Openet: Open Networking through Programmability

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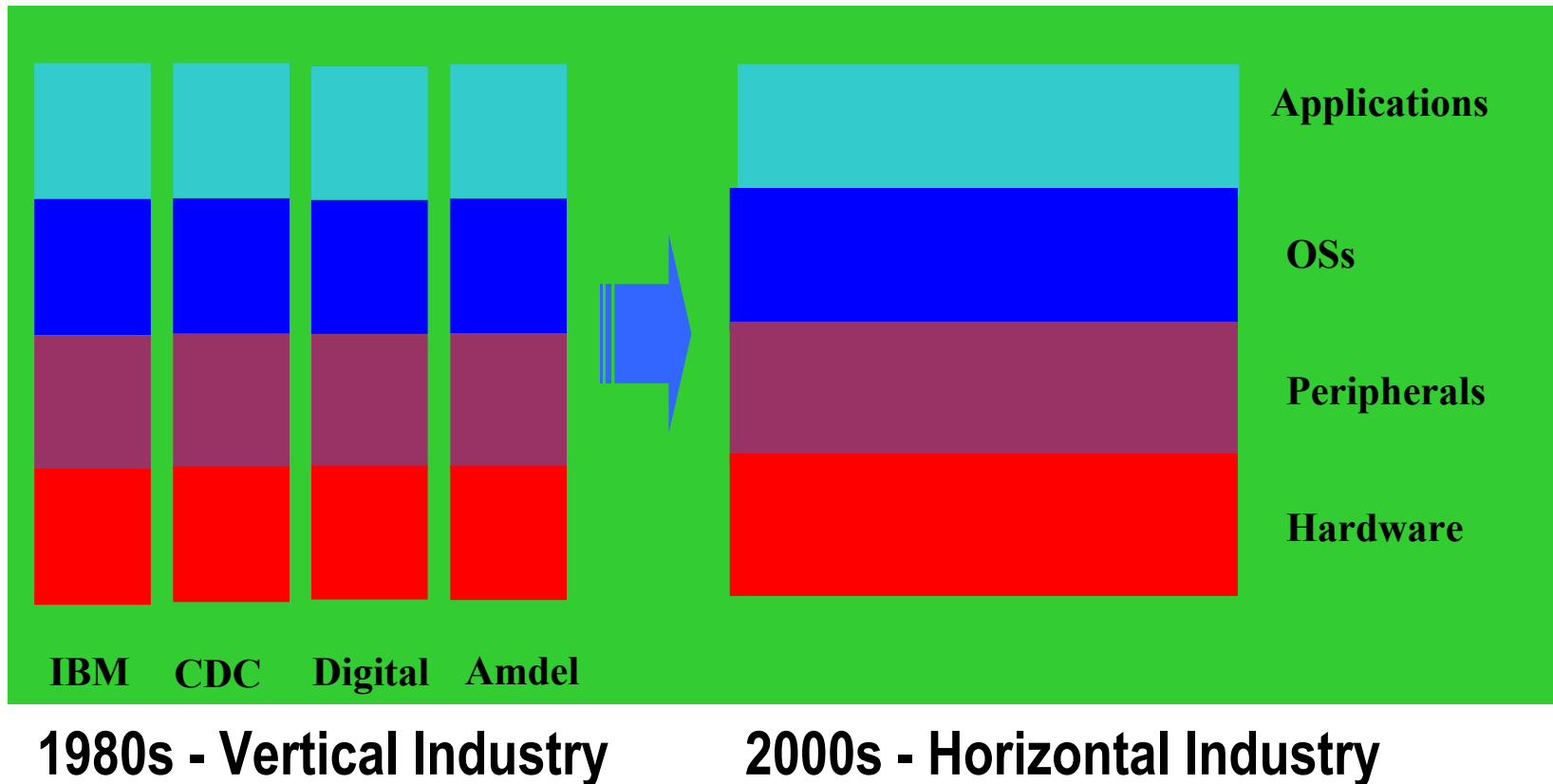
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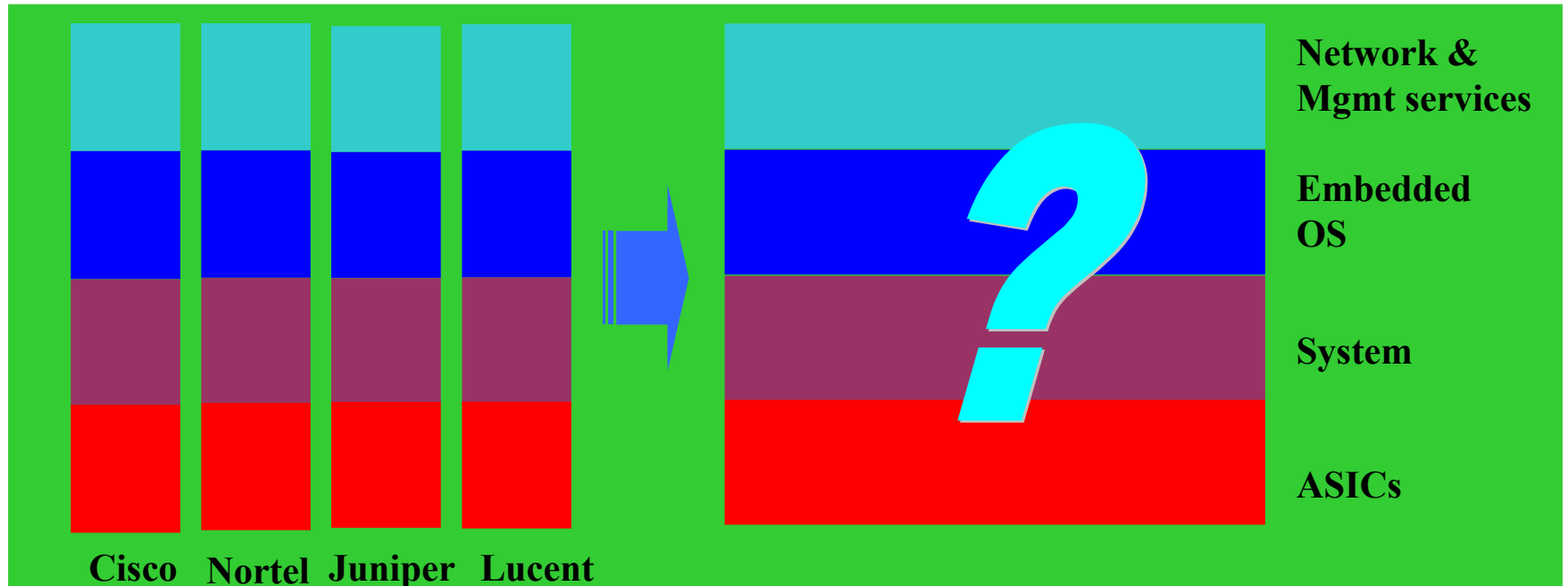
Agenda

