



## Cisco Cable Wideband Architecture

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This chapter explains the architecture used for the Cisco Cable Wideband Solution, Release 1.0. It explains the following topics:

- [Wideband Channel Bonding, page 3-1](#)
- [Modular CMTS, page 3-4](#)
- [Gigabit Ethernet Switch Functionality, page 3-8](#)
- [Edge QAM Device Functionality, page 3-8](#)
- [Wideband Cable Modem Functionality, page 3-9](#)

The DOCSIS 3.0 Downstream Channel Bonding feature is backward compatible with DOCSIS 1.X/2.0 services and networks.

### Wideband Channel Bonding

The DOCSIS 3.0 Downstream Channel Bonding feature uses a selected subset of the DOCSIS 3.0 downstream channel bonding protocol.

With channel bonding, bandwidth is increased by combining or bonding multiple RF channels to create a wideband channel. The DOCSIS 3.0 Downstream Channel Bonding feature affects the CMTS and the cable modem as well as the provisioning and network management systems.

The core of the DOCSIS 3.0 Downstream Channel Bonding feature is the sending of DOCSIS packets for a given service flow across multiple RF channels. The transmit framer in the Cisco Wideband SPA “stripes” the DOCSIS packets for a given flow and transmits them across the multiple RF channels of the wideband channel. When the packets are received at the wideband cable modem, the modem’s receiver framer uses a sequence number embedded in each DOCSIS packet to reassemble the packets into the original flow.

A *wideband channel* is a unique combination of downstream RF channels. The wideband CMTS manages up to 24 wideband channels (12 wideband channels per Wideband SPA). A wideband cable modem joins a wideband channel. Many wideband cable modems can share the same wideband channel.

In this document, the terms *wideband channel*, *bonded channel*, *bonding group* have the same meaning: a logical grouping of one or more physical radio frequency (RF) channels over which MPEG-TS packets are carried.

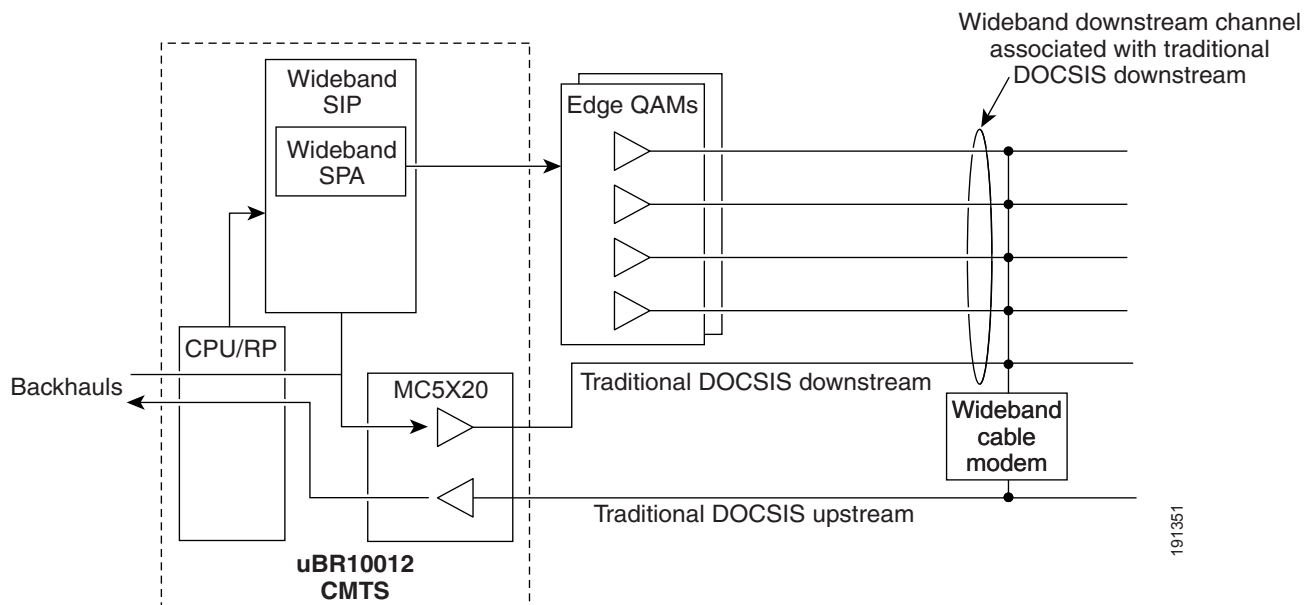
The DOCSIS 3.0 Downstream Channel Bonding feature is overlaid on top of and is transparent to a DOCSIS 2.0 system. In the Cisco Cable Wideband Solution, Release 1.0, these channels are used for wideband operations:

