandwidth.

With IP Multicast, and depending on router configurations and headend combining, the server farm would need to source only 1 data stream to feed the individual fiber nodes. The CMTS would then replicate that stream to each downstream needed to feed the fiber nodes. The savings in bandwidth is readily apparent.

Next Generation CMTS

Given that the second generation CMTS has had many advances, operators may question if there is a need for a NG-CMTS. Now we get to the interesting discussions.

With the NG-CMTS, operators will truly begin moving into converged services. That is, all IP devices connecting to the cable plant will get their services through a CMTS. Right now, IP is thought of as a service that allows subscribers to do email and web surfing. With the NG-CMTS, operators should also consider moving completely to IP as the method to control devices that connect to cable plant. Clearly IP is the world standard for internetworking and with the adoption of both DOCSIS and PacketCable, the cable industry is gaining more and more experience with IP services. Since these two services run over IP, the cable operators will continue to be developing their IP expertise. Expanding the CMTS to include the management and control of all IP devices on the cable network seems to be an evolutionary step.

The benefit would be a reduction of both operational and capital cost for the cable operator. Currently for a headend that offers multiple services and connects to multiple backend networks, there will be separate racks of equipment for each service and network. With services converging over a NG-CMTS, there is the potential for having "fewer boxes" in the headend. In addition, rather than training technical staff to support 3 separate sets of equipment, each a complex technology in and of itself, operations support can begin consolidating around a single technology, the NG-CMTS. In addition, the innovation provided by a multi-supplier network will benefit operators both from the standpoint of feature availability and cost.

Next Generation CMTS – Features

Given that the second generation CMTS is designed for both data and voice, it is possible to envision the NG-CMTS taking on the role of multimedia and video processing. This would make the NG-CMTS responsible for both IP and MPEG services. Adding MPEG services to the CMTS could include such features as:

- Cherry picking
- Rate remultiplexing
- Conditional access

The MPEG processing in a NG-CMTS could relate to either streaming media or broadcast quality VOD content, or both. The choices will be made by the operators. But, having MPEG processing in the CMTS follows from a theme in the proceeding section. If all devices connect to the CMTS for both IP services and control, this would include a next generation set top box (or home gateway) that not only offers IP and MPEG services to the user, but also gets its signaling and control information over IP. CMs and Media Terminal Adapters (MTAs) already get signaling and control information over an IP interface to the CMTS, so the industry is heading in that direction. These types of standard devices, based on the

DOCSIS protocol for carrying IP over cable networks, are being developed now and should be available in 2002.

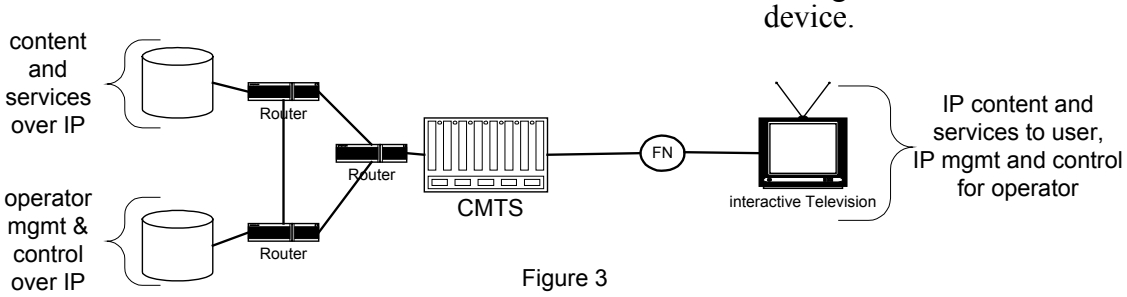

Figure 3

Figure 3 shows the concept of the operator and service providers embracing IP for control and services, respectively.

