DOCSIS 1.1 Cable Modem Termination Systems

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DOCSIS 1.1 Features

- QoS management
  - Dynamic QoS management
    - Dynamic QoS addition
    - Dynamic QoS change
    - Dynamic QoS deletion
  - Policy-based QoS management on a per-subscriber basis
  - Statistics collection on a per Service Flow or per subscriber basis
- Advanced MCNS Frame processing
  - De-concatenation
  - De-fragmentation
  - Payload Header Suppression
- Security
  - Baseline Privacy Plus

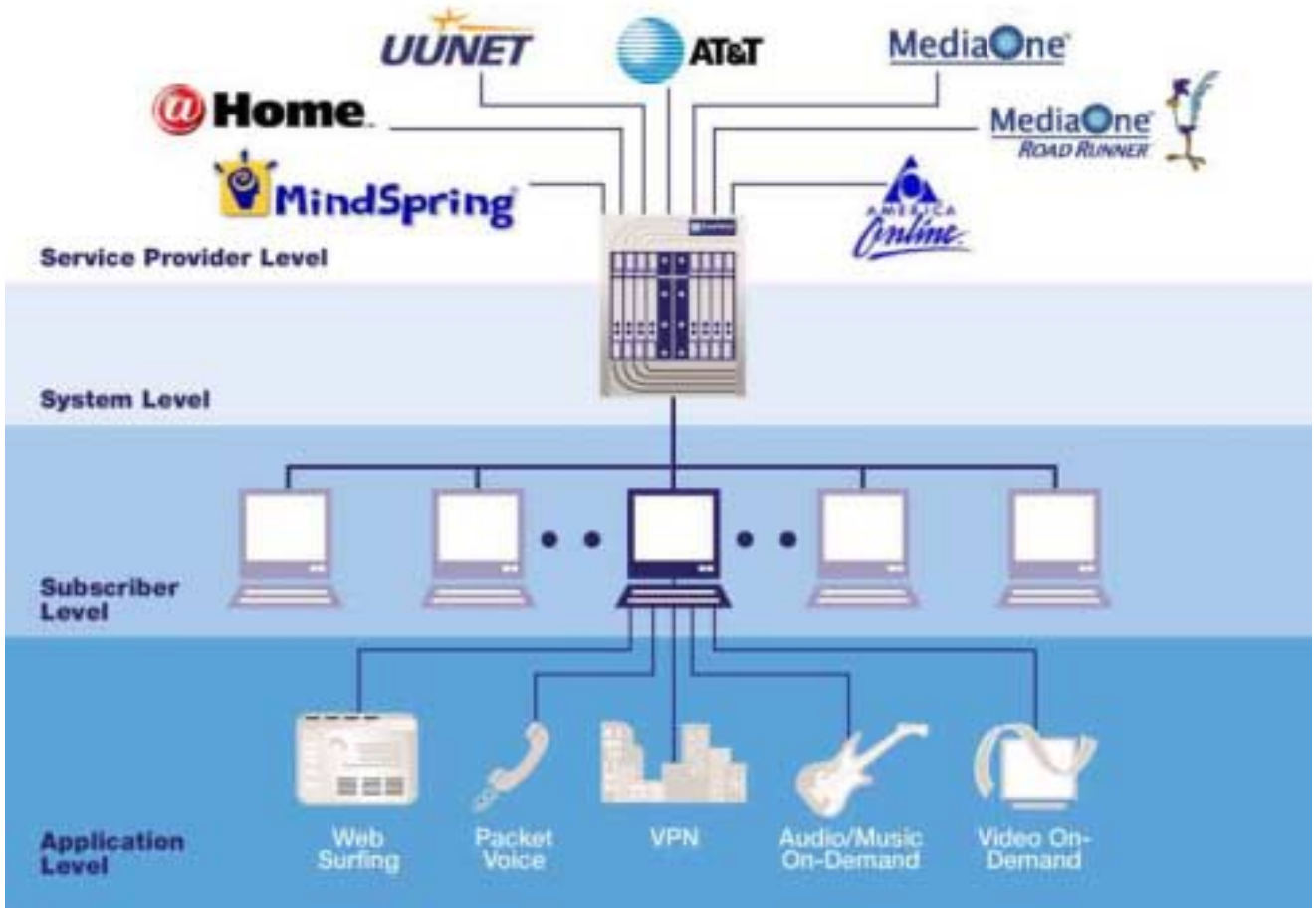
Quality of Service

- Network is a shared resource
- Multiple applications with different needs & values
- Provide applications with required network services
  - data throughput capacity
  - packet loss rate
  - availability
- consistent, predictable service as conditions change
- optimize network use

Why QoS?

