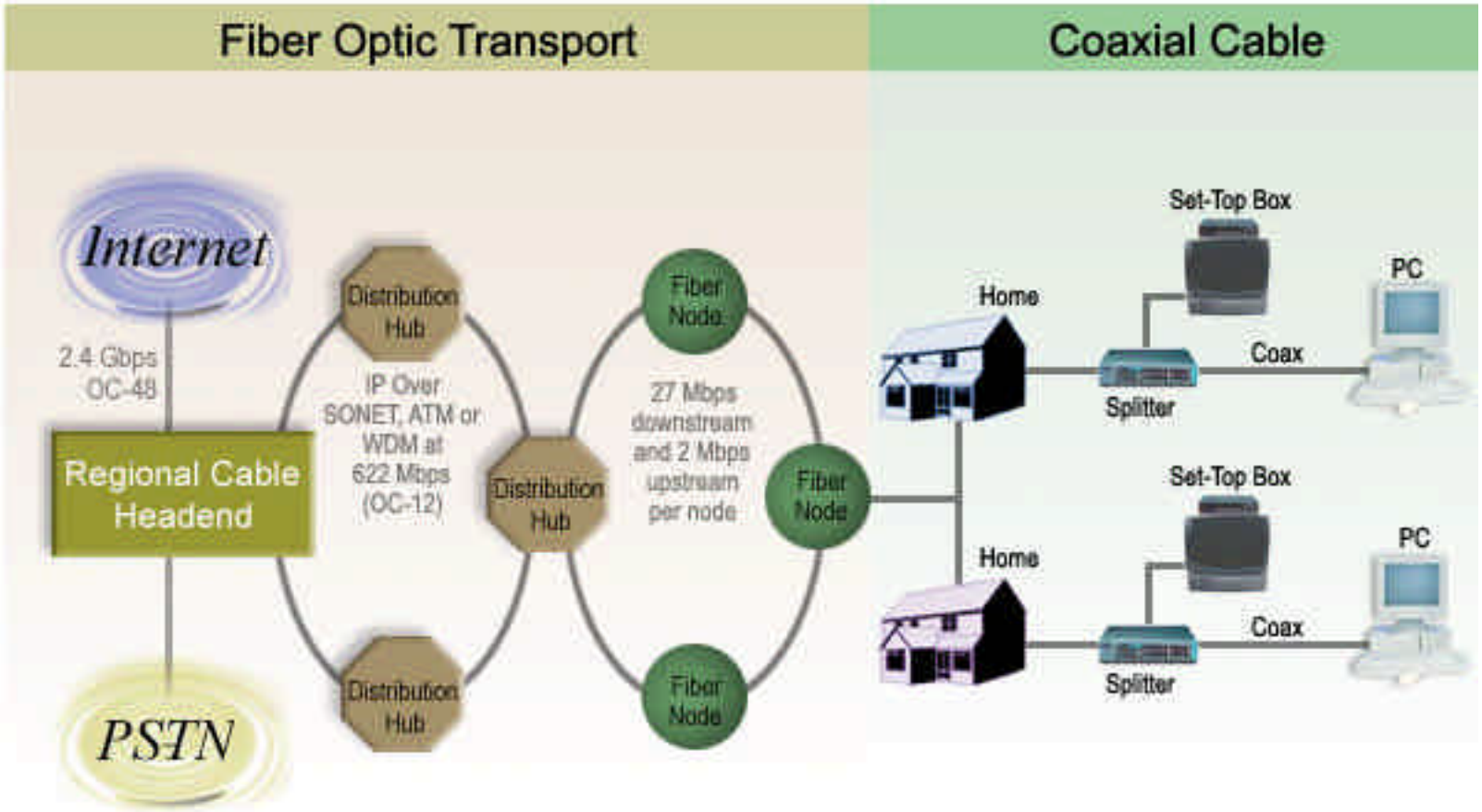
Cable Modems

Cable Modem Overview



Cable

- Internet access on the same cable that delivers regular CABLE (CABLE is short for cable TV (CATV) network)
- Offered by cable companies
- Subscriber uses a cable modem to access this broadband connection
- Potential speeds up to 10Mbps
  - Number of users on the system affects speed

