Design, Configuration and Services

Course NPC0003-001

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Course Instructor

- Background and education
- Current position
- Expectation for this course

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Course Objectives

- Describe Net Insight's solutions for designing scalable QoS networks
- Install, configure and monitor Net Insight's products.
- How to provision data, voice and video services in the network.
- Advanced configuration options for each service
- How to receive performance statistics
- Service troubleshooting.

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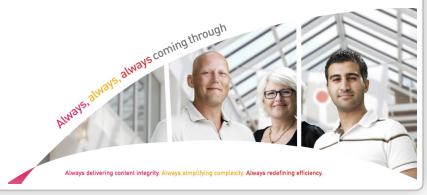
Course Prerequisites

- General knowledge of TCP/IP.
- Introduction to Nimbra System Web-based Training and Design.



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Course Materials

- Handouts
- Workbook
- Element Manager User's Manual

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Course Contents

Configuration

- Initial IP settings
- Network Configuration
  - DTM Addresses
  - Dynamic routing
  - Redundancy
- Hostnames
- Configuration files
- Source routes
- Alarms
- In Band Management
  - Server
  - Client

Service

- Streaming services (ITS)
  - ASI, SD-SDI, HD-SDI, AES/EBU, PDH, TDM
  - Uni- or multicast
- Packet Services (ETS)
  - Uni- or multicast
- Performance Monitoring

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Logistics

- Restrooms/toilets
- Coffee machines
- WLAN access
- Messages/phones

Current log on credentials for the guest WLAN

SSID: **Net Insight Guest**
Client ID: **guest**
Password: **????**

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Attendee Introductions

- Your name
- Organization name
- Current position
- Background
- Expectations

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Questions

- Please feel free to ask questions, and discuss
  - If you are confused, you are probably not alone
- Your instructor will be happy to answer all questions, provided you allow the following responses:
  - We'll be discussing the topic later in the course, so can we defer the question?
  - I don't know the answer to that question off hand, but we can check in the online reference manual at a break

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Net Insight History

- Started in 1997 - after 10 years research
- Listed on the Stockholm Stock Exchange 1999
- Headquarters in Stockholm and Sales Offices in Asia, Europe and USA
- Marketing, Sales and Product Development in-house
- Outsourced manufacturing
- Partners and Distributors/Resellers
- Technology based on ETSI standard
- Numerous patents

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Net Insight Management

- Lars Berg, Chairman of the Board

- Fredrik Trägårdh, Chief Executive Officer

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Net Insight Founders

- Lars Gauffin, founder

- Per Lindgren, VP - Bus Dev, founder

- Christer Bohm, CTO, founder

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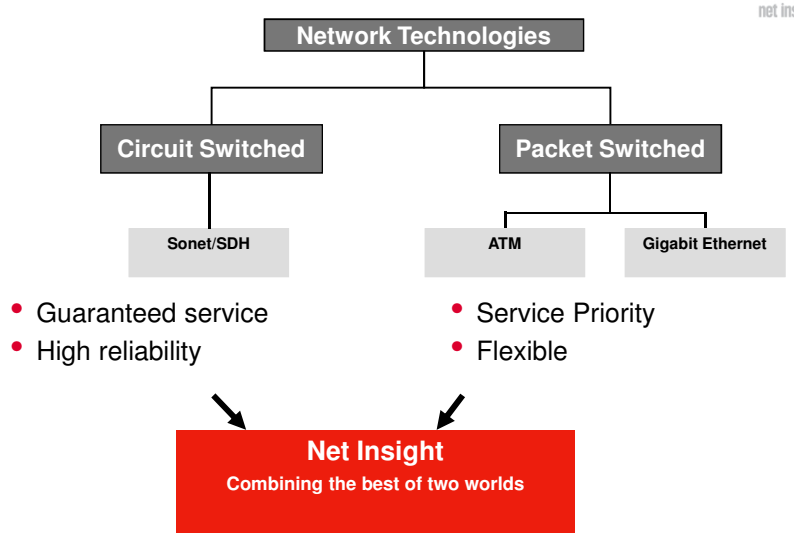
Net Insight's Technology



- Guaranteed service
- High reliability
- Service Priority
- Flexible

Net Insight
Combining the best of two worlds

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Key Competitive Advantages

- 100% QoS
  - Guaranteed bandwidth, even at full utilization
  - Separation of traffic
- Designed for real-time video requirements
  - Low Jitter and Wander
  - Low and constant delay
- High utilization of bandwidth
  - In steps of 512 kbps
- Automated control plane
  - Fast end-to-end provisioning
  - Easy network expansion
  - Automatic network restoration
- Network and Service Flexibility
  - Topology independent
  - True Multiservice platform
  - Comprehensive Ethernet functionality
- Unique Multicast support
  - For all services
  - For any topology and any level of forking
  - Maintaining QoS and high utilization
  - Automatic restoration

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Net Insight's Technology

- Advantages of both synchronous and asynchronous media
  - Guarantees each channel a certain bandwidth
  - Asymmetric channels possible
  - Predictable and constant delay for streaming services
- Trunk Modules:
  - STM-1, STM-4, STM-16, STM-64, DS3/E3 and IP Trunk
- Access Modules:
  - IP/Ethernet (e.g. transport of data or video/MPEG streams)
  - SDI, HD-SDI and ASI (video)
  - AES/EBU (digital audio)
  - E1/T1, E3/DS3 and STM-1 services
- Services run on top of end-to-end channels
- End-to-end channels run on top of Sonet/SDH, (D)WDM or dark fiber
- Supports Uni- and Multicast channels

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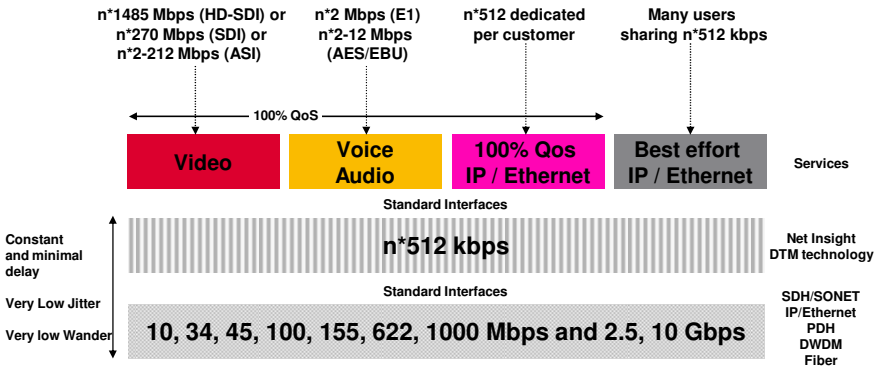
Net Insight Architectural Concept



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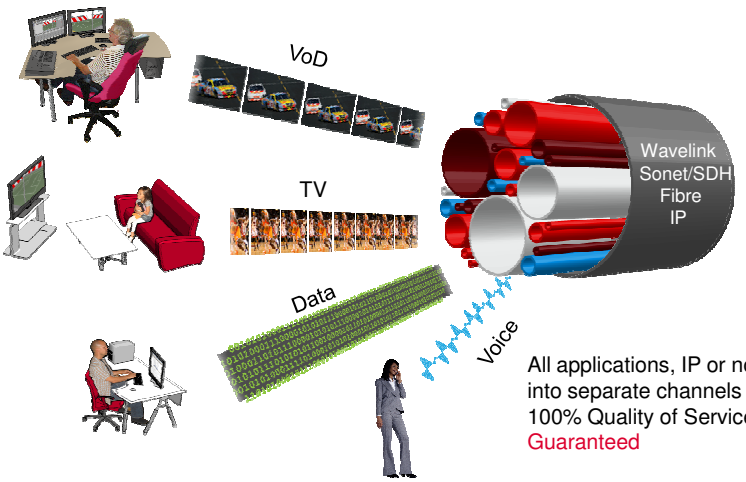
Different Applications in Different Channels



All applications, IP or not, goes into separate channels with 100% Quality of Service – Guaranteed

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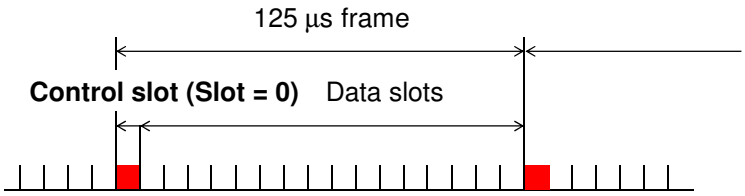
DTM frames and time slots



- The DTM protocol uses frames of 125 µs
- Each frame is divided into 64-bit slots
- The slots are divided into control and data slots
- The number of slots depends on the link bit rate
- One slot per frame equals a capacity of 512 kbps

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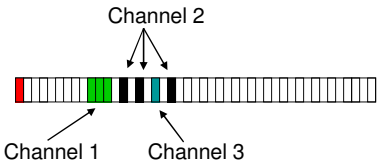
Utilization



- A channel is a set of slots acting as a unit to form data transport
- Channels may consist of continuous, concatenated or distributed slots
- Data is not addressed. The time slot(s) used define the channel.
- Each connection (channel, circuit) has a constant and guaranteed capacity in multiples of 512 kbps

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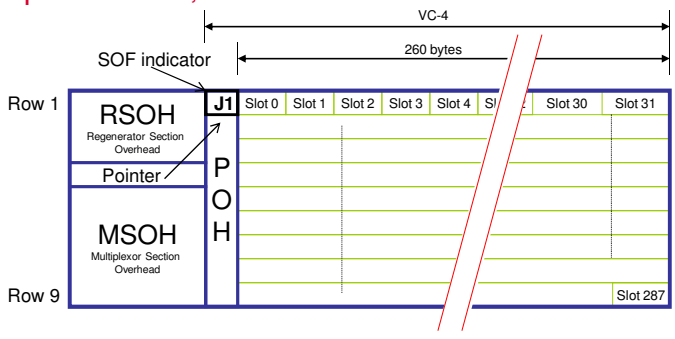
Transport Format, STM - 1



- Capacity: 9 x 32 slots = 288 slots = 288 x 0.512 Mbps = 147,456 Mbps
- VC-4 payload = 8000 x 260 x 9 x 8 = 149,76 Mbps
  => 149,76 - 147,456 = 2,3 Mbps