- ✦ **Two Evolutions: computer vs network**

- ✦ **Openet: open networking approach**

- ✦ **DARPA-Funded Project: Openet/Alteon & Research Platform**

- ✦ **EE CS Collaboration**

- ✦ **Openet Features and Applications**

- ✦ **Summary**

Think of computer evolution …

1980s - Vertical Industry   **2000s - Horizontal Industry**

What's network evolution?

"2000s Vertical Network Industry

Horizontal Network Industry

The inflection point is quickly approaching …

Why Open Networking?

✦ **Open network boxes to public**
- Current network devices are close systems

✦ **Intelligence to network nodes because**
- Internet infrastructure evolves slow
- Customers can not add new services

✦ **Better use of network resources**
- Abundant bandwidth
- Diversified clients' needs

Move Turing Machine onto Device

Add local intelligence to network devices

```
while (true)
doLocalProcessingOnDevice();
```
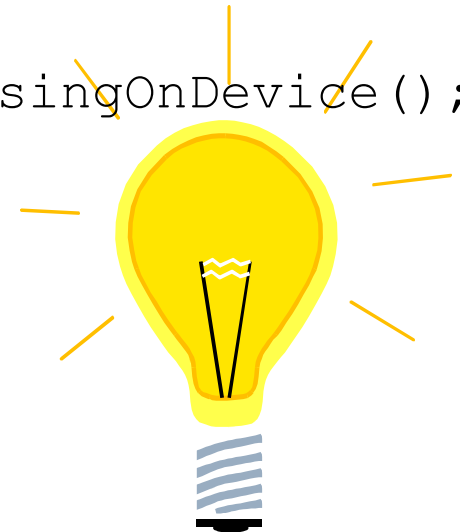
Challenges and Solution

✦ Commercial network devices have

- Ever more use of hardware acceleration
  - Static and well-defined protocols and services
- Little flexibility to introduce users' intelligence
  - Allowing configuration rather than value addition

✦ Active Networks requires

- Open boxes to users
- Networking programmability

✦ Our solution

- Openet
  - A programmable networking platform across devices
- Active Services through Openet
- Wire-speed data plane, powerful computation in the control plane

The Openet Approach

✦ **Open networking through programming**
- A Service-enabled networking platform
- Intelligence to commercial network devices
  - Network control and management
  - Packet forwarding and processing
- Not impeding network performance and reliability
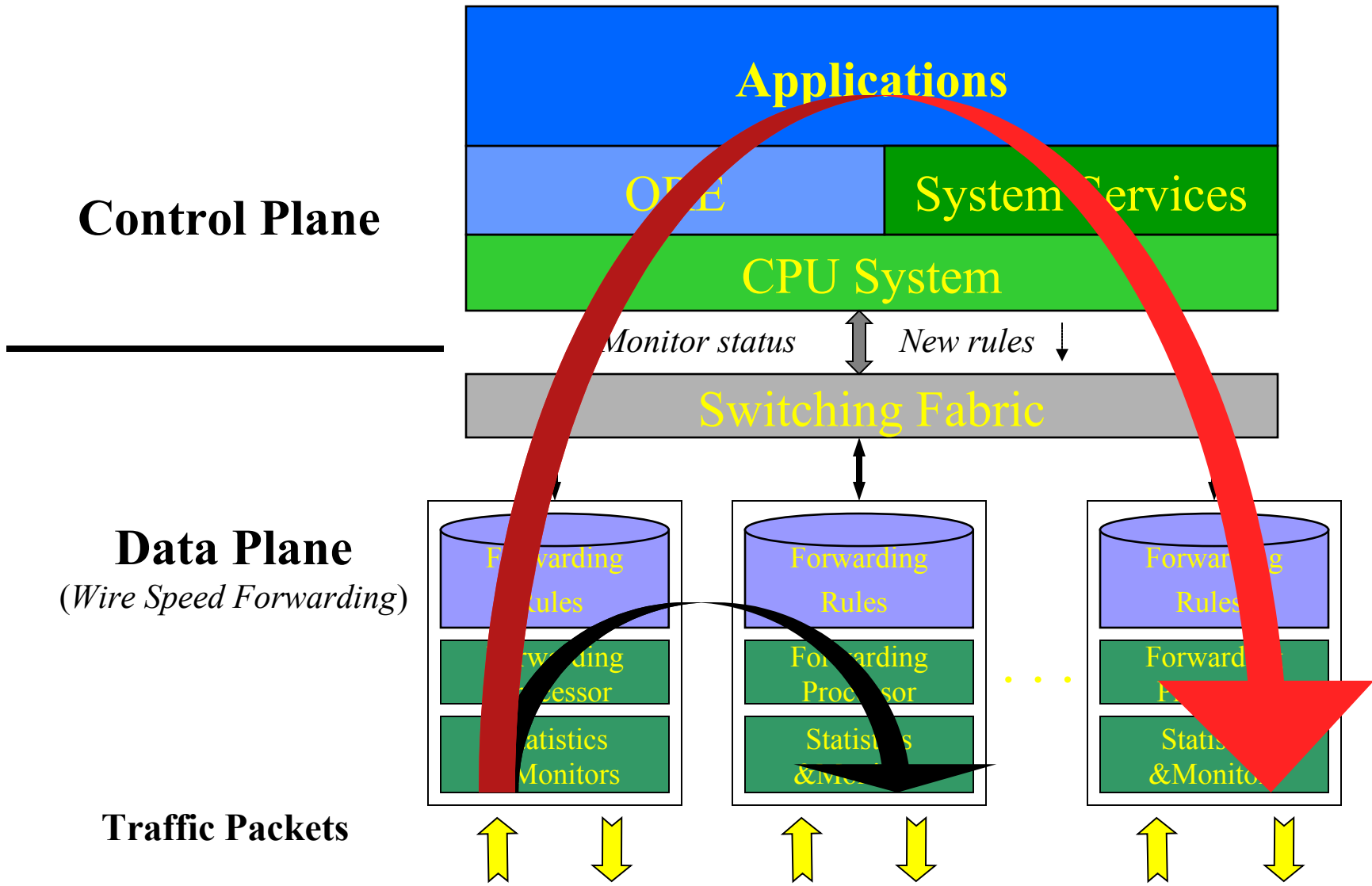 - Forwarding
  - Security

