Differentiated Services

- QoS Problem
- Diffserv Architecture
- Per hop behaviors

Problem: QoS

- Need a mechanism for QoS in the Internet
- Issues to be resolved:
  - Indication of desired service
  - Definition of available services
  - Enforcement of contracts (policing)
  - Providing of service
  - Billing for service

Existing mechanisms: TOS

Current IP TOS/Precendence Bits (RFC 791)

- Must be set by clients — doesn’t work with existing apps
- Defines service type (“control traffic”)
- Defines only a small set of simple services (“minimize delay”)
- Billing and network provisioning hard - ISP doesn’t know what will happen

Existing mechanisms: ATM VCs

- Provides some aggregation
- still requires E2E signaling
- State still a problem

Existing mechanisms: RSVP

- No billing defined - useless without
- end-to-end nature makes billing really hard – multilateral, with path changes
- no way to aggregate $\longrightarrow$ number of reservations scales with link bandwidth
- message overload $\longrightarrow$ e2e signaling bad
- useless path state if no reservations exist
- Existing apps must be changed (even OS!)

Differentiated services

- Provide QoS $<$ RSVP, $>$ best effort – “BBE”
  - No end-to-end signaling
  - Must work with existing applications
  - Move intelligence and service provisioning to edge
  - Simple, well specified behaviors in core
  - Core behavior based on aggregates
  - Aggregation between domains
  - Flexibility for a wide range of services
  - Separate service primitives from implementation

Differentiated service architecture (RFC 2475)

- Service Providers (ISP) define services
- Services are negotiated with customers in the form of potentially complex Service Level Agreements (SLA's)
- Customers can be people or other ISP's or network providers
- At the edge of network, boundary router takes packets and marks, drops, or shapes them based on SLA
- Within the core of the network, routers treat packets solely based on markings they have received
- Markings are in the DS field of IP header (formerly TOS byte)

Defining SLA's

- Service Level Agreement Comprises
  - quantitative performance metrics
    - absolute/relative loss
    - absolute/relative delay
    - absolute/relative throughput
  - service constraints
    - time of day
    - locality - per source, per destination
    - application based
    - traffic contracts - leaky bucket
  - customer identity

Scope of services

- Services are not defined end to end
- Services are bilateral agreements between peers
  - End user to local ISP
  - Local ISP to Backbone ISP
  - Campus Network to Backbone provider
- Simplifies billing issues
- Provides a clean architecture for provisioning and implementation

Instantiating SLA's

- Two kinds of SLA - *static* and *dynamic*
- Static SLA's are pre-provisioned, dyanmic are signalled when needed
- Many ways to instantiate a static SLA in a DS Edge Router

  SNMP Lacks asynchronous notification, replication of data

  LDAP Complex descriptions possible, replication supported, but lacks server to client updates

  COPS Integrates with RSVP policy

  DIAMETER General policy mechanism, meets requirements well
- Instantiating a dynamic SLA is hard - RSVP?