Revenue

Multiservice Delivery over Shared Facilities



DOCSIS 1.1 – Multi-Tier Data Service Model – Kinetic Stategies

- Best Effort vs. Tiered Services – 5 Year Period
  - Residential Customers
    - Basic – Shared 1 Mbps Down; 128 Kbps Up - $29.95 – 75% to 60%
    - Enhanced – Guaranteed 1 Mbps Down; 256 Kbps Up - $49.95 – 15% to 30%
    - Premium – Guaranteed 1.5 Mbps Down; 512 Kbps Up - $69.95 – 10% Throughout
  - Business Customers = 5% of HPs; 6% to 18% penetration
    - Basic – Best Effort 1 Mbps Down; 256 Kbps Up - $79.95 – 60%
    - Enhanced – Guaranteed 1 Mbps Down; 512 Kbps Up - $129.95 – 25%
    - Premium – Guaranteed 1.5 Mbps Down; 768 Kbps Up - $159.95 – 15%
  - Revenue Increase 40%
  - Operating Cash Flow Increase by 95%
  - Addition of IP Telephony, IP Video, Music and etc. would add more revenue

QoS is……

- Classification

  figuring out which packets get better service

- Policing

  preventing packets from getting too much service

- Buffering

  Making sure that packets have someplace to stay.

- Scheduling

  Actually provides the service.

Which parts do you need.

- Classification → Always needed.
- Policing, Buffering, Scheduling
  - In practice any two will do….. If they are the right ones.

Classification

once we have flow identification,
we can have per-flow queuing;

once we have per-flow queueing,
we can skip most of the slides on congestion control

Complex classification not required/desirable.

- "deep packet" classifiers will be rendered obsolete by encryption
- End-user system knows more about QoS requirements than the network will ever be able to 'infer'.
- 'inferred' QoS classification is a open invitation for users to try to steal service.

Policing

- Well understood for “classical” traffic types such as CBR and VBR
- Not well understood for newer types of traffic
  - leaky bucket policers and TCP do not mix well
  - policing / marking of aggregated Diff-Serv traffic
  - policing / marking of aggregated Diff-Serv traffic across more than one ISP
- The least flexible way to provide QoS

Buffering

- Most switches are woefully under-buffered
  - which is ok if they are also under-loaded...
  - … or if only a small portion of the traffic gets QoS
  - TCP needs at least one packet per-session
- How much buffer is needed when switches are used in highly loaded ISP environments?
  - a 1/10th of a second of buffer for a GigEth port is only ~150,000 packets!
- Dynamic buffer management is needed
  - dynamically sized packet buffers
  - dynamic queue sizes/queue service policies

