



Enabling Active Flow Manipulation (AFM) in Silicon-based Network Forwarding Engines

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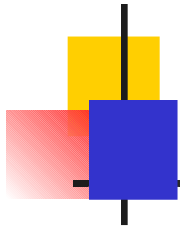
Outline

- Introduction
- Network Element – Control Plane/Forwarding Plane
- Control Functions
- AFM abstractions: aggregated flows/actions
- Possible Realizations
- Examples
- Conclusion: Issues to be resolved



Programmable Internet

- Enhance internetworking functions.
- Move computations into the network for value added services.
- Manage the network more capably than possible with SNMP.
- More quickly introduce Diffserv or Inserv to support new multimedia applications
- Implement traffic control algorithms to support QoS.

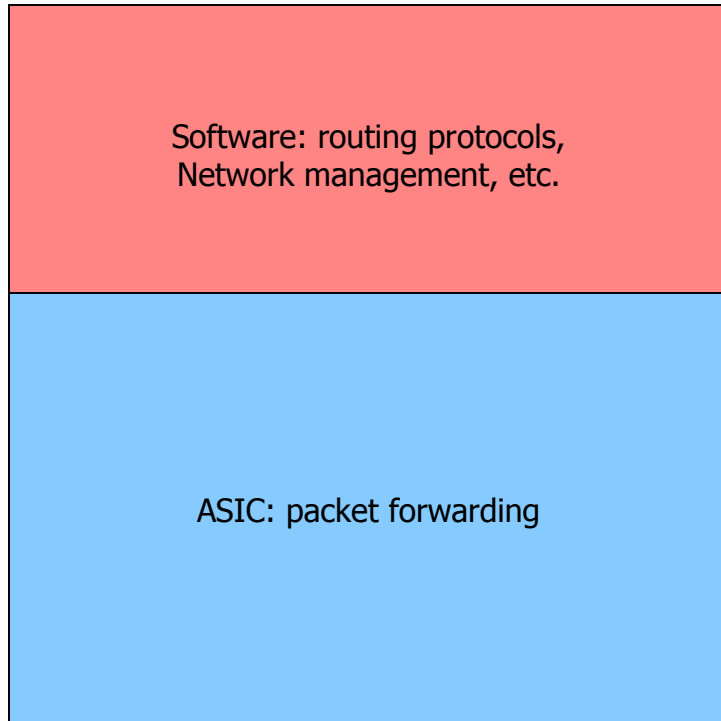


Programmability

- A significant challenge in today's Internet is the ability to efficiently incorporate customizable network intelligence in commercial high performance network devices.
 - Framework for introducing services
 - API for programming network devices

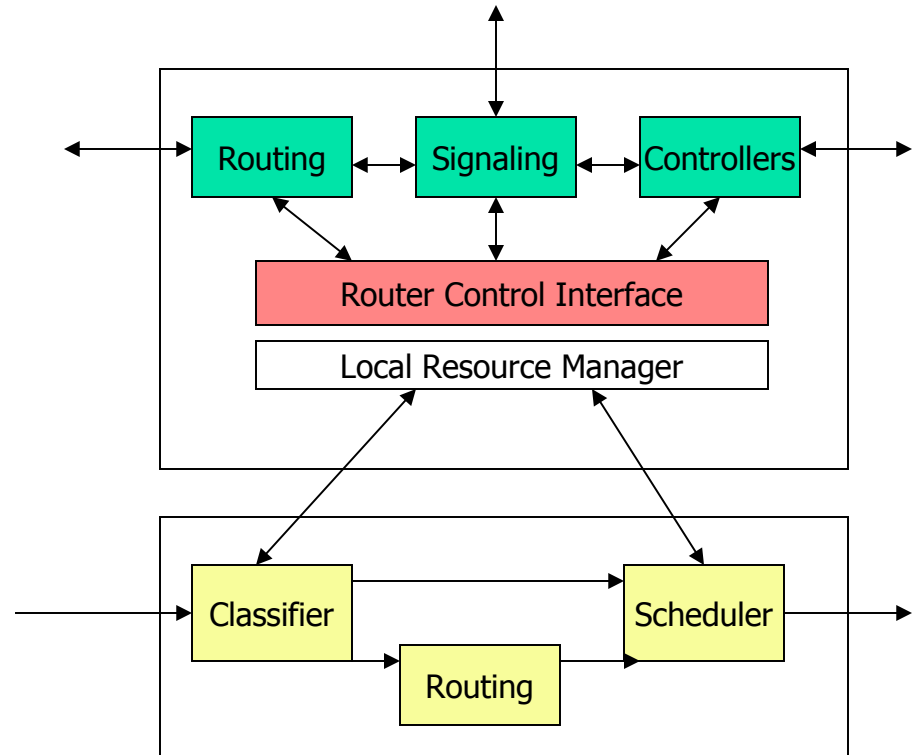
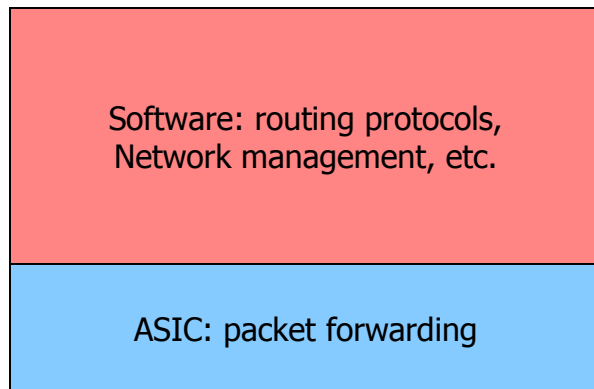


