AN OPEN SPECIFICATION FOR HYBRID FIBER/COAX OUTSIDE PLANT STATUS MONITORING EQUIPMENT

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Abstract

A new, open specification for Hybrid Fiber/Coax (HFC) based outside plant (OSP) status monitoring equipment is becoming available. It details the physical and data link layer protocols, the core message set and the transponder electromechanical interface to be used by HFC status monitoring equipment. It has been developed by CableLabs and its member companies through a cooperative process with the vendor community.

The status monitoring specification provides the structure necessary for vendor interoperability, while allowing vendors 'room' for innovation and product differentiation. Communication is based on two-way burst packet FSK (Frequency Shift Keying) transmission and employs a combination of poll-response and contention based multiple access schemes. The message set provides the means and the structure for communicating information to and from outside plant status monitoring equipment. It is simple, optimized for speed, and extensible. The electromechanical specification provides versatile interconnection between the transponder and the monitored equipment.

INTRODUCTION

A new, open standard for Hybrid Fiber/Coax (HFC) based outside plant status monitoring equipment is becoming available. The specification is a key step toward implementing competitive and reliable HFC networks needed by Cable Multiple Systems Operators (MSOs) for new interactive services, such as high-speed data and telephony. It details the physical and data link layer protocols, the core message set and the transponder electromechanical interface to be used by HFC status monitoring equipment. The standard has been developed by CableLabs and its member companies with strong cooperation from the vendor community.

The CableLabs specification for outside plant status monitoring equipment provides a mechanism for low-cost, interoperable network monitoring that satisfies both the network operator and the vendor communities. It is an essential step towards the delivery of the highly reliable, competitive services essential for next generation MSO networks. Because the status monitoring effort is so important to the operator community, several important goals have been set for it.

STATUS MONITORING GOALS

The goal of the status monitoring effort is to define a standard for HFC network status monitoring equipment that achieves interoperability between different vendors' equipment, satisfies the functional requirements of the network operator and is inexpensive.

Figure 1 shows a generic layout of status monitoring equipment for a HFC network. There are two important parts to the status monitoring equipment: the headend OSP EMS (Element Management System) and the OSP transponders. The transponders monitor various network parameters such as voltage and current, create alarms, when appropriate, and communicate this information to the headend OSP EMS equipment. The OSP EMS gathers this information and relays it onto higher level network management entities.

Technical Functionality

The technical functionality required by the status monitoring system strikes straight at the issue of cost-effectively operating a highly reliable HFC network. Several high-level requirements are needed to achieve the desired levels of reliability and operational savings.

One-to-Many Forward Channel: The status monitoring system needs to operate on the broadcast based HFC forward (headend to user) plant.

Noisy, Many-to-One Return Channel: One of the most difficult requirements to achieve is operation on the many-to-one return channel characteristic of HFC plants. This portion of the HFC plant is very noisy, forcing the modulation technique to be robust and the data rates to be lower. Also, a mechanism for allowing multiple units to communicate with a single headend is re-