- For the wideband downstream channel, the Wideband SPA uses its Gigabit Ethernet port to send data traffic to the EQAM device. This EQAM device uses one or more QAM output channels, depending on how the wideband channel is configured, to send striped packets to the wideband cable modem. In Release 1.0, channel bonding is used for downstream wideband channels only.
  - With the Linksys WCM300-NA modem, a downstream wideband channel can combine up to eight RF channels for a total bandwidth of up to approximately 292 Mbps (at 6 MHz and 256 QAM).
  - With the Scientific Atlanta DPC2505 modem, a downstream wideband channel can combine up to two RF channels for a total bandwidth of up to approximately 74 Mbps (at 6 MHz and 256 QAM).
- A traditional DOCSIS 2.0 downstream channel is associated with the wideband channel and carries MAC management and signaling messages. The traditional DOCSIS 2.0 downstream channel does not carry any bonded traffic. The traditional DOCSIS downstream channel used in this way is called the *primary downstream channel*.
- A traditional DOCSIS 2.0 upstream channel associated with the primary downstream channel carries return traffic and signaling.

The wideband channel, a primary downstream channel, and an associated upstream channel are configured for each fiber node that provides the wideband channel.

Figure 3-1 shows a wideband channel consisting of four bonded RF channels on the EQAM device. These RF channels are asynchronous and carry only bonded traffic. As shown in Figure 3-1, a traditional DOCSIS 2.0 downstream channel associated with the wideband channel carries MAC layer signaling for the wideband channel. The upstream channel associated with the wideband channel is a traditional DOCSIS 2.0 upstream.

Figure 3-1 Channel Bonding to Create a Wideband Channel



19/351

The Cisco Wideband SPA on the uBR10012 router provides the logical RF channels for the DOCSIS 3.0 Downstream Channel Bonding feature. The service provider uses a customized set of Cisco IOS commands to configure the Wideband SPA for each wideband channel and its associated DOCSIS 2.0 downstream and upstream channels.

## Software Configuration for Fiber Nodes

In a cable network, a fiber node is a point of interface between a fiber trunk and the coaxial distribution. A cable modem is physically connected to only one fiber node. Fiber node software configuration mirrors the physical topology of the cable network. When configuring fiber nodes with Cisco IOS CLI commands, a fiber node is a software mechanism to define the following:

- The set of downstream RF channels that will flow into the fiber node
- At least one primary downstream channel (traditional DOCSIS downstream channel) for the fiber node
- The set of upstream channel ports on the cable interface line card that are connected to the fiber node and available as upstream channels

The DOCSIS 3.0 Downstream Channel Bonding feature requires that a fiber node be associated with at least one primary downstream channel (traditional DOCSIS downstream channel). A fiber node can be associated with more than one primary downstream channel though only one primary downstream channel is used at any given point in time. On the uBR10-MC5X20 cable interface card, each primary downstream channel has an upstream port that is statically associated with the downstream port.

For information on configuring fiber nodes, see the *Cisco uBR10012 Universal Broadband Router SIP and SPA Software Configuration Guide*.

