Programmable Network Node: Applications

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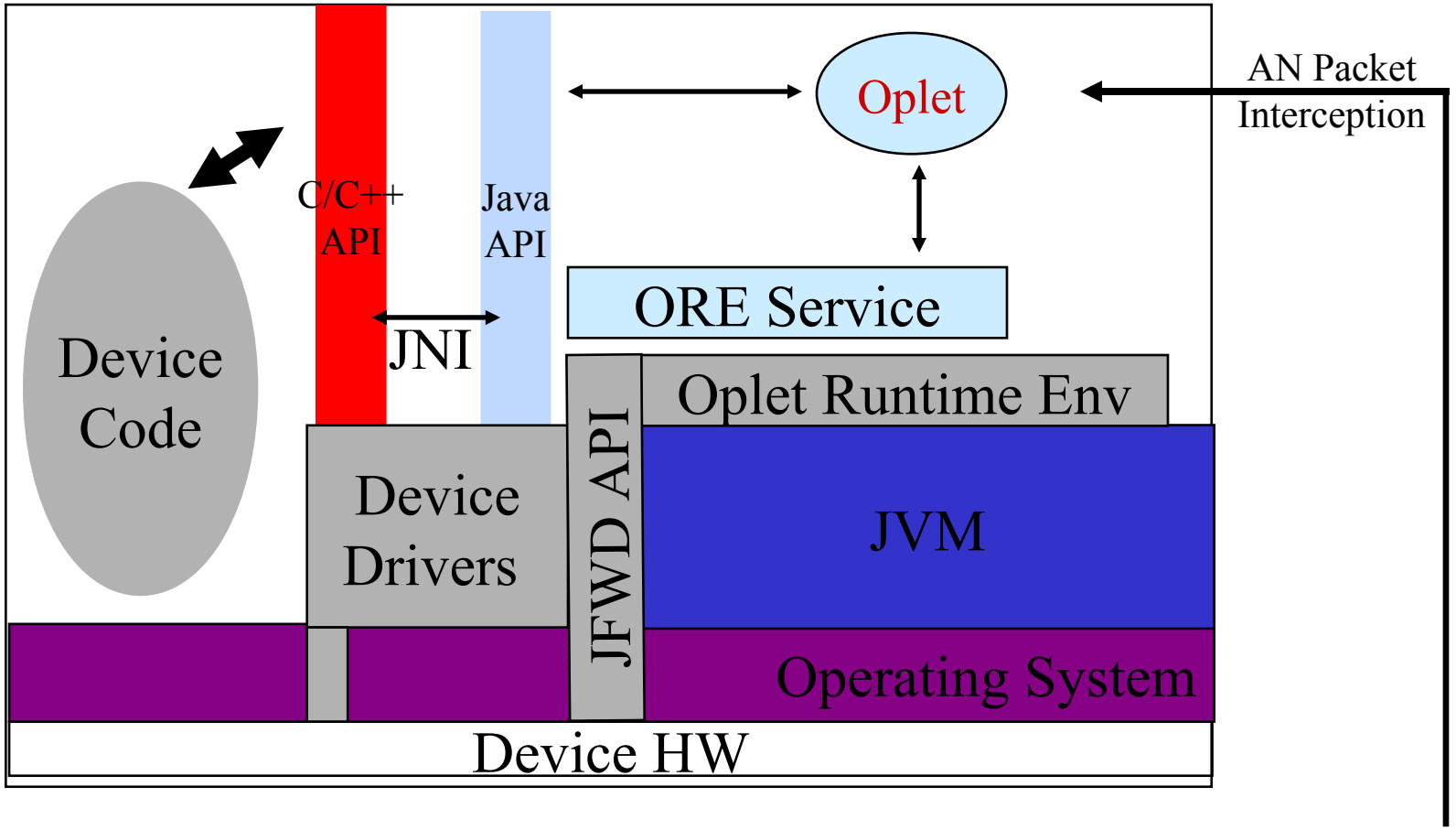
Accomplishments

- **JVM on a silicon-based L3 Routing Switch**
- **ORE - Oplet Run-time Environment**
- **Java-enabled Device Architecture**
- **SNMP MIB API**
- **Network Forwarding API**
- **Active Networks applications:**
  - dynamic control and modification of ASIC forwarding