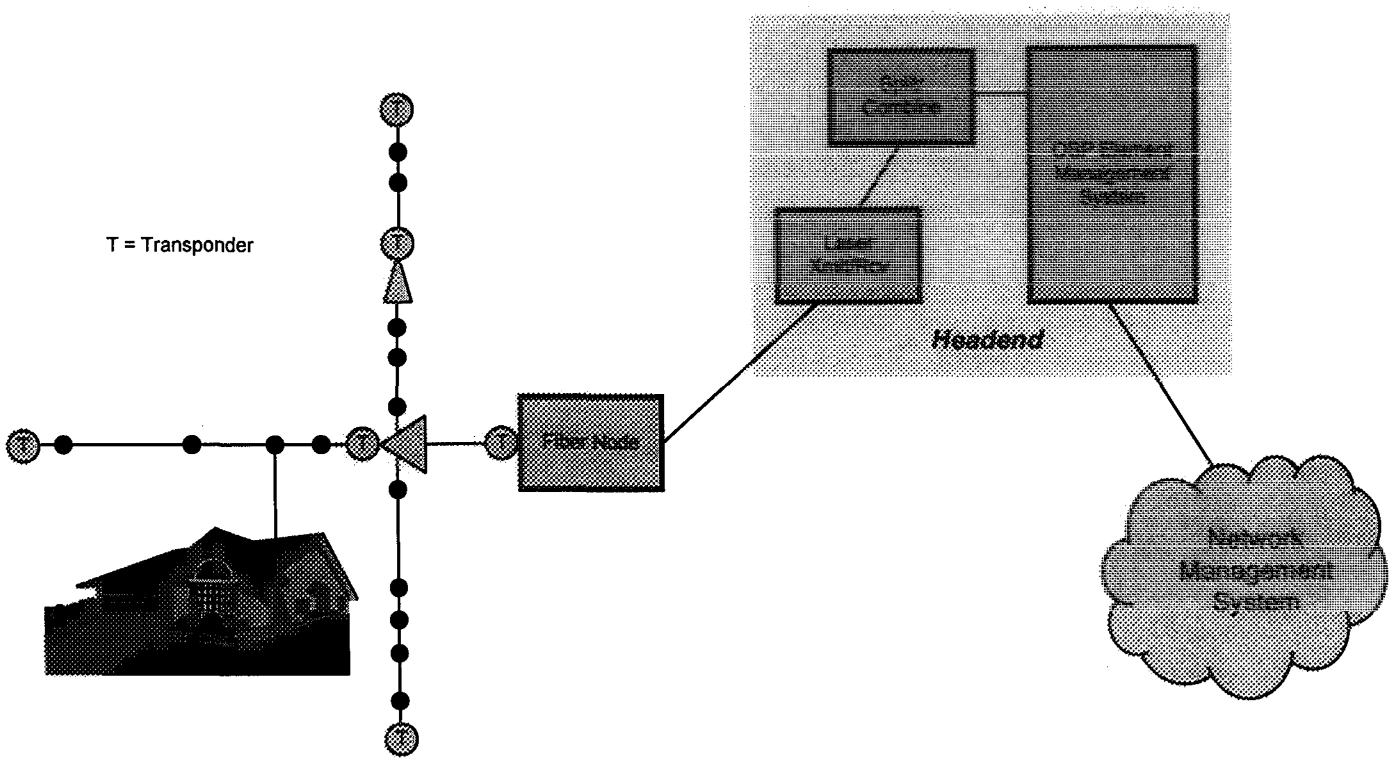

Figure 1: A Generic Layout of a Status Monitoring Equipment on a HFC Network

quired.

Quick Alarm Reporting: When an fault occurs in the network, the status monitoring network needs to present an alarm to the headend within seconds of the fault's occurrence.

Unresponsive Units: When an individual transponder fails, the status monitoring network needs to detect this within a few minutes of the failure.

Catastrophic Failures: A catastrophic event, such as a power failure or a lightning hit, that effects a large portion of the network, may cause multiple alarms to occur virtually simultaneously. The status monitoring system must recover quickly and robustly from such events.

Power Level Calibration: In some cases, the network operator would like to have a transponder provide a signal with an extremely accurate power level for use in calibrating amplifiers and fiber nodes on the HFC plant.

Room for Innovation: From both the vendor and the network operator points-of-view, the standard must not be so rigid as to eliminate future innovation in the status monitoring system. It is important to vendors to be able to differentiate themselves from their competition. It is important to operators in order to continually improve their operations and maintain their competitive edge.

Some Cake and a Fork, Too

Network operators obviously want to have their cake and eat it, too. The ideal is to write a standard that helps achieve an inexpensive transponder with timely availability and interoperability with other vendors' transponders.

A standard is an important step in achieving these goals. A properly written specification can obviously achieve the goal of interoperability between different vendors' equipment. This is important to network operators because it allows them to purchase equipment from the vendor of their choice, as long as that vendor adheres to the standard. Also a carefully crafted and well reasoned standard can help reduce expense by providing clear incentives for mass production of key parts, subassemblies and even entire transponders. The standard must be written carefully, though, with focused attention paid to vendor commentary on cost. Finally, in several ways, a standard gets in the way of achieving timely introduction of status monitoring systems. A standard takes time to complete and this time could be spent in bringing proprietary status monitoring solutions to market. However a standard is essential in achieving the first two goals. Therefore the standard writing process must progress quickly and efficiently.

THE PROCESS

The goal of the Outside Plant Management specification effort is to quickly achieve a workable standard which would facilitate cost-effective implementation by vendors. CableLabs and Stout adhered to four basic philosophies to achieve this goal.