Network Element



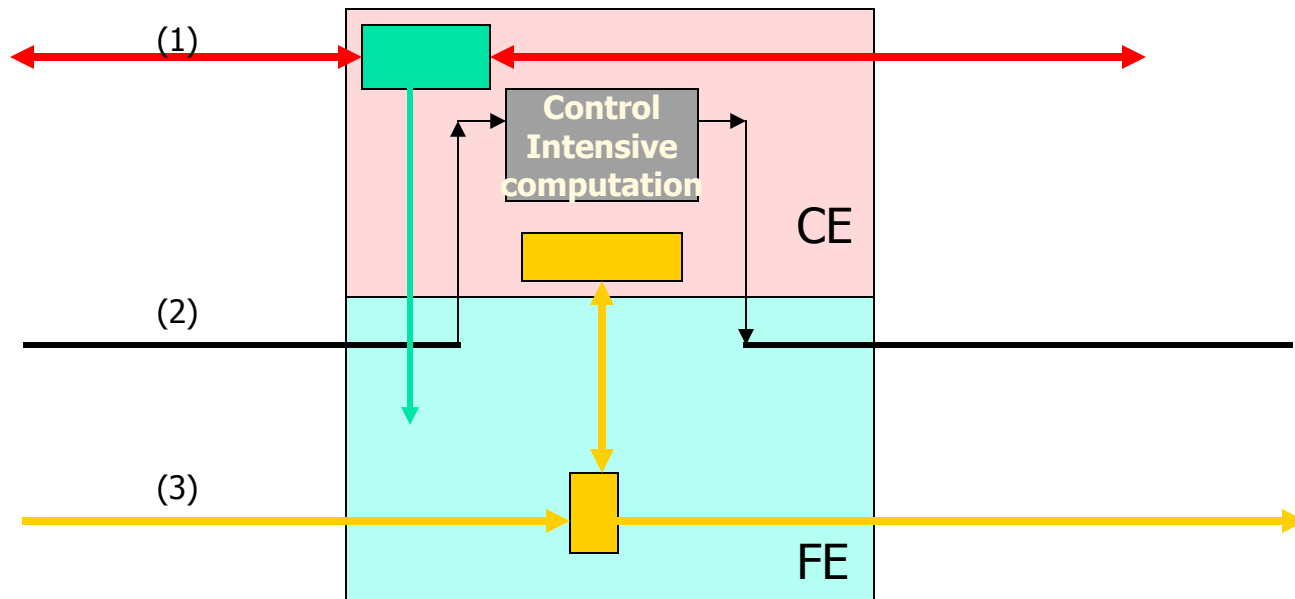
- Limited control of the forwarding plane
- Routers are not reprogrammable (except by vendors)
- Users can only see IP/ICPM packets, but have no direct control over the internal handling of their data.