## Virtual Interface Bundling for Primary Downstream Channels and Wideband Channels

The Cisco IOS virtual interface bundling feature is used for the wideband channel and the primary downstream channels. Both the wideband channel and primary downstream channel must be members of the same virtual bundle. Virtual interface bundling prevents loss of connectivity on physical interfaces should there be a failure or problematic insertion and removal (OIR) of one line card in the bundle.

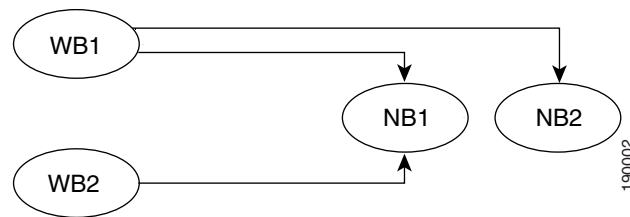
The DOCSIS 3.0 Downstream Channel Bonding feature allows the following scenarios for wideband channel to primary downstream channel association on a fiber node:

1. WCMs on one wideband channel use the same primary downstream channel.
2. WCMs on one wideband channel use different primary downstream channels.
3. WCMs on different wideband channels use the same primary downstream channel.
4. Combinations of scenarios 2 and 3.

Figure 3-2 provides an example of wideband channel to primary downstream channel association on a fiber node.

- Wideband channel WB1 is associated with primary downstream channels PDC1 and PDC2.
- Wideband channel WB2 is associated with only primary downstream channel PDC1.

**Figure 3-2 Wideband Channels and Primary Downstream Channels on a Fiber Node**



A WCM on the fiber node can come online on WB1/PDC1, on WB1/PDC2, or on WB2/PDC1. On the CMTS, WB1, WB2, PDC1, and PDC2 all are members of the same virtual interface bundle.

For information on configuring virtual bundle interfaces, see the *Cisco uBR10012 Universal Broadband Router SIP and SPA Software Configuration Guide*.

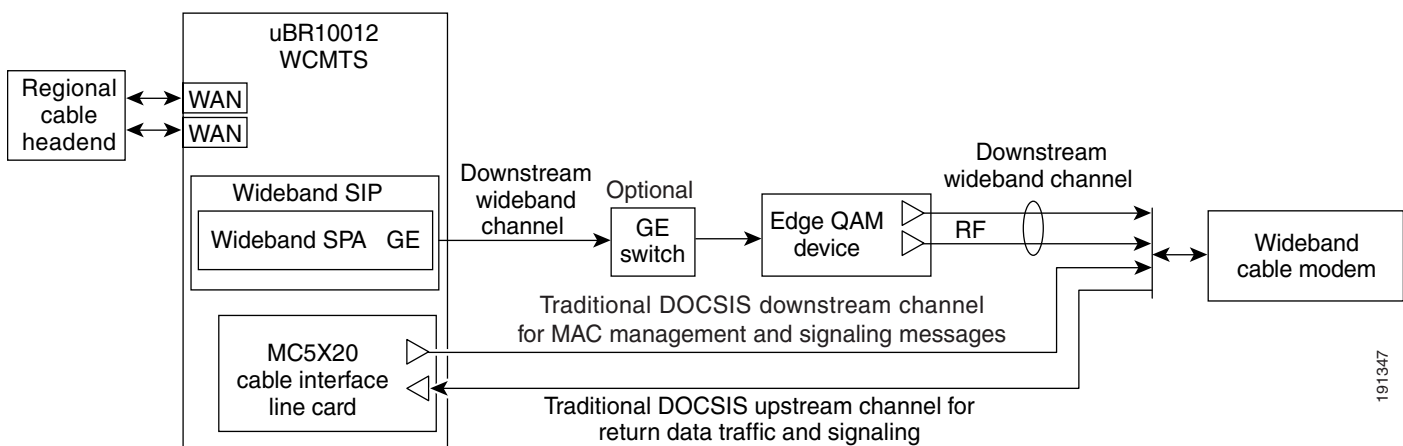
## Modular CMTS

The Cisco Cable Wideband Solution, Release 1.0, uses a variant of the modular CMTS (M-CMTS) architecture. With a modular CMTS architecture, the downstream PHY (physical layer) of the CMTS is located in a separate network element: the edge QAM device. CableLabs defines the M-CMTS architecture, which is one of the DOCSIS specifications. The M-CMTS architecture and wideband (DOCSIS 3.0) channel bonding are closely related technology pieces.