Don't Reinvent the Wheel

There was no need to begin the development of a standard from scratch. The vendor and operator community have too much experience to begin at ground zero. Therefore, the process began by requesting from the vendor community information on their existing and proposed Physical, Data Link Layer and Message Set specifications.

Table 1: OSP Management Standardization Milestones			
Document	**RFI**	**Draft**	**Interim**
Electromechanical Specification	December 9, 1996	—	—
Physical Layer Specification	August 12, 1996	October 28, 1996	December 9, 1996
Data Link Layer Specification	August 12, 1996	September 25, 1996	November 14, 1996
Message Set Specification	August 12, 1996	December 9, 1996	—

A similar approach was used to get started on the Electromechanical specification.

A working group composed of CableLabs staff, CableLabs member companies' staff and Stout Technologies' staff was organized to compare and analyze vendor responses to assess their workability relative to the CableLabs member companies' operating plans and experience. Individual specifications were chosen to meet the needs of network operators while at the same time maximizing the match with products already offered by the vendor community. This approach should satisfy the network operator, while minimizing the impact on the vendor community.

Move Quickly

A long standardization process was one of the primary concerns of the network operating companies. They needed a status monitoring standard right away in order to remain competitive. Status monitoring is a key part of deploying new services in a reliable manner. It has been estimated by TCI that 5 to 10 minutes can be erased from the Mean Time to Repair (MTTR) by installing a status monitoring system.[1] It is also important to increase the overall reliability of the HFC network and reduce operating expense. Coupling the strategic importance of status monitoring with the short term pressure of the competitive environment results in a resolute requirement for quickly turning around a status monitoring specification.

The strategy for achieving the goal of quick turn around was multifaceted. Not only does it require dedication from the people and companies involved, but it also requires a different process than taken in a traditional standards setting arena. Specifically a proactive posture is required from the group with the most interest in having a specification completed: CableLabs and its member companies. The key milestones achieved thus far are shown in Table 1.

Proactive, Interactive Process

CableLabs has maintained an aggressive, proactive role throughout the status monitoring standardization effort. First, an energetic schedule was formulated. Milestones for delivering draft and interim versions of individual documents were set and have, to a large part, been met. Of course, when the aggressiveness of the schedule conflicted with achieving a specification which was acceptable to both the vendor and network operator community, the schedule was relaxed in order to achieve a more acceptable specification.

The second and most important part of the process is the proactive role taken to produce draft, interim and final specifications. As Figure 2 diagrams, rather than wait for standard contributions from interested parties, CableLabs has taken the information available from the vendor community, assessed it relative to the needs and