Nortel Java-Enabled Device Architecture

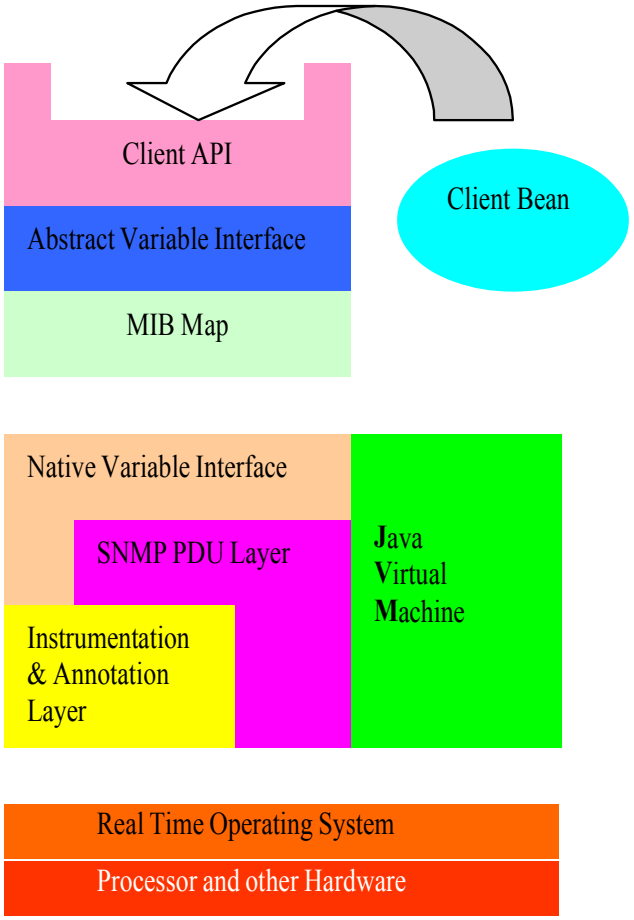


Tools

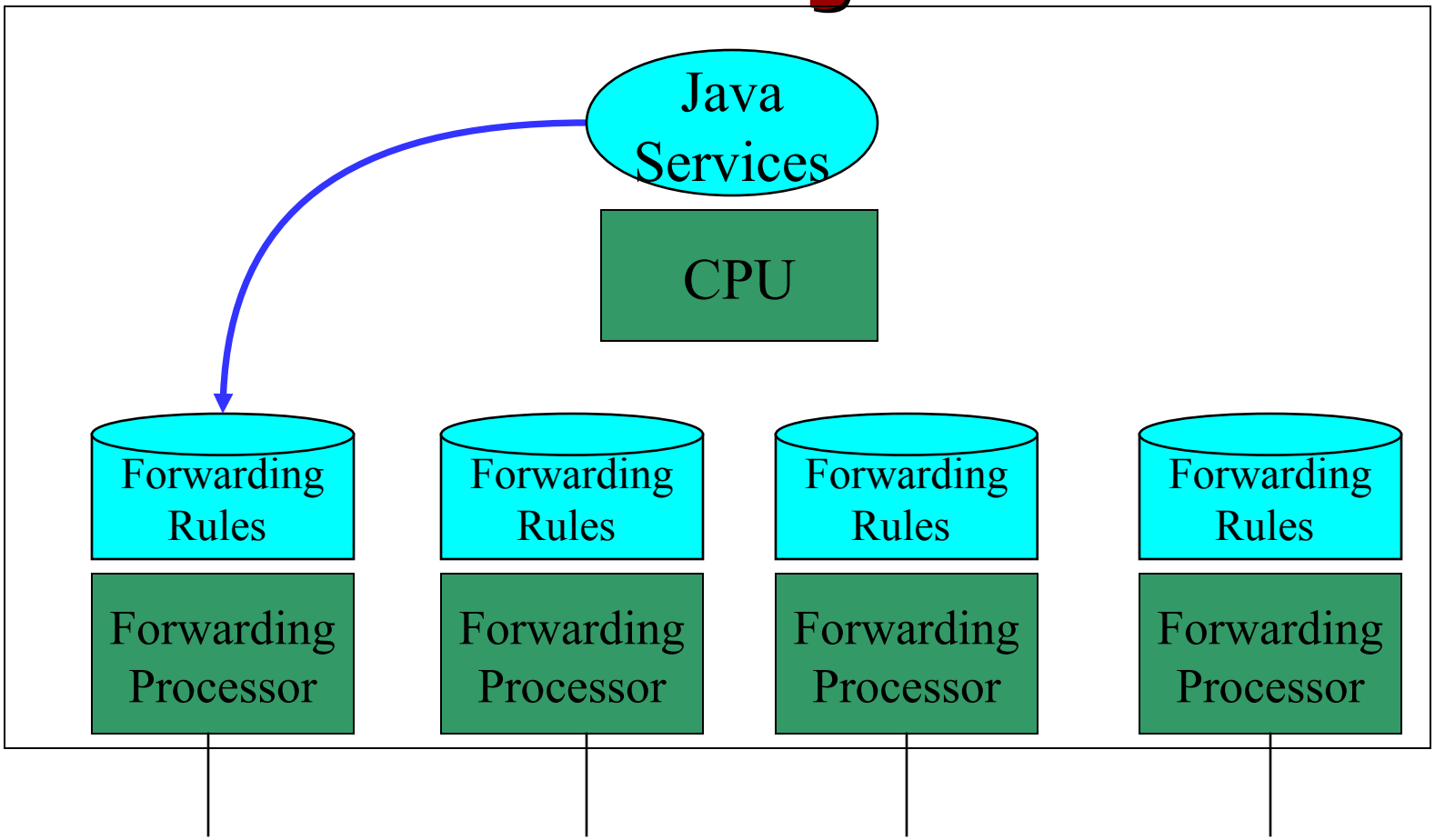
- **MIB API**
  - Monitor device Management Information Base variables
    - MIB
    - RMON and RMON-II
    - DiffServ
- **Network API (JFWD)**
  - Interface to Filters
    - set packet drop filters
    - intercept packets
    - carbon copy packets while forwarding at line-speed

