VoIP SERVICES:PacketCable™ DELIVERS A COMPREHENSIVE SYSTEM

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Abstract

This paper provides a high-level overview of the PacketCable IP-based services delivery architecture as well as a more detailed discussion of the PacketCable Event Messages framework used to track access network resources used by those services.

The cable plant has experienced significant upgrades in the past several years allowing for the delivery of advanced broadband services. The DOCSIS™ 1.1 specification defines the robust, highly-reliable, and highly-efficient broadband transport mechanism necessary to support time-critical services such as voice.

The PacketCable architecture is a multimedia services delivery platform, layered over the DOCSIS 1.1 access network, designed to support a wide variety of quality-of-service (QoS) enabled IP-based services. The end-to-end architecture as designed[1][6], offers a complete system that includes: device provisioning, signaling, event messaging, configuration management, QoS, and security. These services are managed by specific servers and network endpoints that collectively create a PacketCable network.

Voice over IP (VoIP) is the first service identified for delivery over the PacketCable architecture. Additional non-voice services are also being analyzed as candidate services for delivery over the PacketCable architecture. Examples of these beyond-voice services include multi-player gaming, videoconferencing, and unified messaging.

The PacketCable Event Messages framework supports collection of information necessary to create a PSTN-style call detail record (CDR) that may be used for purposes of customer billing, settlements, traffic analysis, and other back office functions.

ARCHITECTURAL OVERVIEW

One of the fundamental PacketCable objectives is to define a QoS-enabled, IP-based services delivery platform that extends the capabilities of the highly efficient DOCSIS 1.1 access network so as to allow cable operators to deploy a variety of IP-based services.

The initial service offering identified for the PacketCable architecture is residential Voice Over IP (VoIP). While the PacketCable architecture doesn't preclude the delivery of small-office-home-office (SOHO) and business VoIP services, the focus has been on residential services allowing cable operators to provide value and to leverage relationships with their residential cable subscribers.

Several factors differentiate Packet-Cable VoIP services from traditional "IP telephony" services. For example:

- PacketCable VoIP is a phone-to-phone service rather than a personal computer-based telephony service.
- PacketCable services are guaranteed priority delivery on the DOCSIS access network ensuring a consistent, high-quality service.
- PacketCable services are not delivered over the public Internet. PacketCable mandates the use of a managed IP backbone that provides service delivery consistent with that of the DOCSIS access network.

The PacketCable architecture, pictured in Figure 1, provides the comprehensive system necessary to deliver VoIP services. When describing the architecture, we often talk about the three networks involved in the delivery of VoIP services: the access network, the managed IP backbone, and the public switched telephone network (PSTN).

Access Network - the HFC network connecting the subscriber to the MSO. The MTA and CM reside on the access network. The CMTS connects the access network to the managed IP network.

Managed IP Network - a high bandwidth IP network used to connect the MSOs headend servers. This network is often called the "Managed IP backbone" when it is used to interconnect several managed IP networks, DOCSIS HFC networks, or connect PSTN gateways to the PSTN.

PSTN - interconnects with the PacketCable Managed IP Network via a PSTN gateway.

FUNCTIONAL COMPONENTS

As part of the comprehensive end-to-end system necessary to deliver VoIP services, the PacketCable architecture requires several network elements with well-defined interfaces between those elements. This section describes several key functional components in the PacketCable architecture.

Multimedia Terminal Adapter

In the home, a standard phone plugs into the multimedia terminal adapter (MTA) allowing voice to be converted into IP packets. An MTA may be designed to be either a separate standalone device or to be embedded within the cable modem.

Cable Modem Termination System

The CMTS is responsible for managing access network resources for PacketCable services. Access network resources are first reserved when service is requested, then committed when service is delivered, and finally released when the service has completed.

Call Management Server

The CMS manages and maintains call state for VoIP services. The CMS is composed of a call agent (CA) and a gate controller (GC). The CA manages the call state and controls the MTA. The GC performs QoS admission control and communicates with the CMTS to allow services to obtain access network resources.