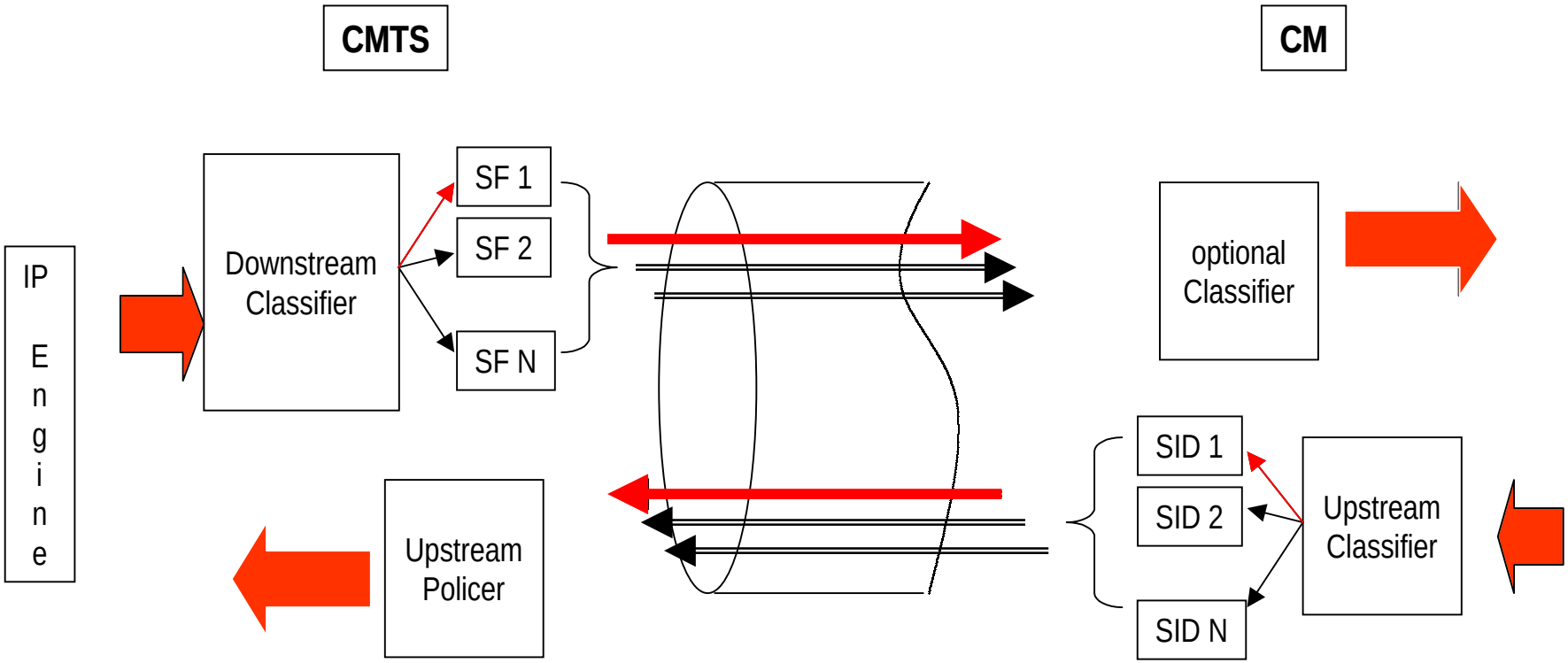
Scheduling

- Unless ALL traffic is strictly policed ONLY scheduling can provide QoS to ALL flows.

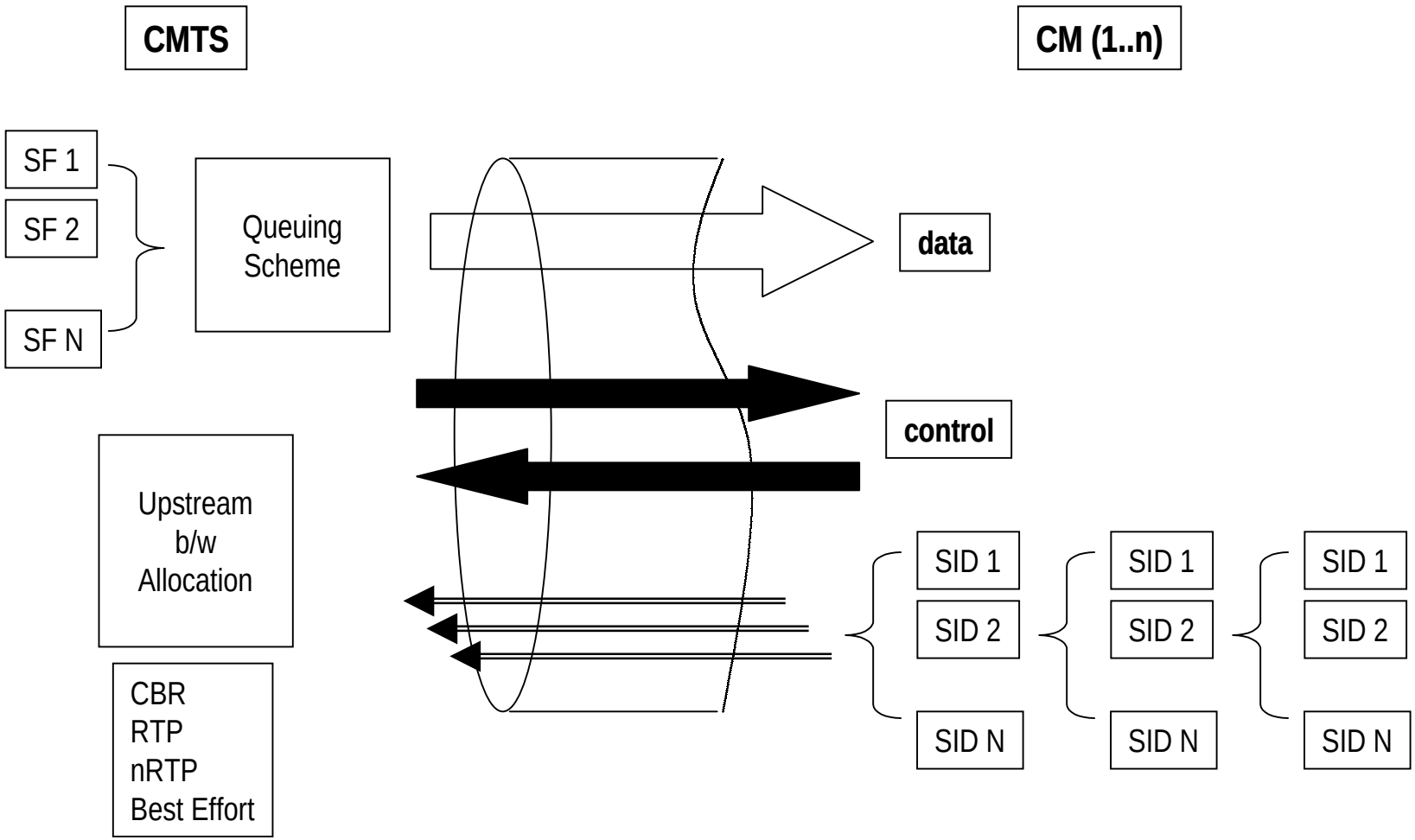
QoS in HFC-DOCSIS 1.1

- Based on service flows (unidirectional packet streams)
- QoS parameters defined per flow
- support for flow creation & deletion
- network access per service flow
- Packet header suppression
- fragmentation