DiffServ functional elements

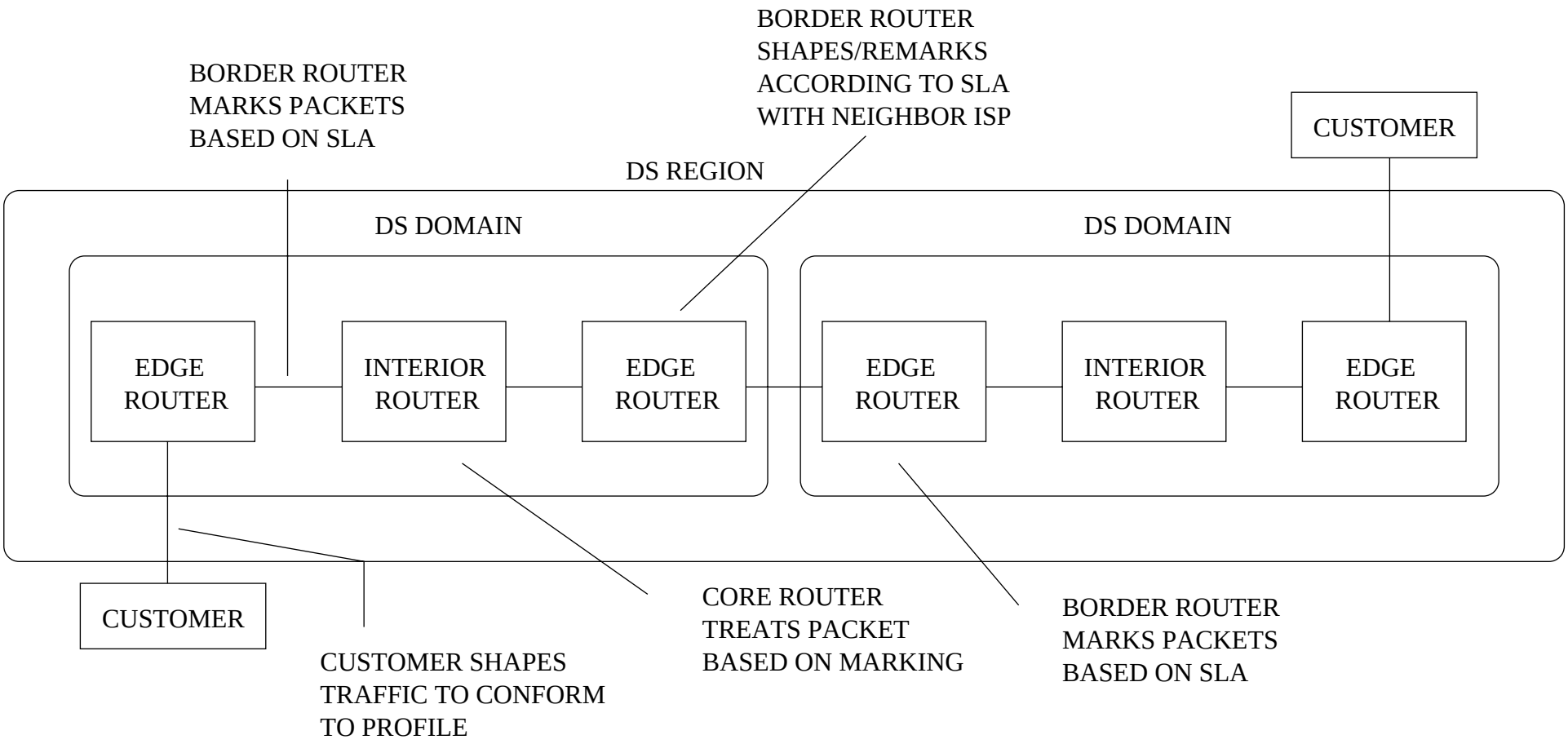
DS Edge Router: Connects to an edge router in a neighboring domain

DS Interior Router: Router inside core of network

DS Domain: Set of routers under a single policy authority

DS Region: Set of contiguous DS Domains

Diffserv functional elements



DiffServ edge routers

- Edge Router contains a number of elements

  Classifier: Looks at fields in the packets to determine what SLA/treatment to given them

  Micro Flow Classifier: Based on 5-tuple
  Bandwidth Aggregate Classifier: DS field

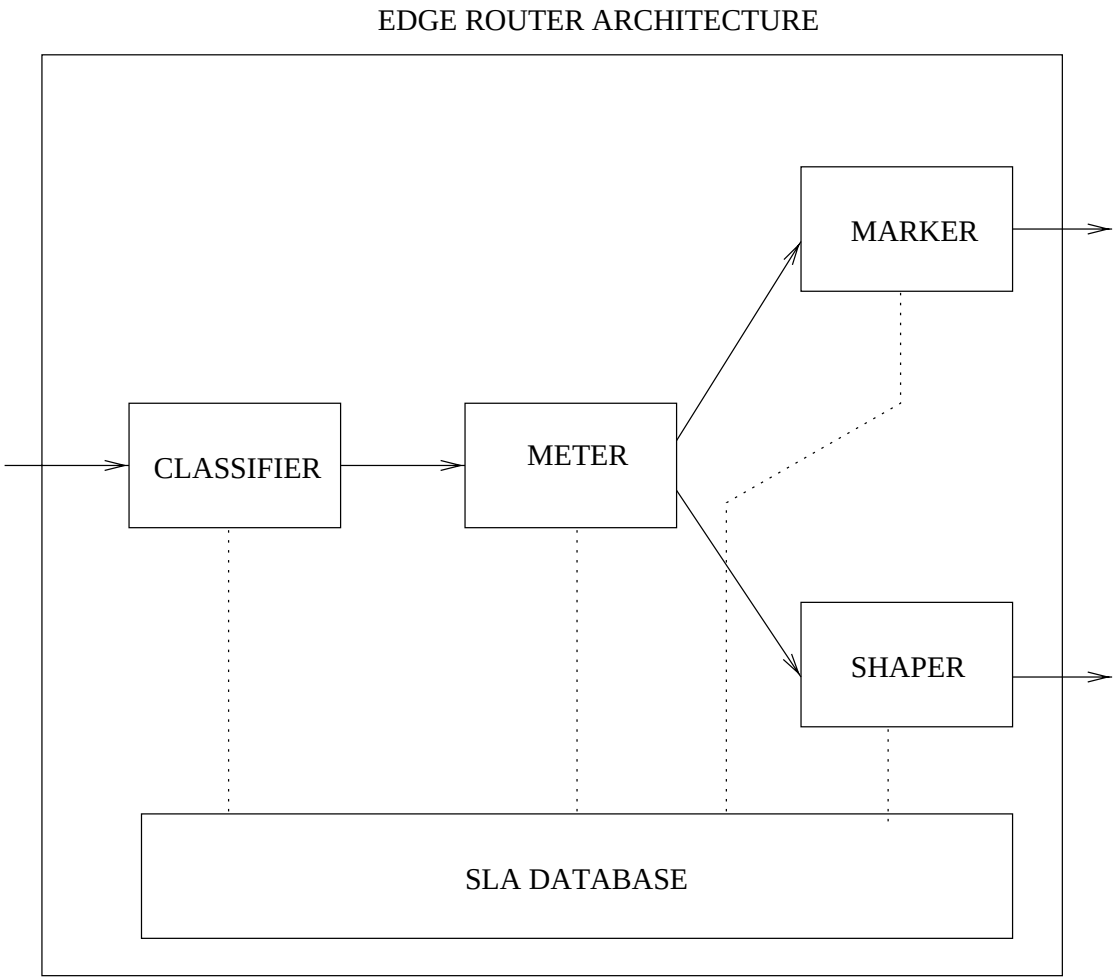
  Meter: Determines traffic char. of classified packets;