MIB API

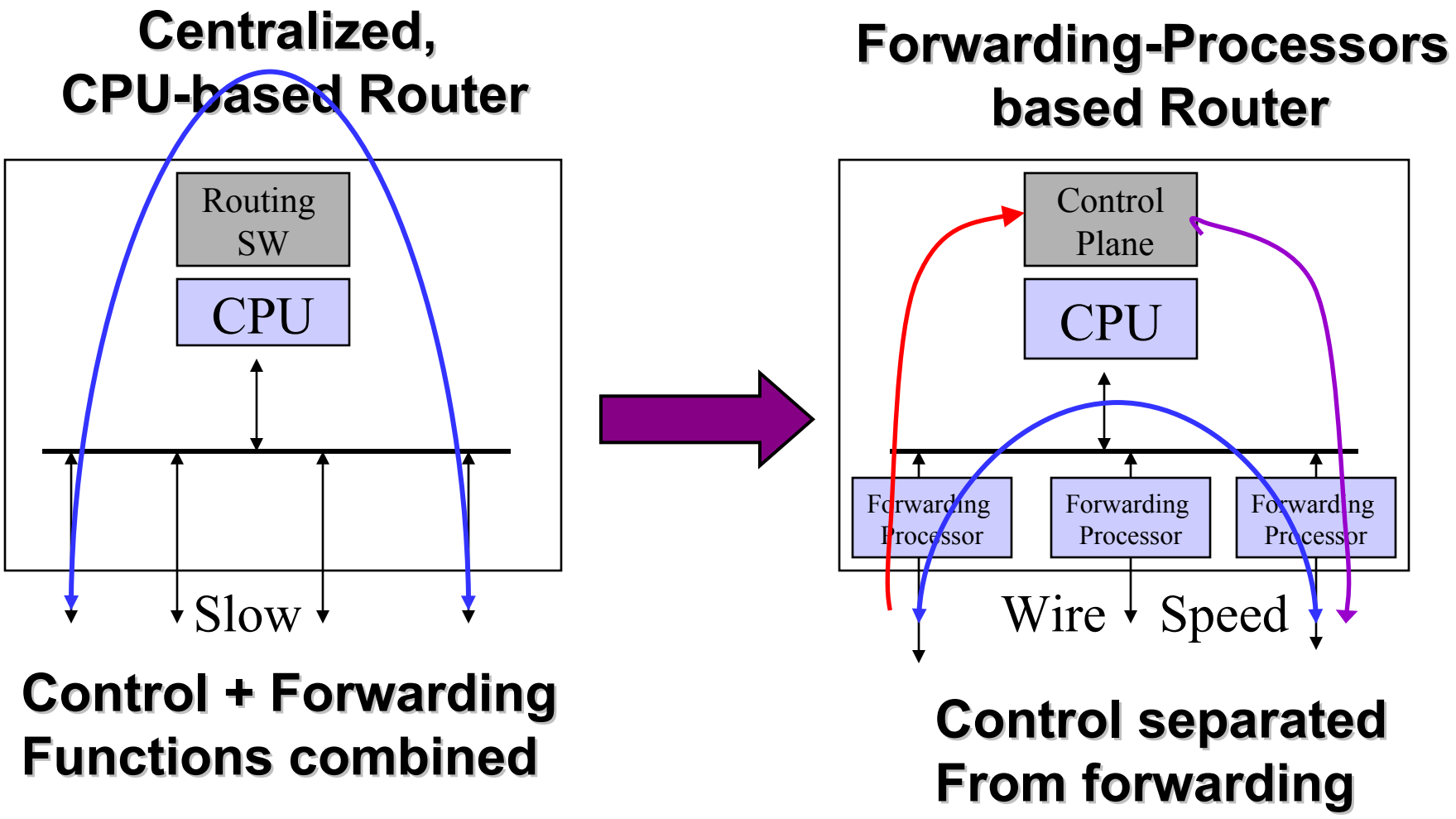
- API uses a MIB Map to dispatch requests to variable access routines
- Different parts of the MIB tree can be serviced by different mechanisms
- Two main schemes:
- An ad hoc interface to the SNMP instrumentation layer
- A generic SNMP loopback



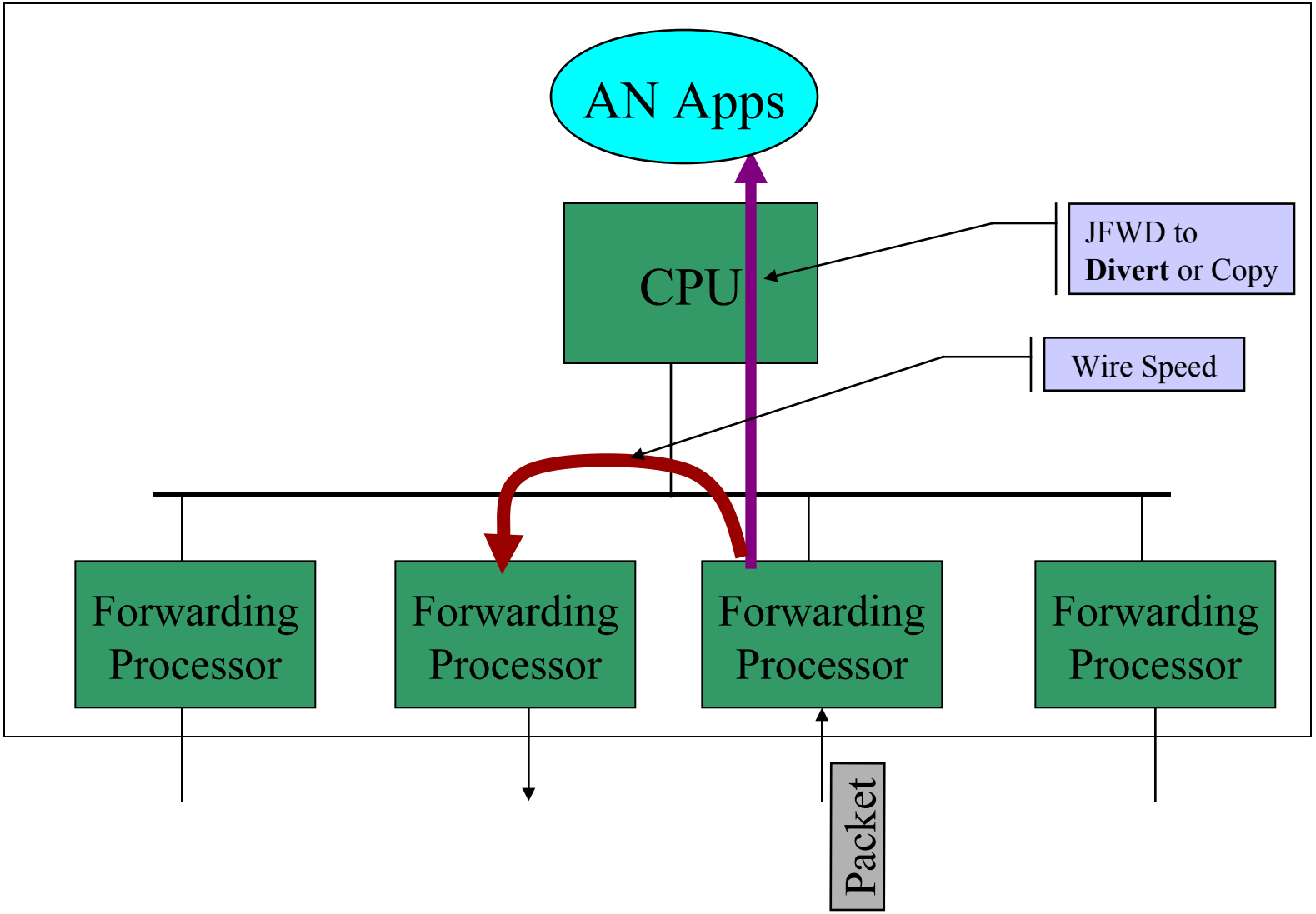
Network API: Dynamic Configuration of Forwarding Rules



