Blue 102

IP Service Architecture Futures

Geoff Huston

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Telstra

Next Wave IP Services

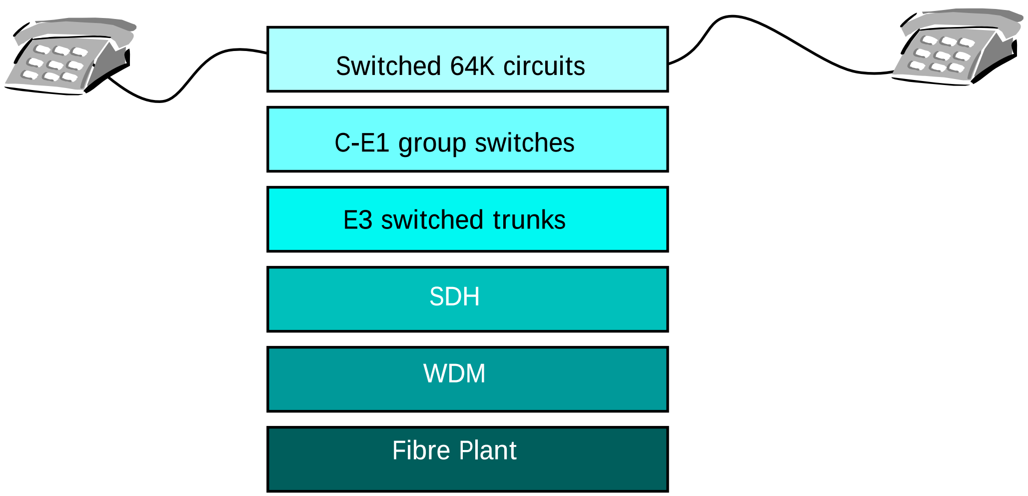
- Service Requirements
  - Connectivity service for customer-operated routers
  - Service payload is IP packet
  - High peak carriage capacity
  - Extremely rapid service activation
  - Lightweight Operations and Management load
  - Rudimentary QoS capabilities
  - Customer control of Service Profile

Data Service Evolution

- Data Service Platforms are changing:
  - IP service networks have evolved in terms of their architecture to respond to demands for increased capacity and reduced unit cost
  - Each evolutionary step has been directed to removing an additional layer of network switching hierarchy