Programmable Network Element



Control Functions

CE: Control Element
FE: Forwarding Element



- 1) Control functions that reside wholly in the control plane
- 2) Control functions that insert software in the critical data path
- 3) Control functions that allow control entities to act both in the control plane and in the data forwarding plane without adding software in the data path



Control categories

- Category 1: Purely on the control plane like off-line or out-of-band services.
- Category 2: Intensive Computation is needed before data is forwarded.
- Category 3: No software delay is introduced in the data forwarding plane. Control is for setting target. Category 3 is applicable to real-time applications.



Application Timescales

- Network Components
- Service creation and introduction
- Sessions (connections)
- Packets



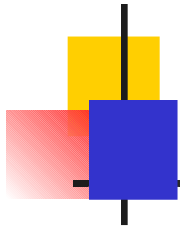
Active Flow Manipulation Abstractions

- Aggregate data into traffic flows
 - Flows whose characteristics can be identified in real-time
 - E.g., “all UDP packets to a particular service”, “all TCP packets from a particular machine”.
- Actions to be performed in the traffic flows
 - Actions that can be performed in real-time
 - E.g., “Change the priority of all traffic destined to a particular service on a particular machine”, “Stop all traffic out of a particular link of a router”.



Identifiable Elements of Primitive Flows

Destination Address (DA)
Range of Destination Address (RDA)
Source Address (SA)
Range of Source Address (RSA)
Exact TCP protocol match (TCP)
Exact UDP protocol match (UDP)
Exact ICMP protocol match (ICMP)
Source Port number, for both TCP and UDP (SP)
Destination Port number for both TCP and UDP (DP)
TCP connection request (TCPReg)
ICMP request (ICMPReg)
DS field of a datagram (DS)
IP Frame fragment (FrameFrag)



Primitive Permissible actions

Drop
Forward
Mirror
Stop on Match (SOM)
Detect Out of Profile behaviour (Out)
Change DSCP value (DSCP)
Prevent TCP Connect Request
Modify IEEE 802.1p bit

