WHITE PAPER

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TEXAS INSTRUMENTS

Upwardly Mobile:

Cable operators moving up to DOCSIS® 3.0

Introduction

Now that DOCSIS® 3.0 has arrived, cable operators are welcoming it for good reason. Actually, they have many good reasons to embrace this new protocol standard.

Certainly DOCSIS 3.0 (Data Over Cable Service Interface Specification) has achieved its goal of much higher line speeds, but many other characteristics make it attractive to operators. The flexibility with which this higher bandwidth can be implemented and the easy scalability of the termination equipment, for example, will simplify and accelerate operators' introduction of new services, hastening the addition of new revenue streams. And the seamless operation of DOCSIS 3.0 modems with legacy network management systems means that network operational expenses may not be affected by a gradual or even a sudden migration. Because there are little, if any, capital investments in the infrastructure to deploy DOCSIS 3.0, operators will enjoy minimal deployment costs and a healthy return on investment on the infrastructure already in place. Moreover, having DOCSIS 3.0 modems in the field opens a clear path to triple-play service offerings involving data communication, voice over cable (VoCable) and, eventually, video transmission via Internet Protocol (IP).

With the technical capabilities of DOCSIS 3.0 in clear focus, some of the remaining questions center on logistical and business issues. Specifically, when should deployment begin? With the introduction of new DOCSIS 3.0 products and platforms like TI's Puma 5 DOCSIS 3.0 solution for cable modems, the answer is increasingly clear: sooner rather than later.

The release of Data Over Cable Service Interface Specification (DOCSIS) 3.0 increases the stakes in the broadband access marketplace, ushering in support for a new generation of applications and services for which today's subscribers are clamoring. Flexible and scalable high-speed broadband access at least four times faster than CableLab's legacy DOCSIS 2.0 standard will simplify and accelerate the introduction of new high-definition (HD) multimedia services such as HD voice over cable (VoCable), Internet protocol television (IPTV) and many others.

By bonding together four or more 6 MHz DOCSIS 2.0 channels rated at 40 Mbps (or four or more 8 MHz channels at 50 Mbps in Europe), DOCSIS 3.0 can achieve minimum downstream data rates of 160 Mbps and upstream rates of 120 Mbps for low-cost residential service offerings. For businesses and other subscribers that require higher bandwidths, eight channels can be quickly and cost-effectively bound together to achieve line rates as high as 320 Mbps downstream. The ease with which channels can be bound together for incrementally higher data rates greatly enhances the flexibility and increases the precision of the network's scalability. In response to competitive situations or to capitalize on emerging opportunities in the marketplace, bandwidth can be deployed quickly and targeted precisely to the location where it is most needed.

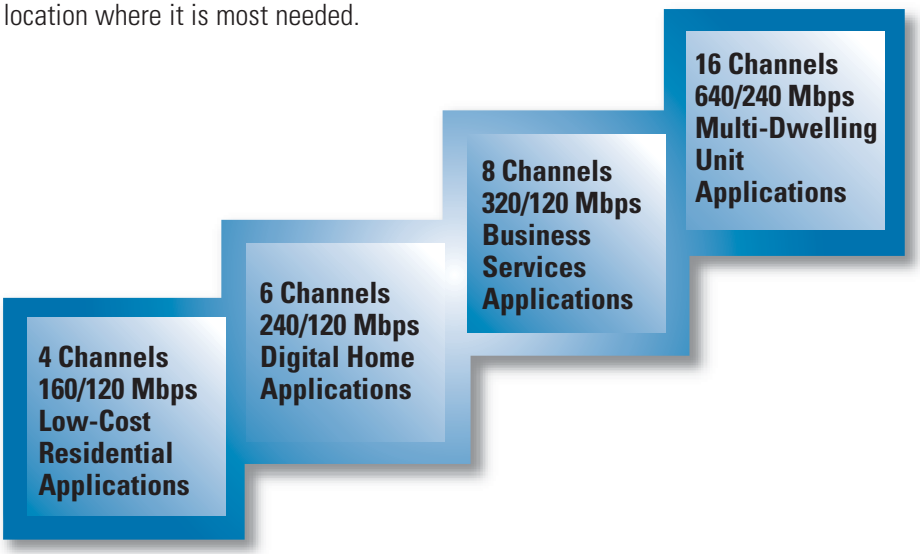

Figure 1: *DOCSIS 3.0 is extremely flexible and scalable. With its channel bonding technology, multiple channels can be bonded together to achieve the line speed and bandwidth needed by a particular segment of the local marketplace.*

Other new and improved features in DOCSIS 3.0 can increase the efficiency of an operator's management systems, lowering operational costs for the network infrastructure and for subscribers' cable modems. DOCSIS 3.0 includes native support for IP Version 6 (IPv6), for example, which expands the number of assignable IP addresses from the millions supported by IPv4 to billions. As a result, IPv6 lowers cable providers' operating expenses by streamlining the network's addressing scheme. It also enables a more efficient deployment of expanded services that could involve assigning IP addresses to multiple set-top boxes (STBs) in a residence, or next-generation initiatives like digital set-top gateways (DSG). In addition, interoperability issues are eliminated, since DOCSIS 3.0 supports a hybrid environment where termination equipment can support either IPv4 or IPv6.

