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What Does DOCSIS Mean to MSOs?

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In North America there have been two prevalent and proven 2-way path OOB channels used in broadcast cable systems: DVS-178 & DVS-167. Comcast chose the SCTE ratified method DVS-178 developed by General Instruments. This was the first OOB channel format *deployed* and still today supports millions of digital set-tops.

Why move to another OOB format?

To understand why you must look at the capabilities of DVS-178 & DVS-167. First, DVS-178 has a very modest forward channel data rate of only 2.048Mbps and minuscule return channel (by today's standards) of 256Kbps. Furthermore, it is a "polling" operation that is less than ideal for today's advanced services. Yes it true, it's a proven method that does support IPPV (impulse pay per view) services. Yet, as services and network subscribers scale upward along with applications (and memory footprints) in the set-tops data rates are pushed against the ceiling. Furthermore, as the networks scale upward, polling uses up more bandwidth to the point where it becomes a substantial overhead on the OOB channel.

Even before DVS-178 was deployed, DAVIC developed an OOB channel format named DAVIC 1.2. This specification was submitted to SCTE as DVS-167 by Scientific-Atlanta (S-A). It was ratified and deployed on DAVIC compatible set-tops like the Pace 500 series, S-A's Explorer series, and Pioneer's Voyagers. DVS-167 had good goals in mind to support interactive services with forward and reverse OOB channels rates hitting up to 3.088Mbps in each direction (1.544Mbps/3.088Mbps forward & 256Kbps/1.544Mbps/3.088Mbps reverse). DVS-167 also employed a unique MAC layer that has three modes: Contention, Reservation, and Contentionless. The overall purpose of these modes was to reduce overhead in polling and reduce or eliminate message collisions.

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So with higher data rates and overhead management of DVS-167, the question still stands, why another format? Why DOCSIS? In short, the cable operators are soon to out grow the capabilities of 167 & 178. Let's look at what is driving us to hit the limits of the current OOB channels:

- Set-tops with very large memory footprints up to 128MB. Set-tops need the ability to have automatic software upgrades downloaded to them quickly. Even at 2 – 3 Mbps this is significant download time in which the set-top may have to be disabled. Not very friendly for a paying subscriber.
- Scaling of the subscriber network. Cable in North America is the fastest growing broadcast method in the world today. As cable networks scale upward in numbers polling techniques become more and more inefficient.
- Growth of new advanced services. Services today have grown beyond IPPV to include VOD/SVOD, high-speed data access for internet surfing, email, IP Streaming and even telephony over broadband. These services put tremendous constraints on the DVS methods because of the data rates required and the need for direct addressing vs. polling.
- MSOs also see a need for consolidation of head-end equipment needed to provide the advanced services. In short, to reduce their infrastructure cost such that common equipment and transport methods can provide video, data, and voice services.
- MSOs would also like to have a more open supply vendor competitive market. Such that they aren't locked into one suppler's equipment based on the OOB format (i.e., DVS-167 = S-A, DVS-178 = Motorola).

DOCSIS is the answer.

With these needs DOCSIS (Data-Over-Cable Service Interface Specification) was developed by Cable Labs. DOCSIS can be used to perform all of the functions of DVS-167 & DVS-178 and more. It's intent was to create an open standard implemented by any vendor supplier that achieves fast data rates for enhanced services such as video, voice, and data. DOCSIS 1.0 accomplished part of this goal with much improved forward channel bandwidth capacity reaching 42.884Mbps. On the reverse channel, bandwidth was comparable with prior technologies. Hence, to address this and open a bigger pipe for more services that required two-way interaction, DOCSIS 1.1 was specified where not only was the reverse channel increased to a whopping 10.24Mbps, but the symbol rate increased four fold. Now applications could flourish by having two-way interaction on the magnitude of computer LANs data rates. In addition to bandwidth capacity, DOCSIS 1.1 added quality of service (QoS) methods and security both of which are essential for telephony services (think 911 – the call must succeed) and e-commerce transactions.