✦ **Enabling service creation and deployment**
- Value-added services across network elements
- Dynamic and downloadable

✦ **Standards and Partners**
- IEEE, IETF, Active Networks and FAIN
- Columbia U., UC Berkeley
- MITRE, TASC, and CSIRO

Openet Architecture

Control Plane

Applications

ODE | System Services

CPU System

Monitor status   *New rules* ↓

Switching Fabric

Data Plane
(*Wire Speed Forwarding*)

Forwarding Rules | Forwarding Rules | Forwarding Rules

Forwarding Processor | Forwarding Processor | Forwarding Processor

Statistics &Monitors | Statistics &Monitors | Statistics &Monitors

Traffic Packets

DARPA-Funded Project

Active Nets Technology Transfer through High-Performance Network Devices

✦ **Exploring new commercial network hardware as a research platform**

- L2-L7 filtering
- Fast content filtering and redirection
- Strong and extensible CPU capability
- Secure partitioning hardware and software

✦ **Server and network collapse**

- Getting computation inside the network
- Explore new ideas

Introducing the Alteon 780 Series
Large-Scale Data Center Content Switch/Router

✦ **Alteon Webworking integrated with Nortel switching technology**

- Distributed Alteon WebICs
- Alteon WebOS services
- Layers 2-7 switching
- 128G switch capacity
- 300+ FE; 60 GbE
- Data center class redundancy
- Future:
  - iSD and PCD integration
  - ATM and PoS connectivity
  - NEBS-3 compliance platform
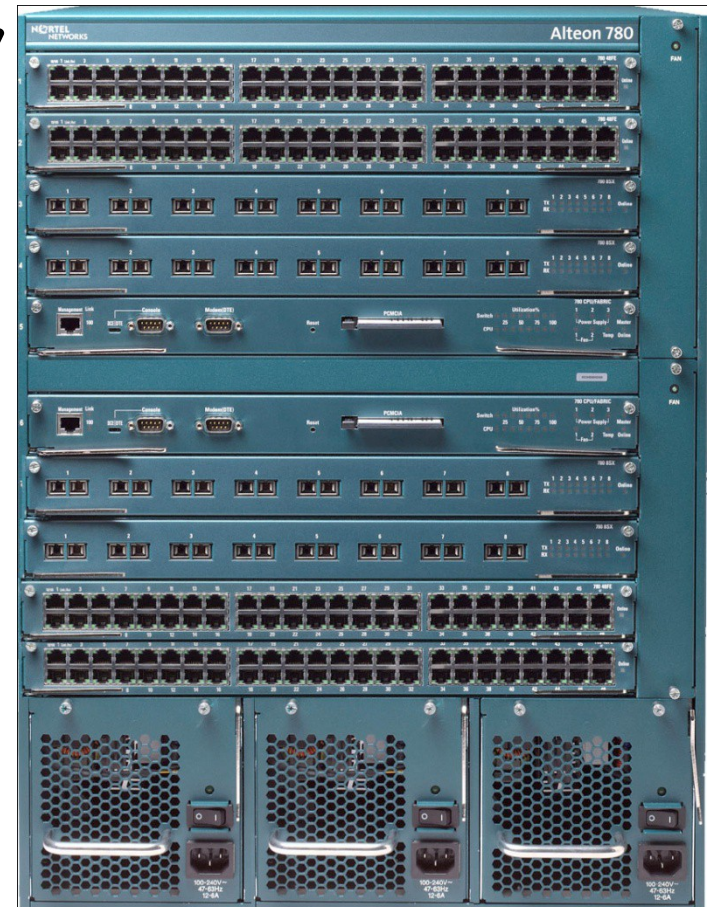
Dynamic L2-L7 Filtering