The security features of DOCSIS 3.0 have also been strengthened to prevent hackers and malicious viruses. Whereas DOCSIS 2.0 supported Data Encryption Standard (DES), DOCSIS 3.0 is capable of the much stronger Advanced Encryption Standard (AES) encryption.

In addition, DOCSIS 3.0 has optimized certain capabilities that will lower overall network operating expenses. For instance, with new enhancements to the multicasting capabilities in previous versions of the specification, DOCSIS 3.0 can more efficiently allocate network bandwidth to multiple users and thereby make network capacity available to other revenue-generating services. DOCSIS 3.0's new control features for multicasting readily identifies multiple users who are receiving the same packet stream. This is particularly useful in IPTV applications, where a group of subscribers may be viewing the same content.

With the enhanced multicasting capabilities of DOCSIS 3.0, the network management system can dynamically add to or remove subscribers from a group and transmit the same packet stream once to all subscribers in the group. Previously, packet streams were individually transmitted to each user, consuming significantly more network bandwidth and management resources.

Keeping Costs in the Same Neighborhood

The many competitive advantages of DOCSIS 3.0 are within easy reach of cable operators because the capital procurement cost of cable modems can be as close as possible to previous generation systems. Thanks to an innovative approach to analog front-end processing, TI's new DOCSIS 3.0 platform, the Puma 5, features a single-tuner implementation for cost- and power-effective systems.

Because DOCSIS 3.0 achieves its higher data rates with channel bonding techniques, one rather expensive architecture for a DOCSIS 3.0 modem might involve a distinct tuner

for each DOCSIS 2.0 channel bound together. If four DOCSIS 2.0 channels were bound, four tuners would be required, and the bill of materials (BOM) cost of the modem would escalate.

TI has developed a high-performance yet cost-efficient analog front-end solution for DOCSIS 3.0 modems that can process as many as eight 6 MHz channels for the United States or eight 8 MHz channels in Europe through the same tuner technology. Instead of incrementally adding to the cost of the modem to achieve full DOCSIS 3.0 line speeds, this innovative technology has optimized the architecture of a DOCSIS 3.0 modem to reduce the cost difference from the previous generation. Network operators can begin deploying DOCSIS 3.0 cable modems and minimize their capital expenditure premium. Even if full DOCSIS 3.0 line speeds are not required throughout the network today, deploying DOCSIS 3.0-ready cable modems now would prepare the network for a fast and effective upgrade when subscriber demand warrants it.

Because DOCSIS 2.0 cable modem termination systems (CMTS) will function seamlessly with DOCSIS 3.0 cable modems, upgrades to the network and CMTSs can wait until the timing is right.

Moreover, DOCSIS 3.0 will have very little, if any, effect on operating expenses because network management and control mechanisms will be virtually unchanged from DOCSIS 2.0 to 3.0. In essence, heterogeneous networks with both 2.0 and 3.0 modems in the field can operate seamlessly as if all subscriber end-point equipment were identical. But with DOCSIS 3.0 modems already installed in the field, the changeover to the higher speeds and greater capabilities of next-generation technology can transpire very quickly, and on very short notice.

Deployment Flexibility and Scalability

The facile channel bonding on which DOCSIS 3.0 is based gives cable companies and multiple service operators (MSOs) the ability to rollout high-speed services on an as-needed basis. In addition, TI's Puma 5 platform has significantly enhanced configurability so that the network and individual subscriber bandwidth is scalable on a moment's notice.

As a minimum under DOCSIS 3.0, four 6-MHz channels are bonded together for 120 Mbps line speeds, but as many as eight such channels can be combined to achieve speeds as high as 320 Mbps. So, for example, a business might require line speeds of 100 Mbps or higher to adequately serve all of its employees. Channel bonding allows MSOs to quickly deliver the precise bandwidth needed at the location.

In addition to the innate flexibility of the standard, the Puma 5 platform has been designed with configuration flexibility in mind to ensure that the services and line speeds delivered to a particular location can be quickly scaled upward. Although the

base configuration of the Puma 5 supports four 6- or 8-MHz channels, the Puma 5 architecture is capable of a bandwidth equivalent to as many as eight channels, or 320 Mbps. So if the bandwidth requirement for a location should grow, the Puma 5 is able to grow right along with it.