Network API: Control-vs-Forwarding Plane



Network API: Packet Capture

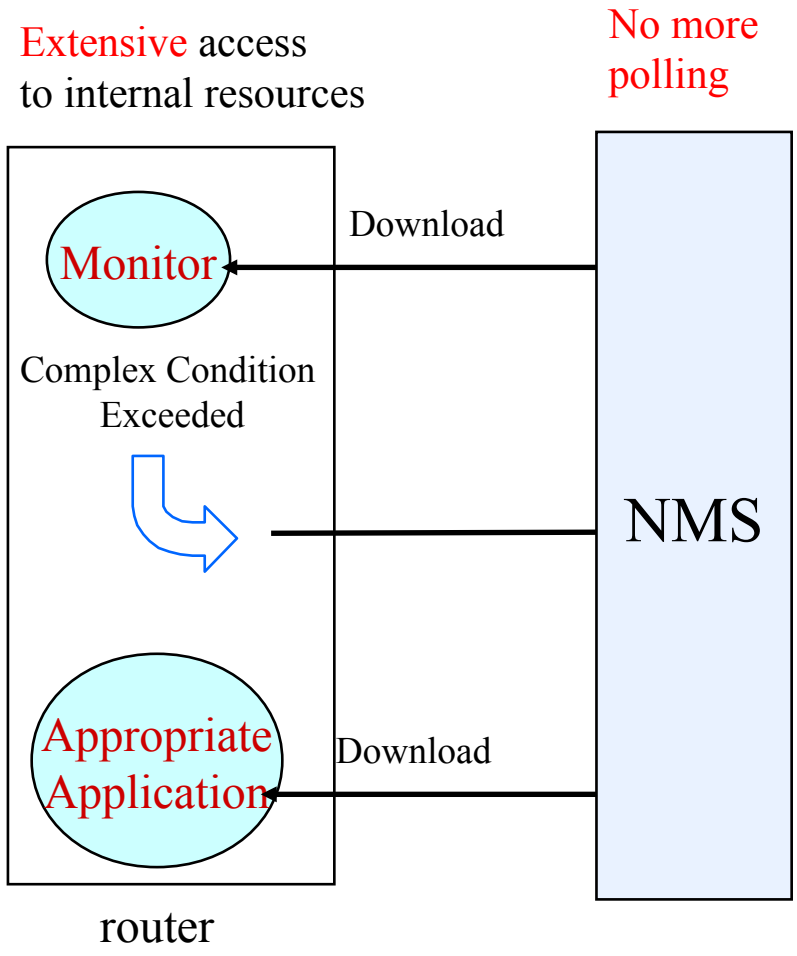


Applications

- **Active Network Management**
  - Proactive Network Management
  - Diagnostic Agents
- **Dynamic DiffServ Classifier**
- **Active Intrusion Detection**
- **Multicast Caching**
- **IP Accounting**
- **Application-Layer Router-Server Collaboration**
- **Pseudo Default Drop Capability**

Active Network Management

- **Download Oplet Service to the device.**
- **Monitor MIB variables**
  - Might be complex conditions
  - Trend analysis
  - DiffServ, RMON-II, etc… MIBs
- **Report "events" to NMS**
  - drop rate, packets/second
- **Allow Service to take action**
- **Download application**
- **Adjust parameters based on direction from NMS**



Proactive Network Management

- **Device-based Intelligence is Dynamic**
  - Static Management
    - SNMP set/get mechanisms
    - Telnet, User Interfaces (cli, web, etc…)
  - Dynamic Closed-loop Management at Network Node
    - capable of dealing with new and difficult situations
    - autonomous and rational properties.
    - dynamically system monitoring & modification
    - report status and trends
  - Monitor MIB to identify poor performance and notify NMS prior to failures
  - Downloaded service can instantiate new services