  Overhead: 2,3 /149,76 = **1,5%**
- The same structure applies to the other STM-Modules

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DTM Channels

- Higher network utilization
- Separated/isolated channels
- Asymmetric channels possible

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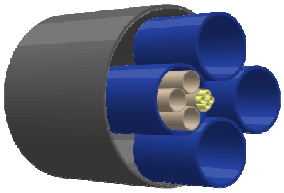
A New Approach To Utilization

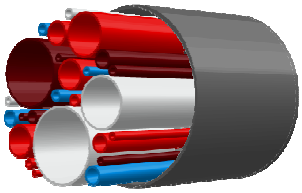
Traditional SDH/Sonet fiber/wavelength hierarchical multiplexing



2 Mbps 34 Mbps 155 Mbps

622 Mbps 2.5 Gbps 10 Gbps

Nimbra fiber/wavelength non-hierarchical utilization



Any Size & Any Mix
(in steps of 512kbps)

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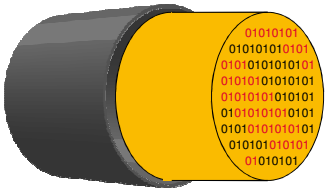
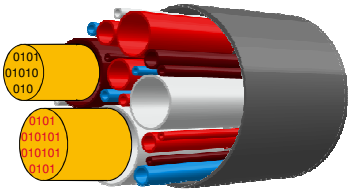
A New Approach To Utilization

IP networking
All traffic in one “Pipe”



Best effort or Classes of service.
All traffic routed and treated in order of priority

Many IP “Pipes”
Combine best effort pipes with Priority “Pipes”
Pipes are “real” not virtual



Logical division of traffic of
Any Size & Any Mix
(in steps of 512kbps

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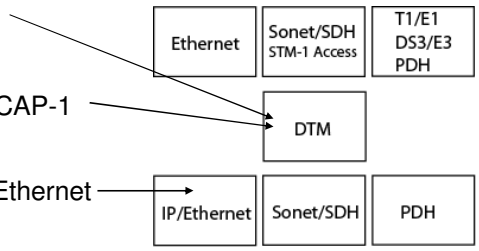
Protocol Suite

- Service Layer
  - Ethernet, AES/EBU, ASI, SDI, HD-SDI, PDH, SDH
- Network Layer
  - DCP, DRP and DSYP
- Link Layer
  - DLSP, DCAP-0 and DCAP-1
- Physical Layer
  - SDH, PDH (DPP), IP/Ethernet



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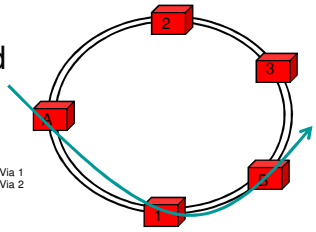
DRP (DTM Routing Protocol)

- A link state routing protocol
  - Links reported from DCP are distributed on the network layer
- Based on OSPF and PNNI
- Finds one or several routes towards a destination
  - Builds a routing table
  - Rebuild when the topology changes
- Supports dynamic and static routes
- Node (DTM) addresses are required



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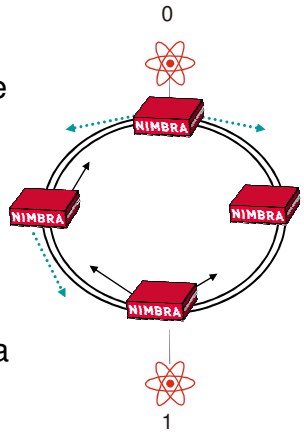
Synchronization

- DTM is a Synchronous solution
- DTM needs to have one clock source in the entire network
  - 2.048 and 1.544 MHz sync (or 10 MHz for Nimbra 360)
  - Physical interface: Nimbra One SMB, Nimbra 300 and 600 BNC connector
- The reference clock is distributed in a minimal spanning tree structure, i.e. there is no synchronization loop.



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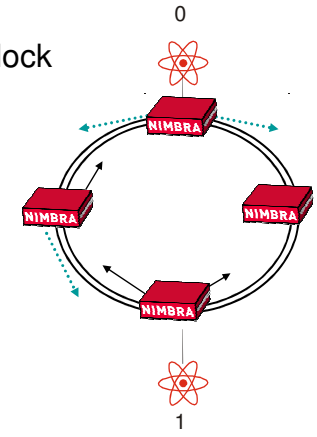
DSYP (DTM Synchronization Protocol)

- Exact route of synchronization
- Shortest path from the master clock
- No synchronization loops
- Automatically recovers from
  - Node failure
  - Link failure
  - References clock failure
  - Topology changes
- Sync source
  - Internal clock
  - External clock (GPS)
  - TT (Time Transfer, Nimbra 360)



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Addressing

- IP address (Access address)
- DTM Address (Routing/services)

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Addressing

- DTM address = 64 bits long
- Pairs of hexadecimal digits separated by a dot
  - Leading zeroes are spelled out

00.00.00.00.00.32.1B.01 =>
00000000.00000000. 00000000.00000000.00000000.00110010.00011011.00000001
0 0. 0 0. 0 0. 0 0. 0 0. 3 2. 1 B. 0 1

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Addressing

DTM address = 00.00.00.00.00.32.01.02
DTM address range may be written in short form
X = 00.00.00.00.00.32;
DTM address = X.01.02

Within this range DTM addresses may be written like;
X.01.01 meaning 00.00.00.000.00.32.01.01
X.1B.F6 meaning 00.00.00.00.00.32.1B.F6

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Addressing

- A suffix is similar to an IP subnet and mask or a telephone “area code”.
- The suffix length is represented after the DTM address as a decimal number separated by a slash.
  It represents the prefix length in bits.
- 00.00.00.00.00.32.1B.00/56
  This is a range of 256 addresses
  from 00.00.00.00.00.32.1B.00
  to 00.00.00.00.00.32.1B.FF

How will the suffix 48 look like?

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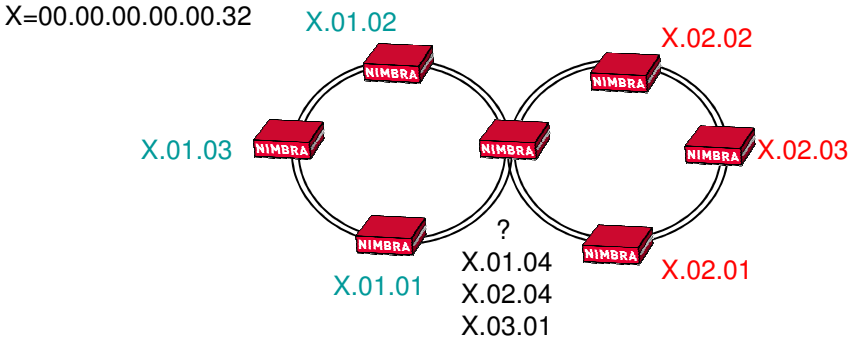
Addressing

- Do we need to assign two DTM addresses to the Nimbra 680? If so, which?



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Addressing

- One node address – not one per i/f
- Scalable
- Easy to add on
  - New interfaces
  - New nodes
  - New areas
- Net Insight administers network address allocation

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Routing

- A channel is routed at establishment
- Nodes need routing tables for channel establishment
- DRP (Dynamic Routing Protocol)
- Static routes
  - Host route, all bits are set in the subnet mask for a destination
  - Network route, one or more zeros in the subnet mask for a destination
  - As in IP - no zeros before ones in a subnet mask

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Routing

- Channels choose the “cheapest” DTM route by default
- Channels can be source routed (gives control over channel path)
- When a link breaks, channels are automatically re-routed
- Channels up again after re-routing (typically around 1s)
- Channels take an alternative path if congestion occurs
- Unaffected channels has no downtime

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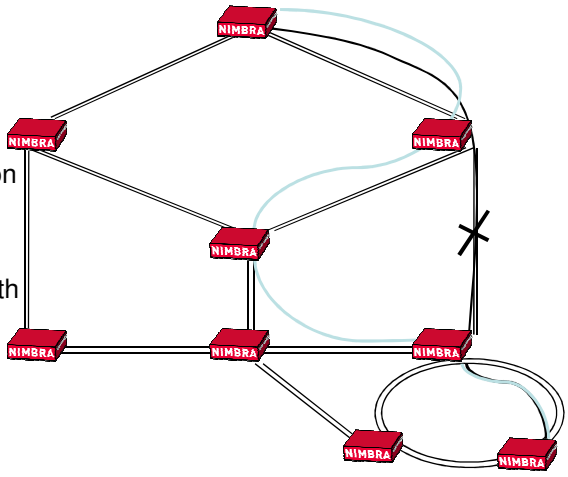
Fast and Reliable Service Restoration

- Automatic
  - failure discovery
  - restoration
- On-the-fly restoration
  - Crank-back function
- Prioritiezed channels
  - set up first
- Pre-planned backup path (source routing)



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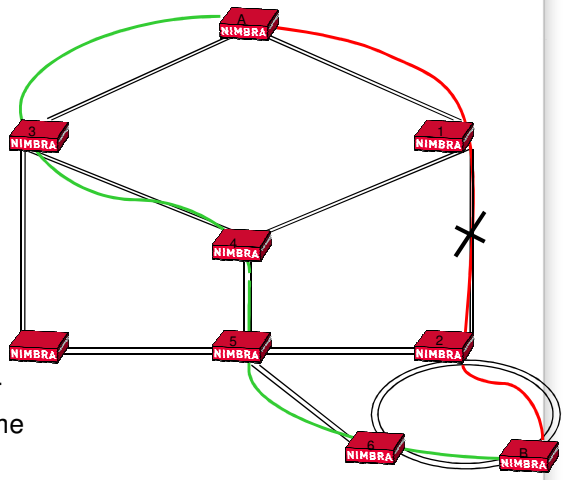
Source Routing

- Specify intermediate nodes
- Source routing guarantees physically separated channels
- Loose or strict routes
  - Strict 1,2
  - Strict 3,4,5,6
  - Loose?
- Used for
  - 1+1 Service Fail Over
  - <50 ms switchover time
  - Traffic engineering



