S-38.192 Verkkopalvelujen tuotanto

S-38.192 Network Service Provisioning

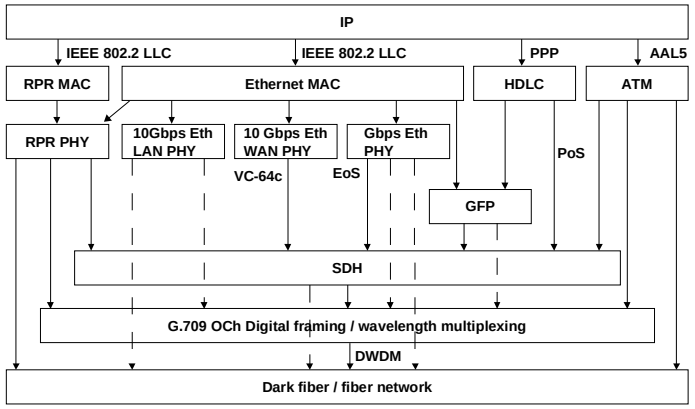
Lecture 2: Core Network Technologies

Core Network

- Connects MAN networks together
- Requires high bandwidth technologies with long range passive operation
  - Transmission speed and distance without repeaters tend to be inversely proportional
    - 1Gbps Ethernet -> 80-150km in SM-fiber with ZX-transmitter
    - 10Gbps Ethernet -> 10-40km in SM-fiber with ZX-transmitter
- Typical medias are
  - Fiber (Single Mode)
  - Radio (Microwave, Satellite)

Core Network Technologies

- **High bandwidth requirements**
- Transmission speeds are jumping up with constant rate
  - 1995: 155Mbps (SDH/ATM)
  - 2000: 2.4Gps (SDH)
  - 2004: 10 Gbps (SDH/Ethernet)
  - 2000-2004 wavelength technologies brought a new means to increase capacity
    - DWDM
    - CWDM
- **Frame based multiplexing**
  - Irrespective of low layer functionality
    - Fiber/Radio
  - Options today are
    - GMPLS
    - SDH
    - ATM
    - Ethernet
    - GFP

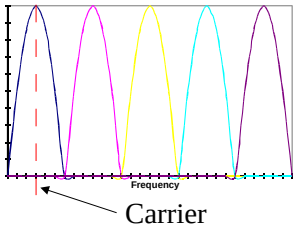


EoS Ethernet over SDH (Proprietary)
PoS Packet over SDH
RPR Resilient Packet Rings (IEEE 802.17)
GFP Generic Framing Procedure

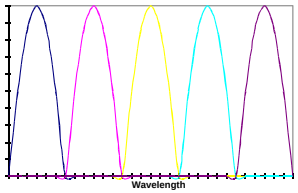
WDM

- Optical counterpart for Frequency Division Multiplexing

FDM



WDM

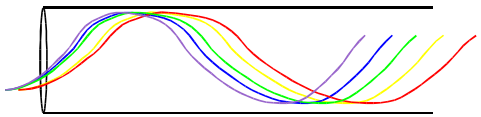


WDM

- Effectively N fold increase of transmission capacity from the same fiber infrastructure
  - Wide band components are relatively more expensive than N times narrow band components
  - Individual lambdas can be used independently
    - Usage depends on transponder unit
      - Framing is in general from SDH (interface may be what ever)
        - » STM-16 – 2.4Gbps
        - » STM-64 – 10 Gbps = 10GbE
        - » STM-256 – 40 Gbps = 40GbE

WDM

- Two operative versions
  - CWDM – Coarse Wavelength Division Multiplexing
    - Max 8 channels between (1470 - 1610nm with 20nm steps)
  - DWDM – Dense Wavelength Division Multiplexing
    - ITU Grid (100 Ghz resolution)
      - 50 channels between 1569.80nm to 1611.79nn
      - 50 channels between 1529.75nm to 1569.59nm
      - 50 channels between 1491.69nm to 1529.55nm