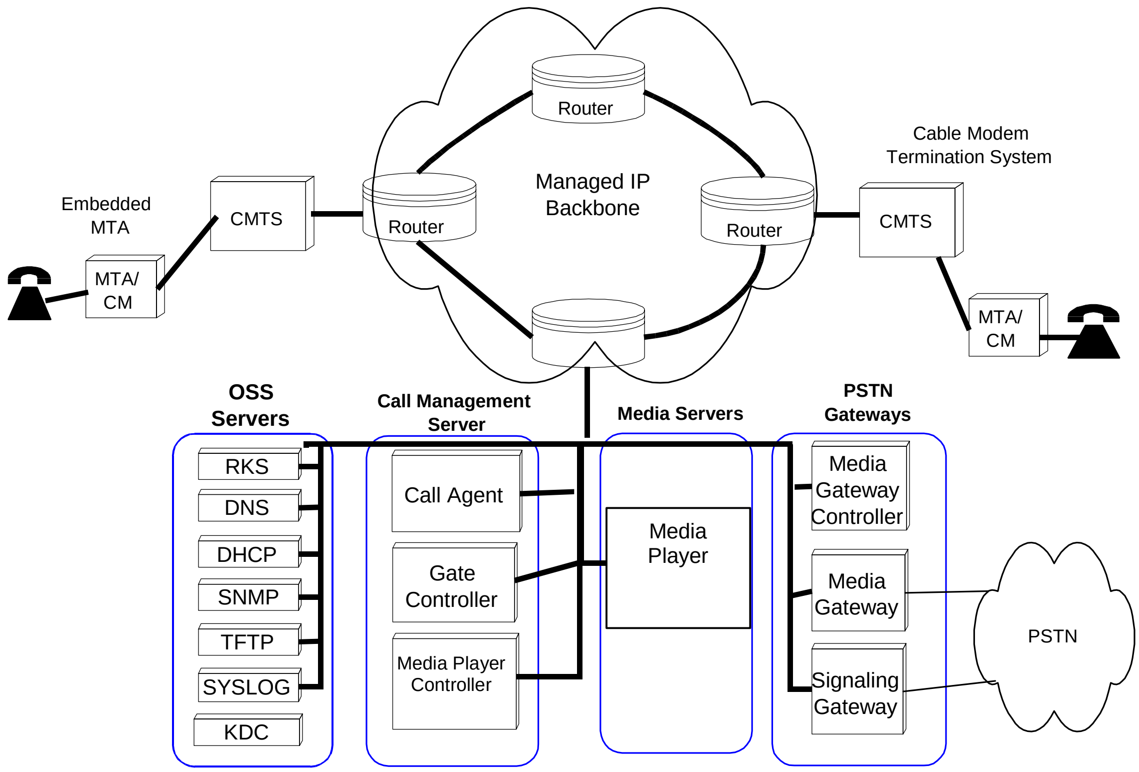

Figure 1: PacketCable 1.0 Network Component Reference Model

<u>Record Keeping Server</u>

The RKS is the short-term repository for PacketCable Event Messages. It receives messages from the CMS, CMTS and MGC then collates them into coherent sets for designated back office systems for additional applications processing. It serves as the interface between the PacketCable network and relevant back office servers.

<u>Operational Support Systems</u>

Operational support systems (OSS) contain a variety of supporting servers and infrastructure functions for such activities as provisioning, record keeping for billing, key distribution for security, domain name service (DNS) for name resolution, etc.

The OSS back office contains service and network management components supporting the core business processes.

<u>Media Server</u>

The media server provides network announcements and information, e.g. *"The number you have called is no longer in service…"* . There are two logical pieces to the Media Server, the Media Player Controller (MPC) and the Media Player (MP). The MPC requests the MP to play announcements based on call state as determined by the CMS. The MP is responsible for delivering the appropriate announcement to the MTA or to the MG.

PSTN Gateway

A PacketCable PSTN Gateway can be decomposed into a Media Gateway Controller (MGC), Media Gateway (MG), and Signaling Gateway (SG). The MGC manages the interconnection with the PSTN by controlling the MG and SG. The MGC is responsible for maintaining the call state for calls requiring PSTN interconnection.

The PacketCable architecture also supports a hybrid gateway solution that takes advantage of legacy PSTN switches already owned by cable operators while providing a migration path to the fully IP-based PacketCable solution. This hybrid architecture uses PacketCable IP-based components on the access network and circuit switch call control derived from a PSTN local digital switch location.