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Routing

- Restoration
  - DRP
  - Crank back
  - Source routing
- Nimbra Vision protection
  - Redundant Headend protection
  - Preemption (channels are taken down or have bandwidth reduced in order to restore critical services)

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Services

- Packet Services (ETS)
  - In-band management using IP
  - Ethernet Tunneling Service (ETS) with IEEE 802.1Q VLAN, diffserv and ethernet prio 802.1D (former 802.1p) support
- Streaming Services (ITS)
  - PDH transport (E1/T1 - 2/1.5 Mbit/s)
  - SDI Uncompressed video BT.601 (270 Mbit/s) PM G.826
  - ASI/DVB (2+2xASI 2-200 Mbps, 8xASI 2-212 Mbps) PM G.826
  - Sonet/SDH tunneling (STM-1/OC-3)
  - HD-SDI SMPTE 292M video standards
- Multicast Services
  - ETS/SDI/ASI/HD-SDI/PDH/Sonet/SDH

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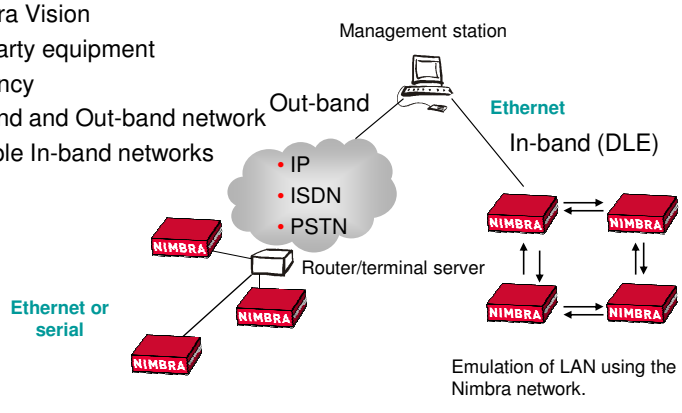
In-band Management

- Possible to access nodes without a parallel network used for:
  - Remote log in
  - Management
    - Nimbra Vision
    - 3rd party equipment
  - Redundancy
    - In-band and Out-band network
    - Multiple In-band networks



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In-band and DLE – What is it?

- DTM LAN Emulation
- Used only for in-band management network
- Emulates an IP sub-network using the existing DTM network (DLE segment)
- IP routing must be set-up between DLE segment and other IP sub-networks
- Totally secure from other channels transporting IP over ETS

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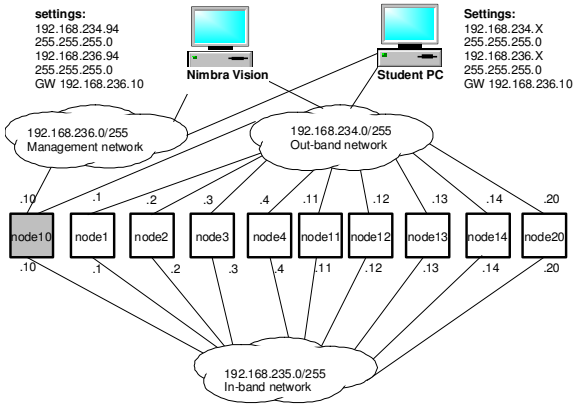
In Band DLE



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In-band

- DLE Server
  - Responsible for the segment: one per segment (multiple)
  - A DLE Server can only be used for in-band management
- DLE client
  - Provides IP interface to segment in each node

- Every client has one channel to the server
- The server has one multicast channel to all clients
- Automatically sets up channel from client to client when IP data is sent
- Automatically tears down channel when not used

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DLE segment

- Every DLE segment has one DLE server
  - Responsible for providing information to the DLE clients about the other nodes in the segment
  - Enables the clients to establish their connections

- Channel between DLE Server and DLE Client
  - Permanent channels between client and server, since they always must be able to communicate
  - The channels between the DLE server and DLE clients are used to distribute broadcast packets
  - The broadcast packets from a client is sent to the server, and then distributed to all the other clients on the segment. I.e. broadcast packets will not result in establishment of new channels between two clients.

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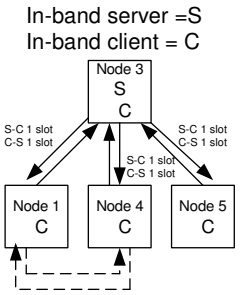
In-band, Client to Client

- DLE Client asks DLE server - where is “MAC address/DTM address ”
- Server answer “MAC address/DTM address” is here
- Client to Client channel is established between the two clients



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In-band, DLE Segments

- Several DLE segments can coexist in a DTM network
  - Each DLE segment requires it’s own DLE Server
  - The DLE Server forwards broadcast packets to all DLE Client’s within the segment
- To send data from one DLE segment to another, the packets must pass through one or several IP routers!

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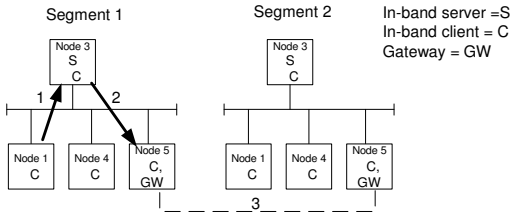
In-band, multiple segments



- DLE Client asks DLE server
- Server find the address, goes to gateway
- Routed over IP net

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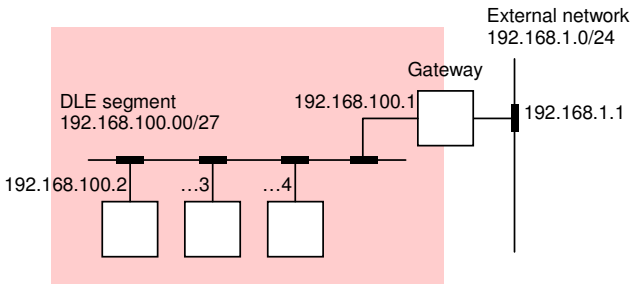
In-band, Configuration of a small network



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In-band, Recommendations

	Nimbra One	Nimbra 340	Nimbra 600
Maximum recommended number of DLE clients for one DLE server	16	16	64
When working as gateway: maximum recommended number of nodes to route traffic for	255	255	1 000
Channel capacity for DLE client-server channels	512 kbps (1 slot)	512 kbps (1 slot)	512 kbps (1 slot)
Channel capacity for DLE client-client channels	512 kbps (1 slot)	512 kbps (1 slot)	512 kbps (1 slot)
Maximum recommended number of DLE clients on a gateway	3	3	3
Time out before tearing down unused channels (flow timeout)	Configurable	Configurable	Configurable

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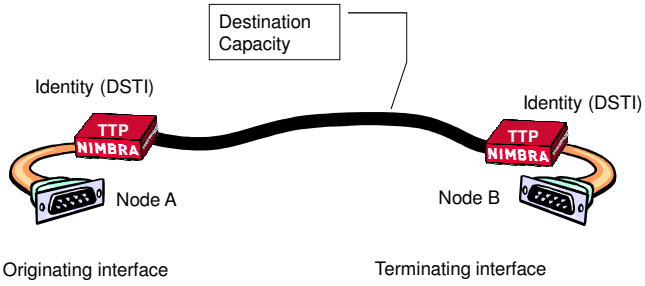
Service Provisioning, General



- Simple process:
- 1. Define trail termination points (TTP)
- 2. Associate interface with TTP
- 3. Define connection between TTPs

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Ethernet Transport Service (ETS) ver.2

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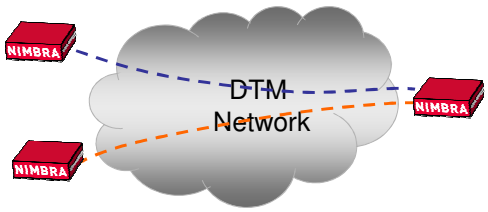
Ethernet Tunneling Service - ETS

- Transparent point-to point Layer 2 connectivity
- Handles multicast traffic at same rate as unicast
- VLAN transparency
- Provides full QoS guarantees for all tunnels



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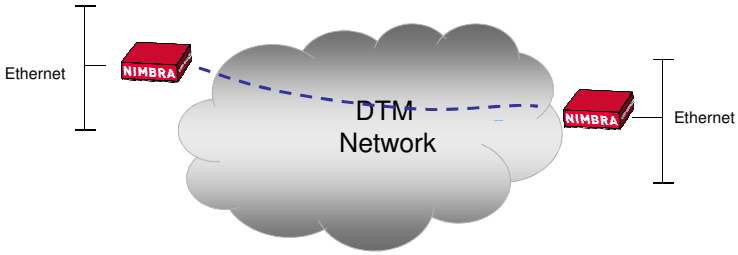
ETS Unicast



- ETS allows DTM to be used as a connection within different Ethernet segments. Diffserv and Ethernet prio can prioritize packets when needed.
- Diffserv: Differentiated services, IETF standard for prio of IP packets
- Ethernet prio: Ethernet user priority

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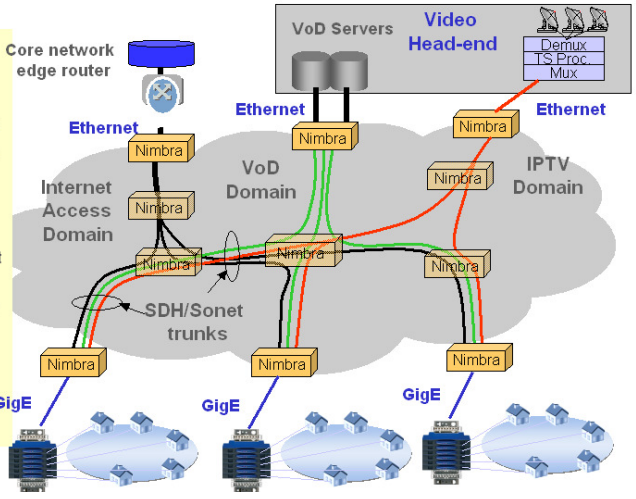
Complete IPTV architecture