  Marker: Sets DS field based on meter & classifier;

  Dropper: drops out-of-bound packets (“policing”);

  Shaper: Shapes traffic by adding delay

DiffServ edge router



Per-Hop Behaviors (PHB)

- DS field consists of a 6 bit *codepoint*, identifies a *Per Hop Behavior (PHB)*
  - Defines low level service treatment the packet should get
  - Does not specify implementation, just service
  - Not dependent on 5-tuple
- codepoints mapped to PHB's via a lookup table
- some PHB's standard, others experimental/proprietary
- PHB's that only have meaning relative to others form a PHB Group
- likely there will be a small number of PHB's

Per-Hop Behaviors

- Example PHBs and PHB Groups

  Best Effort: Current best effort service

  Assured: Two PHB's in this group: high drop priority and low drop priority.

  Premium

- *Services are created by intelligently classifying, metering, and then assigning packets to a small number of PHB's*

Assured Service (RFC 2597)

- mark packets as “in” or “out” based on profile
- **RIO**: schedule based on variation of random early drop (RED):
  - if average queue size below minth, don’t drop
  - if average between minth and maxth, drop with prob. 0 to maxp
  - if above maxth, drop all
  - OUT packets: measure whole queue
  - IN packets: count only “in” packets

Premium, Expedited Forwarding (EF) (RFC 2598)

Packets should experience almost no queueing delays – “virtual leased line”

- priority service
- weighted round robin (WRR)
- class-based queueing (CBQ)

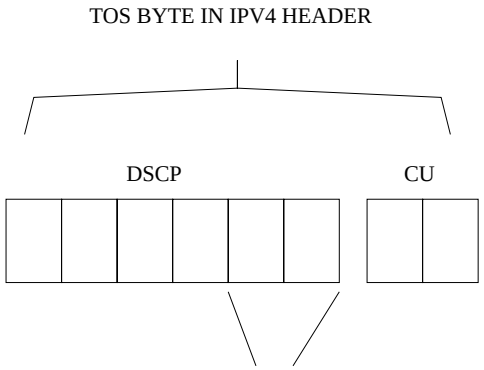
must *drop* excess packets

Receiver-Based

- DS mechanisms sender oriented
- Receiver oriented is much harder
- Requires reverse congestion notification
- Requires co-operating sources
- Exception - receiver policies for access links

The DS field (RFC 2474)

- BA: behavior aggregate (DS field)
- MF: multi-field (DS field + source, destination, . . .)



X0: Standardized
11: Experimental, not standards tracked
01: Experimental, used in standards if needed

DSCP: Differentiated Services Code Point
CU: Currently Unused

may be rewritten in the network

Interoperability with Intserv

- Three modes:
  - Parallel - both exist, no interaction
  - IntServ over Diffserv - Diffserv agreements purchase tunnels over which RSVP can be used to finely manage bandwidth
  - IntServ aggregation - use Intserv, but aggregate at edges into diffserv

Admission control

in-band: reserve “pipes” or “trunks” via RSVP or specialized protocol

out-of-band: bandwidth broker; track usage within domain ➠ needs to keep congestion map

Example SLAs with a single PHB

- Single PHB 1: packets receive almost no delay or loss
- SLA 1:
  - User can send up to 100 kb/s with no loss on Saturdays, 50 kb/s during week
  - Implementation: Classifier selects customers packets. On Saturdays, traffic is leaky bucket shaped to 100 kb/s, 50 kb/s during week. Packets leaving shaper have PHB of 1.

Example SLAs

Toll quality IP telephony:

- Implementation: Classifier detects customers IP telephony traffic based on port/protocol field in headers (not easy. . .). All telephony classified traffic is marked with PHB 1, else PHB 0 (best effort)