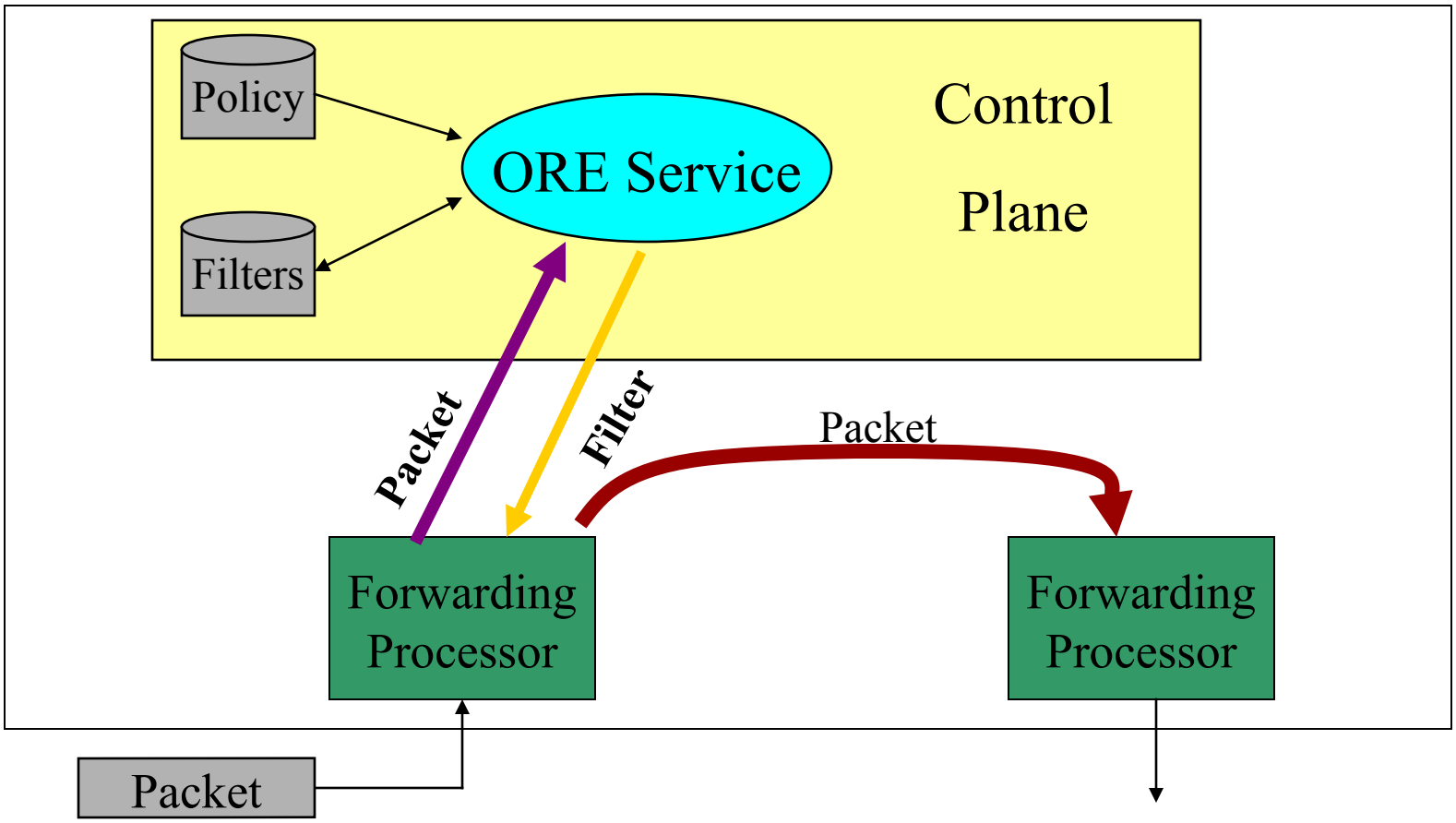
Diagnostic Agents

- **Automatic traceroute from edge router where problem exists.**
  - Each node reached generates a report to NMS
  - Traceroute code "moves" to next node in path
  - Mobile agents identify router health
  - Create logs for NMS

Dynamic DiffServ Classifier

- Set router filters to sample packets from edge device host ports
- Identify real-time traffic (RTP flows)
- Set filter on port to adjust DS-byte value based on policy
- Keep track of filters set
- Remove filters no longer in use

Dynamic DiffServ Classification



- **Sample packets, set filters to modify DS-byte for Per-Hop-Behavior modification**

Active Intrusion Detection

- **Intruder is identified by Intrusion Detection software**
- **Intruder signature is identified**
- **Mobile agent is dispatched in direction of intruder (based on physical port of entry)**
- **Mobile agent "chases" intruder and terminates him (shuts down link, reboot host, notify NMS)**

Multicast Caching

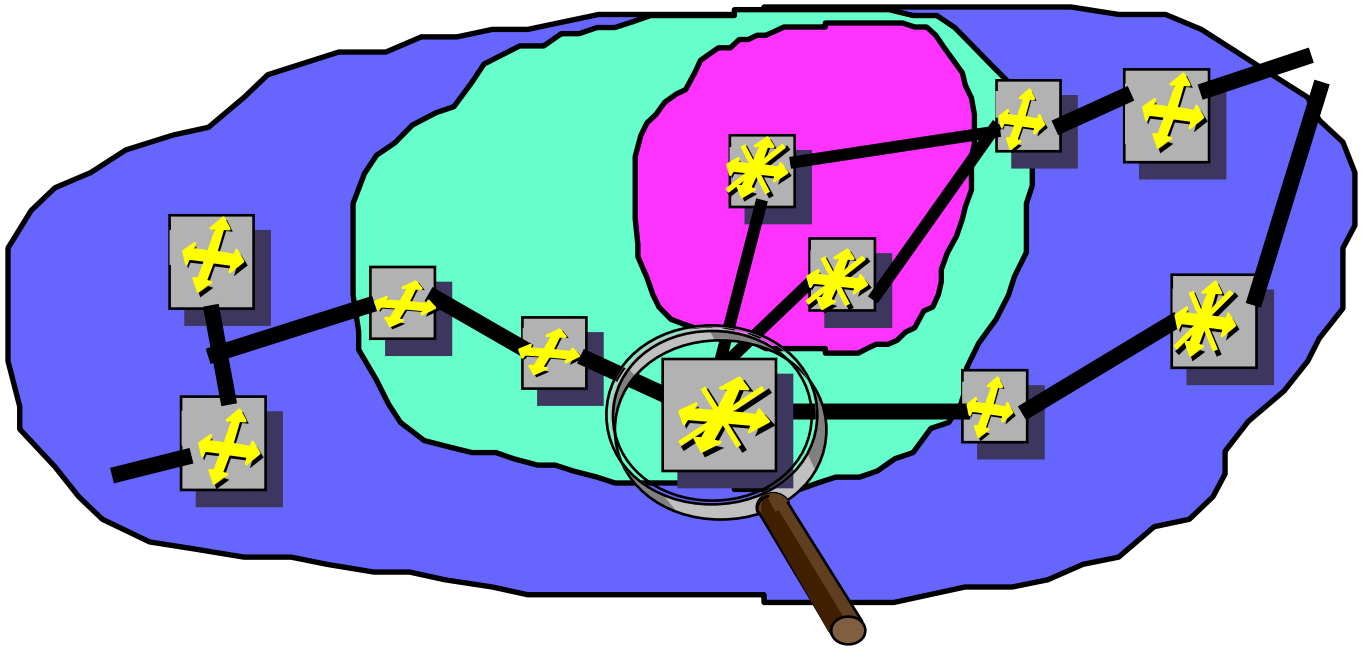
- **Reliable Multicasting**
- **Distribute error control throughout multicast tree**
- **Retransmission a local node keeps control close to lossy links**
- **Balances processor load away from multicast source**