Combining transparent transport and switching for maximum performance

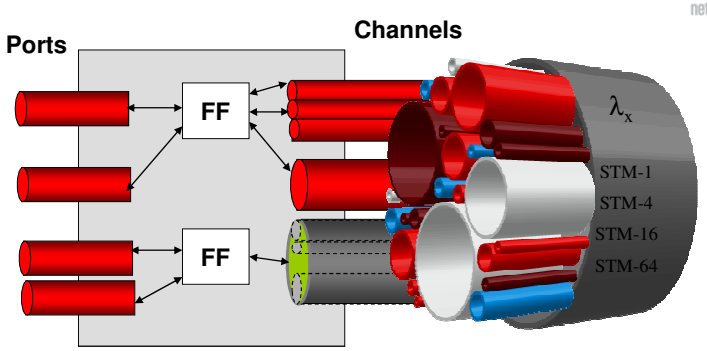
- Transparent transport of video with 100% QoS
- All TV channels multicast to the edge, one per VLAN
- Unicast VoD services from servers located anywhere in the network
- Broadcast TV and VoD only experience one packet hop
- Best effort Internet overlay with full layer 2 switching capabilities
- Separate IP channels for robust VoD Connection Admission Control



Ethernet switching functionality (“ETSv2”)

- Ethernet MAC layer switching
  - 8 x Gigabit Ethernet Access Module for Nimbra 600
- Forwarding Function (FF)
  - virtual Ethernet switch defined on a module
- Each FF is associated with a number of physical Ethernet interfaces and virtual ports of an ETS
  - ETS interfaces are endpoints of DTM channels
- 8 separate Ethernet switches (FFs) on one board
  - configured with up to 255 ports, 8 physical (on the front) and 247 “logical” that is the ETS channel end points

Ethernet switching overview

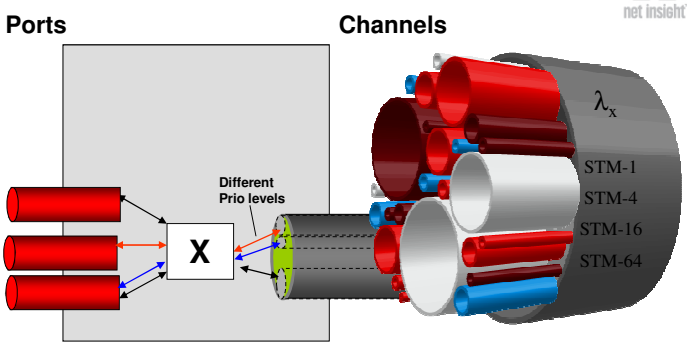


- TDM channels have the same functions as the physical ports
- Multiple FFs can be connected to the same port or channel using VLANs to determine to which function the traffic shall be forwarded to.

Forwarding Function modes

- Each Forwarding Function has its own VLAN space and MAC learning tables, i.e. constitutes a complete layer 2 switch
- Logical ports can be configured with any bandwidth to match the ETS channels.
- The Forwarding Function can be configured
  - to do look-ups based on VLAN tag or MAC address or both
  - to transparently forward packets between a physical and logical port

Ethernet QoS within channels



- Within a channel, IEEE 802.1p or DiffServ priority can be used to prioritize different traffic over the same channel. 2 queues per channel with strict priority.
- For example, VoIP or video traffic can be multiplexed with LAN2LAN or Internet traffic on one channel where the video and VoIP traffic has higher priority
- The mapping of priority on channel at the ingress point is much easier to engineer than priorities in each hop through a complete network

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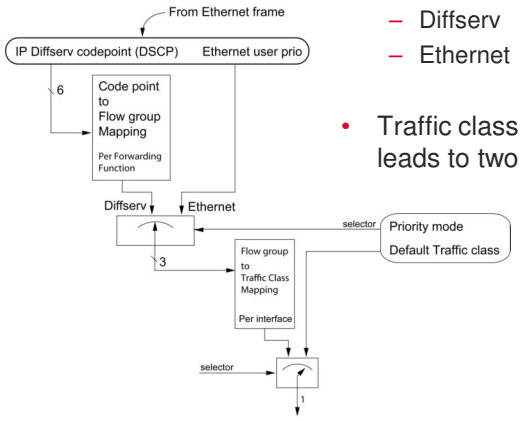
Forwarding Function modes

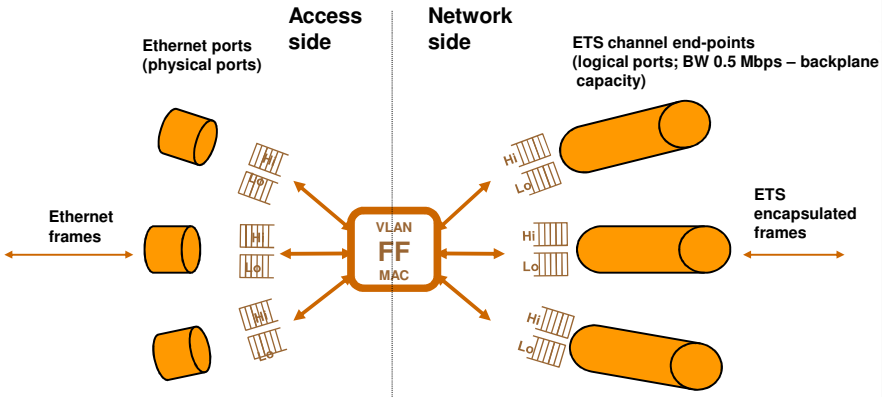
MAC mode FF config VLAN mode	NO-MAC	MAC
Transparent	Transparent mode • Forwards all incoming packets	Bridged MAC mode • Switching mode (VLAN transparent; IEEE802.1D)
VLAN	VLAN mode • Forwarding based on VLAN only (only mode that is supported in Nimbra One/300)	Bridged VLAN/MAC mode • Switching mode (VLAN aware; IEEE802.1Q)

Priority configuration

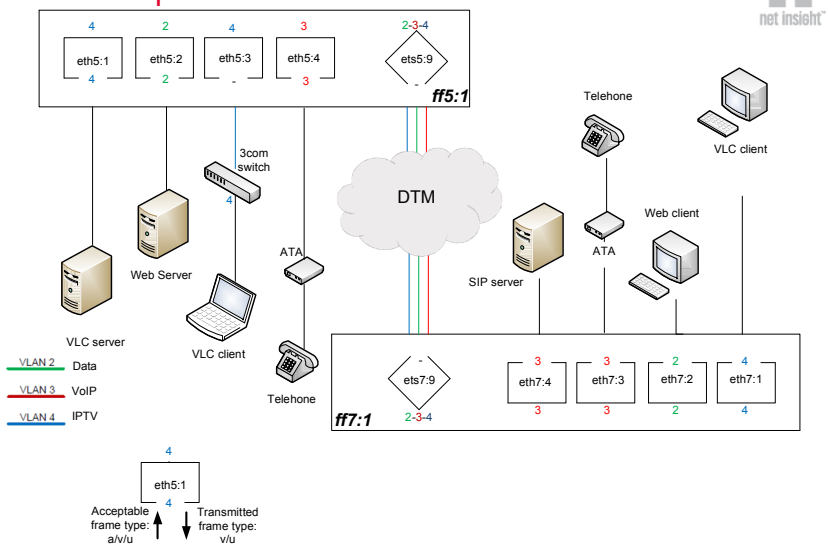
- Two priority modes are allowed on per-interface basis
  - Diffserv
  - Ethernet
- Traffic class priority mapping leads to two queues



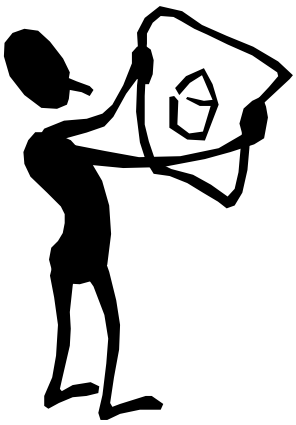
Forwarding Function (FF)



ETS Example



Streaming Services



- PDH
- SD-SDI
- ASI
- SDH/Sonet (VC4)
- HD-SDI

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Service Provisioning (ITS) – what to configure

- Setting up
- Unicast/multicast
- Local identity (DSTI)
- Local interface
- Capacity (if applicable)

- Remote node
- Remote identity (DSTI)

- Source route
- Protection switch

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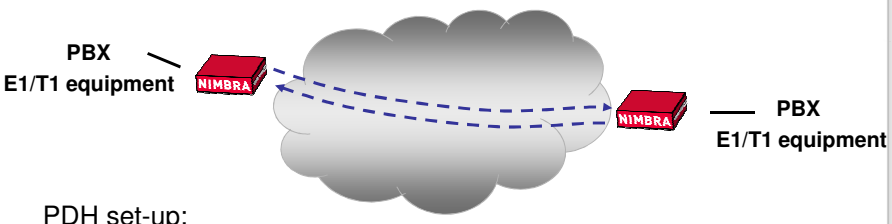
Streaming Services, PDH



PDH set-up:

- Two PDH tunnels are required to communicate both ways (a PDH tunnel is one-way) when using unicast
- Specify only end-points (node/card/port)
- Primary and secondary (backup) channels can be used.
  - This is PDH 1+1, the primary and secondary channel is manually source routed

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Streaming Service, PDH

- Can be used to connect for example local PBXes
- PDH paths are provided by DTM channels
- Protection switching is set up by using redundant channels
- The 8 kHz frame structure of DTM suits PDH transport

E1 / T1

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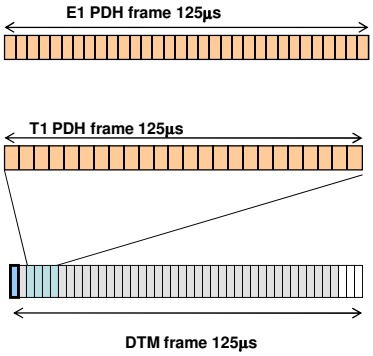
Mapping of PDH



- E1 PDH bitstream (256 bits/125ms)
- Mapped into 5 timeslots.
- T1 PDH bitstream (193 bits/125ms)
- Mapped into 4 timeslots

DTM frame

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SD-SDI Streaming Service

- Uncompressed 270 Mbps video service for real-time video production/contribution
- Serial Digital Interface (SDI/SDTI)
- ITU-R BT.601/656 compliant
- 2 In, 2 Out, 2 Monitoring ports
- Up to 16 SDI streams per Nimbra On
- Studio quality jitter and wander performance
- Low latency (< 400us)
- G.826 PM end-to-end
- Near-end and far-end loopback
- Support for external 1+1 protection