L2-L7 Filtering Capability

✦ Source Address

✦ Source Port

✦ Destination Address

✦ Destination Port

✦ Protocol

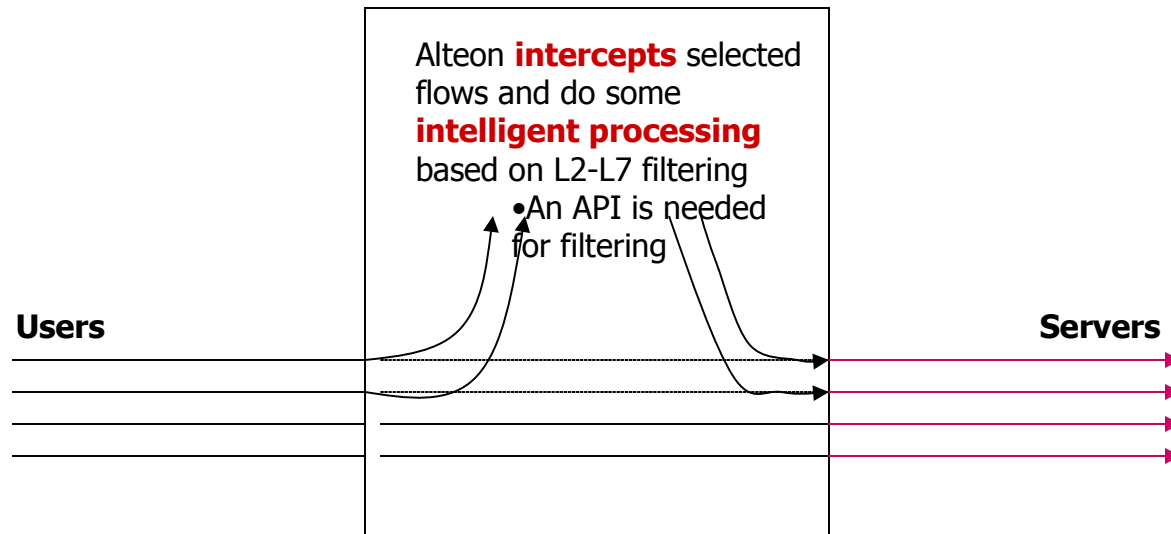✦ Diffserve Code Points

✦ Content Filtering

✦ Cookies Filtering
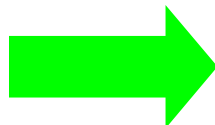
JFWD 5-tuple Filtering

✦ Divert the packet to the control plane

✦ Don't forward the packet

✦ Change DSCP field

✦ Set VLAN priority

✦ Adjust priority queue

✦ Modify session table

✦ Parsing request header

✦ Parsing application contents

The value of Alteon:
Alteon = Control + Processing + Storage + Programmable Services

Alteon **intercepts** selected flows and do some **intelligent processing** based on L2-L7 filtering
•An API is needed for filtering

Users

Servers

**The emphasis is on interception and processing transparently.
Entities at both ends may not be aware of the existence of the Alteon in the path**

What does Alteon do that cannot be done by another processor? (X=Processor+1Gbyte+SWs)

✦ Before X can do any processing X has to do filtering and/or redirecting the intended flows (flows in general sense, i.e L2 – L7). Alteon does this within its architecture.

✦ Some intended flows require Ln processing. X processor has to process L2 – L(n-1) before Ln level processing can be done. Alteon prepares up to and including L(n-1) level processing within its architecture.

✦ X processor can be an iSD or any general processor as long as there is an Alteon API.

Alteon API – differentiates itself from other boxes

iSD or other intelligent processing devices
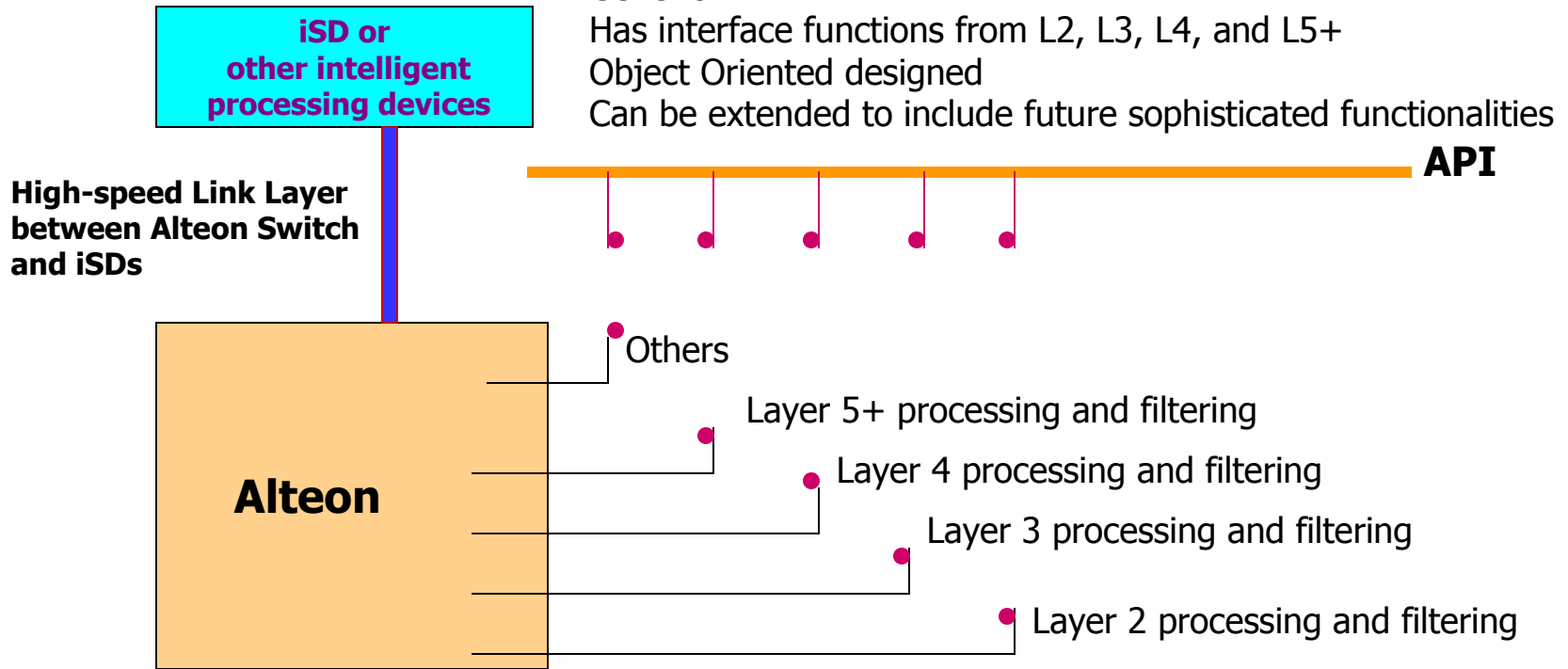
Alteon API
Generic
Has interface functions from L2, L3, L4, and L5+
Object Oriented designed
Can be extended to include future sophisticated functionalities

API

High-speed Link Layer between Alteon Switch and iSDs

Alteon

Others

Layer 5+ processing and filtering

Layer 4 processing and filtering

Layer 3 processing and filtering

Layer 2 processing and filtering

T1: Programmable content switch

✦ **Openet on Alteon**

- L2-L7 filtering
- Fast content filtering and redirection to active services
- Enhanced closely with Alteon features