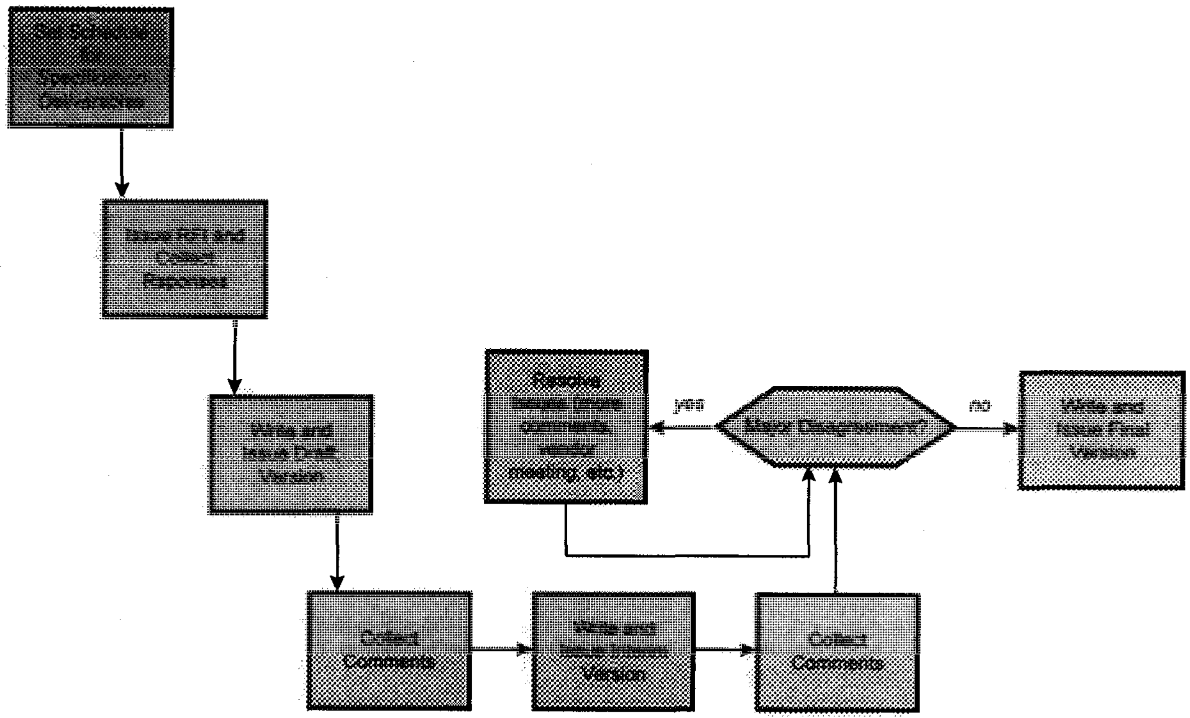

Figure 2: The Specification Preparation Process

experience of the network operators and written appropriate draft specifications. These drafts were then circulated for comment, the collected comments assessed and, if suitable, built in to the interim version of the specification. Differences regarding the interim version were then resolved through a combination of further commentary and general vendor community meetings. A proactive approach has helped to achieve the quality and the speed desired for the status monitoring standard.

Facilitate, Not Dictate

In order to serve the interests of all involved (MSOs and vendors) the best approach to the status monitoring specification development by CableLabs and its chosen contractor, Stout Technologies, was facilitation, not dictation. A dictated specification would not be an acceptable solution for all parties, would never gain widespread industry support and would not be useful. The only process leading to a widely supported specification is an inclusive one. All interested parties must be involved and proper facilitation is required to make sure that that involvement is complete and equitable.

At each step of the development of the status monitoring specification, all vendors' comments were carefully considered and weighed as to their contribution toward delivering a quality product to the network operators. Of course, there were several conflicting requirements, including low cost, time to market, high functionality and differing approaches to the same problem. The facilitation process attempted to make rational decisions to achieve the ultimate goal of a functional and a timely status monitoring solution.

ELECTROMECHANICAL SPECIFICATION

CableLabs is striving for interoperability on the communication level as well as the mechanical level. Interoperability means that a network operator could replace one vendor's status monitoring device with another vendor's without having to modify the communication mechanism it uses or without having to add or remove any special hardware. As a first step toward achieving the mechanical aspects of interoperability, CableLabs has issued a mechanical and electrical RFI.[2] The goal of this RFI is to obtain proposals, comment, and insight from the vendor community to aid the development of a cost effective and common form factor, connector, and electrical interface for status monitoring devices in Hybrid Fiber/Coax outside plant.

Each respondent has been requested to provide the reasoning, including technical and financial concerns, behind their responses so that an accurate assessment can be made. Respondents have also been requested to identify cost tradeoffs and issues on each of the following items, as well as for the overall proposal.

- Form Factor Description and Connector Location
- Temperature Range
- Relative Humidity
- Power Supply Voltages and Currents
- Weight
- Analog Monitor Inputs (Types and Number)
- Digital Monitor Inputs/Outputs/Bi-directional (Types and Number)
- Expansion I/O (SPI, I^2C, other)
- Local Craft Access
- RF Interface
- Surge Protection
- ESD Grounding

An initial proposal for using a PCMCIA form factor and connector looks promising, but more vendor comment and analysis are required before a decision can be made. The complete electromechanical RFI can be downloaded from the CableLabs home page, "http://www.cablelabs.com/."

PHYSICAL LAYER SPECIFICATION

All of the network operator requirements affect the Physical Layer, but there are two key requirements which have the strongest impact. First, since the Physical Layer details the requirements for the modem, it has a direct and substantial impact on the transponder's Bill of Materials and, therefore, direct and substantial impact on the cost of the transponder. Second, since the Physical Layer comes in direct contact with the cable plant, including the noisy return channel, it must be designed to overcome the detrimental effects of impulsive, ingress noise.

The following is an overview of the Physical Layer specification.[3] The complete specification can be downloaded from the CableLabs home page, "http://www.cablelabs.com/."

