OpenCable Specifications
Home Networking 2.0

Reserved Services Domain Technology Specification

OC-SP-RSD-TECH-I01-080630

ISSUED

Document Status Sheet

Document Control Number:	OC-SP-RSD-TECH-I01-080630			
Document Title:	Reserved Services Domain Technology Specification			
Revision History:	I01 – Released 6/30/08			
Date:	June 30, 2008			
Status:	~~Work in Progress~~	~~Draft~~	**Issued**	~~Closed~~
Distribution Restrictions:	~~Author Only~~	~~CL/Member~~	~~CL/ Member/ Vendor~~	**Public**

Key to Document Status Codes

Work in Progress	An incomplete document, designed to guide discussion and generate feedback that may include several alternative requirements for consideration.
Draft	A document in specification format considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.
Issued	A stable document, which has undergone rigorous member and vendor review and is suitable for product design and development, cross-vendor interoperability, and for certification testing.
Closed	A static document, reviewed, tested, validated, and closed to further engineering change requests to the specification through CableLabs.

Trademarks

Contents

Figures

Tables

1 SCOPE

1.1 Introduction and Purpose

The cable industry would like to provide interactive cable services to customers on various in-home devices connected using IP-based home networks. This includes a myriad of devices, such as IP-STBs, personal computers, portable media devices, cellular telephones, etc. It is critical to ensure that a quality user experience is maintained when distributing cable content and services over the home network. Some important cable services that are being considered to be offered over the home network include:

- Multi-room digital video recording
- High definition content
- Switched digital broadcast (SDB)
- Electronic Program Guide (EPG)
- Interactive applications (OCAP)
- Video on Demand (VOD)

Reserved Services Domain (RSD) is a collection of networked devices that are capable of supporting reservation of network resources (bandwidth, delay, etc.) needed for various cable operator and user services and applications. The general purpose (e.g., Ethernet / WiFi based) home network in a customer's home may not be able to support reservation of network resources, but may be capable of supporting prioritized Quality of Service (QoS). Such general purpose home networking is termed as Prioritized Services Domain (PSD). Devices in the RSD need to implement a home networking technology that meets cable operator requirements for bandwidth and resource reservation to ensure quality of the user experience for services offered over the home network. Such home networking technology is termed RSD Technology.

1.2 Purpose of Document

This specification identifies technical requirements that need to be met by a home networking technology implemented by a device for it to be part of the RSD. The intent of this specification is to facilitate innovation and competition in the marketplace for RSD technologies and to ensure that cable operators and their customers have multiple choices for the RSD technology. Devices that intend to participate in the RSD will be tested against the requirements identified in this specification.

1.3 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

"SHALL"	This word means that the item is an absolute requirement of this specification.
"SHALL NOT"	This phrase means that the item is an absolute prohibition of this specification.
"SHOULD"	This word means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.

"SHOULD NOT"	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
"MAY"	This word means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2 REFERENCES

2.1 Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references.

[HNP 2.0] OpenCable Home Networking Protocol 2.0, OC-SP-HNP2.0-I01-080418, April 18, 2008, Cable Television Laboratories, Inc.

[UQD 3.0] UPnP QoS Device Service 3.0, Proposed DCP, June 27, 2008.

[UQM 3.0] UPnP QoS Manager Service 3.0, Proposed DCP, June 27, 2008.

[UQPH 3.0] UPnP QoS Policy Holder Service 3.0, Proposed DCP, June 27, 2008.

2.2 Informative References

This specification uses the following informative references.

[CEP2.0] Content Encoding Profiles 2.0, MD-SP-VOD-CEP2.0-I02-070105, January 5, 2007, Cable Television Laboratories, Inc.

[DRFI] Downstream RF Interface Specification, CM-SP-DRFI-I06-080215, February 15, 2008, Cable Television Laboratories, Inc.

[DTCP] Digital Transmission Copy Protection Specification, DTCP, Revision 1.51, October 1, 2007, DTLA.

[PHYv3.0] DOCSIS 3.0 Physical Layer Interface Specification, CM-SP-PHYv3.0-I07-080522, May 22, 2008, Cable Television Laboratories, Inc.

[RFC 2212] IETF RFC 2212, Guaranteed Quality of Service, September 1997, Internet Engineering Task Force.

[RSD PROT] Reserved Services Domain Protocol Specification, OC-SP-RSD-PROT-D01-080404, April 4, 2008, Cable Television Laboratories, Inc.

2.3 Reference Acquisition

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027;
  Phone +1-303-661-9100; Fax +1-303-661-9199; http://www.cablelabs.com
- Internet Engineering Task Force (IETF) Secretariat, 46000 Center Oak Plaza, Sterling, VA 20166, Phone +1-571-434-3500, Fax +1-571-434-3535, http://www.ietf.org
- DTLA, www.dtcp.com
- UPnP, www.upnp.org

3 TERMS AND DEFINITIONS

This specification uses the following terms:

Reserved Services Domain	A collection of networked devices that are capable of supporting reservation of network resources (bandwidth, delay, etc.) needed for various cable operator and user services and applications.
Prioritized Service Domain	A general purpose (e.g., Ethernet / WiFi based) home network in a customer's home that does not support reservation of network resources, but may be capable of supporting prioritized Quality of Service (QoS).
RSD Technology	A home networking technology that meets cable operator requirements for bandwidth and resource reservation to ensure quality of the user experience for services offered over the home network.
Certified RSD Technology	A home networking technology implementation in a product that is certified against this RSD Technology Specification.