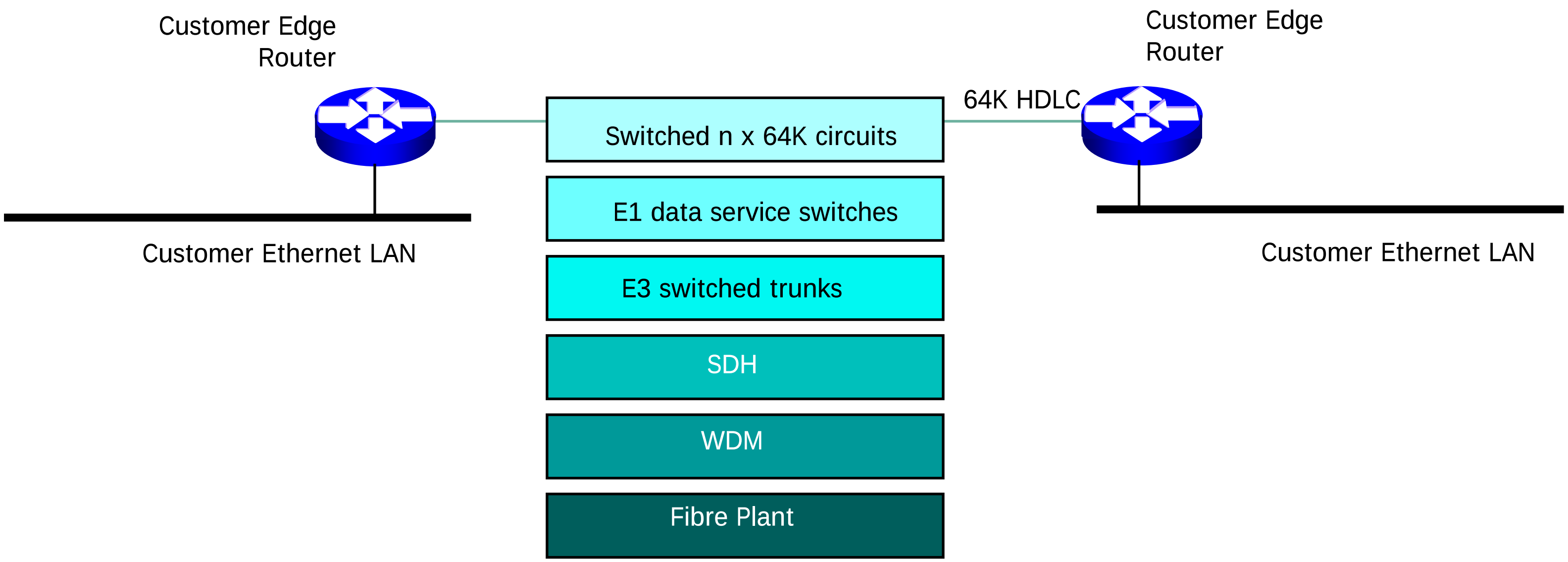
Data Service Evolution

- Hierarchical Time Division Switching Architectures
  - PSTN networks require the network to perform switching of synchronous bit streams. This is performed through a hierarchy of transport layers, where each layer is an aggregation of the higher layer.



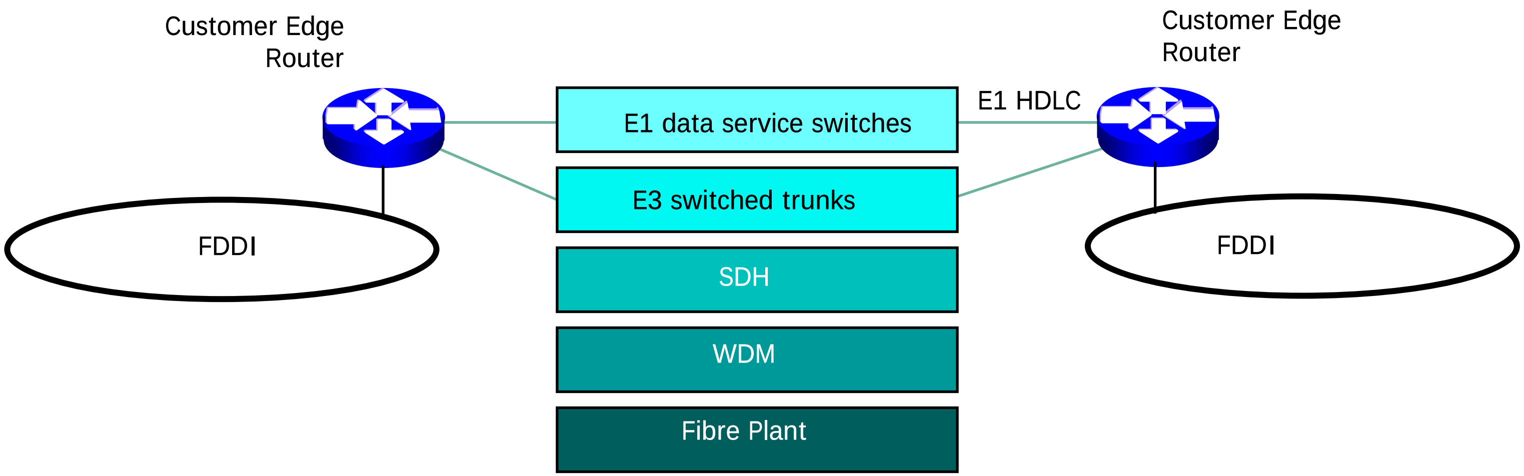
Data Service Evolution

- Data circuits are layered above point-to-point data circuits, using the complete PSTN circuit switching hierarchy
  - n x 64Kbps