Robust, Inexpensive

To achieve robust performance while maintaining an inexpensive implementation, low-rate FSK (Frequency Shift Keying) was chosen for both the forward and return channels. FSK is very simple to implement and quite robust in the presence of noise. In fact, the specification requires that the system provide a 10^{-7} bit error rate (BER) when the received signal's CNR is as low as 14dB when operating only in thermal noise. Levels like this are easily achievable on today's HFC plants. The frequency shift chosen is +/-67 kHz relative to the center frequency. +67 kHz corresponds to a binary '1' and -67 kHz corresponds to a binary '0.'

This specification requires a minimum rate of 19.2 kbps with 9.6 and 38.4 kbps as rates that vendors can optionally provide. The overall bandwidth of a single channel is 400kHz. Such a wide bandwidth relative to the maximum data rate of 38.4kbps allows the modem's front-end filters to be designed simply and inexpensively.

Catlike Agility

MSOs require new systems such as a status monitoring system to be frequency agile. Their plants are in flux as new services are added and dropped in an effort to respond to market pressures. In order to operate efficiently in spite of this spectral churn, systems must be dynamically agile so that they can be reassigned to different frequencies at a moment's notice. Ideally, the agility should span the bulk of the available spectrum to give the operator the greatest range of flexibility. Unfortunately, delivering such a wide range of agility is expensive.

The Physical Layer specification currently compromises by setting the return channel spectral range at 5 to 25 MHz. However, this may be too wide for inexpensive implementation. A proposal is being considered to split this range into two smaller pieces — 5 to 10 MHz and 10 to 20 MHz. The transponders would be provisionable to operate over either range, but would operate only on one range at a time. Hopefully this proposal will provide the required agility at the necessary cost target.

Hermits Not Allowed

The status monitoring system will not be working by itself on the HFC plant. It must coexist with analog video, digital video, cable modems, analog set top return channels, telephony and other future services. Therefore, it must not interfere with the performance of another service, and its own performance must not degrade when another service is placed close to it on the HFC spectrum.

Interference with spectral neighbors is minimized by the spectral emission and spectral tone generation requirements. Any tones generated by the status monitoring system must be 50dB below the in-band transmitted power. Since status monitoring systems will usually be operated 10dB below analog video, this gives a 60dB carrier margin for analog video—plenty to maintain high quality analog video. The wide band spectral emission of the status monitoring system must 41dB below the in-band power when normalized to a 6MHz bandwidth. Again, since these systems will typically be operated 10dB below the analog, this gives a 51dB CNR on the analog video system—plenty to give high-quality analog video.

Susceptibility from spectral neighbors is minimized by compliance with the Selectivity specification. The Selectivity requirement states that the status monitoring system performance must not degrade as long as carriers between 200 and 400 kHz away from center are 30dB or less relative to the received in-band power; 400 to 800 kHz away are 40dB or less; and over 800 kHz away are 50dB or less.

Packets, Packets, Packets

The status monitoring system communications is packet based. Packets are used in both the forward and return directions. In addition, transmitters may be turned off during idle periods. Turning off is optional on the forward channel, while it is required on the return channel. As described in the Data Link Layer Specification section (below) many-to-one multiple access is achieved on the return channel through a rudimentary form of TDMA (Time-Division Multiple Access). The Physical Layer must therefore be able to turn on, transmit a packet and turn off in a specified manner.

The ramp times for the turn-on and -off are specified as 50μs. This is roughly two bit periods at 38.4kbps and is short enough to negligibly affect throughput performance but long enough to eliminate the need for complicated spectral emission control solutions which would be needed if very short 'square' edges were used. An extinction ratio of -50dB guarantees that when the transmitter is off, its output power is 50dB below its output power than when on.

Variety is the Spice of Life

Two flavors of transponders are being considered. Network operators feel that they need two particular features that could dramatically impact the cost of the transponder. First, they occasionally need a transponder that can transmit a particularly powerful signal. An application of such a transponder occurs when a transponder is placed at the end of a long coaxial run to monitor the health of the entire run, including the portion from the last amplifier to trunk termination. Second, they also have a limited need for a very accurately controlled power output when using the transponder to aid power calibration of amps and fiber nodes. Both of these features can increase the cost of a transponder up significantly.