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations:

DTCP	Digital Transmission Copy Protection
DVR	Digital Video Recorder
EPG	Electronic Program Guide
HD	High Definition
IP	Internet Protocol
MAC	Media Access Control
OCAP	OpenCable Application Platform
PER	Packet Error rate
PSD	Prioritized Service Domain
QoS	Quality of Service
RSD	Reserved Services Domain
RTP	Real Time Protocol
SDB	Switched Digital Broadcast
STB	Set-top box
UDP	User Datagram Protocol
VOD	Video On Demand

5 TECHNICAL OVERVIEW

5.1 RSD Architecture

The Reserved Services Domain consists of the following logical entities.

- RSD Manager
- RSD Host
- RSD Bridge
- PSD Bridge

The RSD Manager [RSD PROT] is a logical entity that is responsible for managing network resources (e.g., bandwidth, delay, etc.) on an RSD technology to ensure quality of the user experience for services offered by cable operators. The RSD Manager entity implements UPnP QoS Manager [UQM 3.0] and UPnP QoS Policy Holder Services [UQPH 3.0]. The RSD Manager stores cable operator QoS policies communicated to it from the headend and enforces QoS on the RSD Technology according to these policies.

Client devices residing in the RSD implement RSD Host functionality [RSD PROT]. RSD Host functionality mainly is composed of UPnP QoS Device Service [UQD 3.0]. The RSD Manager communicates with the RSD Host devices using UPnP QoS messaging protocol to establish QoS for various streams on the RSD.

Cable operators are also interested in offering services that allow customers to stream their personal content (e.g., pictures, video, music, etc.) stored on PSD devices to the devices in the RSD. This is accomplished using a PSD bridge that bridges traffic between PSD and RSD [RSD PROT].

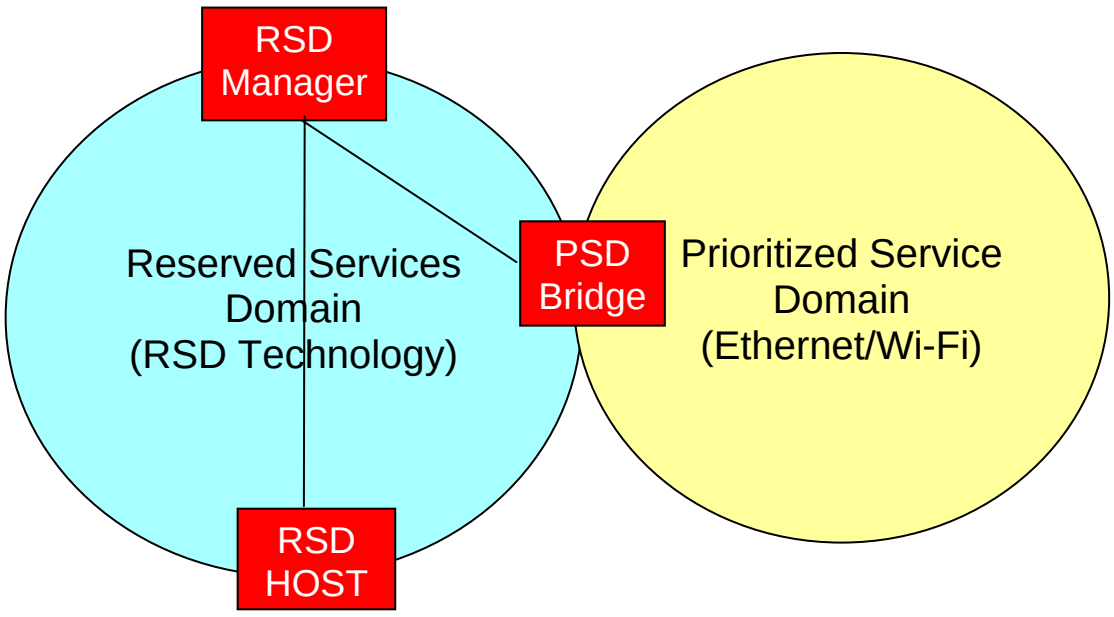

Figure 1 - High Level RSD Architecture

It is possible that a customer has devices with different RSD technologies in the home. To ensure that the customer enjoys cable operator services with quality user experience across such heterogeneous home networking technologies, it is necessary to specify a bridging functionality between various RSD home networking technologies. This functionality is referred to as an RSD Bridge [RSD PROT].