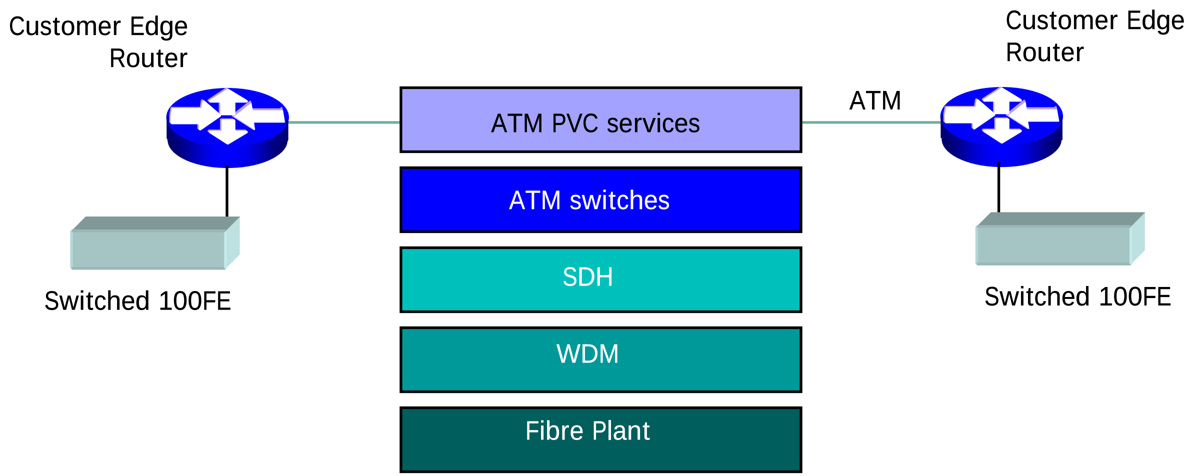
Data Service Evolution

- 2nd Generation IP Services
  - 1990 - IP is a customer of the E-1 / E-3 trunk bearer network (2Mbps and 34 Mbps)



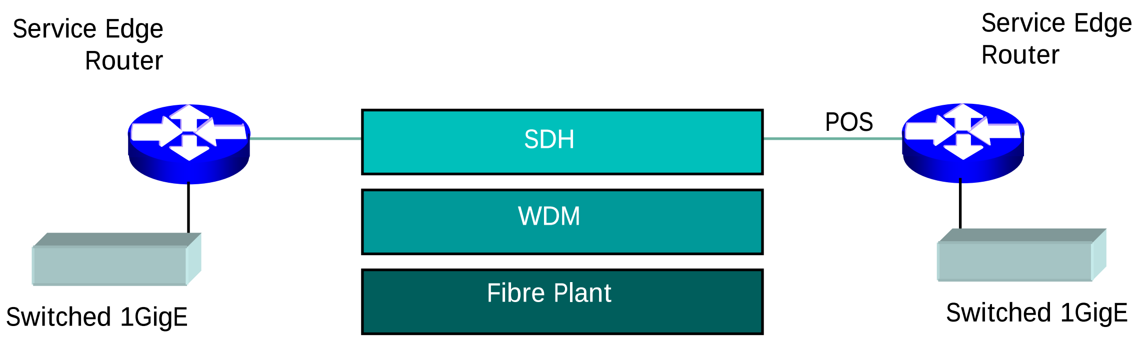
Data Service Evolution

- 3rd Generation IP Services
  - 1998 - IP over ATM (MPOA) (34M CBR, UBR, ABR)



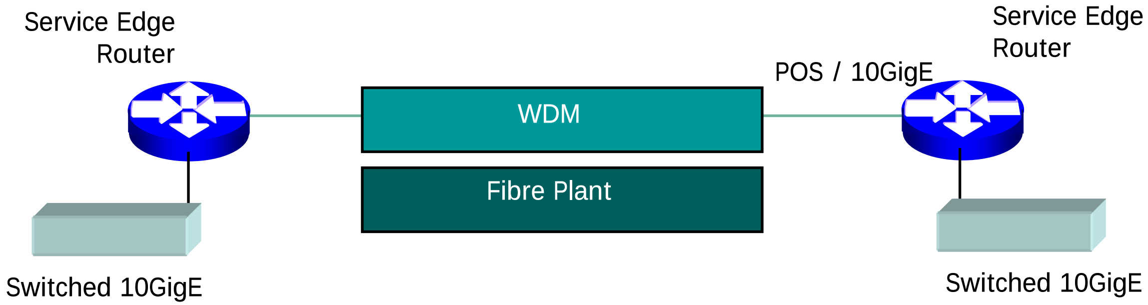
Data Service Evolution

- 4th Generation IP Services
  - 1999 - IP over SDH (POS) (155M, 622M, 2.5G, 10G)



Data Service Evolution

- 5th Generation IP Services
  - 2001 - IP over WDM (10Gbps trunks) (10GigE)



Data Service Evolution

- Each Service generation:
  - uses fewer elements of the PSTN carriage hierarchy
  - reduces the number of infrastructure support groups
  - requires longer planning cycles and coarser provisioning increments, but involve fewer provisioning groups
  - results in:
    - order of magnitude increase in capacity
    - order of magnitude decrease in unit cost of IP carriage