✦ **Alteon: new generation of content switch**

- Multiple processors and ASICs
- Programmable microcode
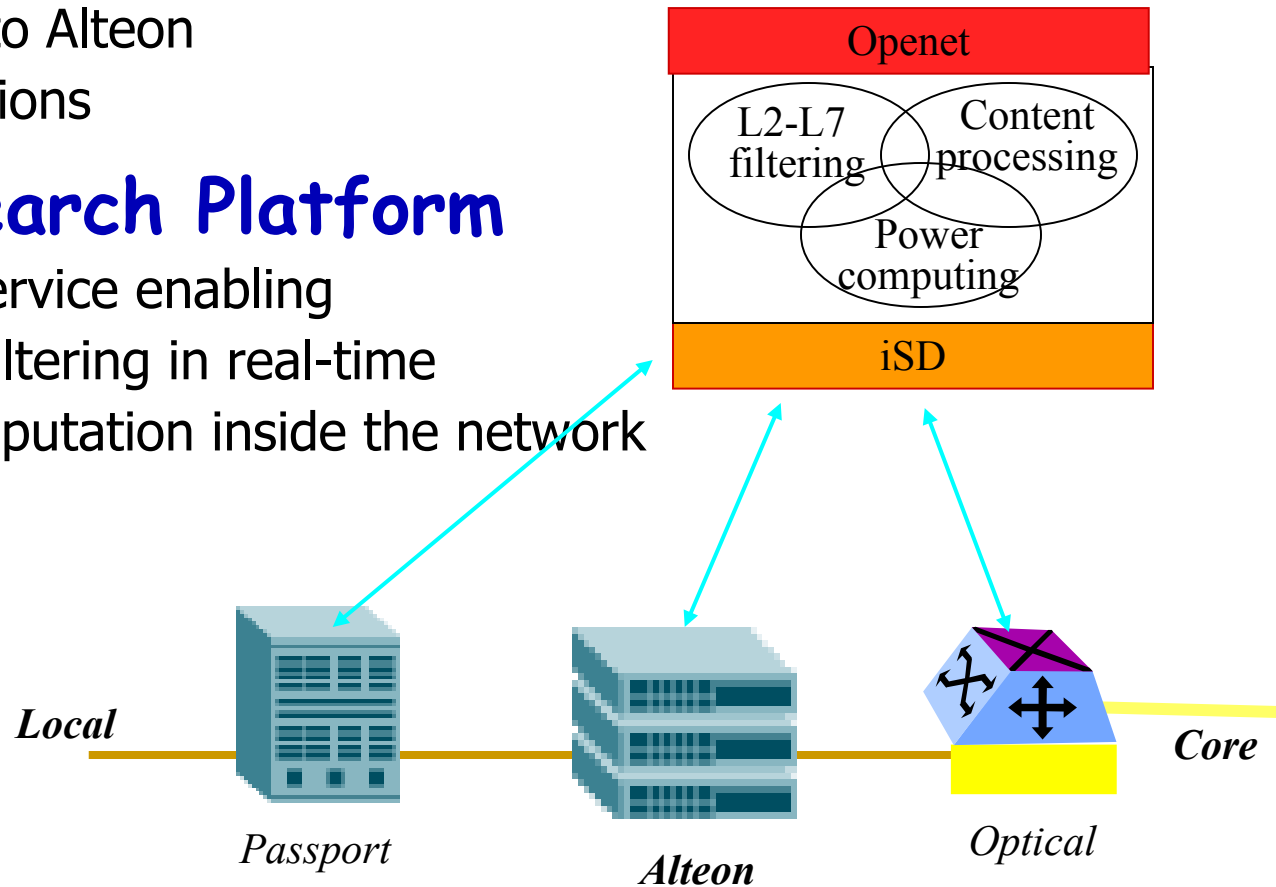- L2-L4 and application filtering and processing

T2: Research Platform

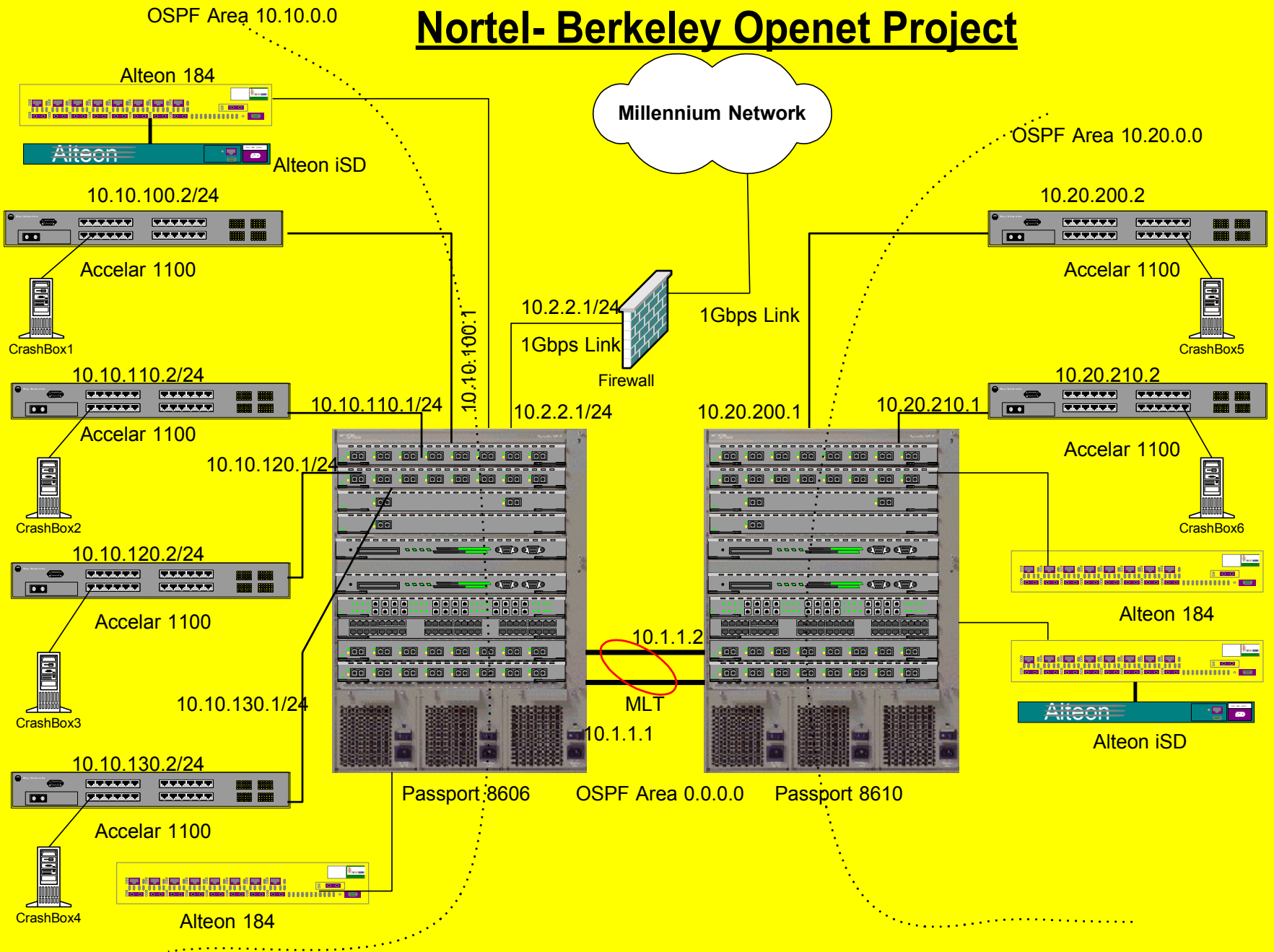✦ **iSD: powerful and extensible computational plane**