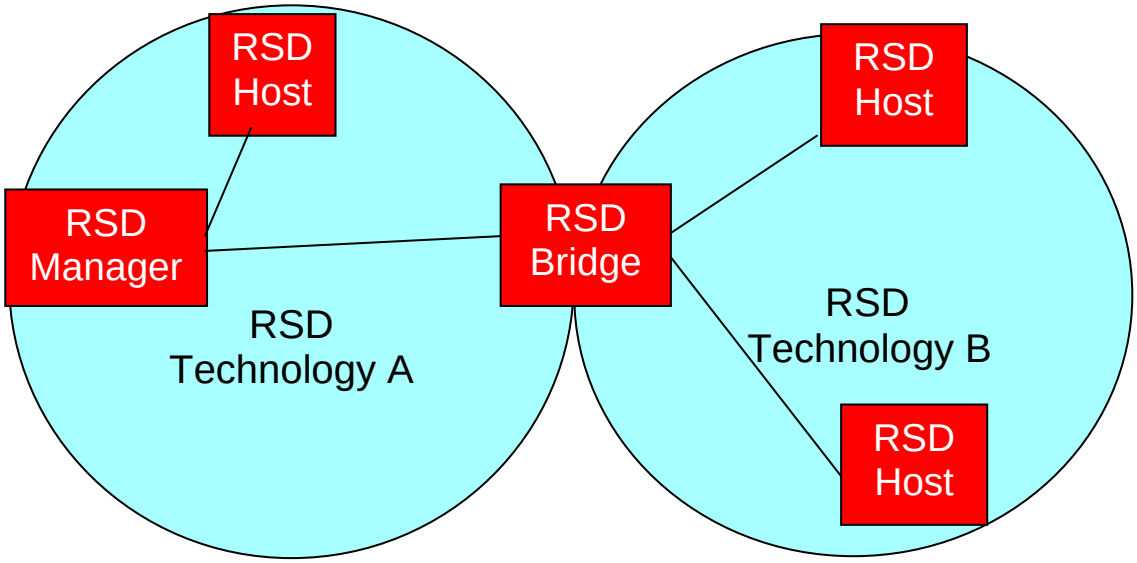

Figure 2 - RSD Bridge

6 TECHNICAL REQUIREMENTS

This section identifies technical requirements that are required to be met by an RSD Technology.

6.1 Network Resource Reservation

When offering cable services over the home networks, it is necessary to ensure the same quality user experience of traditional cable services. Hence, it is critical that the home networking technology used for distributing content around the home is able to reserve network resources (bandwidth, delay, jitter, etc.) dedicated for a particular content stream. Once network resources are allocated for a content stream, any other traffic on the media should not interfere with the content stream for which network resources are already allocated.

The RSD Technology SHALL support the parameters of Table 1 in the request for network resource reservation for an individual traffic stream. The RSD Host is required to supply the following mandatory RSD QoS parameters in the QoS request to the RSD Technology.

Table 1 - Mandatory RSD QoS Parameters

#	QoS Parameter	Description
1	Data Rate (r)	This integer field specifies the average data rate, in units of bytes per second, for transport of IP packets belonging to the traffic stream [RFC 2212]. The Data Rate represents the long-term behavior of the traffic stream. The average should be measured over an interval that is long enough (preferably, the entire duration) to represent the average rate over the duration of the traffic stream. See [UQM 3.0] for more details on the Data Rate parameter.

2	Peak Data Rate (p)	This integer field specifies the maximum allowable data rate in units of bytes per second, for transfer IP packets belonging to a traffic stream. The Peak Data Rate (p) characterizes the instantaneous burstiness of the traffic source [RFC 2212].
		If (p) is the peak rate in bytes/s, then the maximum amount of data transmitted from the traffic source on the RSD Technology in any time interval, [t1,t2] seconds, does not exceed p*(t2-t1) bytes, where t2>t1 and (t2-t1) > time required for transmission of a single packet. But interval [t1,t2] should not be too long either, because the longer the interval, the closer the Peak Data Rate (p) approaches the Data Rate (r).
		The main purpose of Peak Data Rate is to define an upper bound on the data rate at which this traffic stream needs to be served.
		If the application doesn't explicitly specify this value, then RSD Host sets this value to Data Rate parameter supplied by the application.
		If (p) is the peak rate in bytes/s, the RSD HOST needs to ensure that the maximum amount of data transmitted in any time interval, [t1,t2] seconds, does not exceed p*(t2-t1) bytes for the traffic stream, where t2>t1 and (t2-t1) > time required for transmission of a single packet.
		See [UQM 3.0] for more details on the Peak Data Rate parameter.