A proposal to solve this problem is to specify two flavors of transponder: standard and premium. The standard transponder would meet all the nominal specifications given in the Physical Layer standard. The premium version would also meet the nominal specifications but would exceed them in maximum transmit power and transmit power accuracy. The proposal would have its maximum transmit power increase by 10dB from the nominal of +40dBmV to +50dBmV. The transmit power accuracy would tighten from the nominal of +/-2dB to +/-0.5dB.

The two version solution allows the purchase of the cheaper standard version for the bulk of applications, while allowing the purchase of the more expensive premium version for those few applications where extended functionality is required.

DATA LINK LAYER SPECIFICATION

The Data Link Layer (DLL) specification describes the tools which must be implemented by all status monitoring devices and which will be used by the headend EMS to allocate bandwidth and establish communication links. The goals of this specification are to specify a simple but functional MAC (Media Access Control) and LLC (Link Layer Control) that can be quickly implemented with inexpensive off-the-shelf components. The specification as described below allows simple polling with an ALOHA based contention scheme. Other variations of ALOHA and polling may be implemented. The specification is the result of several merged vendor responses.

Note that the following is an overview of the Data Link Layer. The complete specification can be downloaded from the CableLabs home page, "http://www.cablelabs.com/."

As part of the process of choosing and supplementing vendor responses to the Data Link portion of the CableLabs Outside Plant Management System RFI,[4] specific system and cost requirements had to be identified since, at the time, there were no hard requirements. One of the cost requirements specific to the DLL was that it must be sim-

Table 2: Forward and Return Path Data Link Layer PDU		
Length (bits)	Name	Description
8	Sync	Identifies beginning of message
8	Control	Protocol, Contention enable
48	Address	Unique MAC address or group address
8	Message Length	Length of the payload field in bytes
n	Payload	
16	CRC-16	CRC-16 of entire packet

ple enough to be implemented by an 8 bit processor driven by a slow speed clocks. This forced complex synchronization techniques such as those used by TDMA systems (e.g., ranging) to be abandoned. Forward error correction was also abandoned to reduce cost and because the FSK modulation specified in the Physical Layer is already quite robust in noisy environments.

The Package and Its Contents

The Packet Data Unit (PDU) format for the forward and reverse paths is identical. It is described in Table 2 and Table 3. The only difference between the two forward and reverse formats lies in the control byte; a contention bit located in the control byte in the forward path PDU is not present in the return path PDU.

The sync byte identifies the start of the MAC layer PDU and is set to 0xa5. The sync byte also serves as an idle code in headend implementations that require idle codes. The control byte consists of a 7 bit protocol field and a 1 bit contention on/off indicator. The protocol field indicates the type of protocol used for the payload field of the Data Link PDU. This enables the use of multiple Message Layer protocols if, in the future, other types of devices on the network implement the Physical and Data Link layers. The use of the contention bit is described further below. The address is a 48 bit long IEEE MAC layer address. Status monitoring vendors will solicit the IEEE for a range of MAC addresses. The MAC address can be used for broadcast, multicast, or unique addressing. The message length identifies the size of the payload field from 0 to a maximum of 255 bytes. The payload field contains the information to be communicated between devices. The last field is a CCITT CRC-16 over the entire PDU excluding the CRC-16 itself.

Slicing the Bandwidth Pie

The Data Link layer specification allows access techniques ranging from polling to pure ALOHA to be implemented by the Headend EMS. This is accomplished through the use of several rules that govern

Table 3: PDU Byte Ordering					
Start					End
Sync	Control	Address	Message Length	Payload	CRC-16