Service Flows

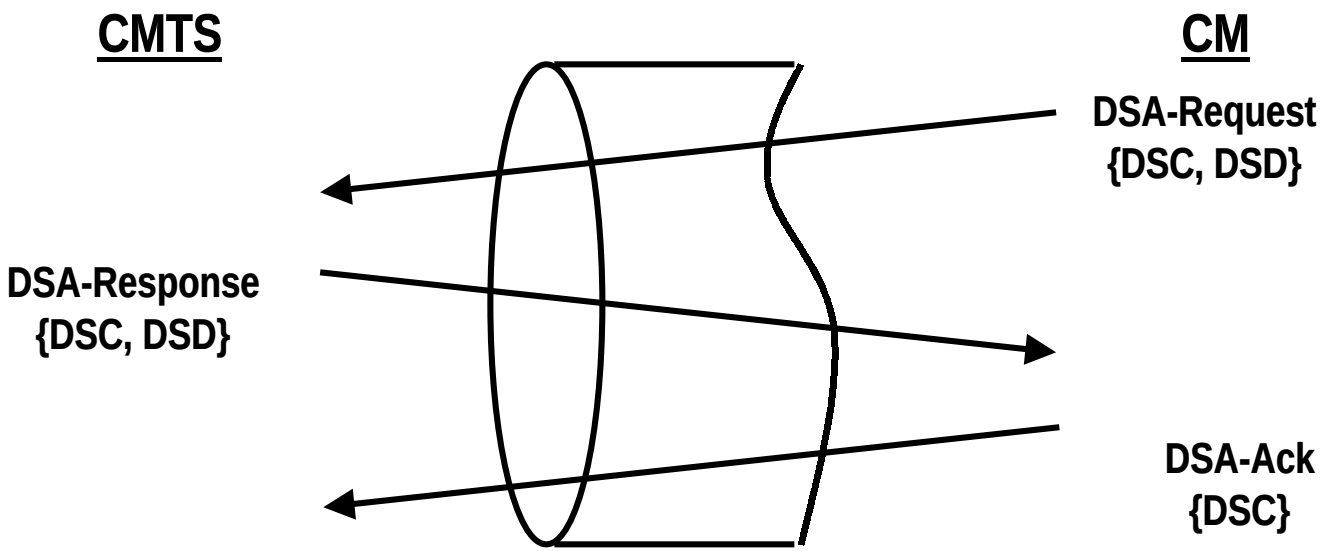


Network Access



Service Flow Control

- Pre-configured & dynamic
- Authorization & Admission control at CMTS
- Symmetric



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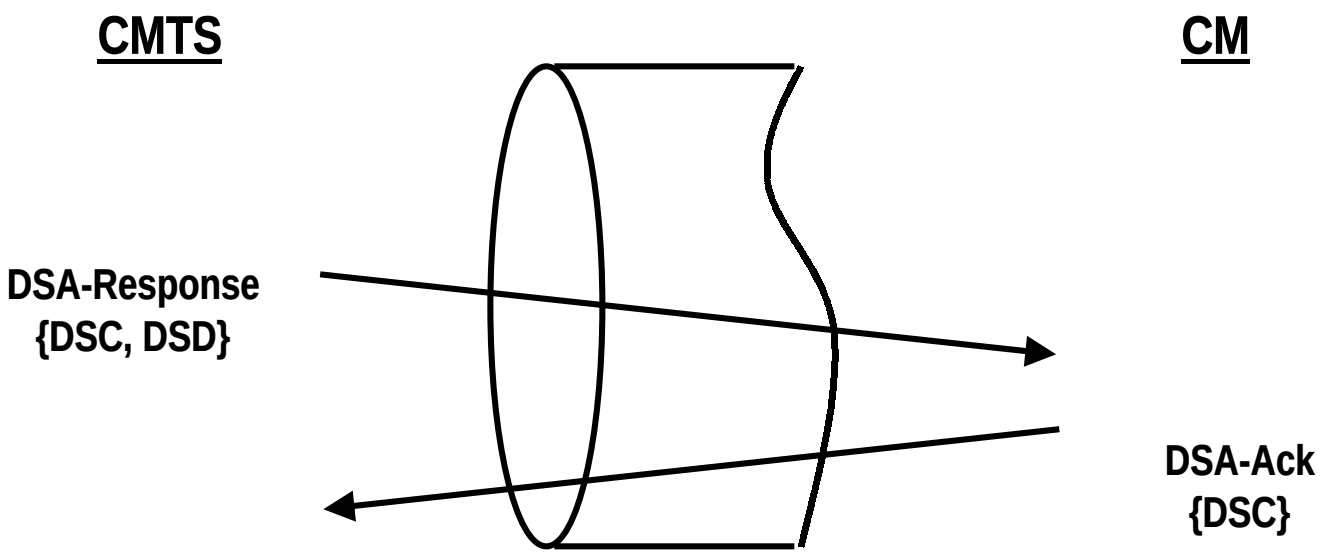
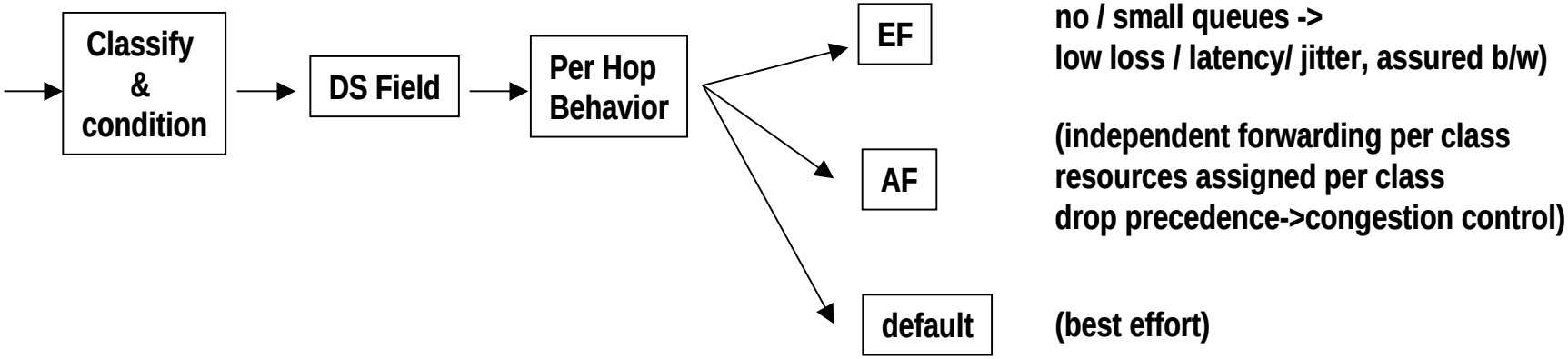