#	QoS Parameter	Description
3	Maximum Burst Size (b)	This integer field specifies the maximum burst, in units of octets (bytes), of the IP packets belonging to a traffic stream that is sent by the traffic source at the PeakDataRate [RFC 2212]. This parameter characterizes the long-term accumulative burstiness of the traffic source. If ® is the Data Rate, (p) is the Peak Data Rate, and (b) is the Maximum Burst Size, then the maximum amount of data sent by the traffic source into the RSD Technology in any time interval, [t1,t2] seconds, does not exceed r*(t2-t1)+b bytes, where t2>t1, and (t2-t1) > time required for transmission of a single packet. The main purpose of Maximum Burst Size parameter is that it defines an upper bound on the buffer size if the traffic stream is served at a service rate between Data Rate (r) and Peak Data Rate (p). If the buffer is at least b, packets need not be dropped. This is an essential parameter to characterize bursty traffic such as Variable Bit Rate (VBR) video traffic generated from a DVD source. If the application supplies a value of 0 to RSD Host, then it indicates that there are no bursts and a traffic stream is a Constant Bit Rate(CBR) stream, i.e., Peak Data Rate (p) = Data Rate (r). In this case, buffer size is determined based on the QosSegmentMaxJitter parameter identified below. See [UQM 3.0] for more details on the Maximum Burst Size parameter.
4	Maximum Packet Size (M)	This integer field specifies the maximum size, in units of octets, of the IP packets belonging to the traffic stream [RFC 2212]. If the application doesn't specify this value, the default value for this parameter is 1500 bytes. See [UQM 3.0] for more details on the Maximum Packet Size parameter.
5	QosSegmentMaxDelayHigh	The QosSegmentMaxDelayHigh parameter defines an upper bound on the delay experienced by packets belonging to a traffic stream on the RSD Technology Segment. The QosSegmentMaxDelayHigh parameter is defined in [UQM 3.0].The QosSegmentMaxDelayHigh parameter is measured in milliseconds.
6	QosSegmentMaxJitter	The QosSegmentMaxJitter parameter defines an upper bound on the jitter experienced by packets belonging to a traffic stream on the RSD Technology Segment. The QosSegmentMaxJitter parameter is defined in [UQM 3.0] The QosSegmentMaxJitter parameter is measured is milliseconds. In case of CBR streams, this parameter is useful in identifying buffer size requirements on a sink device or on an intermediate device.

The RSD Technology SHOULD support the parameters in Table 2 in the request for network resource reservation for an individual traffic stream. An RSD Host optionally supplies the following RSD QoS parameters in the QoS request to the RSD Technology.

Table 2 - Optional RSD QoS Parameters

#	QoS Parameter	Description
1	Minimum Packet Size (m)	This integer field specifies the minimum size, in units of octets, of the IP packets belonging to the traffic stream [RFC 2212]. If the application doesn't specify this value, the default value for this parameter is 1500 bytes.

If an RSD Host specifies QosSegmentMaxDelayHigh parameter in the layer-2 QoS request and the request is successful, then the RSD Technology SHALL deliver packets from the transmitting device to the receiving device with delay less than or equal to the QosSegmentMaxDelayHigh parameter, provided the traffic source transmits the data such that it meets the equations for Data rate [r*(t2-t1)+b] and Peak Date Rate [p*(t2-t1)] for any time interval [t1, t2], where t2>t1, with m<=(packet sizes)<=M.

If the RSD Technology only supports a fixed amount of delay by design, then the RSD Technology SHALL compare the QosSegmentMaxDelayHigh parameter requested by the RSD Host with the fixed design delay that it can provide in deciding whether to accept or reject the request.

If an RSD Host does not supply QosSegmentMaxDelayHigh parameter, the RSD Technology SHALL deliver packets from transmitting device to receiving device in any finite time duration, provided the traffic source conforms to the Peak Data Rate and Data Rate equations above.

If the traffic source exceeds the Peak Data Rate and Data Rate equations, then the RSD Technology MAY delay or discard excess packets.

If a layer-2 QoS request made by the RSD Host for a traffic stream is successful, then the RSD Technology SHALL return to the RSD Host an identifier for the successfully established reservation for the traffic stream. This identifier SHALL be unique between the RSD Technology nodes. RSD Host uses this information for generating Layer-2StreamId [RSD PROT].

When the RSD Host queries for availability of resources for a traffic stream, the RSD Technology SHALL return values for all the mandatory QoS parameters (identified in Table 1) that can be supported for the traffic stream at that point. When the RSD Host queries for availability of resources for a traffic stream, the RSD Technology SHOULD return values for all the mandatory QoS parameters (identified in Table 2) that can be supported for the traffic stream at that point. The RSD Host issues such a query in response to the GetExtendedQosState action invoked by the RSD Manager for a specific traffic stream. The RSD Host returns these parameters to RSD Manager using ProtoTspec structure [RSD PROT]. See [RSD PROT] for more details on how RSD Manager utilizes ProtoTspec parameters.

If a layer-2 QoS request made by the RSD Host for a traffic stream with set QoS parameters fails, then the RSD Technology SHALL return values for all the mandatory QoS parameters (identified in Table 1) that can be supported for the traffic stream at that point. If a layer-2 QoS request made by the RSD Host for a traffic stream with set QoS parameters fails, then the RSD Technology SHOULD return values for all the optional QoS parameters (identified in Table 2) that can be supported for a traffic stream at that point. The RSD Host returns these parameters to RSD Manager using ProtoTspec structure [RSD PROT]. See [UQM 3.0] and [UQD 3.0] for more details on how RSD Manager utilizes ProtoTspec parameters.