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Yet with these great improvements of 1.1 some original goals of DOCSIS were still not quite met. Yes, data traffic for web surfing and e-commence are satisfied because those applications are more asymmetrical on the forward channel (i.e., downstream) where the 42Mbps:10Mbps forward:reverse channel ratio is sufficient. However, one can see that applications requiring a more symmetrical bandwidth will have issues. For example, telephony, video conferencing, home servers, and web cameras are peer-to-peer applications that need a more even distribution of the capacity and a higher bandwidth capacity too.

Cable Labs addressed this need with the specification of DOCSIS 2.0. 2.0 was created to increase bandwidth by using advanced physical layer technology. It's true that "quickfixes" do exist such as a technique of allocating more upstream spectrum into smaller channels, but this tends to be short lived as the number of subscribers scale upward. A better approach, as outlined by 2.0, is use of higher order of modulations (64QAM & 128QAM/TCM) and a wider channel bandwidth (doubled from 1.1 to 6.4MHz). Cable Labs didn't stop there with just increased bandwidth and more symmetry. They specified 2 modulation methods: (1) S-CDMA, advanced Synchronous Code Division Multiple Access and (2) A-TDMA, advanced Agile Time Division Multiple Access. And also added forward error correction to guard against noise corruption. There are numerous papers and technical studies publicly available that go into the details of how the technology works. Suffice it to say, that all of these techniques combined allow for reverse channel bandwidths to reach 30.72Mbps while preserving forward channel parameters to be backward compatible with previous DOCSIS versions to save the operator from replacing the previous DOCSIS hardware investments. And besides the hardware investments, existing protocols for conditional access, network monitoring, and other software mechanisms continue to function as before.

This means that bandwidth hungry applications not only run better, but operators can scale their network without inducing "quickfixes". Table 1 gives a summary of the DOCSIS generations.

	DOCSIS 1.0	**DOCSIS 1.1**	**DOCSIS 2.0**
Modulation	QPSK	16-QAM	64QAM or 128QAM/TCM
Channel	1.6MHz	3.2MHz	6.4MHz
Symbol Rate	1.28Msym/sec	2.56Msym/sec	5.12Msym/sec
Bandwidth	2.56Mbps	10.24Mbps	30.72Mbps

The key take-away here is that DOCSIS 2.0 provides 3 times the upstream bandwidth and it does this by being compatible with both the previous head-end equipment (CMTSs) and the previous subscriber equipment (cable modems and set-tops). Hence, an operator who currently has CMTSs versioned at 1.1 can continue to use that equipment for 1.0, 1.1, 2.0 subscriber devices. Furthermore, as operators build out their DOCSIS networks, they can specify 2.0 silicon that is available today and move in that direction with software downloads as they require. Deploying with this strategy preserves the previous DOCSIS 1.x investment while still getting the benefits of all devices that have transitioned to 2.0.

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As with any new technology, cost of upgrading equipment is never trivial and DOCSIS 2.0 is no different. However, the operator's focus should be on the upside of this technology. First, 2.0 silicon is readily available and as this silicon matures with significant volumes, prices fall. Second, as previously eluded to, with a significant increase in bandwidth more pay services and tier levels can be offered by the operator for increase revenue, yet no so obvious is the increased bandwidth also yields the network to scale upwards better by alleviating the need to divide the network into smaller nodes. Thus with increased scalability comes a reduction in equipment costs in servicing more subscribers. Hence, transitioning a network to 2.0 is less costly than continuing to build-out a 1.x network.

As networks continue to be upgraded to DOCSIS, operators will see the benefits in increased revenues, decreased costs, and better reach of their network. For the subscribers, more bandwidth means faster services, more applications, and enhanced services like networking and video telephony. DOCSIS really is a case of technology providing a win-win situation for operators and subscribers alike.

References:

DOCSIS, Cable Labs Specifications, http://www.cablemodem.com/specifications.html