The CableLabs specification for the M-CMTS architecture defines changes to the edge QAM device that require it to be both DOCSIS-aware and synchronized to the DOCSIS subsystem. The Cisco Cable Wideband Solution, Release 1.0, implementation of the M-CMTS architecture does not place these requirements on the edge QAM device.

For a single wideband channel, [Figure 3-3](#) shows the M-CMTS architecture as it is used in the Cisco Cable Wideband Solution, Release 1.0. In this example, two downstream RF channels are bonded together into one wideband channel. The Gigabit Ethernet (GE) switch is optional.

**Figure 3-3 Cisco Cable Wideband M-CMTS Architecture**



In the M-CMTS architecture used for the Cisco Cable Wideband Solution, Release 1.0, traditional CMTS functionality is divided into two network elements as follows:

- *M-CMTS Core*—Contains the traditional functionality of a CMTS except for the downstream PHY. The M-CMTS Core provides CMTS functionality, such as DOCSIS MAC (media access control) and upstream QPSK and QAM demodulation. DOCSIS MAC includes upstream and downstream packet transmission services and MAC management message exchanges with cable modems. In the Cisco Cable Wideband Solution, the Cisco uBR10012 router is the M-CMTS Core device.
- *Edge QAM (EQAM) Device*—Connects to the M-CMTS Core and contains PHY-related hardware, such as QAM modulators. For input, the EQAM device communicates with the M-CMTS through redundant Gigabit Ethernet interfaces. For output, the EQAM device has multiple QAM modulators and RF upconverters that connect to a hybrid fiber coaxial (HFC) network. In the Cisco Cable Wideband Solution, six EQAM devices are tested for interoperability with solution components:
  - Cisco RF Gateway 1
  - Cisco RF Gateway 10
  - Scientific Atlanta Continuum DVP eXtra Dense QAM Array 24 (XDQA24)
  - Harmonic Narrowcast Services Gateway (NSG) 9116
  - Harmonic Narrowcast Services Gateway (NSG) 9000
  - Vecima Networks VistaLynx VL1000

## Benefits of M-CMTS Architecture

Some of the benefits of a modular CMTS architecture are described in these sections:

- [Cost Effective Architecture, page 3-5](#)
- [Multiservice Architecture, page 3-6](#)

### Cost Effective Architecture

The Cisco Cable Wideband Solution, Release 1.0, can use the MSO's existing network. Deployed uBR10012 routers that are used as a DOCSIS 1.x/2.0 CMTS's can be upgraded to a modular CMTS's that support wideband cable by adding on hardware (the Cisco Wideband SIP and SPA) and upgrading software. Some existing external QAM array devices used for video on demand (VOD), with a software upgrade, may be able to be employed as the edge QAM device. For edge QAM devices that have been tested for interoperability, see the "[External Edge QAM Device](#)" section on page 2-11.

MSOs can repurpose their existing network infrastructure, including existing fiber nodes, for wideband cable. The benefits of the M-CMTS architecture include:

- Takes advantage of the lower cost, lower power requirements, and higher density of edge QAM devices.
- Uses less-expensive external QAM arrays for downstream wideband channels. This is more cost effective than locating the downstream QAMs in the CMTS chassis.
- Saves operating costs by avoiding rewiring and moving customers to new systems.

With traditional CMTS architecture, adding downstream RF channels for a wideband channel would mean also adding multiple upstreams. With the M-CMTS architecture, multiple downstream RF channels can be aggregated into a wideband channel without adding any additional upstreams. This independent scaling of downstream channels makes wideband channels economically feasible.