Cable Modems

- Device that allows high-speed data access from a PC to the Internet via a cable TV (CATV) network
- Modem in the true sense of the word
  - Modulates and demodulates signals
  - Delivers Internet data to the desktop at blazing speeds
  - It simply uses the increased bandwidth of the TV cable instead of an ordinary phone line
- Can be part modem, part tuner, part encryption/decryption device, part bridge, part router, part NIC card, part SNMP agent, and part Ethernet hub

Cable Modems

- They typically have two connections
  - One to the cable wall outlet and the other to a PC
- Online access via cable modems provides PC users faster access to online information
  - Up to 1000 times faster than today's fastest telephone modems
  - Cable modem speeds range from 500 Kbps (500,000 bits per second) to 10 Mbps (10 million bits per second)
    - In comparison V.90 56K modems top out at 56,000 bps

Cable Modem - Market Drivers

- Increasing popularity of the Internet
- Increasing demand for high speed access to Internet
- Rapid entrance of AT&T into cable business
- Increasing use of cable modem services by small businesses and SOHOs
- Growth in telecommuting
- Increasing availability of multimedia & interactive applications requiring high-bandwidth capabilities

Cable Modem - Market Drivers

- Cable already passes by the majority of all households
- Cable modems were the first to market and have the largest customer base
- Increasing acceptance of DOCSIS standard
- Increased deployment of hybrid fiber coax systems
- Aggressive marketing of cable modem services stimulates demand

Cable Modem - Market Restraints

- Limited availability of cable modem services to residential customers
- Speed decrease due to shared nature of cable modem services
- Relatively expensive cost of service
- Expensive cost of equipment purchase and installation
- Competition from ADSL services

Cable Modem - Market Restraints

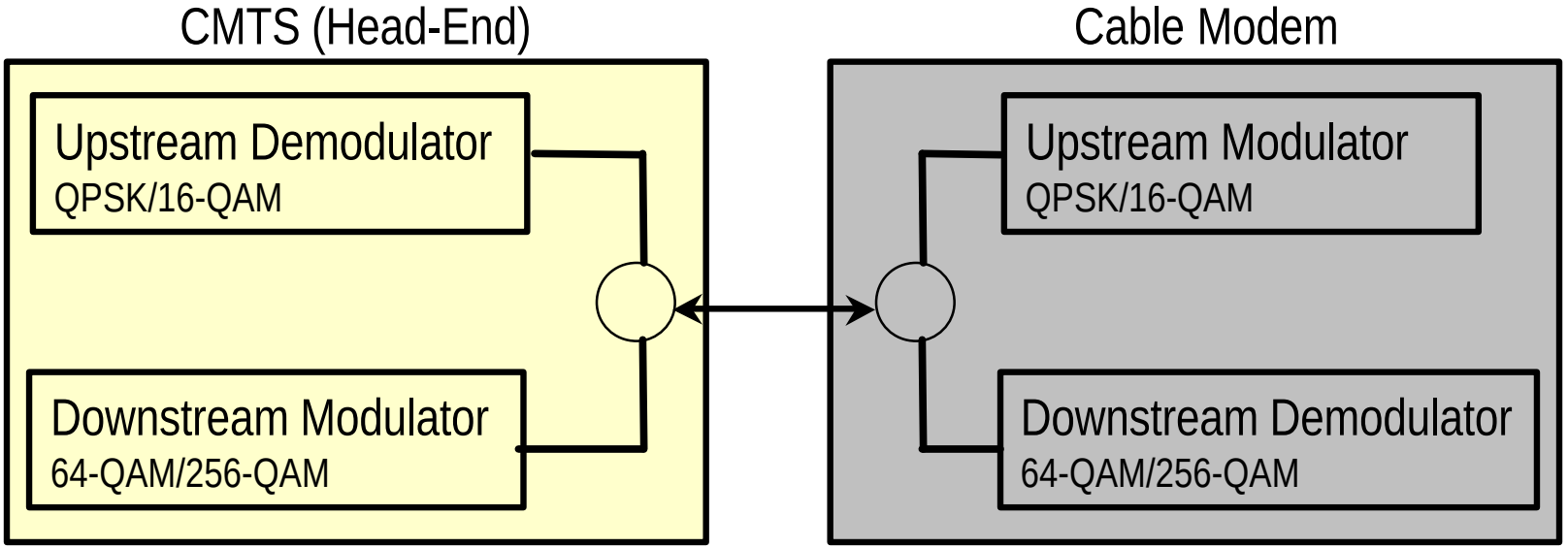
- Limited availability of cable modem services to businesses
- Concerns over data security
- Limited choices of Internet Service Providers (ISPs) due to fight over open access
- Low upstream transmission speeds discourage the usage of cable modem services

What is a Cable Modem?