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SD-SDI

- An uncompressed SDI 270 Mbps service for real-time video production/contribution
- Optional (1+1) channel protection support with hardware redundancy
- Port isolation
  - Enables streaming to several different end sites
  - Enables multicast of streams to several sites
- Immediate end-to-end provisioning
- Supports SDTI
- Uni-directional

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ASI Transport Access Module (DVB/ASI MPEG video)

- Two incoming and two outgoing ports + 2 monitoring ports
  - Optional (1+1) channel protection support with hardware redundancy
- 8 in or outgoing ASI ports
  - Optional (1+1) channel protection support with hardware redundancy
- Adjustable tunnel bandwidth
- Multicast support
- Line/DTM loopback
- 2 – 212 Mbps

ASI
2 - 200 Mbps

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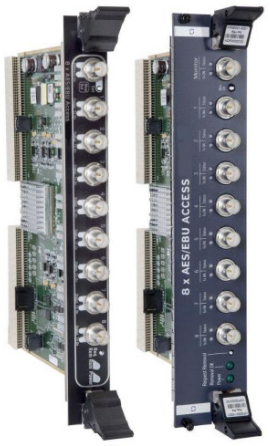
AES/EBU Digital Audio Service

- 8 BNC ports
- Ports individually configurable as In or Out
- One separate monitor port monitoring any other port
- Complies with AES3-2003 standard
- Sample rates 32/48/96/192/44.1/88.2/176.4 kHz
- Channel bandwidth configurable 2-12 Mbps
- Transparent or Frame Aligned mode
- Optional 1+1 protection <50ms
- G.826 PM per channel



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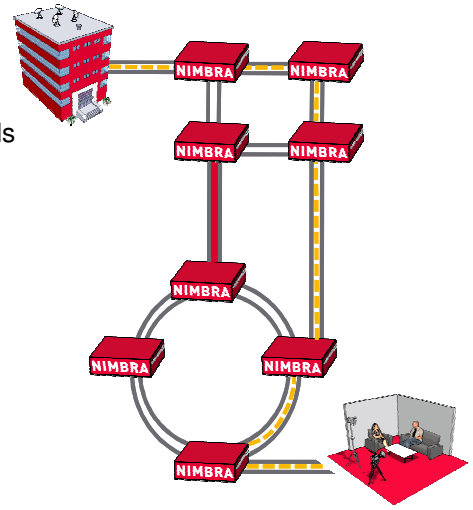
Network Functionality – Automatic Signaling & Control

- Automatic node discovery
- Automatic routing of channels
- Automatic failure discovery
- Automatic restoration
- Crank-back function
- Prioritized channel set-up



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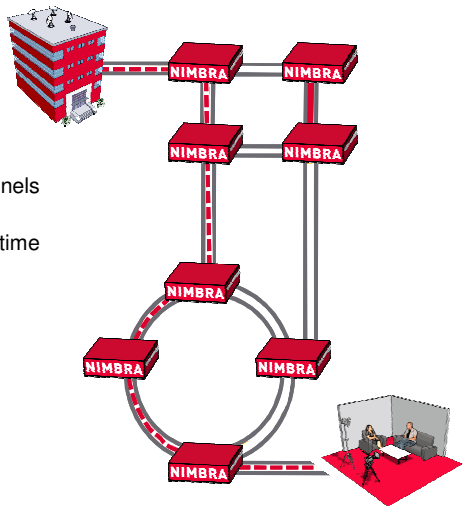
Network Functionality – Automatic Signaling & Control

- 1+1 Channel Protection
  - 2 SDI or 2 ASI channels
  - Guaranteed on separated channels
  - Approximately 1ms switchover time



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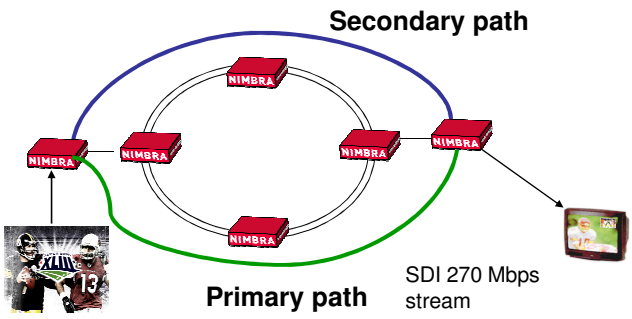
(1+1) Channel Protection

- Data is sent on two channels using two interfaces on different cards/chassis
- Source routing is used to guarantee physically separated channels



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(1+1) Channel Protection

Split
The signal is split in the node and sent along two separate routes in the network

Secondary path

Selector node
Selects one video signal

Forwarded stream

Primary path

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(1+1) Channel Protection

Split
The signal is split in the node and sent along two separate routes in the network

Primary path

Selector node
Now it receives only one video signal

Forwarded stream

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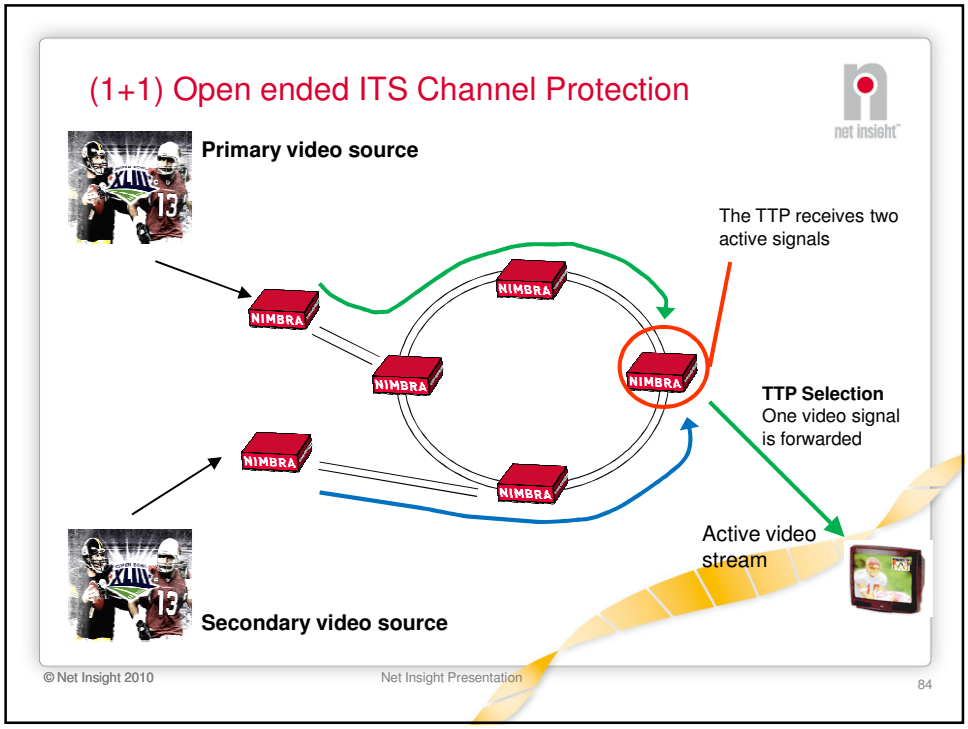
(1+1) Open ended ITS Channel Protection
net insight
Primary video source
The TTP receives two active signals
NIMBRA
NIMBRA
NIMBRA
NIMBRA
NIMBRA
NIMBRA
TTP Selection
One video signal is forwarded
Active video stream
Secondary video source
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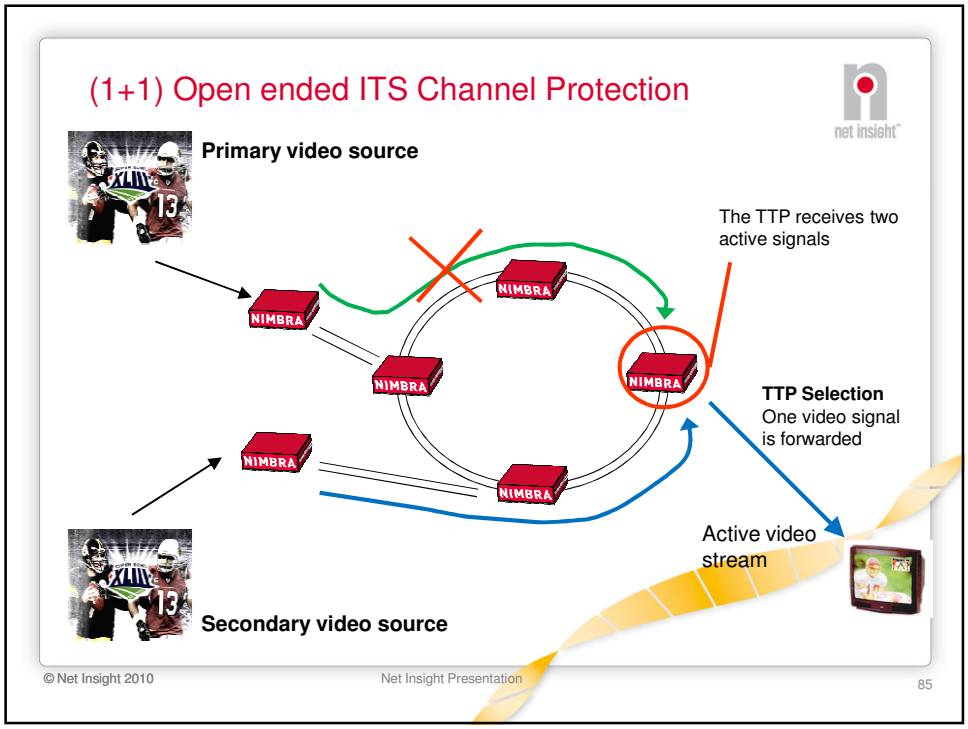
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NIMBRA
NIMBRA
NIMBRA
NIMBRA
TTP Selection
One video signal is forwarded
Active video stream
Secondary video source
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Services

- Multiservice over one infrastructure
- Multicast
- Service adapted solution
- Standard interfaces
- QoS Ethernet with legacy interfaces
- Simple end-to-end configuration
- Logical service isolation ensures QoS, integrity and security.
- Flexible service provisioning
- High utilization for high demanding services