- Partitioning hardware and software resources
- Close interfaces to Alteon
- Cluster computations

✦ **Network Research Platform**

- Openet: active service enabling
- Alteon: content filtering in real-time
- iSD: integral computation inside the network

Openet

L2-L7 filtering | Content processing

Power computing

iSD

Local

Passport

Alteon

Optical

Core

Nortel- Berkeley Openet Project

OSPF Area 10.10.0.0

Alteon 184

Alteon iSD

Millennium Network

OSPF Area 10.20.0.0

10.10.100.2/24

Accelar 1100

CrashBox1

10.20.200.2

Accelar 1100

CrashBox5

10.10.110.2/24

Accelar 1100

CrashBox2

10.10.120.2/24

Accelar 1100

CrashBox3

10.10.130.2/24

Accelar 1100

CrashBox4

Alteon 184

10.2.2.1/24

1Gbps Link

10.10.110.1/24

10.10.100.1

1Gbps Link

Firewall

10.2.2.1/24

10.10.120.1/24

10.10.130.1/24

10.1.1.2

MLT

10.1.1.1

Passport 8606   OSPF Area 0.0.0.0   Passport 8610

1Gbps Link

10.20.200.1

10.20.210.1

Accelar 1100

CrashBox6

10.20.210.2

Alteon 184

Alteon iSD

Any interest?

Looking for a grant?

- ✦ **Interested in summer internship?**
  - Talk with me later

How Can We Collaborate?

✦ **Corry is not far from Soda**

- Are we EE+CS or EECS?
- How can we bridge CS and EE projects?
- Can we create a virtual lab? How?

✦ **Openet and SmartNet are supported by DARPA**

Summary

- ✦ **Openet on Alteon is a powerful programmable networking platform**
  - Great Research platform to explore new ideas
  - Commutation embedded within the network
  - Linux development environment

- ✦ **Gigabit speed data-plane with programmability on the control-plane**

- ✦ **Openet-Alteon is a sophisticated platform for developing real applications and for introducing services on-demand**

- ✦ **Openet-Alteon SmartNets requires your collaboration!**
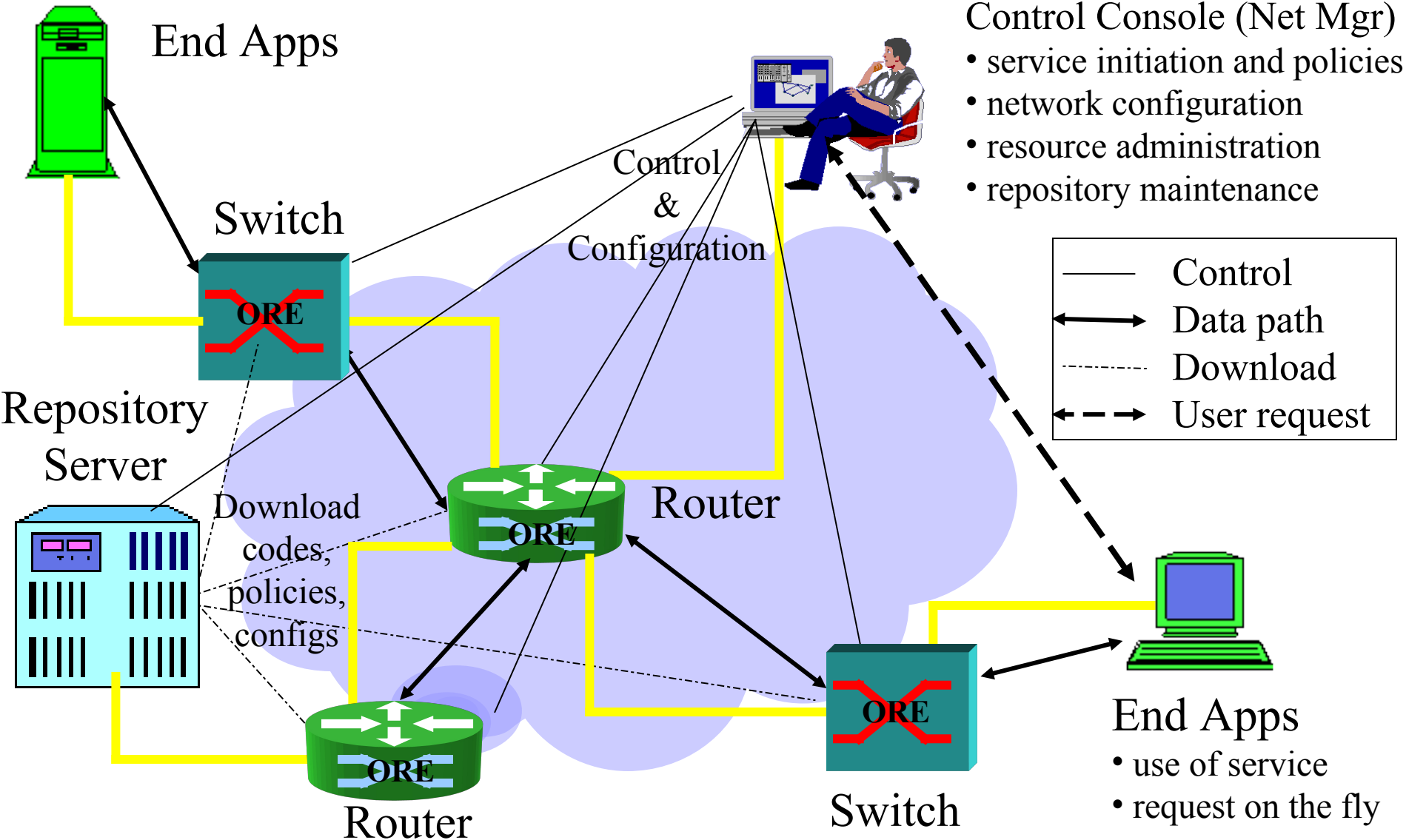
Q & A