IP Accounting

- Project ABCD (Active Bean Counter in Device)
- Perform usage accounting at edge node
- PreCorrelate/aggregate/reduce accounting record on-site
- $1 rule for billing
- Real-time billing can be realized
- Customize billable resources

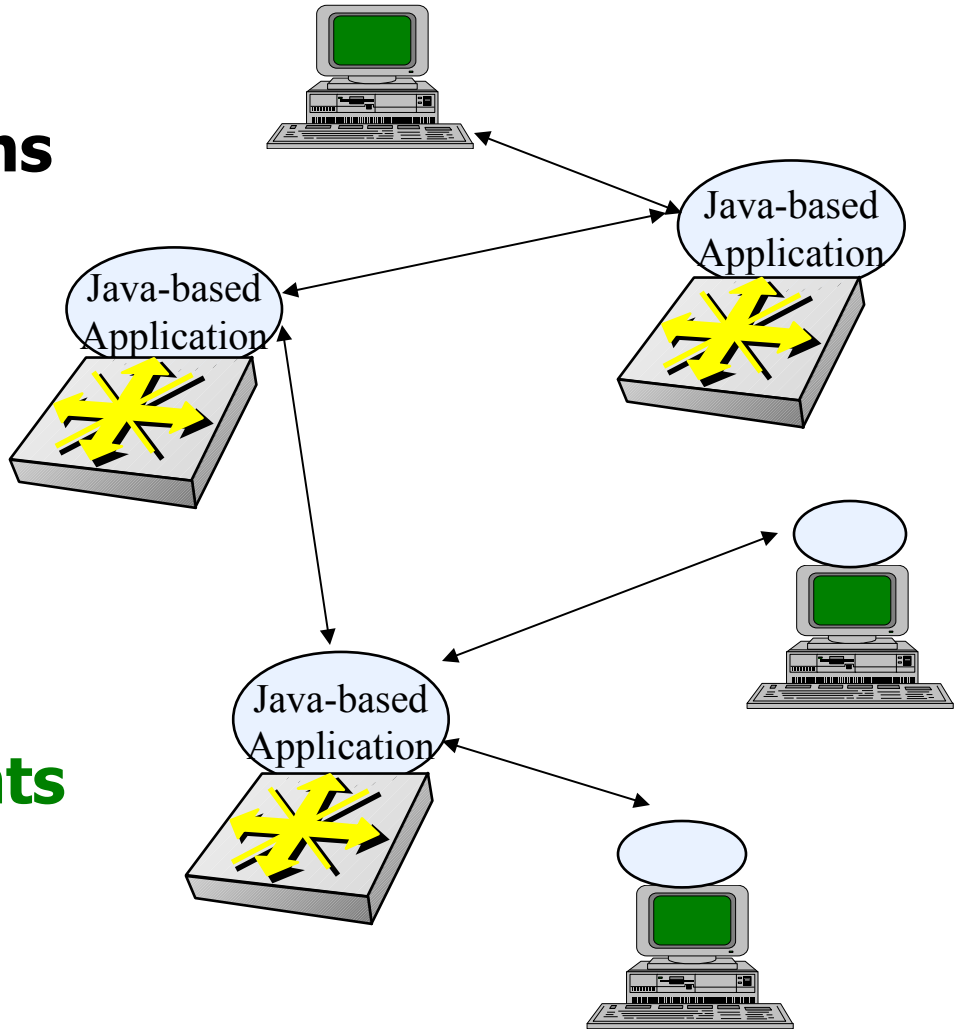
Application Layer Collaboration Among Routers and Servers

- **Server farm load balancing**
  - server state monitored; rerouting based on congestion/load
- **Auctioning Applications**
- **Bandwidth Broker**