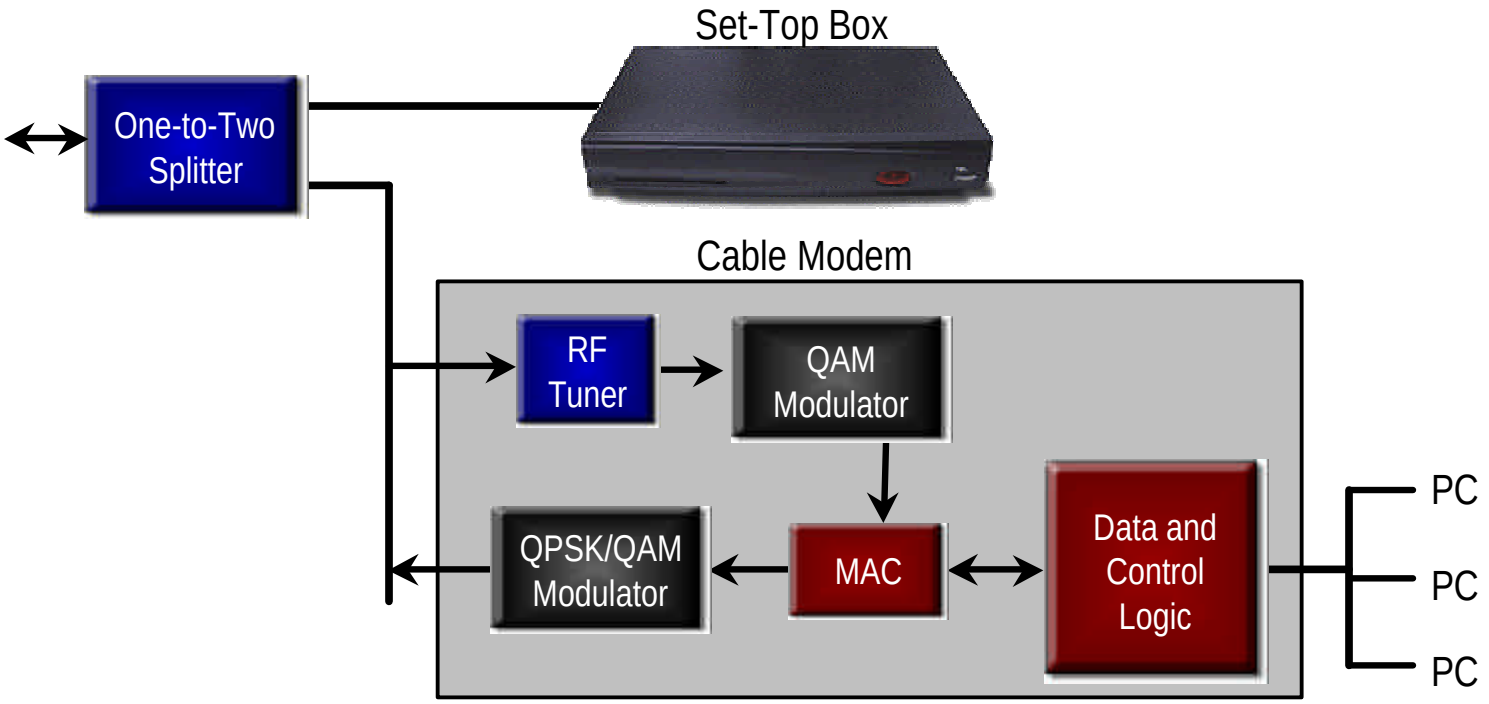
- CABLE - short for cable TV (CATV) network
- MODEM - MOdulator-DEModulator
- Cable modem
  - Client device for providing 2 way communications (data, voice and video) over the ordinary cable TV network cables
    - Downstream - Data flowing from the CMTS to the cable modem
    - Upstream - Data flowing from the cable modem to the CMTS

How Do Cable Modems Work?