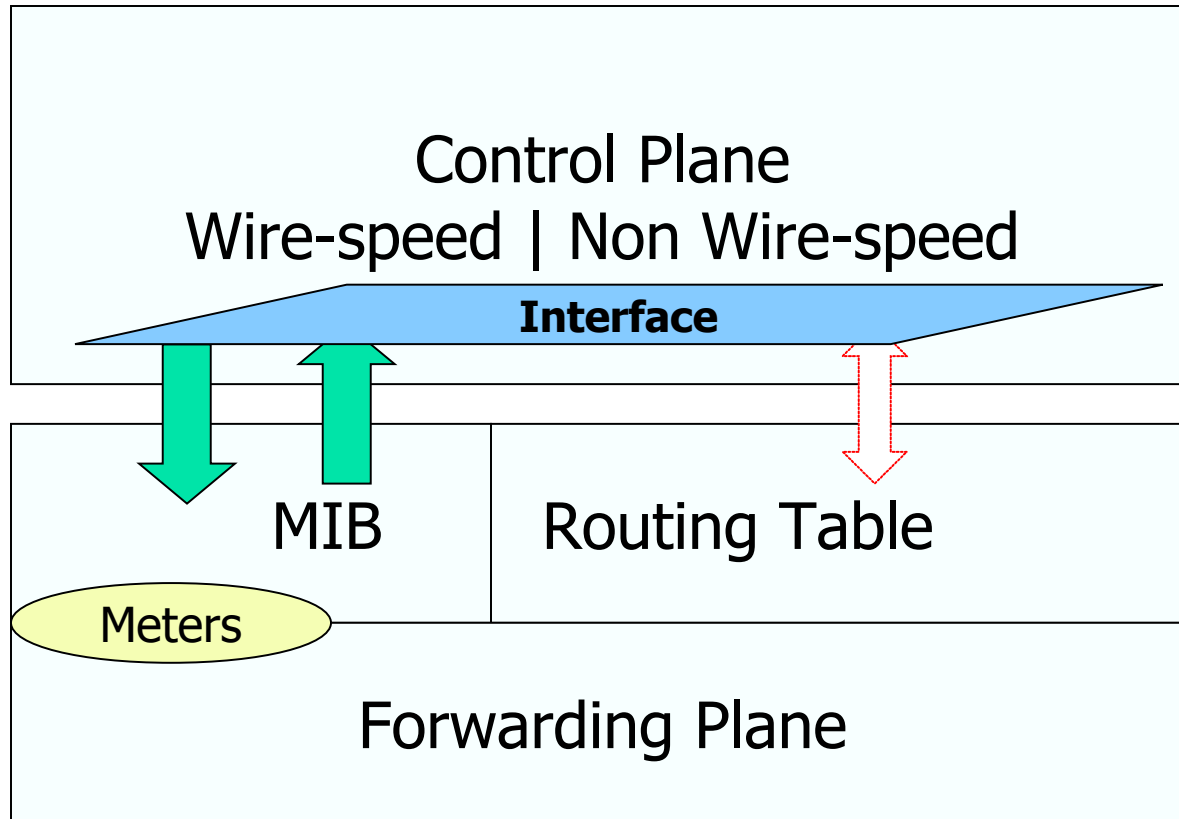


More Specific Goals

- Allow introducing services and control on demands dynamically
 - Services can be any general network applications
 - Control on demands to manipulate flows and flow aggregates
- Allowing dynamic and mobile agents
- Respond quickly to changes in traffic conditions.
- Cope with unforeseen requirements
- Extending router functionality (optimization)
- Multiple control elements are installed at routers or hosts and they collaborate to achieve some overall objective.