QoS in the Backbone

- priority based (Diff-Serv)
- reservation based (RSVP)
- connection based (ATM, MPLS)

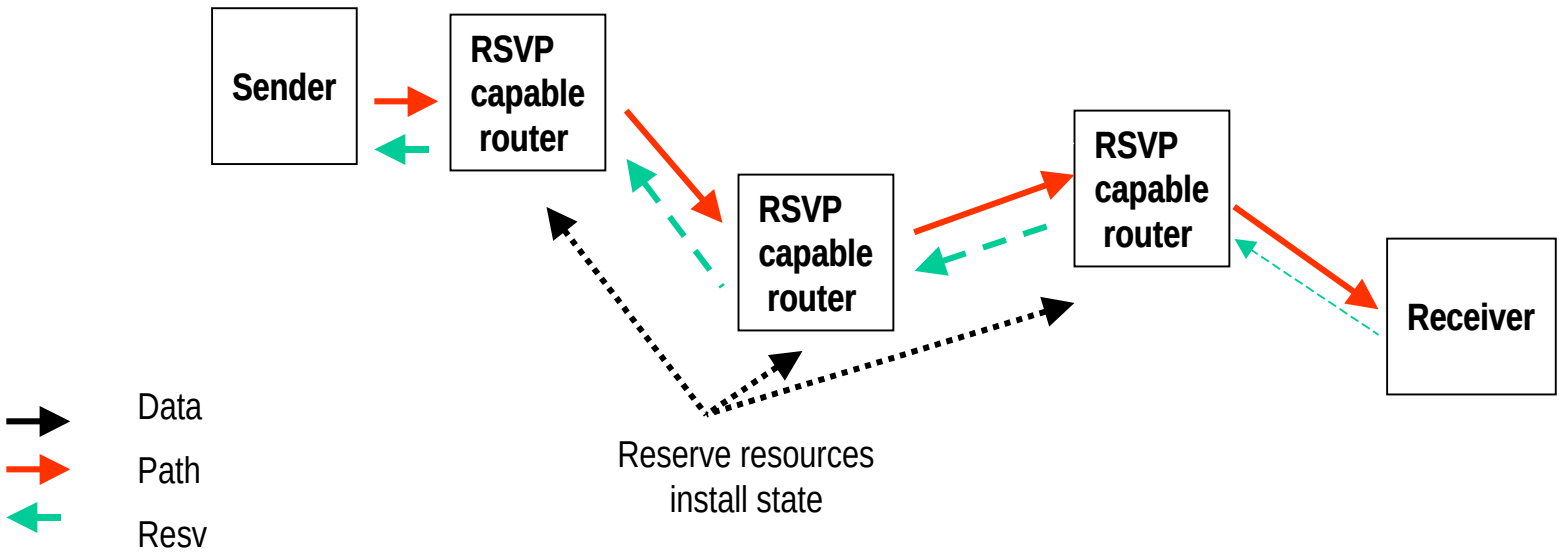
Priority Based - Diff-Serv

- Aggregated flows for network core (no per flow state)
- traffic is policed & marked at network edge
- QoS based on marker in IP header