Visit us at
HTTP://www.openetlab.org

Thank You !

Backup

Openet Features and Applications

Openet Architecture

End Apps

Control Console (Net Mgr)
- service initiation and policies
- network configuration
- resource administration
- repository maintenance

Switch

ORE

Control
&
Configuration

	Control
	Data path
	Download
	User request

Repository
Server

Download
codes,
policies,
configs

Router

ORE

Router

ORE

Switch

ORE

End Apps
- use of service
- request on the fly

Openet DARPA UC Berkeley

3/6/2002   24

Openet Compositions

✦ **ORE**
- Service creation and deployment
- Service lifecycle management

✦ **Services**
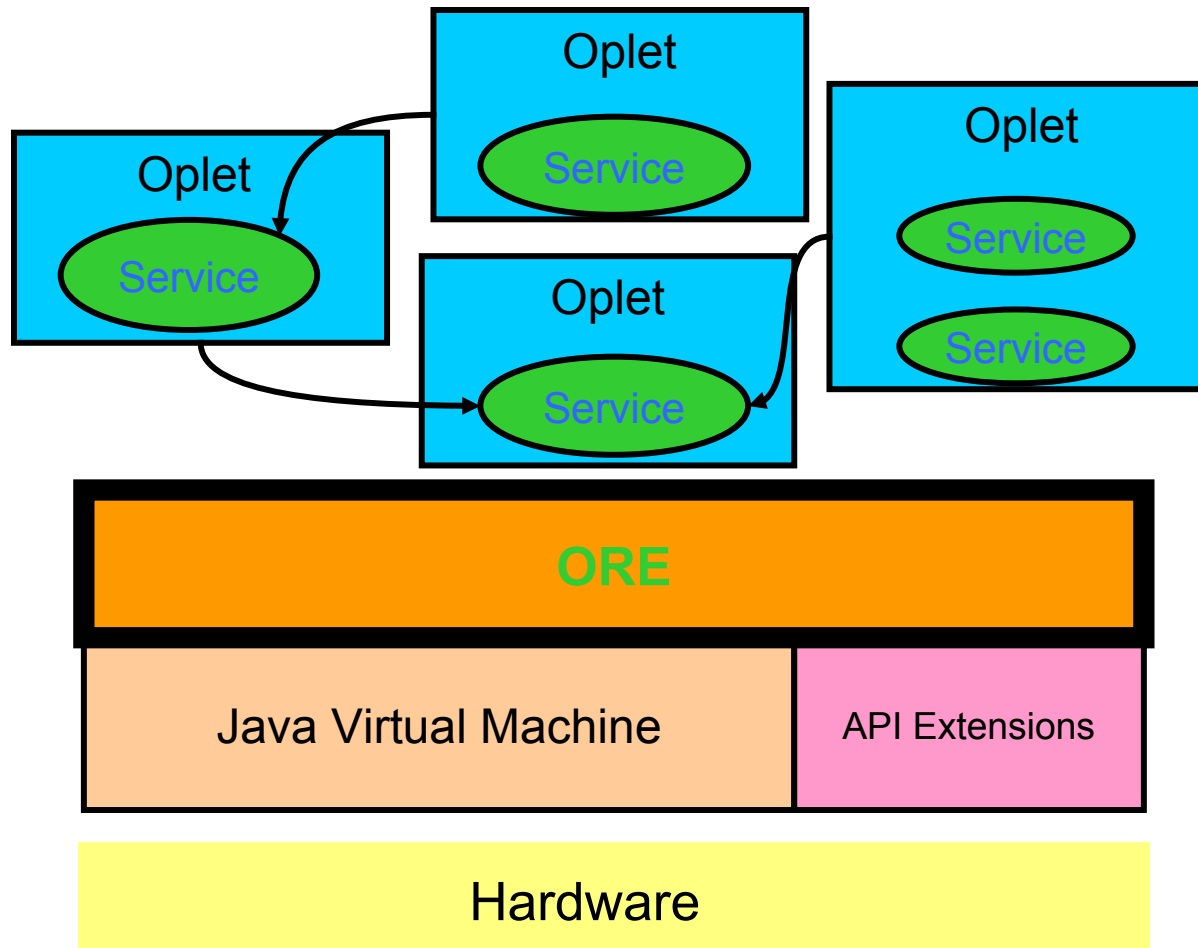- Every network function is a service
- Every service provides object APIs

✦ **ODK**
- Service development and encapsulation

✦ **Management**
- Service mgmt: initiation, policy and configuration
- Manager on console and Agents on nodes