## Multiservice Architecture

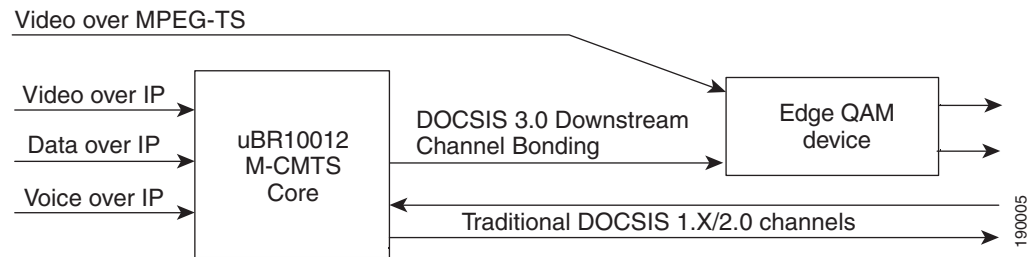
With M-CMTS architecture, the use of external edge QAM devices allows MSOs to use the same network resources for a video on demand (VOD) network and a Cisco wideband cable network. With updated firmware, some edge QAM devices can be used for VOD and for wideband channels though individual output QAM channels in the device cannot be shared.

The wideband channel uses the edge QAM device for downstream data traffic, and uses the M-CMTS's uBR10-MC5X20 cable interface line card for upstream traffic and for downstream MAC management and signaling messages.

In the Cisco Cable Wideband Solution, Release 1.0, traditional DOCSIS 1.X/2.0 services are supported by the CMTS; uBR10-MC5X20 cable interface line cards (not edge QAM devices) are used for these services.

A multiservice architecture (see [Figure 3-4](#)) with converged IP triple play (voice, data, and video services) on wideband channels is the ultimate goal for DOCSIS 3.0 services.

**Figure 3-4 M-CMTS Multiservice Architecture**



### Note

In the Cisco Cable Wideband Solution, Release 1.0, the uBR1012 router currently supports a data-only service on wideband channels. A Cisco Cable Wideband Solution, Release 1.0, system does not currently support video or voice on wideband channels.

## M-CMTS Interactions with Wideband Cable Modems

The following sections provide information on interactions between the M-CMTS and wideband cable modems:

- [MAC Domains, page 3-6](#)
- [Addressing, page 3-7](#)
- [Security, page 3-7](#)
- [Quality of Service, page 3-8](#)

## MAC Domains

A DOCSIS MAC Domain is a logical subcomponent of a CMTS and is responsible for implementing all DOCSIS functions on a set of downstream channels and upstream channels. All MAC Domain operations are performed by the Core CMTS's uBR10-MC5X20 cable interface line cards. A CMTS MAC Domain contains at least one downstream channel and at least one upstream channel. Each downstream channel or upstream channel is contained by a single MAC Domain.

A MAC domain is responsible for all MAC Management Messages to the set of cable modems that are registered on that MAC Domain. A cable modem is registered to only a single MAC Domain.

A MAC Domain provides Layer 2 data forwarding services between the CMTS and the set of cable modems registered to that MAC Domain.

In the downstream direction, the MAC Domain classifies downstream packets into downstream service flows based on Layer 2, 3, and 4 information in the packets. The MAC Domain then schedules the packets from each downstream service flow onto the set of downstream channels of the MAC domain.

The CMTS assigns a downstream service flow to either a single downstream RF channel or to a Downstream Bonding Group for a wideband channel. A downstream sequence of bonded packets is identified at the CMTS and wideband cable modem by a Bonding Group ID (BG ID). Packets destined to different wideband cable modems can share the same Bonding Group ID. The CMTS assigns a downstream service flow to either a single downstream RF channel or to a downstream Bonding Group for a wideband channel.