Server Collaboration

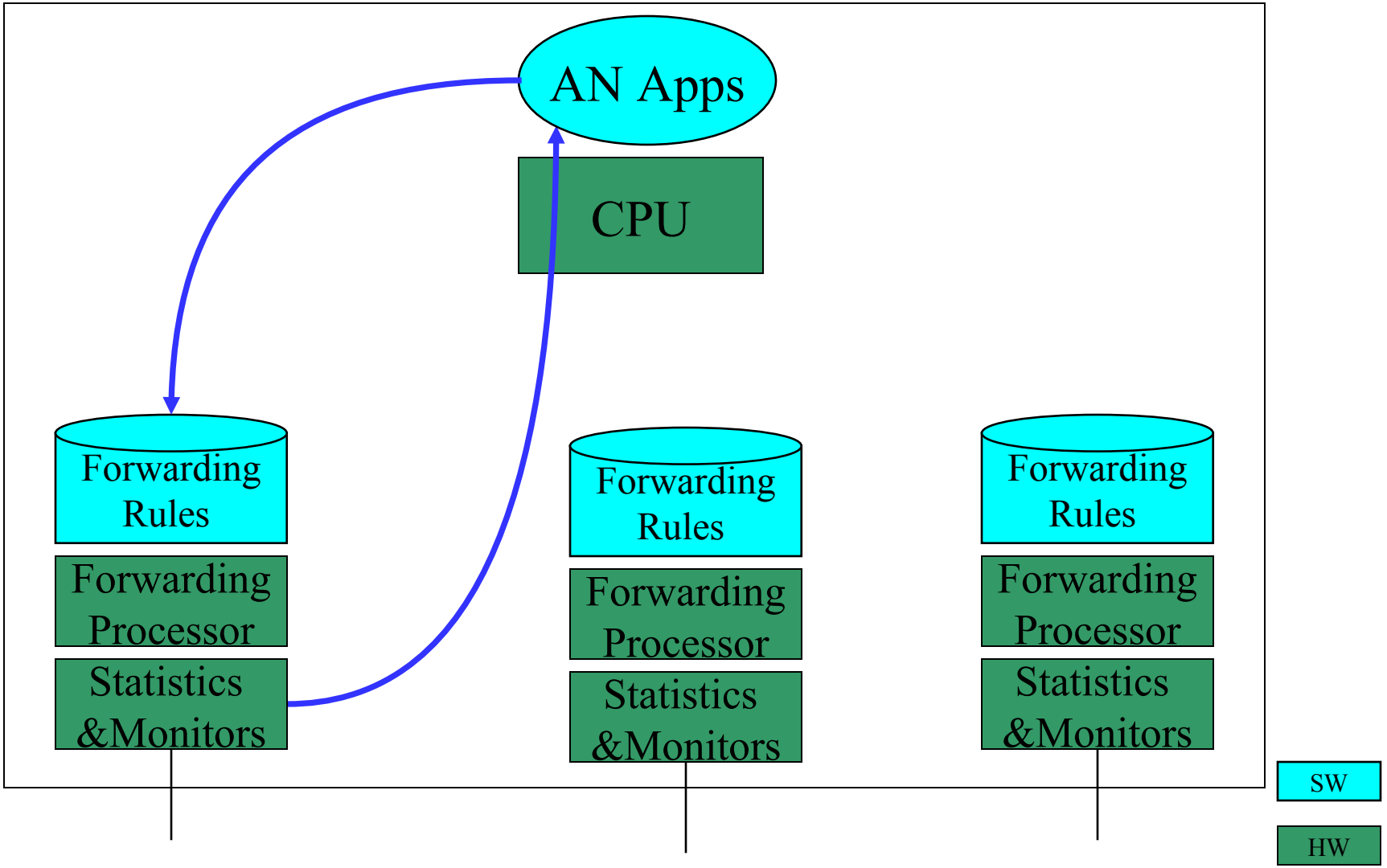
- **Supports distributed computing applications in which network devices participate**
  - router to router
  - server to router
- **Supports Intelligent Agents**
- **Supports Mobile Agents**



Bandwidth Broker Collaboration

- **Routers Monitor RMON and DIFFSERV MIB**
- **Report Per-IPAddress, Per Protocol statistic to resource broker**
- **Adjust DS-byte and Per Hop Behavior based on Bandwidth Broker directions**