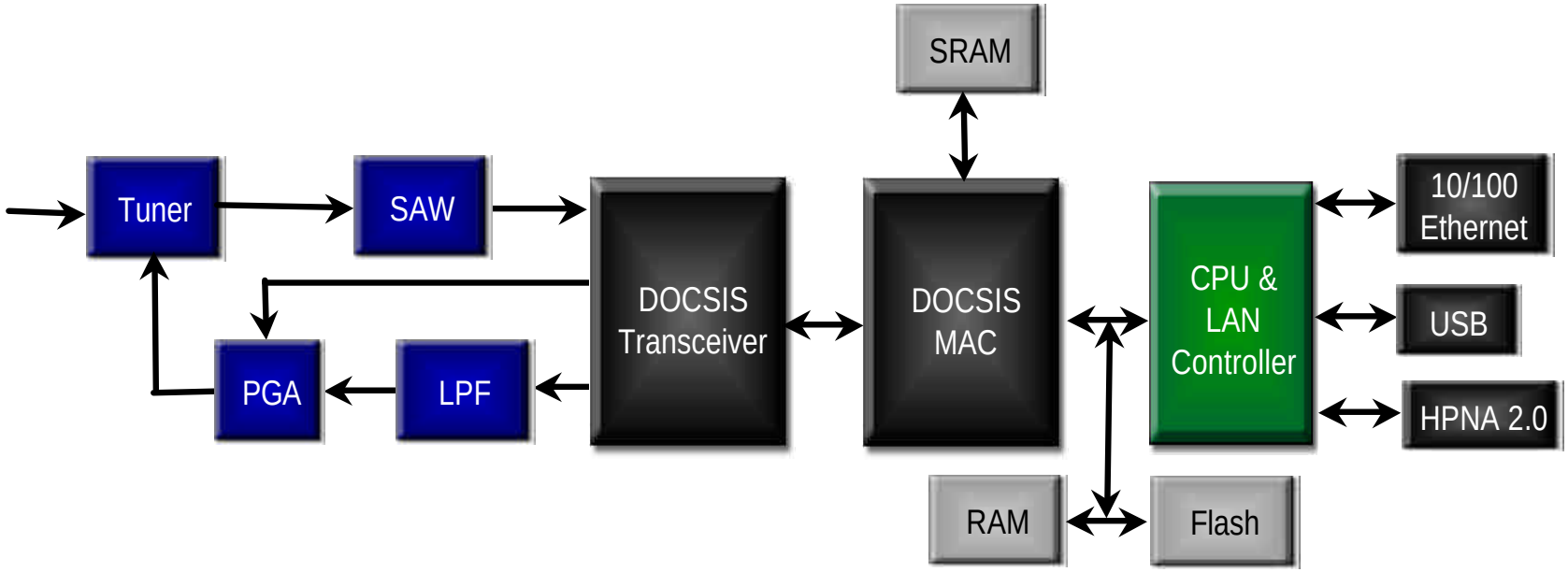
- Connect the Cable Modem to the TV outlet for your cable TV
- The cable TV operator connects a Cable Modem Termination System (CMTS) at their end (the Head-End)
  - The CMTS is a central device for connecting the cable TV network to a data network like the Internet



Cable Modem at the Subscriber Location



DOCSIS Cable Modem



- DOCSIS - Data Over Cable Service Interface Specification
  - The dominating cable modem spec that defines the technical specs for both the cable modem and the CMTS
- Architecture
  - Tuner, transceiver (modulator/demodulator), MAC, CPU, interface

OSI Layer Stack-up for DOCSIS Cable Modem

OSI	DOCSIS	
Higher Layers	Applications	DOCSIS Control Messages
Transport Layer	TCP/UDP	
Network Layer	IP	
Data Link Layer	IEEE 802.2	
Physical Layer	*Upstream*	*Downstream*
	TDMA (min-slots) QPSK/16-QAM	TDM (MPEG) 64/256-QAM

Inside a Cable Modem

- Tuner
  - Connects directly to the CATV outlet
  - Converts TV channel to a fixed lower frequency (6-40 MHz)
    - Normally a tuner with build-in diplexer is used, to provide both upstream and downstream signals through the same tuner
    - Must be of sufficiently good quality to be able to receive the digitally modulated QAM signals
    - A new concept of a silicon tuner is in the works
      - "Tuner on a chip"
      - Expected to cut the cost down quite a bit compared to a more conventional tuner module
  - Companies
    - Sharp, Temic, Panasonic