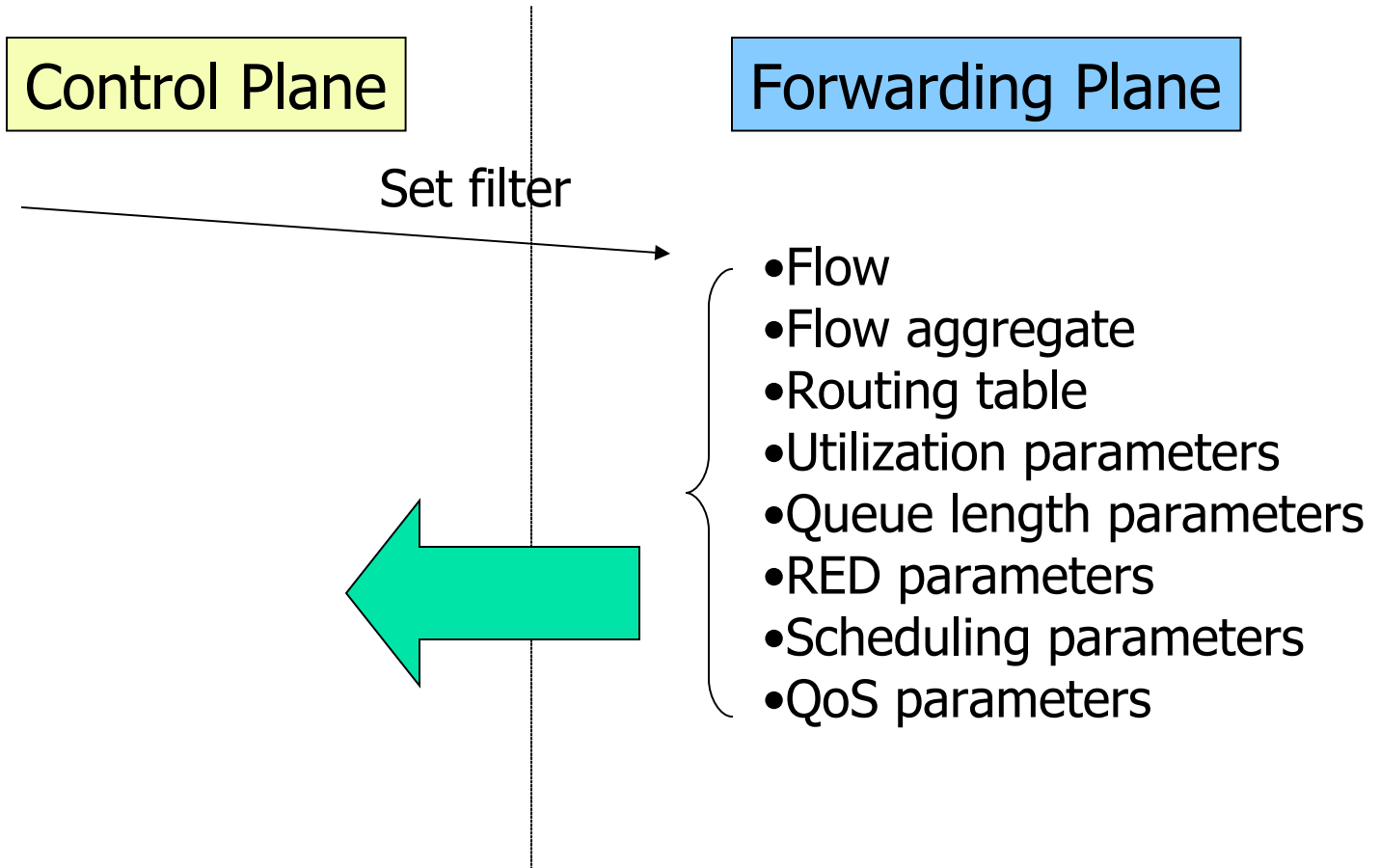


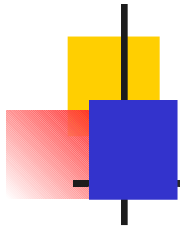
Realistic Framework



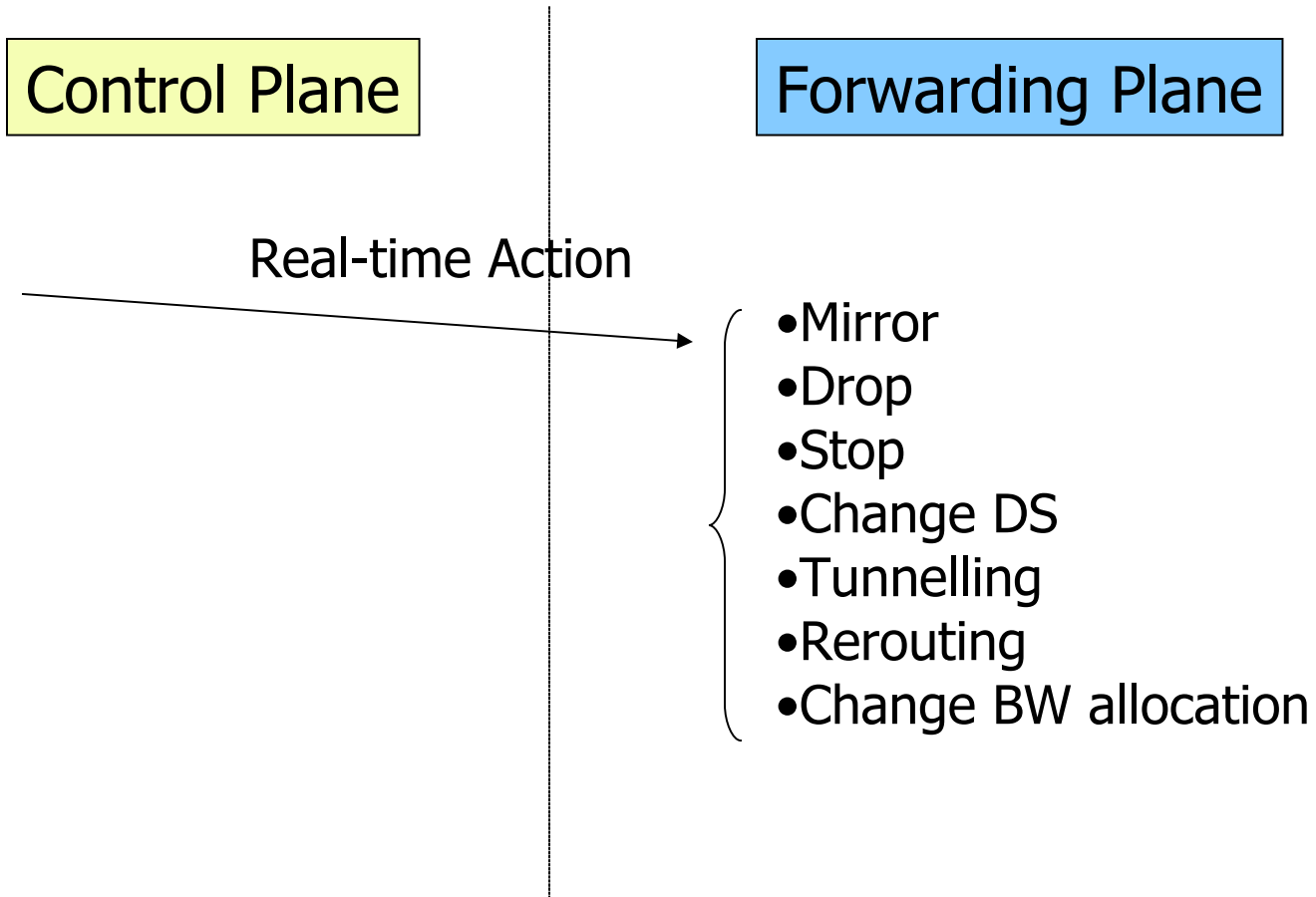


Realization





Realization





Possible Realization

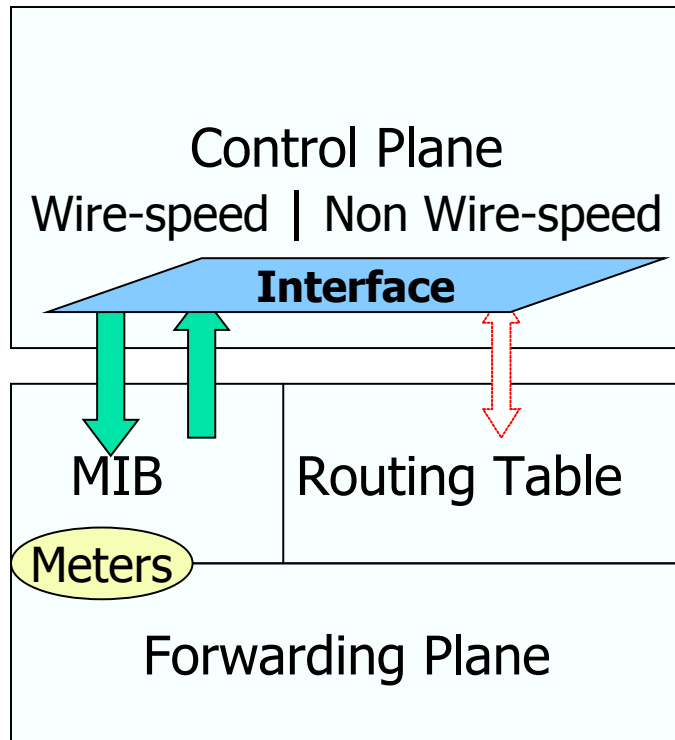
Control Plane

Forwarding Plane

Non-Real-time Action