ARCHITECTURAL CAPABILITIES

Several core capabilities are fundamental to the delivery of VoIP services on the PacketCable architecture. This section provides a high-level discussion of Dynamic QoS and Security. Event Messaging is also a core capability that is discussed in more detail in a later section.

Dynamic QoS

An IP-based network, by definition of the underlying TCP and UDP transport mechanisms, delivers packets in a best-effort manner. Dropped or delayed packets result in unpredictable end-to-end throughput.

PacketCable and DOCSIS 1.1 provide a comprehensive, integrated QoS delivery mechanism [4] that ensures PacketCable packets are delivered in a guaranteed manner, not a best-effort manner.

PacketCable splits the management of QoS resources into access network segments and backbone network segments. This approach allows for different bandwidth provisioning and signaling mechanisms for different network segments: the origination side, the far end, and the backbone network. Additionally it allows for resource-constrained segments to manage resource usage and maintain per-flow reservations carefully. The PacketCable DQoS Specification details this design [3].

Security

PacketCable security spans all interfaces in the PacketCable architecture [5]. It provides confidentiality for media packets and for signaling communication across the network via authentication, encryption, and key management. It ensures that unauthorized message modification, insertion, deletion and replays anywhere in the network are easily detectable without affecting network operation. Security is interface specific, but the majority of signaling interfaces are secured using IP security (IPSec). The media stream is secured by encrypting and authenticating the payload directly.

In addition to defining the security protocol that will be applied to each interface, PacketCable also defines a corresponding key management mechanism. There are three basic key management mechanisms defined for use in PacketCable: Kerberized Key Management, internet key exchange (IKE) with either pre-shared keys or X.509 digital certificates, and randomly generated keys exchanged within secured signaling messages.

OPERATOR OBSERVATIONS

The multiple vendor and service provider environment into which a cable operator enters with the delivery of VoIP services through a distributed architecture requires on-going attention. It has been observed that this is not necessarily one-stop shopping and each cable operator will be required to develop their own management strategies to navigate the variety of vendor, network provider, and service provider relationships. Take for example, resolving a fault management issue. These can arise within any number of scenarios, each with their own respective source and solution. Having the expertise in place, whether in-house, or supported by a third party, to deal with such an issue will be important.

Another example of managing the multi-service provider environment can be found in the issue of local number portability (LNP). In those instances where a PSTN customer would like to keep their existing telephone number as part of their cable VoIP service, LNP comes into play. The interval of porting a subscriber's telephone number has to be managed closely in order for the subscriber to experience a seamless service transition.

PACKETCABLE EVENT MESSAGES

The PacketCable architecture provides a QoS-enabled IP-based service delivery platform for voice and other multimedia services. The PacketCable Event Messages framework provides a mechanism for tracking access network resources that have been requested and consumed by these services. This information can be used by back office systems for many purposes including billing, settlements, network usage monitoring, and fraud management [2].

The PacketCable Event Messages framework has been designed to be flexible and extensible enough to support the initial suite of PacketCable voice services, as well as accommodate beyond-voice services in the future.

A single PacketCable Event Messages framework has been defined to support a variety of service-delivery scenarios and network topologies. For example, tracking information for services that either originate or terminate on the PSTN, as well as services that stay on the MSOs network are supported by the framework.

Event Message Information

An Event Message is a data record containing information about usage and service activities. Telephone number is an example of the type of information carried in an Event Message. An event-based format is necessary to accommodate the distributed architecture where complete "session state" no longer resides in one or two network elements, but is instead spread across any of these, i.e. CMS, CMTS, and MGC.

A single event message may contain a complete set of data regarding usage or it may only contain part of the total usage information. When correlated by the RKS, information contained in multiple event messages provides a complete record of the service. Event messages are collected and are sent to one or more back office applications such as a billing system, a fraud detection system, or a pre-paid services processor.

Originating/Terminating Model - PacketCable makes use of an “originating/terminating model” based on the PSTN “half-call model.” In this model, the originating party’s service provider is responsible for tracking information sufficient to bill the originating party for service, and to settle with the terminating provider. The terminating party’s service provider has the same responsibility for the terminating party. This “originating/ terminating model” supports the various PacketCable network topologies.