Packet-Based Services

- Each architecture places additional functionality within the packet frame and requires fewer services from the network

NETWORK →	**PACKET**
real time bit streams	asynchronous data packet flows
network data clock	per-packet data clock
end-to-end circuits	address headers and destination routing
fixed resource segmentation	variable resource segmentation
network capacity management	adaptive dynamic utilization
single service platform	multi-service payloads

IP Service Architecture

- Major elements in the platform architecture:
  - carrier network edge switch to customer handover demarcation point

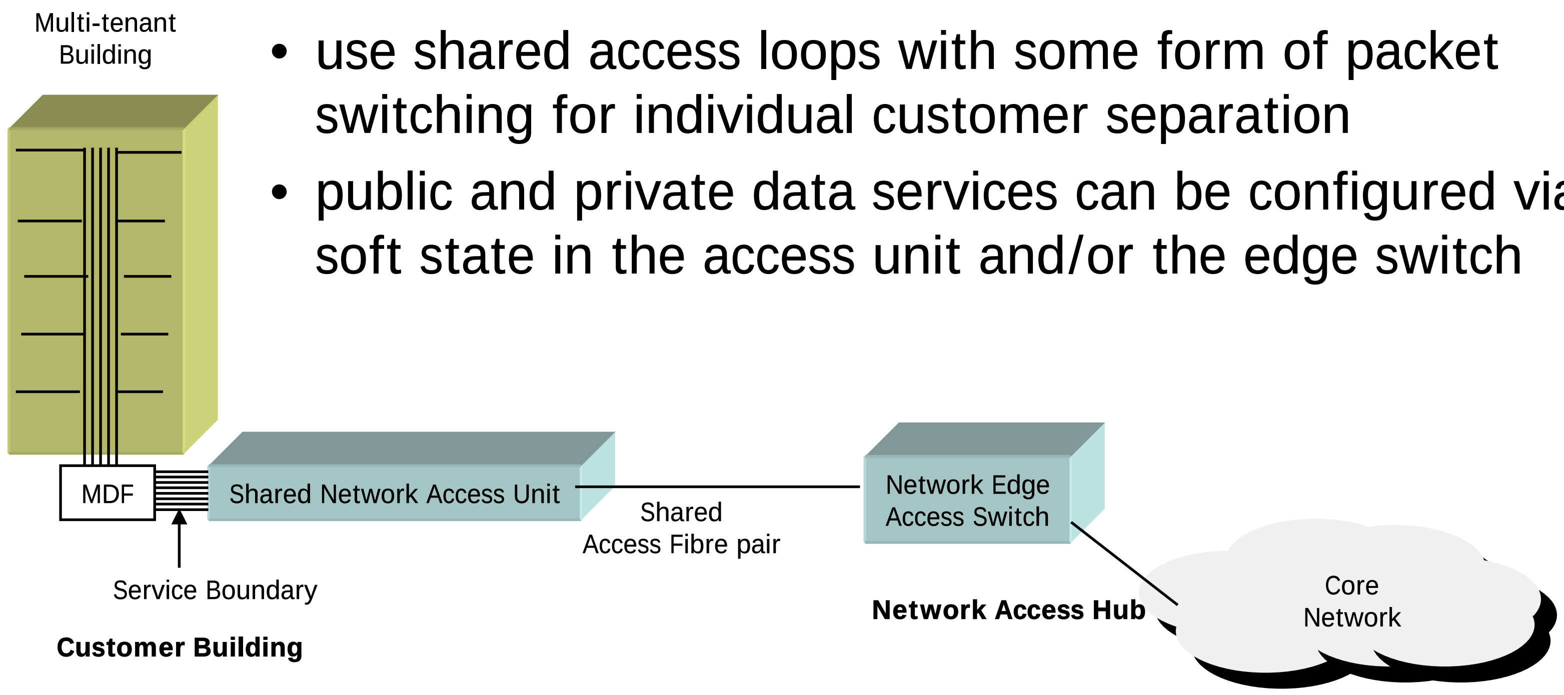
    access network
  - network edge-to-edge internal transit