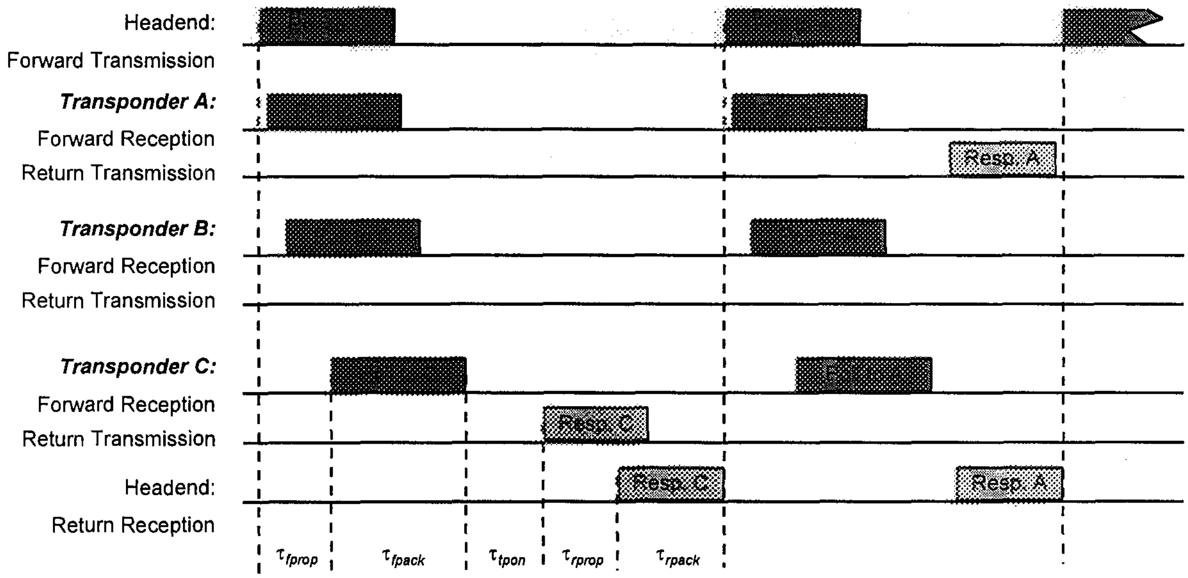

Figure 3: Forward and Return Packet Timing Relationships

message response and transmission times and through the use of a contention access indicator in the forward path PDU.

- Transmissions on the forward and return channels can occur independently of each other.
- The headend can transmit as often as it desires on the forward channel.
- A message received by a status monitoring device on the forward channel must be responded to in 10 ms or less.
- A message sent autonomously by a status monitoring device, such as might occur in the event of an unanticipated amplifier failure, must be acknowledged by the headend EMS within a backoff window, defined at the message layer, or it will be retransmitted. (The reader will recognize this MAC technique as pure ALOHA.)
- Autonomous messages may not be transmitted by status monitoring devices when the contention indicator is off and the message is not addressed to it.
- If the message is addressed to it, the status monitoring device may transmit its message regardless of the contention bit's value.

Upper layer processes handle all the message flow control and reliable transmission. Collisions on the reverse channel are detected by the lack of a response from the headend. No specific collision indication is provided at the data link layer.

This set of rules, as well as those discussed in other CableLabs documents,[5,6] allows the headend EMS to implement a variety of access schemes. Straight polling can be implemented by disallowing contention access, pure ALOHA can be implemented by allowing contention access but not polling, and a combination of polling with a pure ALOHA overlay can be implemented by selectively allowing or disallowing contention access. Figure 3 shows straight polling.

If the contention bit in the forward path PDU is turned on then status monitoring devices that need to autonomously transmit can do so at their convenience. This may

Figure 4: Message Structure

Message Header		Message Payload
Message Tag	Control/Command	Payload
1 byte	1 byte	n bytes

lead to a collision, for example between transponder C and transponder B, which will be resolved through a binary backoff algorithm. An access scheme such as this is best described as polling with an ALOHA overlay.

The theoretical throughput of a polled access technique approaches 50% for forward and return paths as propagation and processing delays approach zero. The theoretical throughput of a pure ALOHA access technique is approximately 18%. A hybrid implementation will result in a throughput somewhere between these two values and its exact value will depend on several factors including the percentage of time spent in ALOHA mode vs. the time spent polling.

Slotted ALOHA was initially considered instead of pure ALOHA since its theoretical throughput is approximately 37% for the same 'slot' size. But the slot size used for a poll and wait scheme is more that twice that required for pure ALOHA, since a 'slot' in an ALOHA scheme is only the length of a single packet. Therefore, the theoretical throughput for pure ALOHA using the rules presented offers better efficiency than a slotted ALOHA approach. It also scales better as the transmission bit rate increases.

The set of rules presented in the Data Link layer specification provides for a flexible and efficient means of offering bandwidth and establishing communication links. Access techniques such as polling, pure ALOHA, or polling with a pure ALOHA overlay can be implemented by a headend EMS adhering to this specification.

MESSAGE SET SPECIFICATION

Upper layer communication is achieved through use of the message set. The message set provides the means and the structure for communicating information to and from outside plant status monitoring equipment. It is simple, optimized for speed and extensible. The following is an overview of the message set. The complete message set document can be downloaded from the CableLabs home page, "http://www.cablelabs.com/."