For the Scientific Atlanta DPC2505 or EPC2505 wideband cable modem, each of the modem's unicast service flows is sent as a bonded group and is tied to the modem's bonded downstream channel. A downstream sequence of unicast bonded packets is identified at the CMTS and the cable modem by a unique Downstream Service Identifier (DSID). Multicast traffic on bonded downstream channels is not supported. Multicast service flows that the modem sees on the bonded downstream channel are discarded.

In the upstream direction, the behavior and handling of traffic by the CMTS is identical to the DOCSIS 2.0 behavior and handling.

## Addressing

All addressing is done with Ethernet and IP addresses. The wideband cable modem uses the same IP address space as a standard cable modem so it is able to use the same DHCP procedure to procure an IP address.

The DOCSIS 3.0 Downstream Channel Bonding feature does not limit the number of wideband cable modems that can exist on a downstream channel. The limit is set either by the availability of bandwidth, or by the 8175 service identifiers (SIDs) limit in DOCSIS 2.0.

Because wideband channels and a traditional DOCSIS channel can be within the same subnet, a wideband cable modem can be moved between services without the need to change the IP address space of the home network.

Since the IP address space is homogeneous, it is not necessary to have a NAT function in the wideband cable modem. The rules for distribution of IP address for a home network with a wideband cable modem are the same as for a DOCSIS 2.0 cable modem.

## Security

A wideband channel uses Baseline Privacy Plus (BPI+) for its link level encryption. As with DOCSIS 2.0, BPI+ provides cable modem users with data privacy across the cable network by encrypting traffic flows between the wideband cable modem and the wideband CMTS. BPI+ also provides MSOs with protection against theft of service.

The wideband cable modem uses the same BPI+ keys on its wideband channels as it does on its traditional DOCSIS channel. The wideband cable modem uses the BPI+ keys negotiated on the primary service flow of the traditional DOCSIS downstream channel for the service flows on the wideband channel.

## Quality of Service

For quality of service (QoS) on a wideband downstream channel, a wideband cable modem can be assigned multiple service flows. Only Best Effort (BE) service flows are currently supported. The CMTS sends data traffic on a non-guaranteed best-effort basis.

For the traditional DOCSIS upstream channel associated with a wideband channel, QoS capabilities supported are identical to those in DOCSIS 2.0.

## Gigabit Ethernet Switch Functionality

The Gigabit Ethernet (GE) switch is an optional device that receives downstream packets from the Cisco Wideband SPA and passes the packets to the edge QAM device. The Gigabit Ethernet switch is used for these purposes:

- To concentrate traffic from multiple Gigabit Ethernet links to a smaller number of Gigabit Ethernet links prior to fiber transport to the edge QAM devices
- To provide 1+1 or N+1 redundancy for downstream Gigabit Ethernet links
- To multiplex wideband DOCSIS traffic and video traffic onto the same edge QAM devices

If more than two EQAM devices are required for two Wideband SPAs, a Gigabit Ethernet switch is needed to connect the SPAs to the EQAM devices.

If video-on-demand (VOD) traffic and the RF channels for wideband channels are mixed on the same EQAM device, a Gigabit Ethernet switch is required.

When an RF channel for a wideband channel is configured using Cisco IOS commands on the uBR10012 router, the **rf-channel** command's **mac-address** argument specifies the MAC address for the next-hop interface on the switch if it is a Layer-2 GE switch. The **rf-channel** command's **ip-address** argument specifies the IP address of the Gigabit Ethernet interface on the edge QAM device. The MAC address on the switch and the IP address on the EQAM device are used to route downstream traffic for the RF channel to the correct destinations.

## Edge QAM Device Functionality

The edge QAM (EQAM) device receives wideband as MPEG-TS over IP on its Gigabit Ethernet interfaces. The edge QAM device extracts the MPEG-TS packets from the MPEG-TS over IP stream and routes them to the proper QAM RF outputs to the HFC plant for transmission to the wideband cable modem.

The edge QAM devices are not involved in the active management of bandwidth or QOS for wideband channels. The edge QAM devices are not aware of the IP addressing used by the wideband cable modems.