As a location's requirements increase, for example, another Puma 5 could be added to the architecture for higher line speeds. Or if additional bandwidth is needed for HD cable TV signaling, off-the-shelf quadrature amplitude modulation (QAM) receivers could be integrated into the same Puma 5 architecture. The resulting cable modem could support both high-speed data rates and legacy cable programming in the same architecture.

Triple Play-Ready

The raw line speeds of DOCSIS 3.0 give cable networks the kind of capabilities needed for new revenue-producing services like VoCable and various applications resulting from IPTV services. But other considerations concerning the deployment of cable modems in the network will also play a critical role as these services are rolled out.

TI has leveraged its vast voice over IP (VoIP) experience into the Puma 5 platform to deliver a cost-effective solution with demonstrated robustness. With a VoCable-ready modem like the Puma 5, the MSO saves significantly on provisioning costs later when a user decides to subscribe to a voice service. Truck rolls and equipment swaps can be eliminated or drastically reduced.

In addition to voice, IP video applications will become increasingly strategic to cable network operators. Here again, the Puma 5 architecture excels at handling legacy proprietary video signals and cost-efficiently transitioning to IP video applications. Indeed, STB technology is rapidly escalating in sophistication and functionality. Most of the new STBs support more than one video channel, while more homes are requiring more than one STB for the several television sets in the residence. In some cases a single STB will control multiple TVs. Moreover, a gradual migration away from legacy proprietary cable TV signaling to IP video is being prompted by the improved management capabilities, higher line speeds and increased flexibility of DOCSIS 3.0.

The inherent flexibility of the Puma 5, as well as the scalability of the overall architecture, can be a critical enabler for the emergence of IP video on cable networks. For example, with four receivers in the Puma 5, one could be designated as a high-speed DOCSIS data channel while the other three are configured as legacy cable video receivers. But should the makeup of the signaling load change, the Puma 5 can dynamically alter how it allots bandwidth, designating additional receivers to data communications or other purposes if need be. As IP video gains ground, for example, channels initially devoted to legacy cable video might be switched to DOCSIS data channels to accommodate IPTV content.

Moreover, the Puma 5 can function as an effective video front end, interfacing legacy cable video channels to television sets and providing DOCSIS 3.0 data channels to a home network. The platform can also function as a DOCSIS 3.0 set-top gateway application where IP video is distributed over a home IP network to various IP STBs throughout the residence.

Packet Acceleration

Another unique innovation of the Puma 5 platform is its packet processor, a processing engine that offloads the modem's general-purpose central processing unit (CPU), bringing added functionality to the modem and ensuring that it will achieve full DOCSIS 3.0 line speeds. Quite simply, the higher line speeds of DOCSIS 3.0 will greatly increase the processing load on a modem's processing engine(s). This brings into sharper focus the beneficial effects that a dedicated packet processing engine has on the cable modem.

Achieving slower DOCSIS 2.0 line speeds requires processing at approximately 60,000 packets per second, for example, while the line rates of DOCSIS 3.0 requires processing as many as 240,000 packets per second – more than four times the processing load. If the entire processing burden were placed entirely on the CPU, a very powerful high-speed processor would be necessary. This would drive up the cost of the CPU and the modem's BOM, as well as the power consumption of the modem. Full dependency on such a powerful CPU would also limit the modem's scalability and flexibility, since the CPU would almost certainly have very little headroom for expanding its feature set, or for upgrading the functionality of the modem.

In contrast, by offloading the CPU from much of the packet processing, the Puma 5's packet processor is able to reduce the requirements placed on the CPU, lower its cost and the overall BOM platform cost, and enhance the functionality and flexibility of the platform.

Processing Power Solution – TI's Distributed Processor Architecture

Normalize Processing Horse Power to RISC Benchmarks		
Processor	*Frequency*	*Equivalent in RISC MHz*
Packet Processor	200 MHz	1200 MHz
C55x Voice DSP	200 MHz	500 MHz
ARM1176	400 MHz	400 MHz
Total		**2100 MHz**

Figure 2: *The Puma 5's packet processor is able to offload the host CPU, reducing the requirements for a high-performance and expensive RISC processor in a cable modem.*

Exceeding Expectations

Much of the rationale surrounding the development of the DOCSIS 3.0 standard has emphasized higher line speeds. The completed standard has fulfilled those promises. Now, as DOCSIS 3.0 technology such as Puma 5 is delivered to the marketplace, the expectations of the benefits that the cable industry will derive from DOCSIS 3.0 are being not only realized but exceeded.

For relatively similar capital expenditures and identical or reduced operating costs, cable operators can add next-generation capabilities to their networks today and at the same time future-proof their infrastructure and subscriber termination equipment tomorrow, with the functionality, flexibility and scalability required to accommodate new revenue-generating services.

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