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IP/Ethernet Trunk Module

Best Current Practice

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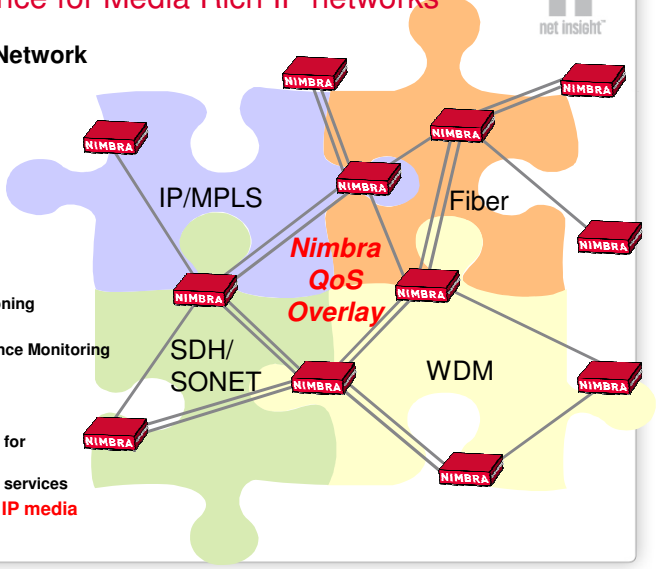
True Convergence for Media Rich IP networks

ONE Unified Media Network

- Any Media Service
- Over Any Network
- Over Any Topology
- Over Any Vendor

- **Unified End-to-End Provisioning**
- **Easy Multicast set-up**
- **Unified advanced Performance Monitoring**
  - Per Service
  - Per Link
- **Guaranteed QoS**
- **Maintained synchronization for video and audio services**
- **Both IP/Ethernet and Native services**
- **Reclaim control of your IP media network !**



IP/Ethernet Trunk for the Nimbra One/300 series

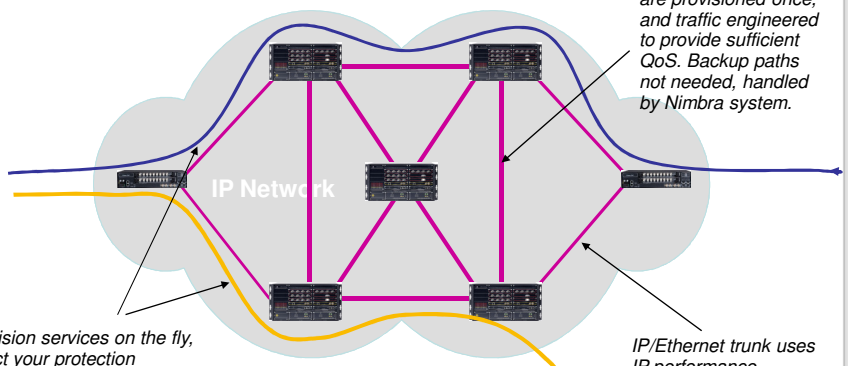
- Trunk link service similar to SDH/Sonet trunks but over a IP/Ethernet network instead
- 3 x IP/Ethernet trunk module for the Nimbra One/300 series
- 2 port FW module for the Nimbra 360 fixed trunks
  - only Nimbra 360 with hardware revision B

IP/Ethernet Trunk for the Nimbra 600

- 6 x IP/Ethernet Trunk Module
- Release LX-ipt600.2 is a first commercial release
  - only five simultaneous active ports on the module are supported
- Same as Nimbra One/300.
  - An Element Manager manual supplement is provided.
  - This release is only applicable for the Nimbra 600 series

IP/Ethernet trunk system overview

Nimbra synchronous overlay over IP/MPLS/Ehernet – Gets you back in control of your media network

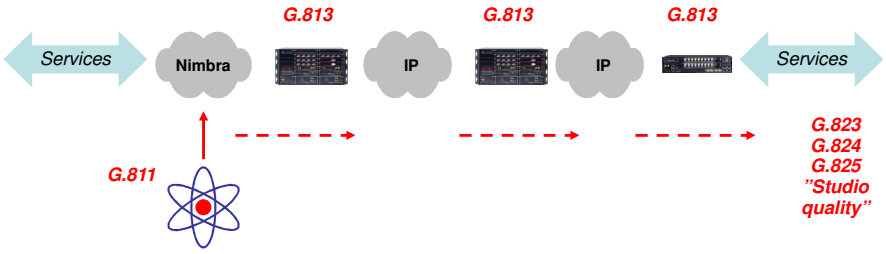


IP trunk connections are provisioned once, and traffic engineered to provide sufficient QoS. Backup paths not needed, handled by Nimbra system.

Provision services on the fly, select your protection alternatives, manage and control your media network with minimum transport network provider dependence.

IP/Ethernet trunk uses IP performance monitoring probe functionality to verify the QoS SLA of the IP connection.

Synchronous overlay network model



- Modelled after timing requirements for Synchronous Digital Hierarchy (SDH)
- Network is feeded by a Primary Reference Clock, PRC, (ITU-T G.811)
- Each node has an equipment clock, corresponding to the a SEC (synchronous equipment clock) in SDH. G.813 specifies this clock
- Network limit requirements (G.82x) shall be fulfilled
- IP connections need to be enginered to fulfil the G.813 requirements

IP connection parameters influencing transport

- In technical terms:
- Packet Loss Ratio (PLR)
- Packet Delay (PD)
- Packet Delay Variation (PDV)

- In SLA terms:
- "Platinum, Gold, Silver, Bronze" services

- In DiffServ terms:
- EF, AF, CS, DF service classes
- Priority queuing, Rate queuing, Active queue management

Required Ethernet Capacity

- OC-3/STM-1 Trunk @ 155.52 Mbps = 288 slots payload
- IP/Ethernet Trunk @ 155.52 Mbps = 282 slots payload
  - => ~ 2% overhead
- How much Ethernet capacity is needed on trunk side for a given number of slots for payload?
  - No FEC

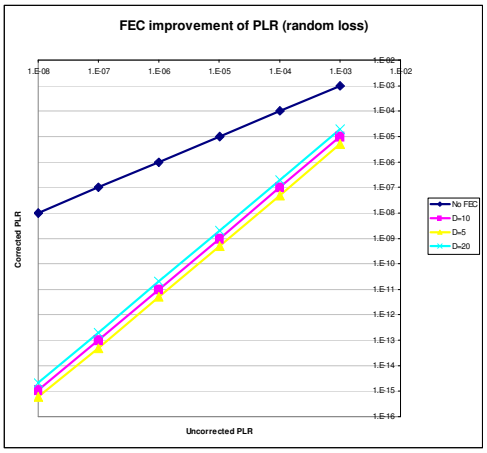
    Eth_{BW}(#slots) = #slots * 0.55 Mbps
  - With FEC

    Eth_{BW}(#slots, D) = #slots * 0.55 Mbps * (1 +1/D)

    L (Col) setting gives burst recoverability, D (Row) gives random loss recoverability

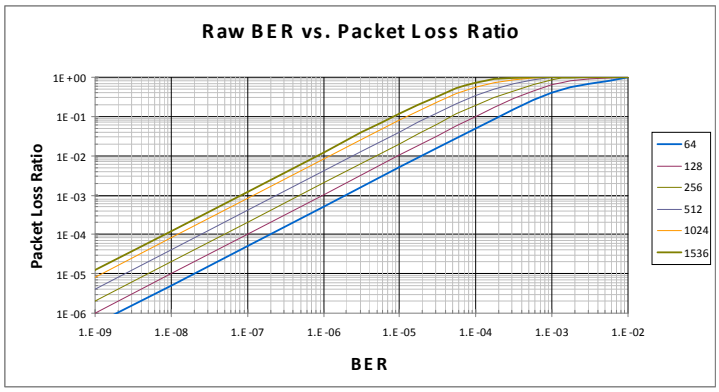
Packet Loss Ratio (PLR)

- Provisional service classes for contribution services specifies a packet loss ratio 10^{-5} or better (ITU-T Y.1541)
- One hit per day performance for ASI/SDI/HD-SDI requires a PLR of 10^{-9} – 10^{-11}
- Hence, Forward Error Correction (FEC) is needed
- The IP trunk FEC provides 10^{-9} PLR at 10^{-5} PLR performance of the IP connection (random loss)
- L (Col) setting gives burst recoverability, D (Row) gives random loss recoverability
- **Best Current Practise:** Request a PLR of 10^{-6} or better from the Operator, to have some margin. Use FEC, for example L = 5, D=10 (10% OH)



BER vs PLR

- Sometimes BER (Bit Error Ratio) is specified instead of PLR
- For random errors the following relationship apply
- Typically a BER of 1 x 10^{-9} gives a PLR of ~ 1 x 10^{-5} for default IP trunk frames



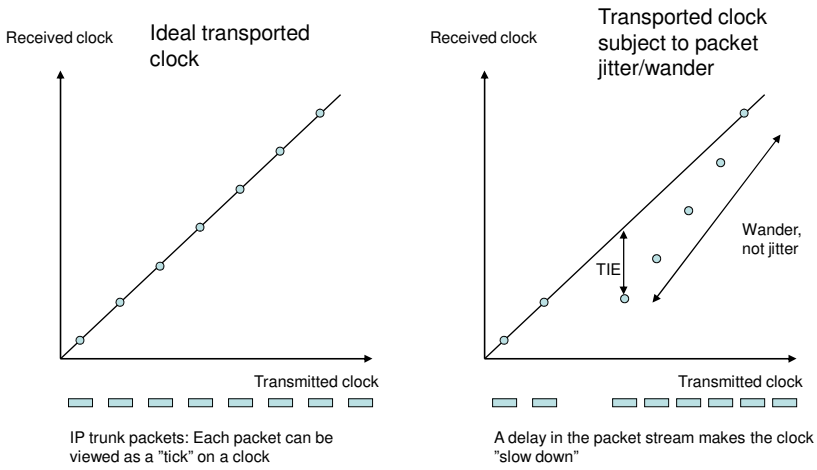
Packet Delay

- Packet delay is not critical for the operation of the IP trunk
- A too long delay may however affect (e.g. interactive) services negatively
- Delay of the IP connection is mostly a function of the physical distance
  - There is also an addition due to the mean buffering delay in each router/switch
  - For very BW narrow connections serialization delay can come into play, but it is not likely to be a problem for IP trunk links
- Delay through a Nimbra node is dominated by the jitter buffer delay and the FEC delay
  - Jitter buffer size can be adjusted, default setting is 2 ms
  - Typical FEC delays at 30 Mbps
    - L x D = 2 x 4 = (25% OH) ~ 5 ms
    - L x D = 2 x 20 = (5% OH) ~ 18 ms
    - L x D = 10 x 10 = (10% OH) ~ 48 ms
- **Best Current Practise:**
  - Depending on the end-to-end delay budget, adjust the jitter buffer delay, while making sure that the packet jitter is accommodated for
    - The PDV counters on the trunk page (RMS jitter, 99.9% percentile and max jitter) are of great help here
  - Use an as small FEC matrix as possible
  - Nothing special to request on the IP connection, except shortest physical route
  - Note however the correlation against IP connection QoS: the higher QoS the smaller the jitter buffer and FEC matrix need to be => both contributing to lower delay