The Toolbox

The messages are the tools used by the system to communicate information to and from the outside plant transponders. They are used primarily to read and write individual parameters at the transponder, but also can be used to give direct commands to a transponder. For example, to change the transmit power level, the `SetParameter` message would be used to write the parameter `TransponderTxmtPowerLevel` with the desired value.

Each message has the same basic structure, as shown in Figure 4. The header of each message includes a tag number to help correlate responses with the originating query and a control/command byte which includes bits to indicate continuation, encryption and perform SAR (Segmentation and Reassembly) of packets too large to be transmitted in a single DLL packet.

The payload of each message contains message specific information, such as the message name, the parameters it addresses (if any) and the data being communicated (if any). The payload is variable length as different messages require differing amounts of information to do their job. The most common messages are kept very short so as to optimize communication speed. Specifically, the `GetStatusMajor` message is the most commonly transmitted message from the headend to the transponder population. It simply requests all current major alarms from a specific transponder. Normally, when there are no alarms present (hopefully this is normal!) the transponder would respond with the `ReportStatusNormal` to indicate not only that there were no alarms but also that the transponder was functioning correctly. These two messages, because they are used so often, have payloads of a single byte, giving them a total length of 3 bytes.

The full list of messages and their meanings can be found in the Message Set specification[5].

The Nuts and Bolts

The parameters are the nuts and bolts of the communication system. The messages operate on the parameters to accomplish a desired task. Each parameter looks like a record in a database. It is composed of several fields which can be read and written by the appropriate message. The fields are detailed in Table 4 and include information about the parameter's actual value as well as information on how an alarm is triggered.

The parameters hold all the information which can be communicated to and from a transponder. They are arranged into groups according to the equipment being monitored by the transponder. These groups are:

- *Common:* Parameters common to all transponders. Examples are `UnitAddress`, `TransponderTxmtPowerLevel`, and `Temperature`.
- *Amplifiers and Line Extenders:* Parameters associated only with amps and line extenders. Examples are `ForwardAmplifierCurrent` and `DCPowerSupplyVoltage`.
- *Fiber Nodes:* Parameters associated with fiber nodes. Examples are `ReturnLaserPower` and `DCPowerSupplyVoltage`.

Table 4: Transponder Parameter Record

Field	Purpose
Parameter Name	Byte code of monitored parameter
Data Type	Type of Data (see Table 3.2.3-1)
Data Value	Actual value of parameter
Monitor Point	Number of the physical monitor point in transponder - this Parameter corresponds to I/O port number.
Alarm Direction	Indication whether alarm point is positive going or negative going
Major Alarm Threshold	Data Value at which Major Alarm occurs
Minor Alarm Threshold	Data Value at which Minor Alarm occurs

- *Power Supplies:* Parameters associated with power supplies. Examples are `InputACVoltageLevel` and `ChargingCurrent`.

Of course, the total list of all the parameters which might be found across the population of transponders on a large HFC plant is quite long. (For details, the specification can be downloaded from the CableLabs home page.) Fortunately, each individual transponder only needs to support a small subset of the parameters, including the common parameters and those parameters connected with the equipment it is monitoring. This makes the total amount of information monitored by a single transponder reasonably small and therefore cost-effective.

Simple or Complex: You Make the Choice

The depth of the message set and the width of parameter set to be implemented is up to the vendor. They can balance the desire to monitor everything under the sky with the cost of doing so. The message set and its associated parameter list has been designed with the flexibility to allow this choice.

Extensible

Finally, the message set and the parameter list are extensible to allow vendors and MSOs to adapt the system to changing networks and technology. It is difficult if not impossible to foresee all the possible items to be monitored by the status monitoring system. As new equipment and technology are implemented and find their way into the HFC network, new voltages, currents, switch positions, and many as yet undetermined items will need to be monitored. The parameter set is dynamically extensible to accommodate such new data.

CONCLUSION

The CableLabs HFC outside plant management specification effort is producing a useful set of specifications by which vendors can quickly and cost-effectively get products to market. Accordingly, the cost of deploying such specifications-based systems will drop thereby increasing the demand and increasing the total market. As usage of status monitoring systems increases, Cable MSOs can more effectively manage their networks in the ever increasing competitive telecommunications marketplace.

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