A single QAM's total bandwidth can be divided up and statically allocated to more than one wideband channel. When a wideband channel is configured on the CMTS, the wideband channel uses multiple specified logical RF channels on the Wideband SPA. Each RF channel is associated with a QAM output on the edge QAM device. The bandwidth of an RF channel can be divided between one or more wideband channels as long as the total allocated bandwidth for an RF channel (and QAM) does not exceed 100 percent. For more information on configuring RF channels, see the *Cisco uBR10012 Universal Broadband Router SIP and SPA Software Configuration Guide*.



The QAM channels on the edge QAM device do not need to be adjacent. If certain QAM channels have already been assigned to non-DOCSIS uses, the DOCSIS 3.0 Downstream Channel Bonding feature uses the channels that are available. The system does impose certain constraints. For example, if the QAMs are frequency stacked, certain QAMs will have to be adjacent.

## Wideband Cable Modem Functionality

The wideband cable modem is a standalone device capable of interoperation with an industry standard DOCSIS 2.0 compatible CMTS, but it supports wideband operation when used with a wideband CMTS. At any one time, the wideband cable modem operates in one of two ways:

- As a traditional DOCSIS 2.0 cable modem, it receives all downstream traffic as non-bonded traffic on its traditional downstream.
- As a wideband cable modem, it receives all downstream traffic as bonded traffic—a wideband channel consisting of one or more RF downstreams.

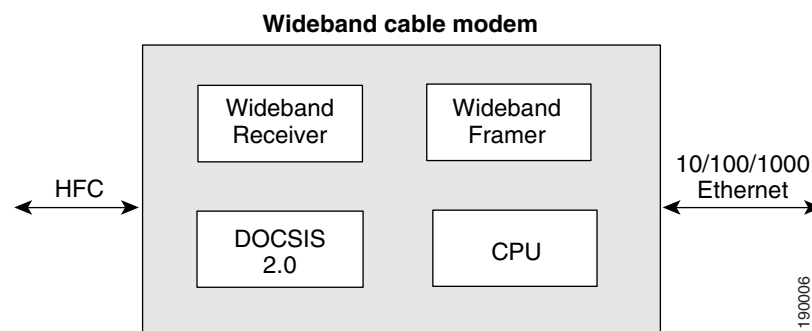
This discussion focuses on the modem's role as a wideband cable modem. The explanations in this section are generic and apply to all wideband cable modems supported by the Cisco Cable Wideband Solution, Release 1.0.

Wideband cable modem functionality may vary depending on the wideband cable modem. For implementation information on specific wideband cable modems, see the [“Wideband Cable Modem Behavior”](#) section on page 4-6.

## Wideband Cable Modem Design and Operation

The wideband cable modem is backward compatible with DOCSIS 2.0 and contains a complete DOCSIS 2.0 core. If a wideband channel is not available, the wideband cable modem can operate strictly as a DOCSIS 2.0 cable modem. [Figure 3-5](#) shows a simplified block view of the wideband cable modem.

**Figure 3-5** Wideband Cable Modem Block View



The wideband cable modem has a wideband receiver that receives the multiple RF channels of a bonded channel. It also has a wideband framer that decodes the signal from the wideband receiver and extracts the packets for the 10/100/1000 Mbps Ethernet home network.

The wideband cable modem identifies itself as being wideband-capable during the configuration process. This allows the DOCSIS TFTP provisioning server to enable or disable wideband mode, and to choose the appropriate configuration parameters.

A wideband channel uses the same DOCSIS frame format as a traditional DOCSIS channel uses. The channel just has more bandwidth. A new extended header for wideband has been added to the DOCSIS protocol. The extended header defines the logical wideband channel and a sequence number that the wideband cable modem uses for re-sequencing the wideband packets.

The CISCO-CABLE-WIDEBAND-MODEM-MIB for the wideband cable modem is supported and is an extension to the existing cable modem MIB.