Packet Delay Variation (PDV)

- PDV have impact on the timing properties of the transported services
- Since the Nimbra network is modeled after SDH timing standards this is a crucial measure
- It is also the least well specified quantity of an IP connection
  - Typically PDV or Jitter is specified with a single number
  - However the PDV distribution is important, but very hard to characterize
  - Wander performance that is very important for video services (and for providing an SDH like service) can not be extracted from the given IP connection SLA
  - Jitter may also vary much over time, especially for lower service classes
  - Hence, IP connection jitter specifications does not give a conclusive measure of the achievable QoS
- Jitter is easier to handle than wander
- Typically packet jitter “transforms” into wander at high network loads
  - Like a crowded highway, a small disturbance may give long range effects
- *Hence, high BW IP trunk link connections must be more carefully engineered*

Effects of PDV on transported clock (high load)

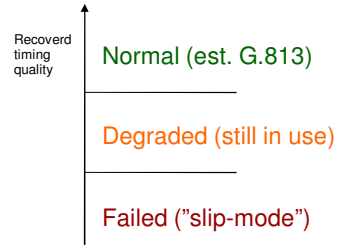


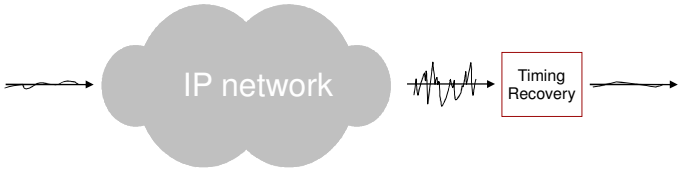
IP trunk packets: Each packet can be viewed as a ”tick” on a clock

A delay in the packet stream makes the clock ”slow down”

Timing Recovery in the IP/Ethernet Trunk

- Advanced timing recovery circuitry using Kalman filtering
- Provides strong jitter supression and fast settling times
- Small jitter buffer delay
- Structured synchronization approach, targeting ITU-T G.813 quality of recovered signal, i.e. SDH/Sonet ADM quality
- Network jitter performance is continually monitored (RMS, 99.9% percentile, max)

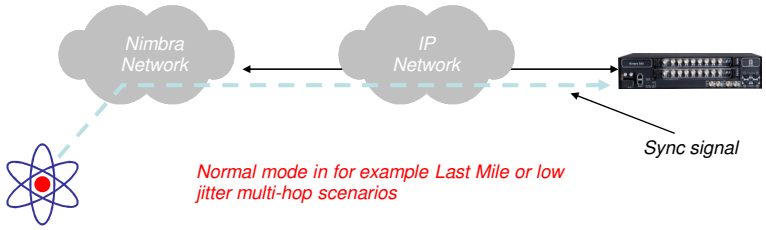




PDV continued

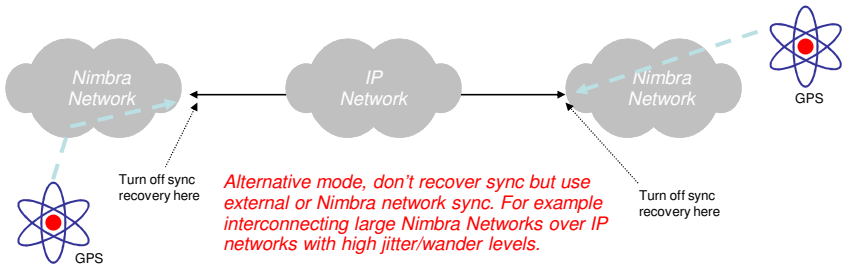
- As mentioned before, the PDV/jitter value of the IP connection is of limited usage for determining the QoS
- At high load, the jitter may be low but the wander high, hence affecting MTIE/TDEV properties of the transported signal
  - Load is the combined load of the IP trunk traffic and Operators other traffic
  - Proper characterization would involve measuring the MTIE/TDEV properties of a packet clock stream, which is complicated
- Hence the discussion will be given in terms of DiffServ service classes instead
  - That is, how traffic is handled in the routers/switches
  - The rationale is that certain service classes has much better timing properties
- Also low load and high load scenarios must be handled separately
  - The border between low and high load is not evident and may vary between different Operator’s networks.
  - For the purposes of this BCP discussion we may draw the border at 300 Mbps, that is, for transport of uncompressed SDI
  - Again, it is the total load that counts
- By using “out-band” synchronization (alternative 2 below) it is possible to handle virtually any level of packet jitter/wander
- Consider the following synchronization alternatives

Synchronization alternatives: 1. “In-band” sync



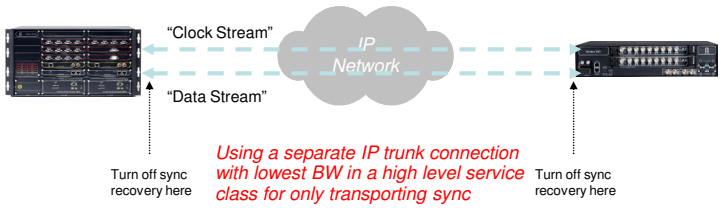
- Sync signal is transported from PRC all the way to the access node
- May be a mixture of links over the path, SDH, dark fibre/WDM and IP
- This is the default mode of operation, Expedited Forwarding (EF) is the recommended service class
- In the case of a “jitter free” transport, this mode can be used at any bandwidth
  - Straight cable, resource reserved transport such as EoSDH, EoWDM etc.

Synchronization alternatives: 2. “Out-band” sync



- While not practically or economically feasible to have GPS clocks on all end-nodes, it may be a good idea to group very different areas, connected with IP trunks, together and use a GPS clock for each area
  - For example, to interconnect two regional networks over a long distance IP link
- With this arrangement, jitter and wander is not an issue for the synchronization, only make sure that the jitter buffer can accommodate for the maximum jitter.

Synchronization alternatives: 3.Separate clock stream



- For high BW connections it may not be feasible to obtain a high QoS service class for the IP trunk connection
- By using a parallel IP trunk connection only carrying the clock information (about 2-3 Mbps) it is feasible to provide a higher service class (e.g. Expedited Forwarding) for this low BW connection and thus provide a better sync transport
  - Set "TX slots" to 2 and MTU to 100 B gives good clock packet rate at 2.5 Mbps Eth BW
- The data stream should then utilize a somewhat relaxed service class with focus on low PLR (Assured Forwarding for example)

DiffServ service classes

- Differentiated Services, or DiffServ for short, is an architecture for provision Quality of Service in IP networks.
  - Many RFCs, most pertinent here is RFC 4594 "Configuration Guidelines for DiffServ Service Classes"
- Main service classes are
  - EF, Expedited Forwarding, "Platinum, Gold" service, priority queuing gives best performance in terms of PLR, PD, PDV, but can only be assigned to a fraction of the total traffic
  - AF, Assured Forwarding, "Silver" service, rate queuing, active queue management, focus on low packet drop, not on low PDV
  - DF, Default Forwarding, "Bronze" service, best effort, no guarantees on anything, should be avoided for IP trunk usage
- Other service classes
  - CS, Class Selector, service class for interoperability with older QoS schemes such as "IP precedence", QoS performance is vaguely defined, but the higher levels of CS may be eligible for the IP trunk, depending on implementation by Operator. Higher level CS classes may be implemented with EF like properties.

BCP for timing recovery

- **Best Current Practice:**
- Never use a DF (best effort) service class unless you have full control over the IP connection, it will most likely give you problems
- In synchronization alternative 1, if possible always use an Expedited Forwarding service class, which is the only service class for real-time, “pseudo-wire” applications
  - Typically EF is offered on up to 10% - 25% of the Operators link/network capacity
- For certain network applications, consider synchronization alternative 2: “out-band” synchronization with GPS clocks for sub-networks
  - For this scenario jitter levels up to hundreds of milliseconds can be handled (depending on trunk configuration)
- For high bandwidth IP trunk applications such as for SDI transport, consider the use of synchronization alternative 3: “separate clock stream”
  - Clock stream in EF service class (DSCP 46)
  - Data stream in higher order AF/CS class such as AF41 (DSCP 34) or CS5/4 (DSCP 40/32)
- A network may contain a mixture of these synchronization alternatives
- Use physical links with as high port BW as possible
  - Buffering delay becomes smaller
  - That is, prefer 1000 Mbps over 100 Mbps over 10 Mbps Ethernet links
- Monitor the PDV statistics counters for jitter info and the DPP-IP counters for loss, recovery, re-ordering etc of packets.