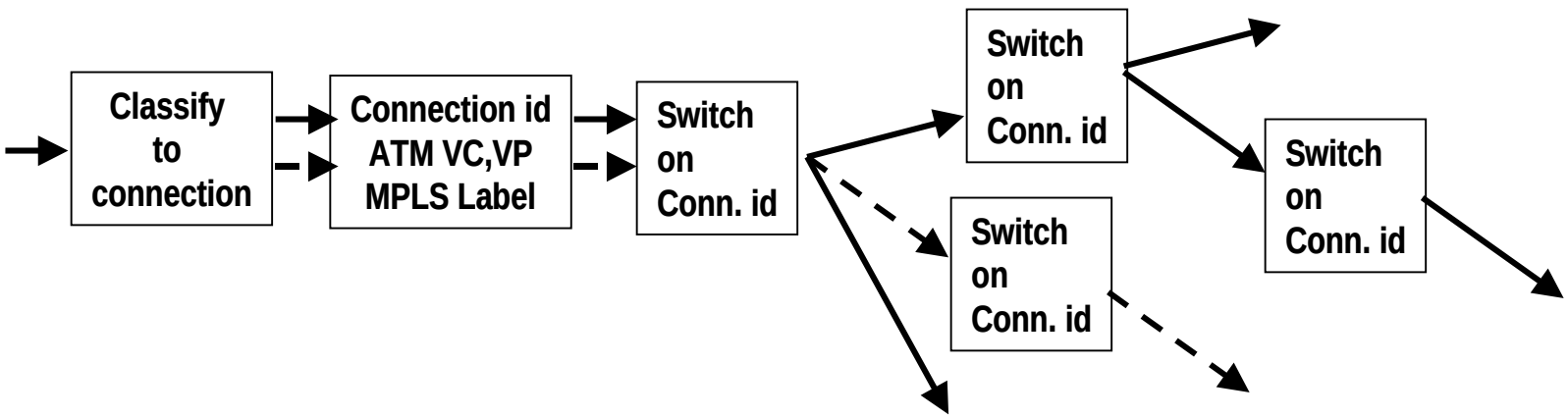
Reservation Based - RSVP

- Integrated Services QoS service definitions -controlled load, bounded delay
- Uni directional flows
- Path messages from source indicate QoS requirements, & traffic path
- Resv messages from receiver reserve resources in routers (if available)
- Resources reserved, (soft) state maintained at each node in the network



Connection Based - ATM, MPLS

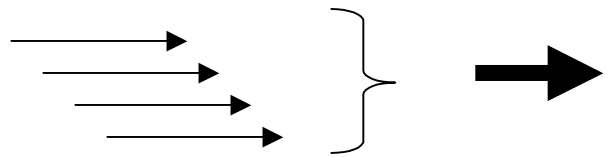
- connection set up through network
- QoS per connection
- traffic is forwarded based on connection id
- per connection state (forwarding & Qos) at each node



QoS @ the Network Edge

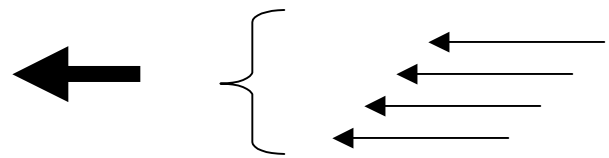
Transition point

- **edge to core**
- **per flow to aggregated**
- **intserv to diffserv**



Policy implementation

- **traffic engineering**
- **MPLS**
- **packet classification & forwarding**
- **policing**



QoS Functions in the Edge Router / CMTS

- admission control
- traffic classification, shaping & policing
- mapping QoS mechanisms between core & access
- sharing link resources
  - Upstream bandwidth management for HFC
  - Downstream queuing to HFC
  - Upstream queuing to backbone
- signaling QoS protocols
- congestion control

Congestion Management

- Admission Control
  - resources available, value of service, impact on existing services
- Discard Policies
  - value of traffic, cost to network, impact of discard
- Buffer Congestion Management
  - Tail drop
  - RED, WRED
  - WLQP, efficient buffer utilization, intelligent buffer selection