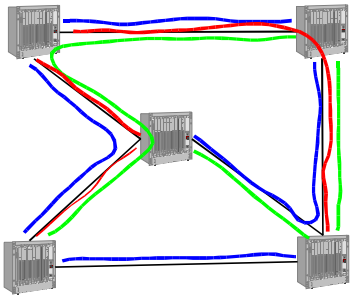


WDM

- DWDM
  - Narrow channel
    - Components need to be compensated for temperature effects
      - Expensive
  - More channels to choose from
    - nonlinearities of fibers can be avoided by selecting proper wavelengths
- CWDM
  - Wide channel
    - Component requirements are looser
      - Cheaper lasers and receivers
  - Less channels
    - Not suitable for long-haul networks
    - Suitable for MANs

WDM

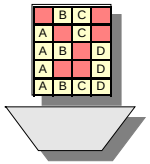
- Can be used as link or network technology
  - Link technology
    - Multiplexers at the ends of the links
  - Network technology
    - Optical switching components
      - Optical delay lines
      - Wavelength conversion
      - Photonic switching



WDM

- Pros:
  - Protocol independent
  - Virtual fiber
  - Multiplexing different traffic through different wavelengths
  - Similar failure protection than SDH networks (SDH framing)
- Cons:
  - Depending on system pay as you go may not be possible
    - The number of required channels need to be estimated for lifetime of systems
    - Not cost effective if capacity expansion is not immediately required

Frame Multiplexing



Synchronous multiplexing
• Fixed usage of resources

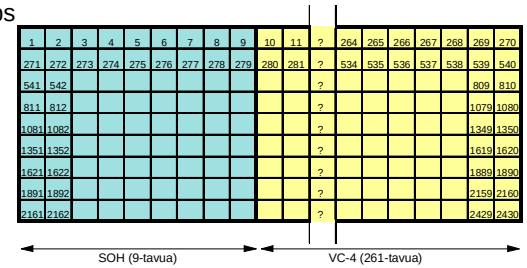
Asynchronous multiplexing
• Free usage of resources

Frame Multiplexing

- Synchronous
  - Fixed usage of resources
  - Information does not need L2 addresses
  - Wastes resources if communication is not CBR
  - Easy to integrate
  - SDH
- Asynchronous
  - Free usage of resources
  - Information requires L2 addresses
  - Does not waste resources
  - Requires additional logics to control resource usage
  - ATM, Ethernet

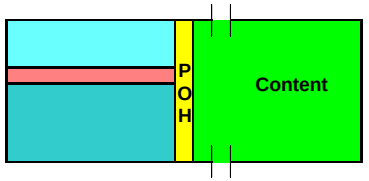
SDH

- Synchronous frame based multiplexing of transmitted signals
  - Link framing is done with 2430 byte frames
  - Generation interval is 125us -> reflects the original coding of speech with 8kHz sampling rate
    - Datarate = 155,52Mbps



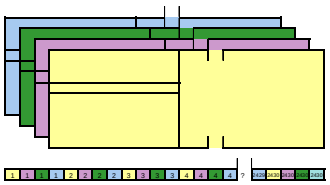
SDH

- Link frames contain virtual containers which carry the actual information
  - Header information (POH)
    - Flow and error control information between edge devices
  - Content
  - Virtual containers form point-to-point permanent connections through SDH network



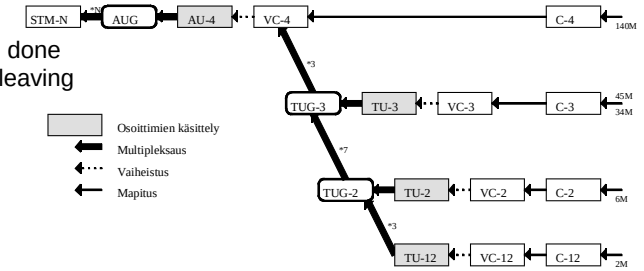
SDH

- SDH hierarchy makes possible to use multiples and fractions of basic rate
  - Multiples are generated by injecting multiple (factor of four) link frames within time-slot
    - STM-1: 155.52 Mbit/s (basic rate)
    - STM-4: 622.08 Mbit/s (first multiplex)
    - STM-16: 2488.32 Mbit/s (second multiplex)
    - STM-64: 9953.28 Mbit/s (third multiplex)
  - Operation is byte synchronous
    - Timing of individual bytes in multiplex is same than in basic rate frame