Inside a Cable Modem

- Demodulator
  - Performs analog-to-digital (A/D) conversion, demodulation (QAM-64/256), Reed Solomon error correction and MPEG frame synchronization
    - In the receive direction, the interface signal feeds a demodulator
  - Companies
    - Broadcom, Conexant Systems, SGS Thomson, VLSI Technologies/Philips, LSI Logic, Fujitsu

Inside a Cable Modem

- Burst modulator
  - Performs Reed Solomon encoding, modulation (QPSK/16-QAM), frequency conversion, digital-to-analog conversion
    - In the transmit direction, a burst modulator feeds the tuner
    - The output signal is fed through a driver with variable output level, so the signal level can be adjusted to compensate for the unknown cable loss
  - Companies
    - Broadcom, Conexant Systems, Analog Devices, SGS Thomson
- Combined demodulator and burst modulator chips are also available
  - The integration race drives more functions into a single chip

Inside a Cable Modem

- MAC (Media Access Control) sub-layer in the network stack (runs on both the cable modem and head-end)
  - Extracts data from MPEG frames, filters data, protocol execution, times transmission of upstream bursts
  - Sits between the receive and transmit paths
  - Can be implemented in hardware or split between hardware and software
  - Assigns upstream frequency & data rate
  - Allocates time-slots (upstream bandwidth)
  - The MAC is complex compared to an Ethernet MAC
  - Requires CPU to handle MAC layer functions
  - Companies: Broadcom, Texas Instruments, Conexant

Inside a Cable Modem

- Interface
  - Data passes through the MAC and goes into the computer interface of the cable modem
  - PCI bus, USB, Ethernet, HomePNA
- CPU - microprocessor
  - Required for external cable modems
- Single-chip cable modem are emerging
  - Combines the MAC, demodulator, burst modulator, CPU, Ethernet/HomePNA/PCI/USB interfaces
  - Additional parts such as memory, tuner, analog, power supply will not be within the single-chip cable modem

QAM & QPSK

- QAM - Quadrature Amplitude Modulation
  - A method of modulating digital signals using both amplitude and phase coding
- QPSK - Quadrature Phase-Shift Keying
  - A method of modulating digital signals using four phase states to code two digital bits per phase shift

Downstream Data Channel in Cable Modem Physical Layer

- Downstream
  - The signal received by the cable modem from the CMTS
- Modulation
  - 64 QAM and 256 QAM
- Bandwidth
  - 6 MHz (USA) & 8 MHz (EU) occupied spectrum that coexists with other signals in cable
- Frequency
  - 42-850 MHz (USA) and 65-850 MHz (EU)

Downstream Data Channel in Cable Modem Physical Layer

- Data rates
  - 27-56 Mbps
- Continuous stream of data with no implied framing, provides complete PHY and MAC decoupling
- Downstream data is received by all cable modems
  - The total bandwidth is shared between all active cable modems on the system
  - Each cable modem filters out the data it needs from the stream of data

Upstream Data Channel in Cable Modem Physical Layer

- Upstream
  - Data flowing from the cable modem to the CMTS
  - It is always in bursts
  - Many modems can transmit on the same frequency
- Modulation formats
  - QPSK (2 bits per symbol) and 16 QAM (4 bits per symbol)
- Bandwidth per channel
  - 2 MHz for a 3 Mbps QPSK channel
- Frequency
  - 5-65 MHz

Upstream Data Channel in Cable Modem Physical Layer

- Data rates
  - 320 kbps to 10 Mbps
- Transmit bursts of data in time slots (TDM)
  - Slots may be marked as reserved, contention or ranging
- One downstream is normally paired with a number of upstream channels to achieve the balance in data bandwidths required

Standards & Technologies - Many Different

- 1st generation - proprietary systems
- MCNS - Multimedia Cable Network System
  - Limited partnership by formed by Comcast, Cox, TCI, Time Warner, MediaOne, Rogers Cable and CableLabs
- DOCSIS
  - Managed by CableLabs (certification program for vendors)
- IEEE 802.14
- Products from different vendors must be interoperable
  - Helps to develop a mass market for cable modems

Summary

- Cable modems provide high-speed Internet access
- Always-on connection
- Cable data networks provide privacy, security, data networking, Internet access and quality-of-service features