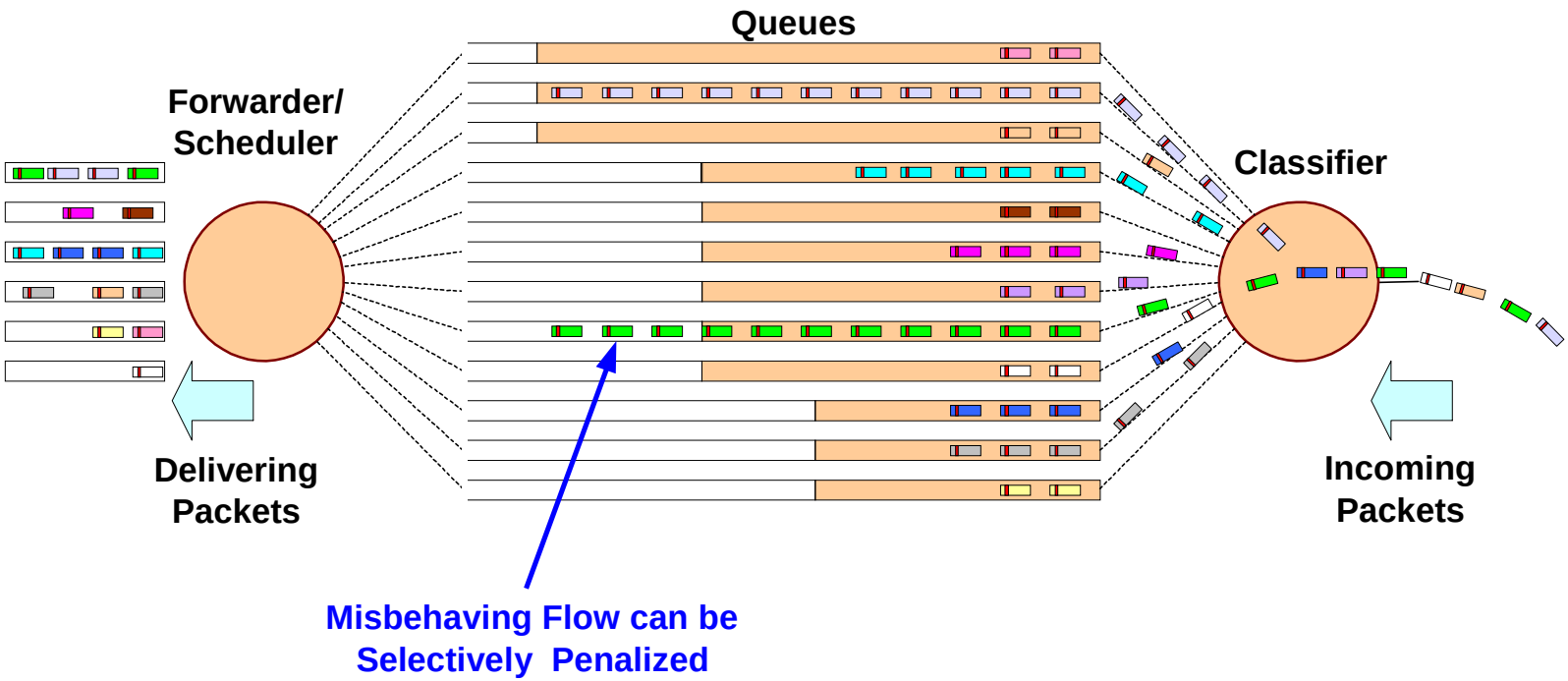
What can you say about a RED router?

- It’s better than a FIFO router…
- Usually……

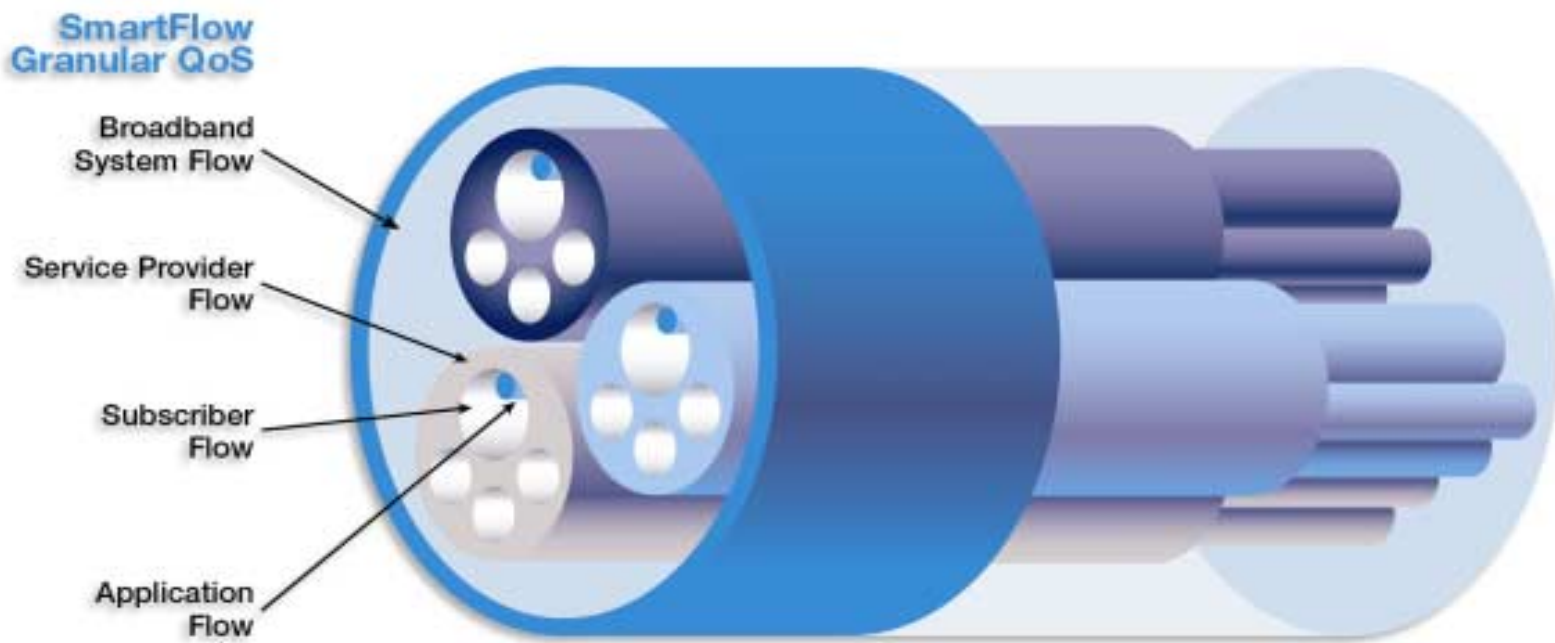
If RED is not good enough, what is?