The RSD Manager utilizes the information returned in the ProtoTspec structure in deciding per-segment distribution of end-to-end QoS parameters (e.g., QosSegmentMaxDelayHigh) for a stream and subsequent invocation of QoS requests for the stream [RSD PROT].

The RSD Technology SHALL inform the RSD Host about a traffic stream for which the source sends traffic at a data rate more than the Peak Data Rate (p).

The RSD Technology SHALL support traffic prioritization for non reservation-based streams with minimum of two priority levels.

The RSD Technology SHALL support roundtrip delay needed for DTCP/IP [DTCP] control messages.

6.2 MAC Throughput Data Rate

Cable operators have identified that, as a part of their multi-room video service offering using home networks, users should be able to watch at least three simultaneous HD streams. In addition, users should be able to use trick modes while watching their HD streams. Thus, there would be at least three cable operator STBs with at least one tuner in each of the STBs. However, not all of the STBs would have storage (or DVR) capability in them.

In a typical deployment scenario, there would be only one STB with storage capability and two STBs without storage capability. In such a scenario, when a user is performing trick modes for an HD stream using an STB with storage capability, no home network bandwidth would be utilized, as the STB would be using local resources such as tuner and hard drive. However, when a user is performing trick modes for an HD stream on an STB without storage capability, the STB without storage uses the hard drive in the STB with storage as a remote time shift buffer over the home network, i.e., the HD program is streamed over the network from a STB to a remote hard drive for time shifting and then again streamed from hard-drive to the STB for actual playback. Such remote time shift buffer functionality utilizes twice the amount of bandwidth needed for a single HD stream.

Thus, the maximum home network bandwidth needed to support three simultaneous HD streams in this typical deployment scenario (one HD stream using local time shift buffer and two HD streams using remote time shift buffer) is four times the maximum bandwidth needed for a single HD stream. Maximum bandwidth requirement for a single, compressed HD stream is estimated to be 20 Mbps [CEP2.0]. In order to ensure quality of the user experience, it is necessary to provide parameterized QoS for these HD streams flowing over the home network. Accordingly, the RSD Technology needs to support minimum bandwidth of 80 Mbps for parameterized flows.

Since there will always be some general purpose best effort traffic or prioritized traffic for other services, the RSD Technology needs to have some additional bandwidth to support such traffic streams as well.

The RSD Technology SHALL provide effective MAC throughput data rate of at least 100 Mbps to support all types of streams (parameterized, prioritized, and best effort).

6.3 Interaction with higher layer QoS Management Protocols

Even if the RSD home networking technology has sufficient bandwidth to carry at least three HD streams, it is likely that multiple concurrent streams may completely saturate the entire bandwidth provided by the RSD Technology. When a customer tries to start a new stream in this scenario, the RSD Manager needs to implement appropriate contention resolution mechanisms based on policies configured by the cable operator. This may include preempting an existing stream with user indication, reducing bandwidth allocated to an existing or new stream, or giving a “busy” signal to a new stream. Such contention resolution mechanisms are implemented by the RSD Manager [RSD PROT] using UPnP QoS Specifications [UQPH 3.0] and [UQM 3.0]. In order to implement such contention resolution mechanisms by the RSD Manager, the RSD home networking technology is required to implement appropriate interfaces to UPnP QoS protocol.

The RSD Technology implemented on the RSD Host SHALL be identifiable using a MAC address.

The RSD Technology SHALL be able to translate UPnP QoS Device Service [UQD 3.0] actions invoked on the RSD Host to its native layer-2 QoS requests.

6.4 Interoperability between RSD Technologies

It is more than likely that the customer's home network is composed of devices that implement different RSD technologies. In this scenario, to ensure homogenous service, it is necessary to ensure that there is interoperability among the approved/Certified RSD Technologies. If the source device is on one RSD Technology segment and the sink device on another RSD Technology segment, then it is necessary that the QoS requests from one RSD technology get appropriately propagated and translated to another RSD technology so that resources needed for that stream are reserved end to end. The RSD Bridge [RSD PROT] element provides such QoS translation functionality.

When operating in the presence of a Certified RSD Technology, the RSD Technology SHALL be able to meet all the requirements identified in this specification.

When operating in the presence of a Certified RSD Technology, the RSD Technology SHALL NOT interfere with the operation of the Certified RSD Technology such that it results in violation of this specification by the Certified RSD Technology.

Special bridges, adapters or filters may be needed to ensure that products implementing two different RSD Technologies using the same physical medium or different media can co-exist.

The RSD Technology SHALL be able to bridge traffic to Certified RSD Technologies by maintaining the network resource requirements (e.g., bandwidth, delay, etc.) for a stream across the two RSD technologies.