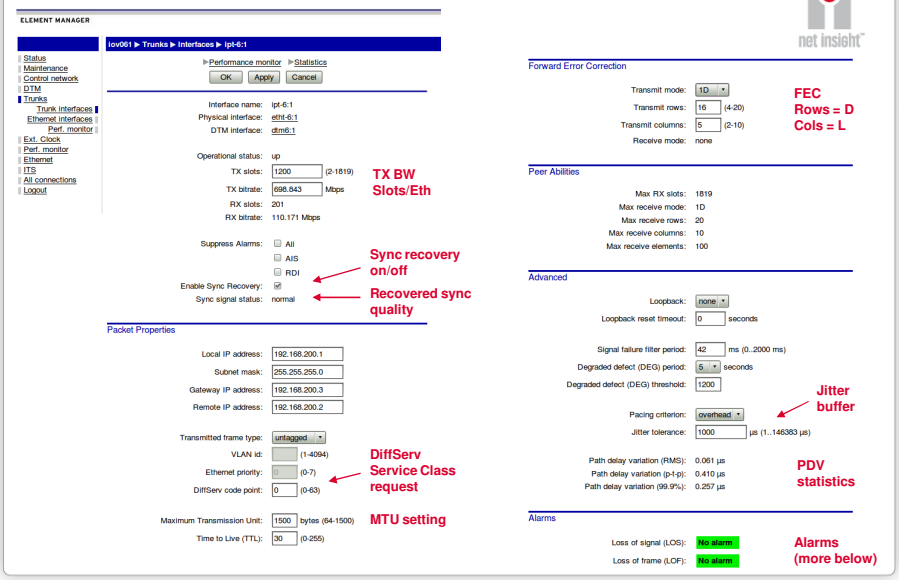
Summary of recommendations

Sync Alt / Require from IP connection	Sync Alt 1.	Sync Alt 2.	Sync Alt 3.
Service Class	EF	AF	Clock Stream: EF Data Stream: AF
Packet Loss Ratio (PLR)	$< 10^{-6}$	$< 10^{-6}$	$< 10^{-6}$
Packet Delay (PD)	N/A	N/A	N/A
Packet Delay Variation (PDV)	FFS[1]	5 – 500 ms[2]	Clock Stream: FFS[1] Data Stream: 5 – 500 ms[2]

1) Packet delay variation spec is depending on trunk bandwidth and with complex dependence on PDV distribution, specification metric and method is under study

2) PDV tolerance is depending on available jitter buffer size, ranges from ~ 5 ms @ 1000 Mbps trunk BW to ~ 500 ms @ 10 Mbps trunk BW

IP/Ethernet trunk i/f element manager overview



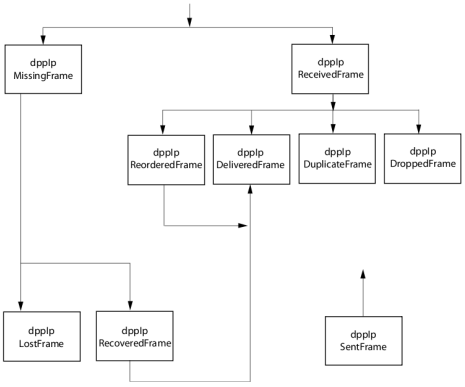
DPP-IP counters

- The DPP-IP counters gives comprehensive statistics
- Sent frames (near-end) -> Received + Missing frames (remote-end) (these are all frames including FEC OH)
- Delivered Frames are the frames delivered to the DTM interface to build the DTM frame
- Dropped/Lost Frames will be substituted with AIS slots in the DTM frame

Interface name: ipt-4:3
Physical interface: etht-4:3
DTM interface: dtm4:3

Counter	Value
dpplpDeliveredFrames	116,301,412
dpplpDroppedFrames	549
dpplpDuplicateFrames	0
dpplpLostFrames	0
dpplpMissingFrames	0
dpplpReceivedFrames	116,301,961
dpplpRecoveredFrames	0
dpplpReorderedFrames	0
dpplpSentFrames	13,751,374

OK Reset counters



Summary

- IP QoS is not an exact science
  - Focus has been on simpler services such as VoIP and rate adaptive low bandwidth video distribution/conferencing
  - Contribution Video and Synchronous Transport applications puts higher demand on the IP transport
- DiffServ is a widespread architecture that give the tools for implementing (class based) QoS and gives a nomenclature for discussing QoS levels for different services in terms that are more exact than “Gold, Silver,…” but without the daunting technical level of PDV distribution/MTIE/TDEV etc
- Following the BCP as outlined in this document will almost certainly give you a a very good result
  - But keep in mind that different operators implement QoS differently, one operators “gold” may in worst case be another operators “silver” or “bronze”
  - This BCP gives you the tools to discuss QoS issues with the operator
- This is a Best Current Practise, it may evolve with time

Management

Management

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Management

- Net Insight products have an Ethernet and a serial port
  - Can be used for out-band management network purposes
- IP based in-band management
  - Can be used to build an in-band management network

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Nimbra Management

- Nimbra Vision
  - Network Manager
- Nimbra Element Manager
  - Node Manager
  - Web-based application through HTTP
- CLI (Command Line Interface)
  - Serial port RS232
  - Telnet

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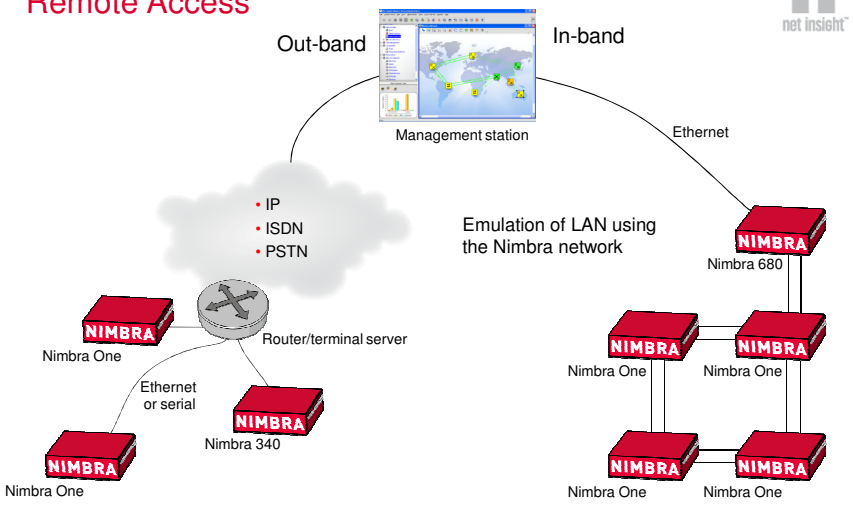
Remote Access



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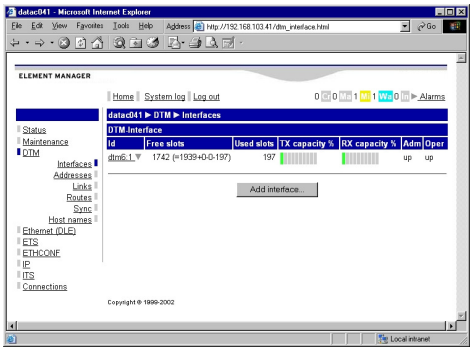
Web Interface

- Status Monitoring
  - Alarms and Events
  - Equipment inventory
- Maintenance
  - Initial configurations
  - Backup of configurations
- Network configuration
  - Interfaces
  - Addresses
  - Routes
- Service Provisioning
  - Set-up of services (ITS/ETS)
  - Source routing
  - Scheduling
- Performance Monitoring

- Built-in web server in each NE
- Complete management tool for the node



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Summary

- Designed for (not adapted to) real-time video requirements
- Strong multiservice support
  - ASI, SDI, HD-SDI, AES/EBU, Ethernet, PDH, SDH
- Cost-efficient use of available bandwidth infrastructures
  - High bandwidth utilization
  - Good mix of network link capacities and media types
- Automated control plane gives minimum OPEX
- 100% guaranteed quality of service

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Summary

- Net Insight – A Solid Company with Global Reach
- Superior Technology and Customer Testimonials
  - 1,3 Billion people world wide is without knowing it, directly dependent on the high quality of the Nimbra™ products portfolio for the delivery of TV to their homes.
  - During the 2008 summer Olympics in Beijing an entire world was addressed with content delivered over the Nimbra™ platform
    - In total 7200 hours of broadcasting was delivered to 1 200 000 000 viewers
    - No service interruptions and Zero packets lost
- Focus on Operational Advantages through Innovative Technology
- 100% Quality of Service – Guaranteed

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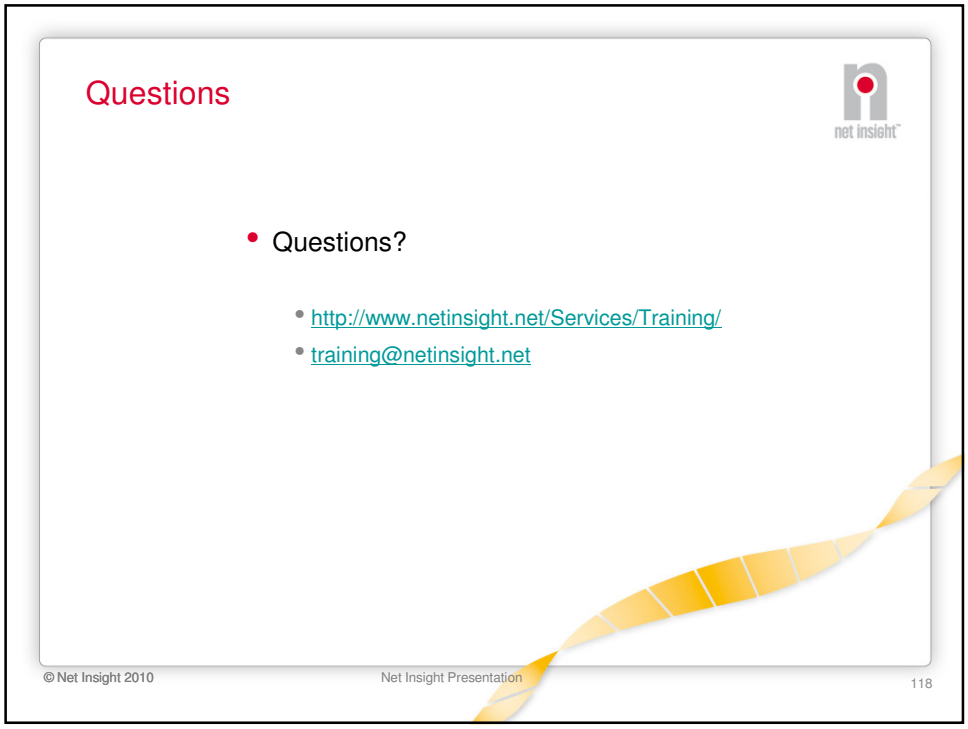
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