    core network
  - network core to inter-carrier handover

    interconnect network

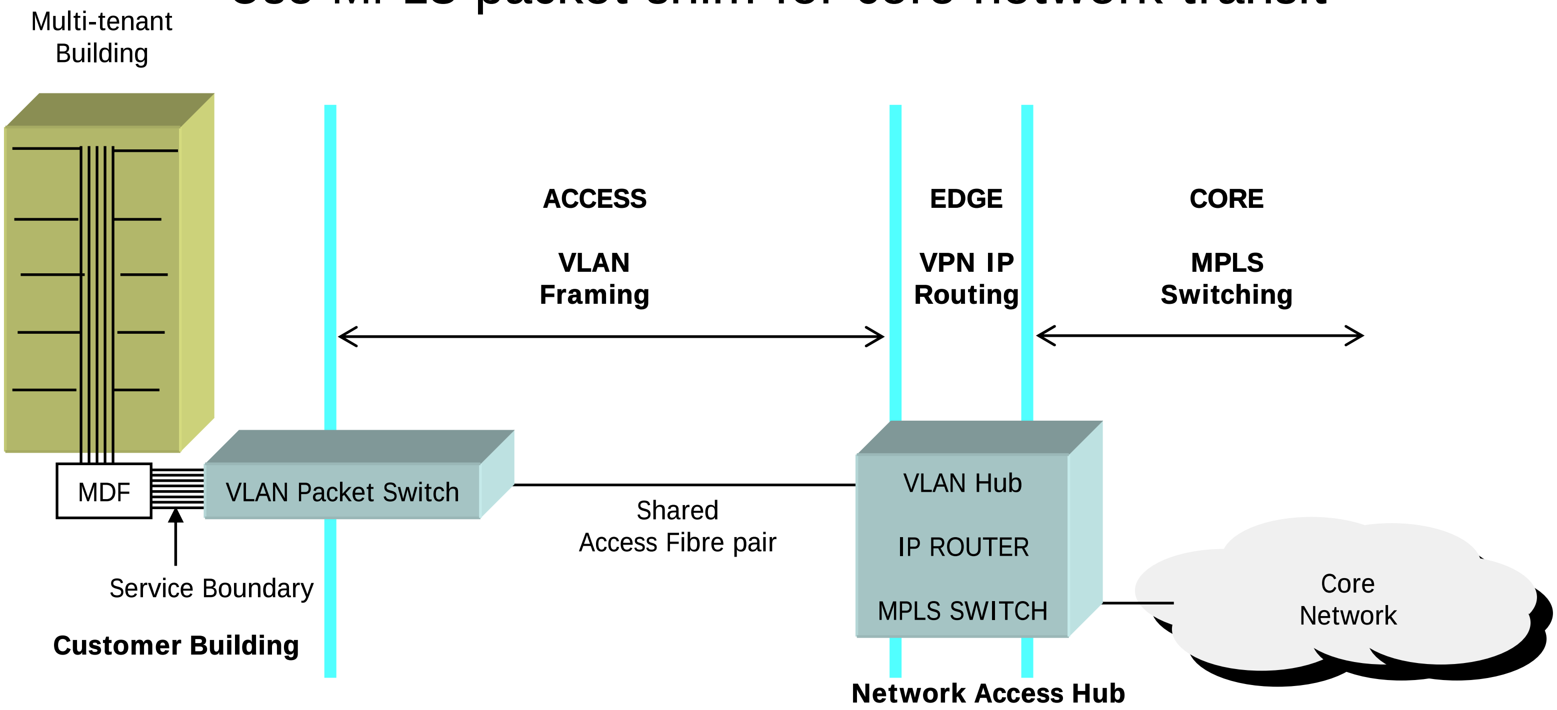
Access

- From circuits to packets:
  - Shift the interface to shared facilities to the building basement
  - use shared access loops with some form of packet switching for individual customer separation
  - public and private data services can be configured via soft state in the access unit and/or the edge switch



Data Framing Model

- VLAN / MPLS approach:
  - Use VLAN thin packet shim for access systems
  - Use MPLS packet shim for core network transit



Access Data Services

- There are a set of service requirements:
  - **point-to-point virtual wireline** service
    ‘traditional’ data circuit service
  - **point-to-multipoint VPN** services
    PVC mesh services without explicit VC enumeration
  - **point -to network access** service
    Carrier Public Internet access services
  - **point-to-interconnect** wholesale service
    competitive access to the customer for carrier services

Access Technology Options

- Various access technologies can achieve many of the desired objectives. The differences lie in resiliency, capital cost and operational robustness
  - SDH city loops
  - IP Packet over SONET Framing (POS)
  - DPT
  - Point-to-point GIG-Ethernet

Trends in IP architectures

- IP trunk networks will continue to grow
  - from OC-n to GigE-based framing
  - from SDH switching to Wave Switching
  - 10G networks that scale to 100G