SDH

- Fractions are generated by multiplexing different streams of content into individual frame
  - Several virtual containers destined to same or different points in network
  - Multiplexing is done with byte interleaving

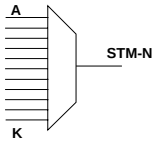


SDH

- SDH supports also concatenation of resources
  - Old version – strict mode
    - Clear channel operation (small 'c' after the virtual container type)
    - All VC:s in different frames form a single bit stream
    - Not feasible in SDH **networks**
    - Feasible if SDH is used as a point to point link technology
  - New version – flexible mode
    - Concatenation is used only in edge devices
      - Supports SDH networks
      - Concatenated VC:s need not be with same speeds
        - » Even over different fibers

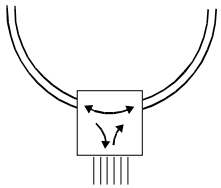
SDH

- Terminal multiplexer
  - Responsible of taking non-SDH and lower rate SDH traffic in and interleave them in STM-N frames.
  - Vice versa on other end of the path
  - Each incoming traffic component has its own virtual container (routed separately within SDH network)



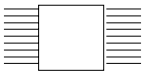
SDH

- Add-drop multiplexer
  - Basic component in ring type SDH networks
    - Most of traffic passes through the ADM on ring interfaces
    - Some traffic is taken out of ring and/or inserted into the ring



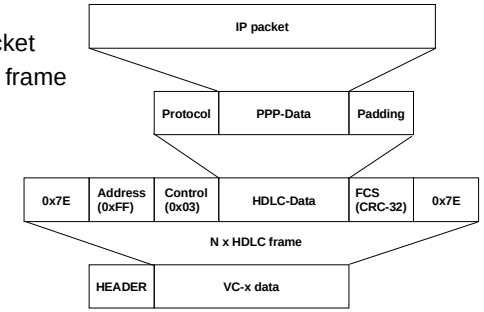
SDH

- Digital Cross Connect
  - Switches SDH traffic
    - Between fibers
    - From individual STM frame to other
  - Basic component on mesh type networks



SDH

- IP can not be used directly with SDH
  - Packet over Sonet (PoS) is method for delivering IP packets in SDH
    - Additional framing
      - IP packet into PPP-packet
      - PPP packet into HDLC frame
      - HDLC frame into SDH virtual container

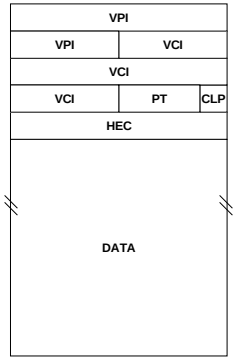


SDH

- Pros:
  - Optimized for TDM services (large income from leased line services)
  - Fully compatible with metro ring networks (SDH ADM rings)
  - Reliable and fast failure recovery (roughly 50ms with APS)
  - Price of SDH continuously coming down
- Cons:
  - Not cost effective for burst data traffic
    - Capacity in SDH network can only be allocated on multiples of 2Mbps
  - No multiple QoSs for different service charges
  - Expensive interfaces at routers