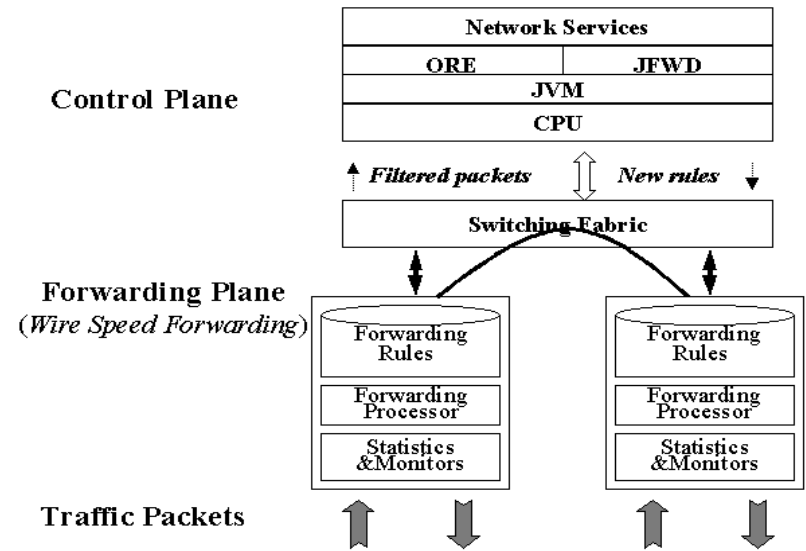
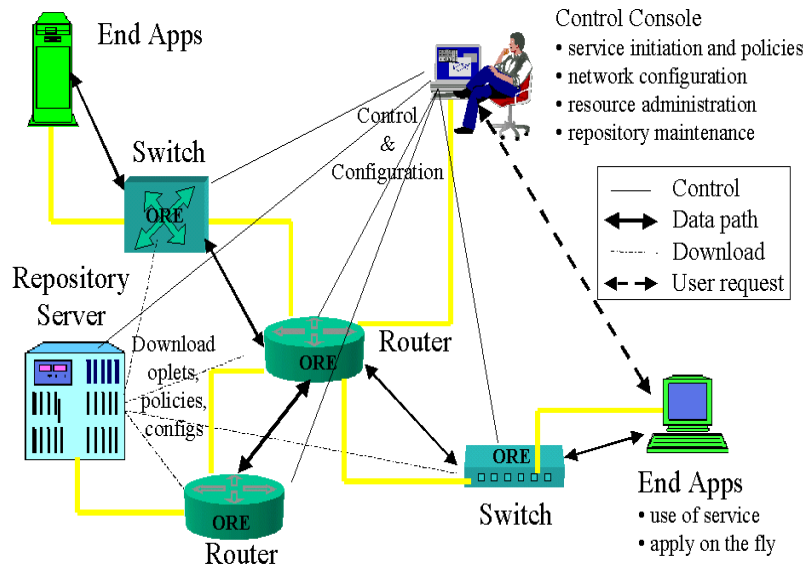
- Alter routing table
- Alter RED parameters
- Alter QoS parameters
- New congestion control algorithms
- New QoS control algorithms
- New Bandwidth Allocation algorithms

Examples



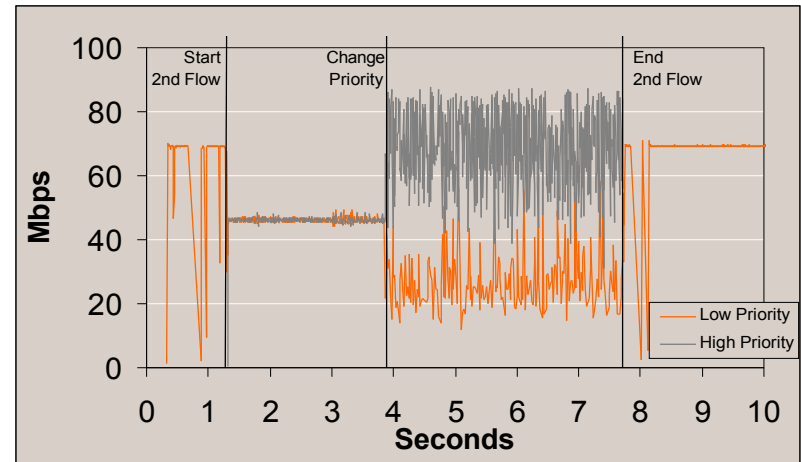
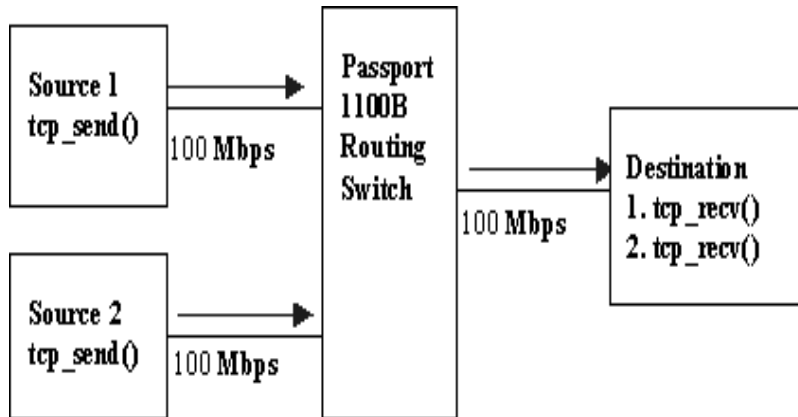
- Active manipulation of flows and flow aggregates to
 - Provide adequate QoS to users: reliability, availability, security, and acceptable quality.
 - Manage resources efficiently: utilization, simple control and maintenance.
 - Control congestion: monitoring, admission control, shaping and policing