6.5 Preventing Harm to Service

In order for cable to honor its agreements with content providers, and in order for cable to compete effectively against other content distribution methods as a service provider, cable services need to be delivered as intended.

RSD Technology SHALL support transmission of packets using media transport protocols specified (both mandatory and optional) in [HNP 2.0].

For a transport protocol that doesn't perform retransmissions (e.g., RTP, UDP, etc.), the RSD Technology SHALL support the packet error rate (PER) of 1e-5 or less. This number provides for a quasi-error-free video transmission using RTP.

RSD Technology SHALL support mechanisms for isolating services offered using the RSD Technology from one RSD Technology segment to another. (e.g., point of entry filter for coax-based RSD technology). This is mainly intended to isolate services between the subscriber homes when the same physical medium is shared across the homes (e.g., in case of multi-dwelling units). Thus, RSD Technology is required to provide some way of preventing signals either from spilling over to the neighbor's home or from getting intercepted. It can be either a physical or logical mechanism.

RSD Technology SHALL NOT interfere with cable services offered in the frequency spectrum from 5MHz to 1002 MHz on the in-home coax wiring. The following sections identify detailed requirements for an RSD Technology that uses in-home coax wiring.

6.5.1 Requirements for Coax-Based RSD Technology

The key impairments and parameters will be described in each section, and, where possible, an example using the DOCSIS specification will be given. Detailed DOCSIS parameters and measurements are available in [PHYv3.0] and [DRFI].

6.5.1.1 Upstream Frequency Band

The following requirements are applicable to the upstream frequency band of 5 MHz to 42 MHz, or if the optional upper frequency is implemented, the requirements are applicable to the frequency band of 5 MHz to 85 MHz.

6.5.1.1.1 Between Bursts

When RSD technology is not transmitting, the noise contribution measured in the transmit bandwidth SHALL be at least 72 dB less than the transmit level in the channel, in the adjacent channels, or elsewhere in the upstream frequency, so that there is no measurable impairment to the upstream cable services resulting in packet loss.

This parameter is derived from the DOCSIS specification.

6.5.1.1.2 Adjacent Channel Spurious Emissions

Spurious emissions from a transmitted carrier of an RSD Technology may occur in an adjacent channel, which could be occupied by a carrier of cable services. It is necessary to ensure that the RF level of such adjacent channel spurious emissions does not cause a measurable impairment to the cable services on those adjacent carriers.

The spurious emissions in an adjacent channel of any RSD Technology carrier in the upstream band SHALL NOT measurably impair upstream cable services.

In DOCSIS, the upstream carriers can be selected from multiple widths, so there are multiple measurements to make. Each measurement is made in an appropriately sized adjacent channel bandwidth at a specified offset from the carrier while the cable modem is transmitting a burst.

6.5.1.1.3 Spurious Emissions Elsewhere in the Upstream Frequency Range

Spurious emissions from a transmitted carrier of an RSD Technology may occur in places other than just the adjacent channel. Among the typical type of emissions are the second and third order harmonics, clock spurs, and modulator artifacts. These emissions must be kept low enough so that they will not measurably impair upstream cable services.

Spurious emissions from an RSD Technology carrier elsewhere in the Upstream Frequency range of 5 MHz to 42 MHz or 5 MHz to 85 MHz, as appropriate, SHALL NOT measurably impair upstream cable services.

In DOCSIS, the upstream carriers can be selected from multiple widths, so there are multiple measurements to make. Each measurement is made in an appropriately sized channel bandwidth at a specified offset from the carrier that places the measurement interval outside the adjacent channels (already measured above) while the cable modem is transmitting a burst. Non-overlapping measurements should be performed to the edges of the upstream bandwidth.

6.5.1.2 Downstream Frequency Band

6.5.1.2.1 Adjacent and Higher Frequency Channel Spurious Emissions

An RSD Technology that places carriers adjacent to or above the upper frequency limit (870 MHz or 1002 MHz) SHALL NOT cause the in-channel interference of any lower frequency channel to rise above -45 dBmV in a 6 MHz bandwidth.

This parameter is derived from the [DRFI] specification.

6.5.1.2.2 RSD Carriers in the Downstream Frequency Range

RSD Technology devices SHALL NOT transmit in the downstream frequency range of 54 MHz to 1002 MHz.

6.6 Diagnostics and Remote Management

Cable operators plan on offering paid premium content services using RSD technologies in a customer's home. In order to enable cable operators to troubleshoot any issues in the home network that may hamper their service offering, and for ongoing monitoring of the home network to ensure reliable and quality delivery of their service, it is necessary that cable operators can remotely manage and monitor the devices that implement RSD technology. This requires that the RSD technology exposes appropriate management objects that allow MSOs to monitor and manage various aspects of the home network such as resource availability, device connectivity, link status, etc.

RSD Technology SHALL support the management/configuration (Read-Write) parameters as identified in Table 3. The RSD Technology SHALL support management of the following parameters via SNMP MIB interface and using OCAP applications.