Batch vs. real time - PacketCable allows Event Messages to be sent to the RKS as they are generated. Alternatively, once generated, Event Messages may be stored on the CMS/CMTS/MGC and sent to the RKS in a single file.

Call Detail Records - Using the unique billing correlation ID (BCID) assigned to a given call, the RKS collects all the individual Event Messages for that call, and assembles them into a single call detail record. The format of the CDR may be AMA, BAF, IPDR, or any format appropriate for the billing and other back-office servers that will make use of the information.

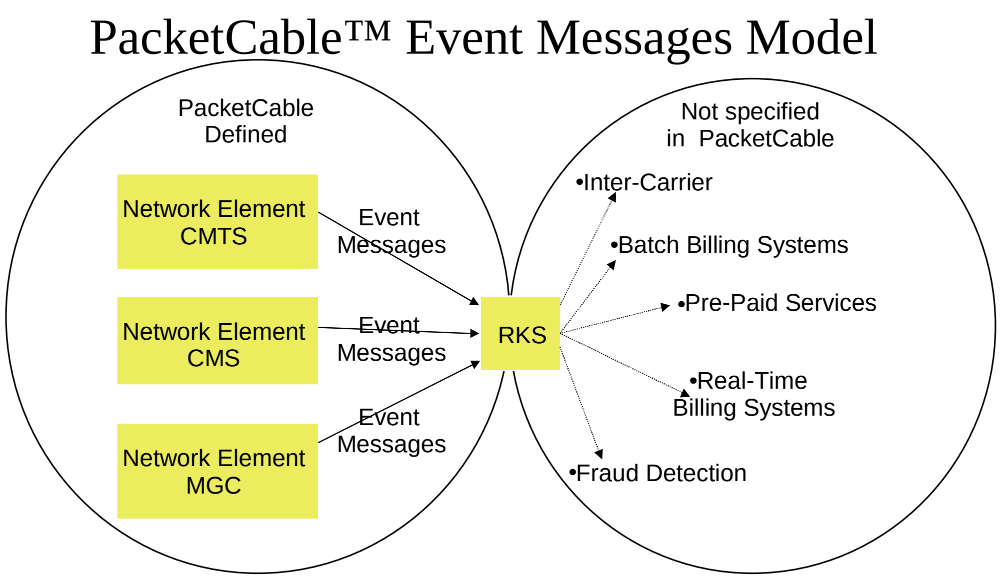

Figure 2: PacketCable Event Message Model

Figure 2 depicts the PacketCable Event Message architecture. By standardizing the transport, syntax, and collection of appropriate Event Message attributes from a distributed set of network elements (CMS, CMTS, MGC), this architecture provides a single repository (RKS) to interface with billing, settlement, reconciliation, and other systems.

The CMS, MGC, and CMTS generate Event Messages for the portion of the communication pertaining to them. For example, the CMTS generates a “start of

QoS" message, when the CMTS commits access network resources to a PacketCable service.

SPECIFICATIONS AND STANDARDS

The comprehensive nature of the PacketCable architecture is the result of a suite of Technical Reports and Specifications that delineate the end-to-end architecture and associated interfaces for a complete IP-based services delivery platform. These Technical Reports and Specifications (available at www.PacketCable.com) have been accepted as standards by several North American and International standards organizations including the Society of Cable Telecommunications Engineers (SCTE), American National Standards Institute (ANSI), and the International Telecommunications Union (ITU).

CONCLUSION

The PacketCable architecture described in this paper is a comprehensive end-to-end system necessary to deliver VoIP and other IP-based multimedia services.

For the delivery of VoIP, the PacketCable architecture can be thought of as three networks coordinated through a collection of functional components and servers. The PacketCable architecture supports several core capabilities, such as dynamic QoS and security, that are fundamental to the efficient, reliable deliver of IP-based services.

Efforts are underway to develop extensions to the PacketCable architecture to support a wide range of IP-based multimedia services.

The PacketCable Event Messages framework is a flexible and extensible model that supports subscriber billing, settlements, and other back office functions. Going forward, the PacketCable Event Messages framework will be expanded to keep pace with a wide variety of IP-based services beyond voice that will be delivered over the PacketCable service delivery platform.

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