Target

- SDH and Packet Services
- Growth Factors
- Requirements
  - Characteristics
  - Ops and Management
  - Service Availability

Outline of Direction

- Packet-based services from edge to core

Critical Technologies for Future IP platforms

- Future IP networks will probably rely on elements of the following technologies:
  - Gigabit Ethernet (10G)
  - SDH switching (STM-16c and STM-64c)
  - Dense Wave Division Multiplexing (DWDM)
  - Wavelength Switching (WLS)
  - Multi-Protocol Label Switching (MPLS)
  - Virtual LAN Switching (VLAN)
  - IP Routing (BGP)
  - Path Resource Management (RSVP)

Quality of Service

Multi-Service IP network architectures

Whats the Problem?

- IP is a uniform best effort service
  - service outcomes are variable
  - service outcomes are unpredictable
  - service outcomes are unmanageable
  - service outcomes are not controllable by either the user or the network operator
- Best Effort is not always enough
  - IP cannot readily fulfil a number of desired roles without better control over service outcomes.
  - This control over service outcomes is termed “Quality of Service”

Whats the Desired Outcome?

- IP QoS efforts encompass many motivations:
  - per-platform
    - real-time emulation, such as Voice / Video over IP
    - service emulation, such as point-to-point leased line services
  - per-service
    - per customer product differentiation - common platform with multiple quality profiles and price points for each customer
    - differentiated congestion response for each customer
  - per-transaction
    - per application per invocation tuned response
    - end-to-end application services with predictable performance

QoS Architectures

- Two QoS architectures for IP
  - **Integrated Services**
    - per flow response
    - application-based resource management system
    - network must support resource reservation
    - achieves predictable network service response
  - **Differentiated Services**
    - per-packet response
    - service outcome control system
    - network responds to per-packet markings
    - achieves relative differentiation of service outcomes

QoS Weaknesses

- Neither architecture is adequate for IP QoS service provider networks
  - per-flow systems do not scale
  - aggregated systems deliver only approximate outcomes

- More refinement of IP QoS architectures is necessary
  - and is underway

QoS Developments

- QoS is a major area of technology refinement today:
  - Windows 2000 has support for Integrated Services QoS
  - Router vendors now support Integrated Services for enterprise networks (RSVP signalling and local queue management)
  - Router vendors developing Differentiated Services support for service provider networks
  - MPLS-based QoS characteristics are still being defined by the industry

Potential IP QoS Products

- Differentiated Services will be the base platform architecture, supporting:
  - **1. IP QoS VPNs**
    - MPLS or IP/IP or IPSEC VPNs to achieve network-level traffic segregation using an edge-to-edge approach
    - Network ingress DiffServ tools to achieve a rough approximation of the point-to-point private circuit service behaviour
    - ‘cheaper net’ VPNs, allowing the IP provider to value-add QoS attributes to basic edge-to-edge VPN

Potential IP QoS Products

– **2. IP SLAs**
  - premium IP service offerings with some form of SLA relating to minimum delivered service attributes (delay, jitter and loss)
  - SLAs will be inherently limited to the service provider's network - multi-provider transit SLAs may follow, or they may not
  - Most useful for customer-operated VPN environments, or for common community of interest distributed environments (e.g. dealer networks) where the common SLA can be translated to an approximate service response profile

Potential IP QoS Products

– **3. IP Service on Demand**
  - customer-selectable premium network service
  - Customer marks packets with a service selector code which triggers a network service response
    – elevated queuing priority
    – discard precedence level
    – lower than best effort
    – real-time emulation (jitter intolerant)
  - on demand service availability
  - useful to high value applications such as voice and video transport or real time signalling applications.

Positioning QoS

- QoS services may be an essential attribute of ISP service offerings
  - IP transport is a commodity service with no inherent differentiation
  - QoS may allow the ISP to position a premium product into the market, with a price point midway between base IP carriage and point-to-point dedicated circuit services
  - QoS may allow the ISP to cover a broader range of market service requirements from a single platform architecture

But…

- Remember, IP QoS is just a means of injecting a level of resource management control signals into the IP network.
- IP QoS is not a panacea

IP QoS is **not** …

- IP QoS is unlikely to provide:
  - a full range of real time synchronous bit stream services
  - strict end-to-end application performance guarantees
  - unlimited bandwidth on demand
  - fully automated resource management with no resource demand conflict at all