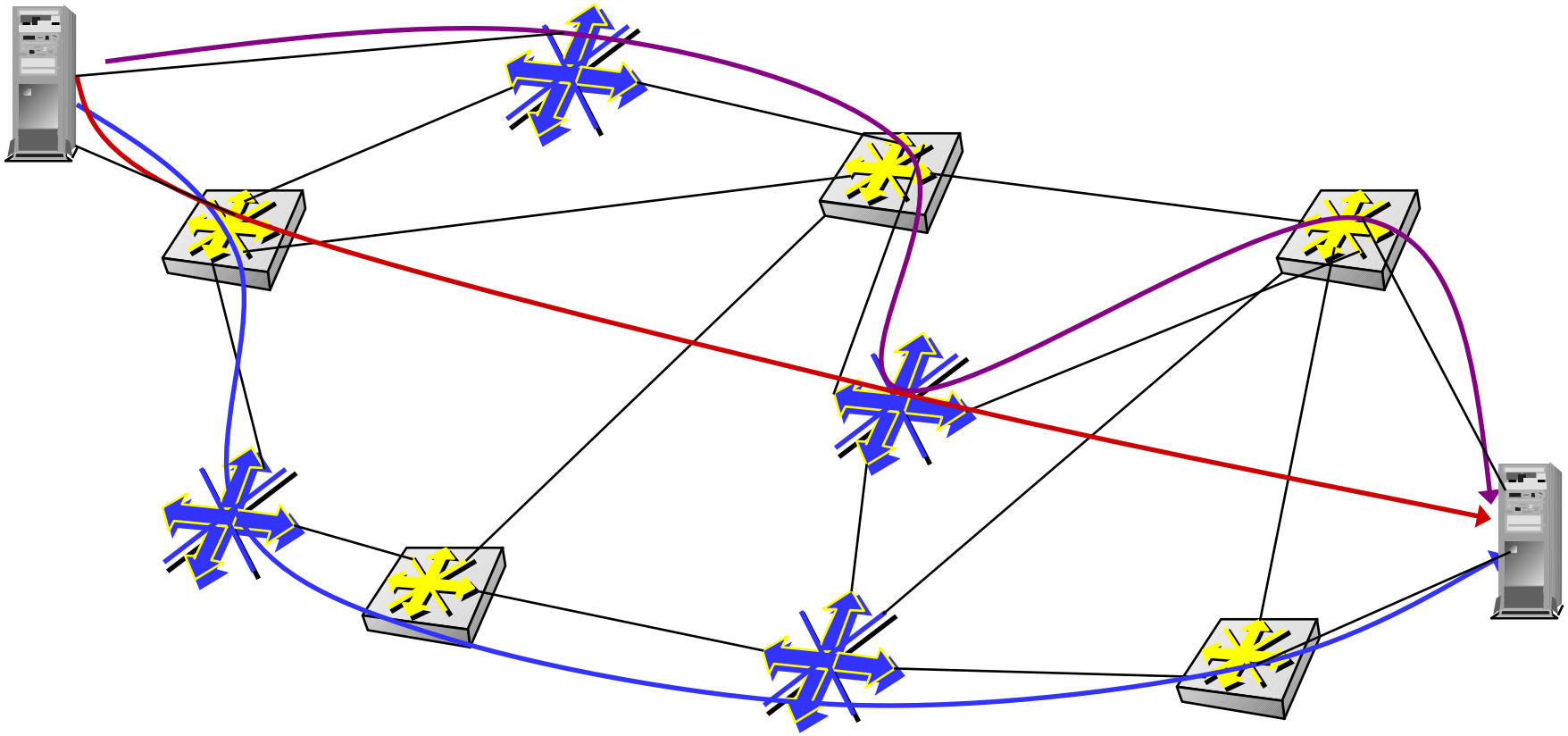
Real-time forwarding Stats and Monitors



Dynamic - On the Fly Configuration

- **From downloadable Java application, we can modify the behavior of the ASICs**

Mixed Topology of AN system

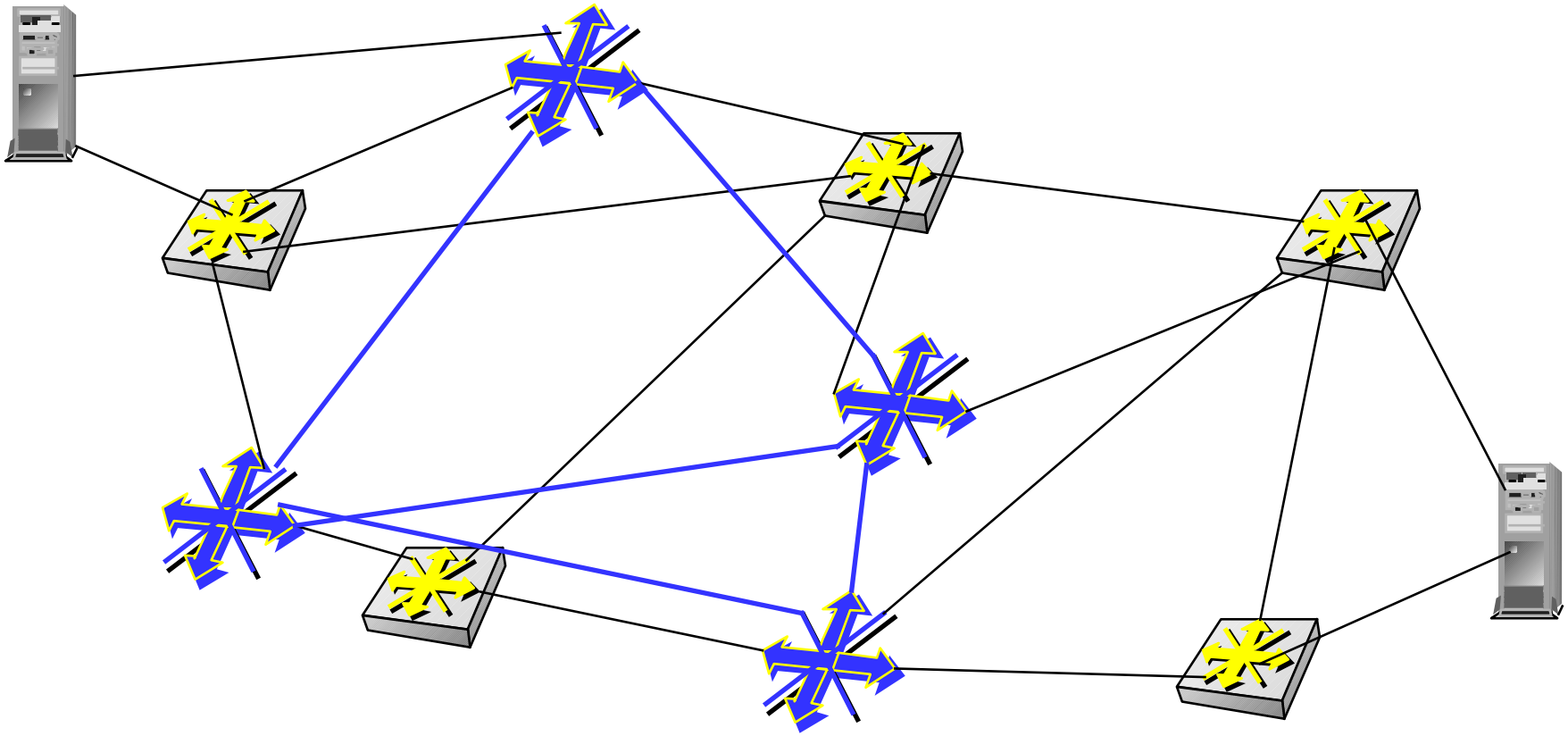


NO need to know the AN topology ahead of time

 - AN Node

 - None AN Node

Active Node Topology Discovery



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 - AN Node

 - Non AN Node