In addition to considering MPEG services, the NG-CMTS will also need to consider dynamic traffic management services, including tools for both controlling overall available bandwidth and how that bandwidth is apportioned to various services and users by QoS mechanisms. DOCSIS v1.1, in the second generation CMTS, introduced the basics of these services, and based on learnings, they will probably be fine-tuned in the NG-CMTS. These tools will be needed not only for subscriber-facing services, but also looking into the back-end network to support both other Internet Service Providers (ISPs) and Alternative Service Providers (ASPs) that are connecting to or providing services over the cable network. These ISPs and ASPs will have contractual agreements with the cable operators for certain levels of service, defined by Service Level Agreements (SLAs). The SLAs will need to be verified and enforced. This will very likely be an important business consideration for cable operators.

Next Generation CMTS – APIs

For first generation equipment, DOCSIS v1.0 placed very few requirements on the CMTS. This was an operator decision to encourage innovation among the CMTS suppliers. The following were two main areas of specification:

- Standard IETF Management Information Bases (MIBs) for the management of the CMTS as an IP device.
- RF requirements to maintain the integrity of the cable network.

Second generation CMTS equipment, under both DOCSIS v1.1 and PacketCable, have had additional requirements placed on them that include:

- Dynamic Quality of Service
- Network time synchronization
- IP Multicast Support
- Certificate-based authentication
- Additional standard MIBs
- SNMPv3
- Etc.

As can be inferred, the CMTS is becoming a more complex piece of equipment.

Continuing to define standard APIs for the CMTS is an important consideration. These APIs should be defined to allow operators to implement standardized control and management functions across the CMTSs. With more and more suppliers entering the CMTS market, operators can either take the route of specifying additional standard APIs, or be prepared to have suppliers solve these needs in a proprietary fashion. While proprietary solutions are sometimes how features are first developed, with operator input these features can be

migrated into the specifications. With the number of suppliers in this space, and the competition and innovation going on, these APIs will appear on CMTSs. But being locked into a single supplier in a highly competitive IP services market may be detrimental. By contributing these interfaces to the specifications, suppliers will make it more feasible for operators to deploy CMTS equipment across diverse networks.

For the NG-CMTS, new APIs that allow a move toward more common management, security, and provisioning should be considered. The issue of concern, again, is having standard APIs on CMTS equipment to allow operators to procure equipment from multiple suppliers and retain their operations and management frameworks.

Operators should still have the capability to define their own APIs in order to best meet their business needs, but as these interfaces mature, or as issues are identified, migrating the API to the specifications should be considered.

Next Generation CMTS – Location

This interesting question revolves around where the NG-CMTS will physically reside. CMTS configurations are available to fit a variety of options to allow operators to design networks as they choose. Possibilities include placing the CMTS in either an environmentally controlled facility such as a distribution hub, or moving the CMTS closer to the subscriber by placing it in a fiber node.

Clearly operators are placing the CMTS in a controlled facility today. However, several suppliers have demonstrated equipment that will fit the CMTS into a fiber node. As these new products mature, operators will have another choice in designing their cable data networks. The "CMTS on a pole" concept is still very new, and operators are encouraged to monitor these developments over the next year.

Locating the CMTS in a fiber node allows the operator to place processing closer to the subscribers. This partitions the DOCSIS network into smaller segments, similar to how making node sizes smaller partitions the RF network. This has the benefit of a more distributed architecture, making an individual CMTS a smaller point of failure. On the other hand, the CMTS would be placed in an environmentally harsh environment, and may be more accessible to tampering.

Regardless, a CMTS in a fiber node is an interesting development and the industry should pay attention to how it develops.

Summary

The evolution of the CMTS does not stop with DOCSIS v1.1. Operators should debate the functions of the NG-CMTS as its quite possible all data, voice, digital video, and device control services may some day be moving through this piece of equipment.

The CMTS will continue to evolve in terms of the services it supports, the APIs that are needed to control the network, and the physical form factor and location of the CMTS. In order to prevent having to do hardware upgrades of CMTSs at a later date, operators should consider the NG-CMTS services they want now and figure these into their services plan for the future.

References:

1. Miller, C. Kenneth, Multicast Networking and Applications, Addison Wesley, 1999.

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