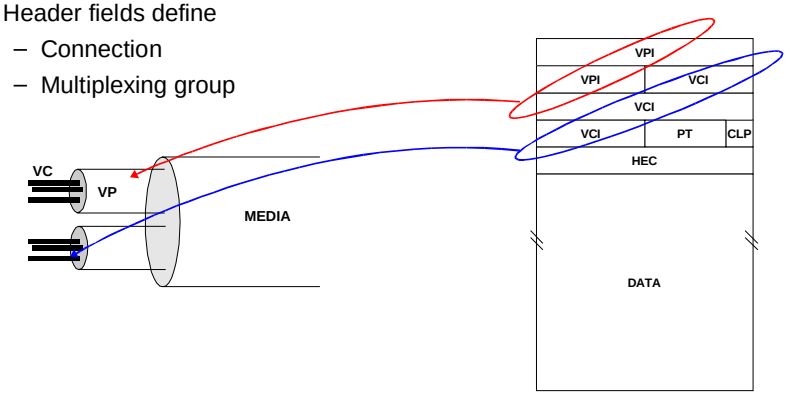
ATM

- Asynchronous frame based multiplexing
- Capabilities for dynamic switching
  - Not only PVP's or PVC's
- Connection oriented
- Fixed packet structure
  - 5 bytes of headers
    - Addresses (VPI, VCI)
    - Packet content type (PT)
    - Priority (CLP)
    - Checksum (HEC)
  - 48 bytes of data



ATM

- Header fields define
  - Connection
  - Multiplexing group

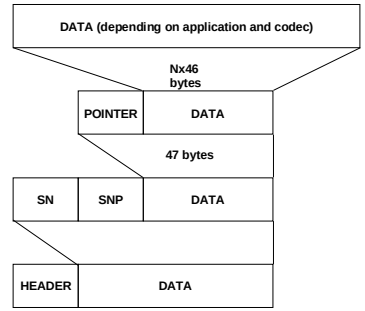


ATM

- Can be used
  - As is over the transmission media
    - Assumes low bit error ratio from the media
  - Over any other L2 protocol
    - Benefits from the error control of L2 media
- Why sensitivity to BER
  - Packet has not markers
    - Delineation is accomplished through state-machine which goes through packet bit by bit and looks header checksum matches
      - Sensitive to errors if high BER

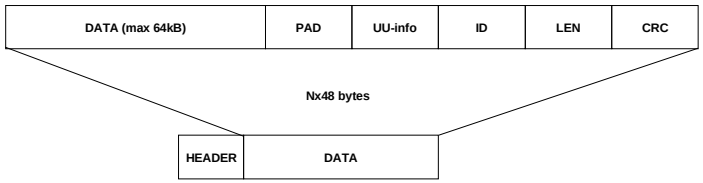
ATM

- 48 byte content field is too big for voice communications
  - Separate protocol layers to handle
    - Sub cell delineation
    - Timing
    - Sequencing
  - Clear channel communication for video applications



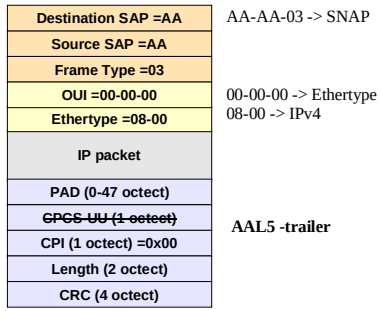
ATM

- 48 byte content field is too little for data networks
  - Fragmentation of data packets into multiple ATM cells
  - Separate protocol layer to handle the fragmentation and reassembly of protocol packets



ATM

- Framing options for IP traffic in ATM links:
  - RFC2684: Multiprotocol Encapsulation over ATM Adaptation Layer 5 (Classical IP)
    - Uses LLC/SNAP encapsulation of traffic within ATM adaption layer 5



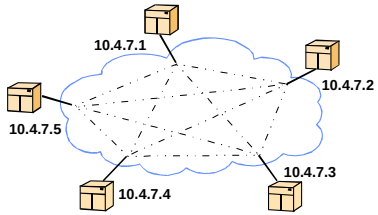
ATM

- Framing options for IP traffic in ATM links:
  - RFC2364: Point to Point Protocol over ATM
    - Uses in AAL5 frames either
      - raw PPP packets
      - PPP on LLC/NLPID packets