Table 3 - RSD Technology Management Parameters[1]

#	Management/ Configuration Parameter	Description
1	Operating Channel(s)/Frequency	Channel/Center frequency to be used by an RSD Technology node.
2	Maximum Transmit Power	Maximum power level, in dBmV, used by an RSD Technology node.
3	Maximum Percentage of Parameterized Bandwidth	Maximum percentage of the total available bandwidth that can be made available for reservation-based (parameterized) traffic streams.
4	Minimum Parameterized Bandwidth	Minimum amount of bandwidth that needs to be made available for parameterized traffic flows.
5	Reset	A boolean parameter that is used to enable or disable the RSD Technology interface on the RSD Host. The value "1" is used to "Enable" the RSD Technology interface, and the value "0" is used to "Disable" the RSD Technology interface.
6	Enable Privacy	A boolean parameter used to enable or disable privacy (link layer encryption) on the RSD Technology.
7	Privacy Credentials (PWD/Key)	A Password or a key used for encrypting data sent over the RSD Technology using a technology-specific encryption algorithm, when encryption is enabled.

The RSD Technology node SHALL operate at a Channel/Center frequency configured in the Operating Channel(s)/Frequency parameter.

The maximum power transmitted by an RSD Technology node SHALL NOT exceed the configured Maximum Transmit Power parameter.

The percentage of the total bandwidth allocated to reservation-based (parameterized) flows by an RSD Technology SHALL NOT exceed the configured Maximum Percentage of Parameterized Bandwidth parameter. The actual upper bound of this maximum percentage may vary depending on a technology, but is typically between 70-90%.

The RSD Technology SHALL allocate the leftover bandwidth (i.e., bandwidth remaining after allocating needed bandwidth for parameterized flows) to non-reservation-based traffic streams (i.e., for best effort or prioritized streams, including the control traffic).

[1] Some of the parameters identified in here may not be applicable for some technologies.

The bandwidth allocated for parameterized flows by an RSD Technology SHALL be at least equal to the configured Minimum Parameterized Bandwidth parameter.

The RSD Technology SHALL ensure that layer-2 and layer-3 network control traffic (e.g., UPnP QoS messages and RSD Technology specific messages for layer-2 QoS set-up) is always forwarded, irrespective of the bandwidth occupied by parameterized and non-parameterized traffic flows at any point in time. One way to achieve this is to leave aside a certain percentage of its total bandwidth for layer-2 and layer-3 network control traffic.

RSD Technology SHALL support the diagnostic/monitoring (Read-Only) parameters as identified in Table 4.

Table 4 - RSD Technology Mandatory Diagnostic Parameters

#	Diagnostic Parameters	Description
	QoS Specific Parameters	
1	Per Stream Packets Dropped[2]	This parameter reports total number of dropped packets of a parameterized traffic stream identified by a Layer-2StreamId over a specified time period.
2	Per Stream Packets Transmitted	This parameter reports total number of packets transmitted of a parameterized traffic stream identified by a Layer-2StreamId over a specified time period.
3	Per Stream Packets Received	This parameter reports total number of packets received of a parameterized traffic stream identified by a Layer-2StreamId over a specified time period.
4	Peak Data Rate Violation	This parameter indicates if the source is exceeding specified peak data rate for a traffic stream over a specific period of time.
5	Total Parameterized Bits Allocated	This parameter reports total number of bits of all parameterized streams over a specified period of time. This parameter, in conjunction with Total Bits parameter below, provides information on bandwidth allocated by a layer-2 technology to parameterized streams vs. bandwidth allocated to prioritized/best-effort flows. If a parameterized stream can't be added because bandwidth allocated to parameterized flows is saturated, a service provider may instruct the layer-2 technology to increase the bandwidth allocated to parameterized streams.
6	Total Parameterized Packets Dropped	This parameter reports total number of packets dropped for all the parameterized streams in the Observation period. By monitoring this parameter, a service provider can detect if a layer-2 technology is suffering noise/interference issues.
7	Total Bits	This is total number of bits of all streams (best effort, prioritized and parameterized) over a specific period of time.
	Generic Parameters	
1	Technology Type	IANA technology type of the RSD Technology.
2	Highest Version	Identifies the highest version of the RSD Technology that is supported by this interface.
3	Current Version	Identifies the version of the RSD Technology that the interface is currently running.
4	Operating Status	A Boolean parameter that indicates if the RSD Technology is in the active (1) or inactive(0) state.
5	Uptime	Time in secs for which the RSD Technology is continuously in the active state.

[2] RSD Technology node may only be able to provide information about streams for which the node is on the path.