Openet Framework

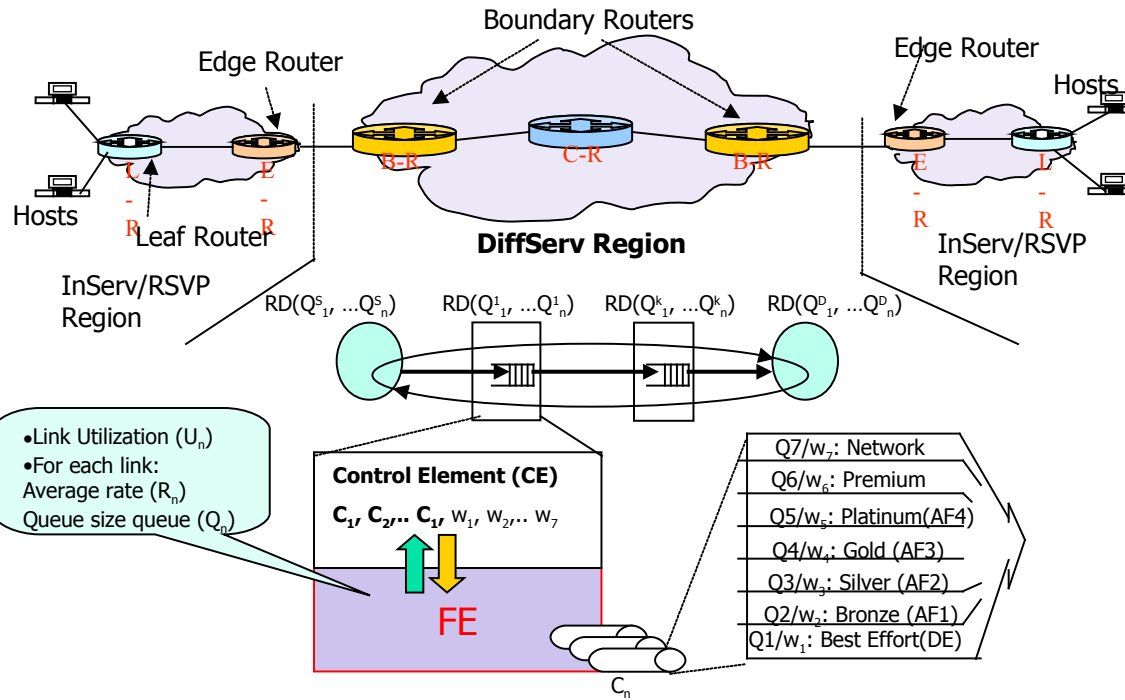


- Openet Architecture with Passport Switches

Active Flow Priority Change in Real-time



Path Capacity Discovery (Plan to do)





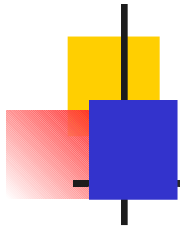
Possible Applications

- VPN
- Video on Demand
- Multicast
- Explicit QoS Control loop
- Traffic Engineering
 - Admission control
 - Path capacity discovery
 - Explicit Congestion control
 - Load or bandwidth balancing
 - Bandwidth shaping



Possible applications

- Mobile agent for Ecommerce-Stock
- Agents for network management
- Allow the service to adapt to demands and locations of customers
- Automatic protocol deployment-IPv6
- Reliable multicast
- Congestion control for real-time audio/video
- Media gateway
- Sensor data mixing



Issues

- API
- Short term – Long term
- Filters
- Meters
- Light signaling
- Fault tolerant mechanisms
- Security