- This question was answered back in 1990
- Fair queuing with longest queue discard
  - Per-flow Fair Queueing (FQ)
    - or Weighted Fair Queueing (WFQ) if you are also using Diff-Serv, RSVP, MPLS, etc.
  - discard packets only when buffer is totally exhausted
  - discard packets from the flow with longest queue
- Took 10 years for practice to catch up with congestion theory

Per Flow Queuing with Longest Queue Push Out



Hierarchical QoS

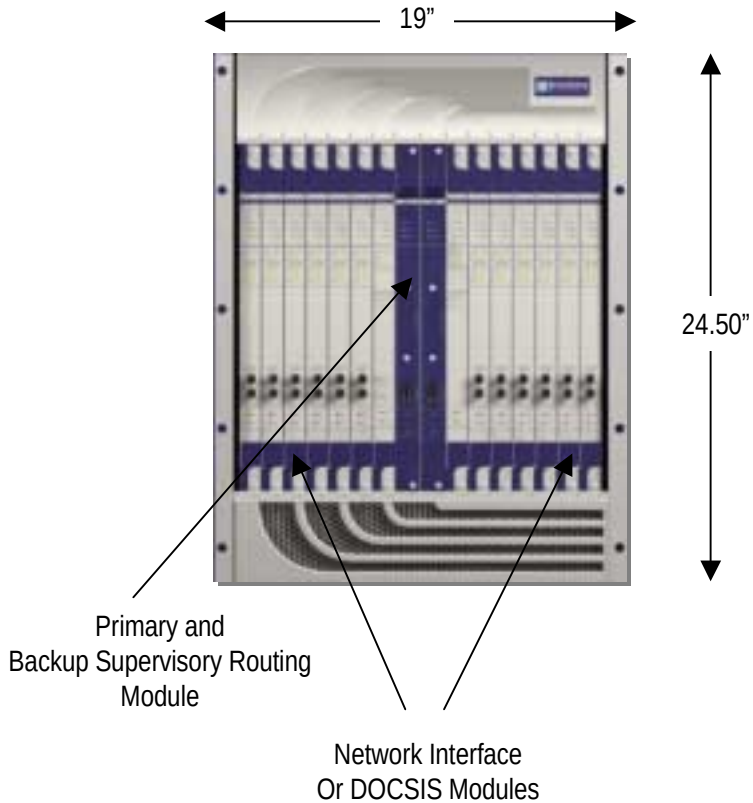


Is it really that much better?

- Fair Queueing with Longest Queue Discard is,
  - "Self Tuning", there are no parameters to set, in fact there are no parameters at all!
  - Impervious to "misbehaved" traffic.
  - Supports low latency flows and bulk transport flows simultaneously

Broadband Services Router (BSR 64000)

- **16 Slot NEBS compliant chassis**
  - **Redundant power supplies and fan modules**
  - **3 chassis per 7ft rack**
- **Passive mid-plane**
  - **Front-panel circuit cards, rear-panel connectors**
- **Supervisory Routing Module (SRM)**
  - **Fully redundant**
  - **64 Gbps/switch fabric**
  - **Routing Protocols (BGP-4, OSPF v2, RIP)**
- **1x4 and 2x8 DOCSIS Modules**
  - **16,000 (32,000) Service Flows per module**
  - **Up to 13 per chassis**
  - **1xN redundant w/automatic RF link switchover**
- **Network Interface Modules**
  - **OC-3c (x4), OC-12c (x4) modules (APS enabled)**
  - **Gigabit Ethernet Module (x2)**
  - **8 port 10/100 Ethernet module**



QoS Functions in the BSR

- Traffic classification, shaping & policing
- Mapping QoS mechanisms between core & access
- Traffic flow isolation
- Sharing link resources
  - Upstream bandwidth management for HFC (DOCSIS 1.1)
  - Downstream queuing to HFC (per flow)
  - Upstream queuing to backbone (MPLS, Diff-Serv)
- Congestion control
- Admission control

RDN BSR-64000