#	Diagnostic Parameters	Description
6	MAC address	MAC address assigned to the RSD Technology interface on a device.
7	Layer2Scheduler	This Boolean parameter indicates whether this particular node (RSD Host) is a layer-2 scheduler for the RSD Technology at the time of reporting this parameter. An RSD Technology node sets this parameter to true if it is a layer-2 scheduler for the RSD Technology; otherwise, sets this parameter to false.
8	Last Operating Frequency/Channel	The channel/frequency (in MHz) to which the interface was tuned when last in the LinkUp state.
9	Supported Channels	This is a list identifying RSD Technology channels supported by a particular RSD node. Each channel is represented as tuple of center freq (MHz) and channel width (kHz). Center freq and channel width fields include decimals.
10	Current Channels	This is a list identifying RSD Technology channels currently being used by a particular RSD node. Each channel is represented as tuple of center freq (MHz) and channel width (kHz). Center freq and channel width fields include decimals.
11	Connected Nodes	A list of other nodes with their MAC addresses visible from an RSD Technology interface on a particular node.
12	Packets Received	Number of all incoming packets to the RSD interface since the interface became active.
13	Packets Sent	Number of outgoing packets from the RSD interface since the interface became active.
14	Received Packet Error	Number of packets received in the error state to the RSD Technology interface since the interface became active.
15	TxModulation	A string value indicating type of modulation currently being used by an RSD Technology node for transmitting data to another node.
16	RxModulation	A string value indicating type of modulation currently being used by an RSD Technology node for receiving data from another node.
17	Transmit Link rate between nodes	PHY transmission rate (bits/sec) from an RSD Technology interface of node to another node.
18	Received Link Rate between nodes	PHY reception rate (bits/sec) at an RSD Technology interface of node from another node.
19	Received Signal Strength between nodes	Received signal strength at the RSD Technology interface of a node from another node. This is represented using the following enumerated values: “Very Low”, “Low”, “Good”, “Very Good”, “Excellent”.
20	TxBcastRate	PHY broadcast transmit rate (bits/sec) form RSD Technology interface of a node.
21	RxBcastRate	PHY broadcast receive rate (bits/sec) at the RSD Technology interface of a node.
22	Received Broadcast Signal Strength	Received broadcast signal strength at the RSD Technology interface of a node. This is represented using the following enumerated values: “Very Low”, “Low”, “Good”, “Very Good”, “Excellent”.
23	Transmit Broadcast Power Level	The power level used for transmission of broadcast messages by the RSD node (dBm).

RSD Technology SHOULD support the diagnostic/monitoring (Read-Only) parameters as identified in Table 5.

Table 5 - RSD Technology Optional Diagnostic Parameters

#	Diagnostic Parameters	Description
	QoS Specific Parameters	
1	Per Stream Bits Transmitted	This parameter reports total number of bits transmitted of a parameterized traffic stream identified by a Layer-2StreamId over a specified time period.
2	Per Stream Bits Received	This parameter reports total number of bits received of a parameterized traffic stream identified by a Layer-2StreamId over a specified period of time. This parameter measured at the sink and the StreamBitsTransmitted parameter measured at the source can be used to detect if the packets are being lost on the shared media due to noise/interference issues.
3	Priority-0 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 0 [UQM 3.0] over a specified period.
4	Priority-1 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 1 over a specified period.
5	Priority-2 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 2 over a specified period.
6	Priority-3 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 3 over a specified period.
7	Priority-4 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 4 over a specified period.
8	Priority-5 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 5 over a specified period.
9	Priority-6 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 6 over a specified period.
10	Priority-7 Bits	Total number of bits of all strictly prioritized flows interpreted as TrafficImportanceNumber 7 over a specified period.

6.7 Ease of Set-up and Installation

When cable operators roll out video distribution services using home networks, it is necessary to install home networks that are based on RSD technology. This will be accomplished either through cable operator professional installation or through customer self-installation. In either scenario, in order to save time and money, it is necessary to ensure that devices implementing RSD home networking technology can be installed quickly and easily. The installation mechanism should require minimal modifications to operational and physical set-up of existing devices and equipments in customer's home (e.g., in-home wiring). This requires that the RSD home networking technology support appropriate easy set-up and installation mechanisms.

The RSD Technology device SHALL support pre-provisioning or self-provisioning mechanisms so that it can join the network without any manual intervention.

Installation of devices implementing an RSD Technology SHALL NOT require additional installation equipment (e.g., RF Analyzer, etc.) for proper functioning of the device on the network.

7 ACKNOWLEDGEMENTS

We would particularly like to thank Chris Cholas (Time Warner Cable), Mark Francisco (Comcast) and Labeeb Ismail (Comcast) for providing valuable input in identifying various requirements in the specification and for their detailed review and overall guidance in the development of this specification. We would like to thank Bill Kostka (CableLabs) for his contribution in defining "Harm to Service" requirements for the RSD Technology. We thank Greg White (CableLabs) for his assistance in the areas of resource reservation and diagnostic requirements. We would like to thank Zong Wu (Entropic), Adrian Macias (PulseLink), Ryan Chiang (Cisco) for their thorough review of the overall specification and valuable input in all aspects of the specification. We thank Amol Bhagwat (CableLabs) who led the team working on development of this specification. And finally, many thanks go out to all the members of the OpenCable Home Networking Focus Team who contributed to this specification.