Destination SAP	
Source SAP	LLC-otsikko
Frame Type (UI)	
NLPID (PPP)	Network Layer Protocol ID
Protocol ID	
PPP Information	PPP
Padding	
PAD (0-47 octect)	
CPCS-UU (1 octect)	
CPI (1 octect)	AAL5 -trailer
Length (2 octect)	
CRC (4 octect)	

ATM

- ATM network is from IP perspective
  - NBMA network
    - Separate virtual connection between each and every router
      - Large number of connections and adjacencies in routing
    - Usually subinterface per connection



ATM

- Pros:
  - Easy capacity management
  - Virtual short-cuts without routing
  - MPLS ready
  - Fault tolerant if ATM-level dynamic routing is used
- Cons:
  - Additional layer of technology
    - Not good for framing itself
  - Expensive interfaces at routers
    - Subinterface structure in networked ATM

Ethernet

- Technology has scaled to level where conventional core network technologies are
  - STM-64 and 10GbE are the same
    - Even in optical interface level they are the same but ethernet is only 20% of the price
  - STM-256 will be the base for 40GbE
  - 1GbE is based on fiber channel but can be multiplexed in STM-16 networks by having two independent connections

Ethernet

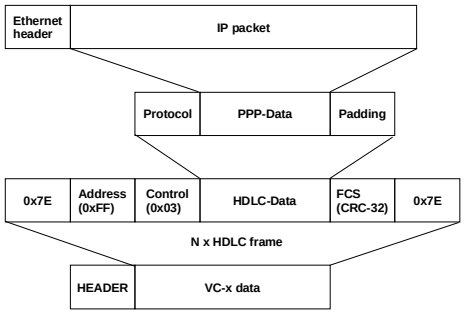
- 10GbE
  - IEEE 802.3ae
  - Full duplex
  - Adjustable MAC speed
    - 10Gb in LAN
    - 9.29Gb in WAN
  - Optical media
  - SDH WAN Phy
  - 10Gb LAN Phy
- 1GbE
  - 802.3z
  - CSMA/CD + Full Duplex
  - Optical and copper media
  - Fiber channel Phy

Ethernet

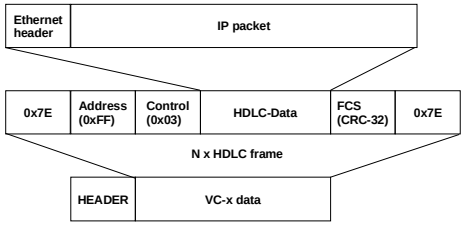
- Possibility to build transparent LAN services
  - Majority of LAN networks are build with ethernet
  - Some applications benefit from the fact that ethernet headers are preserved
    - Possibility to have same IP subnet on both ends
    - WAN network is transparent for ethernet network
      - No PPP protocol in between SDH and Ethernet
  - VLANs provide separation of users within the core
    - Separate forwarding tables per customer
    - If customer has own VLANs so called aggregated VLAN can be used
      - Second VLAN header in packets within the core

Ethernet

- PoS way of doing things

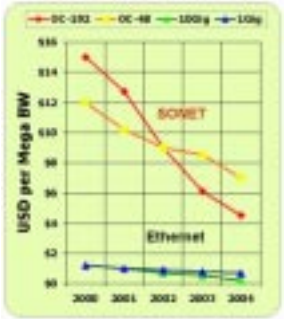


- WAN ethernet way
  - Avoids protocol conversion between ethernet and PPP



Ethernet

- Differencies in framing and error recovery lower the price of Ethernet interfaces compared the same rate PoS interfaces
  - OC-192 <-> STM-64
  - OC-48 <-> STM-16



Source: http://www.foundrynet.com/

Ethernet

- Pros:
  - Optimized for burst data services
  - No protocol conversion for interfacing with routers and LAN switches
  - Plug-and-play ideology in operation
- Cons:
  - Expensive and complicated to support the TDM voice and leased line services
  - Poor in trouble isolation and network recovery
    - Spanning tree operation takes tens of seconds to recover the networks
    - IEEE802.17 (Resilient Packet Ring) and BFD (Bi-directional Forwarding Detection) will eventually help this