Openet: a node's view

Oplet is a program unit wrapping services

ORE: the Openet Core

✦ **ORE**

- Object-oriented Runtime Environment
- Run customized software on network nodes
- Neutral to heterogeneous hardware
- Secure downloading, installation, and safe execution inside JVM
- Fully implemented using Java

System Services: JFWD

✦ **Java Forwarding**

- IP forwarding and routing
  - Diffserv marking
  - Filtering and diverting
  - Forwarding priority
  - Routing

✦ **Platform-independent APIs**

- Implemented on Passport/Accelar and Linux

Function Services

✦ **Common use utility**

✦ **Public neutral APIs**

✦ **Examples**

- HTTP: HTTP service

- Shell: ORE interactive shell

- Packet: packet handling (IP, TCP, UDP)

- Logger: service runtime printout

- OreServlet: Java servlet

Typical Applications

✦ **JDiffserv**
  - Diffserv forwarding and DSCP marking on Passport 8600

✦ **OpeCfg**
  - Dynamic configuration of optical port interfaces

✦ **IP filtering**
  - Dynamic priority changes on Passport 1100

✦ **JSNMP and JMIB**
  - SNMP/MIB access
  - Passport 1100 and 8600

✦ **Regatta: Fault recovery**

JDiffserv

- ✦ **Goals**
  - DSCP marking and re-marking
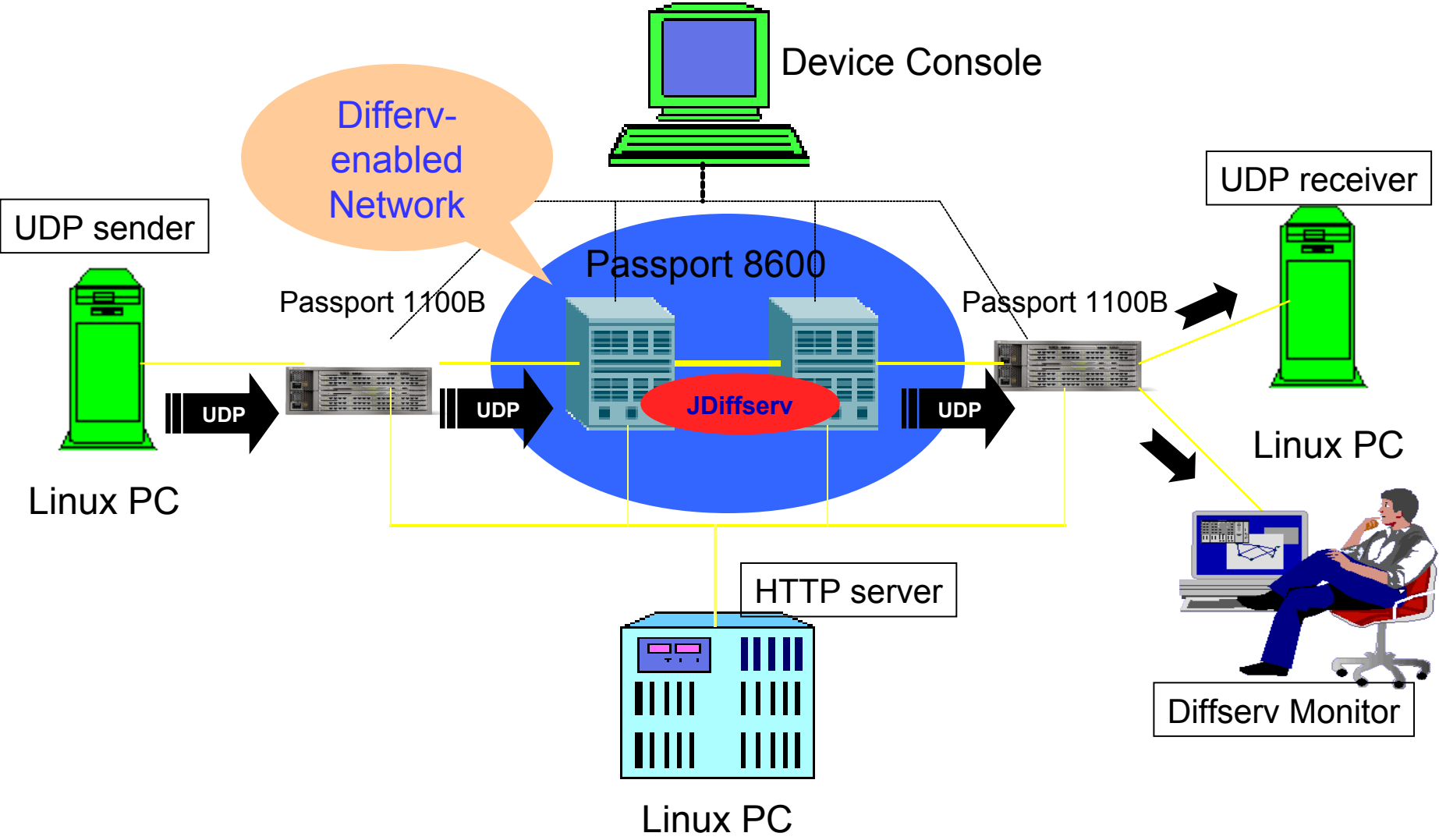 - Priority forwarding or dropping
  - Filtering

- ✦ **Passport**
  - Model: 8600
  - Java 2

- ✦ **ORE**
  - version 0.4.1
  - JFWD/JDiffserv service
  - URL: "http://www.openetlab.org/downloads/"

JDiffserv on Passport

UDP sender

Differv-enabled Network

Device Console

Passport 8600

Passport 1100B

JDiffserv

UDP

UDP

UDP

Linux PC

Linux PC

UDP receiver

Passport 1100B

Linux PC

HTTP server

Diffserv Monitor

Linux PC

JDiffserv Features

✦ **Marking Types**
  - Admission marking
  - condition marking (a.k.a., remarking)

✦ **Filters**
  - IP headers: 5-tuple
    – Source address and port, destination address and port
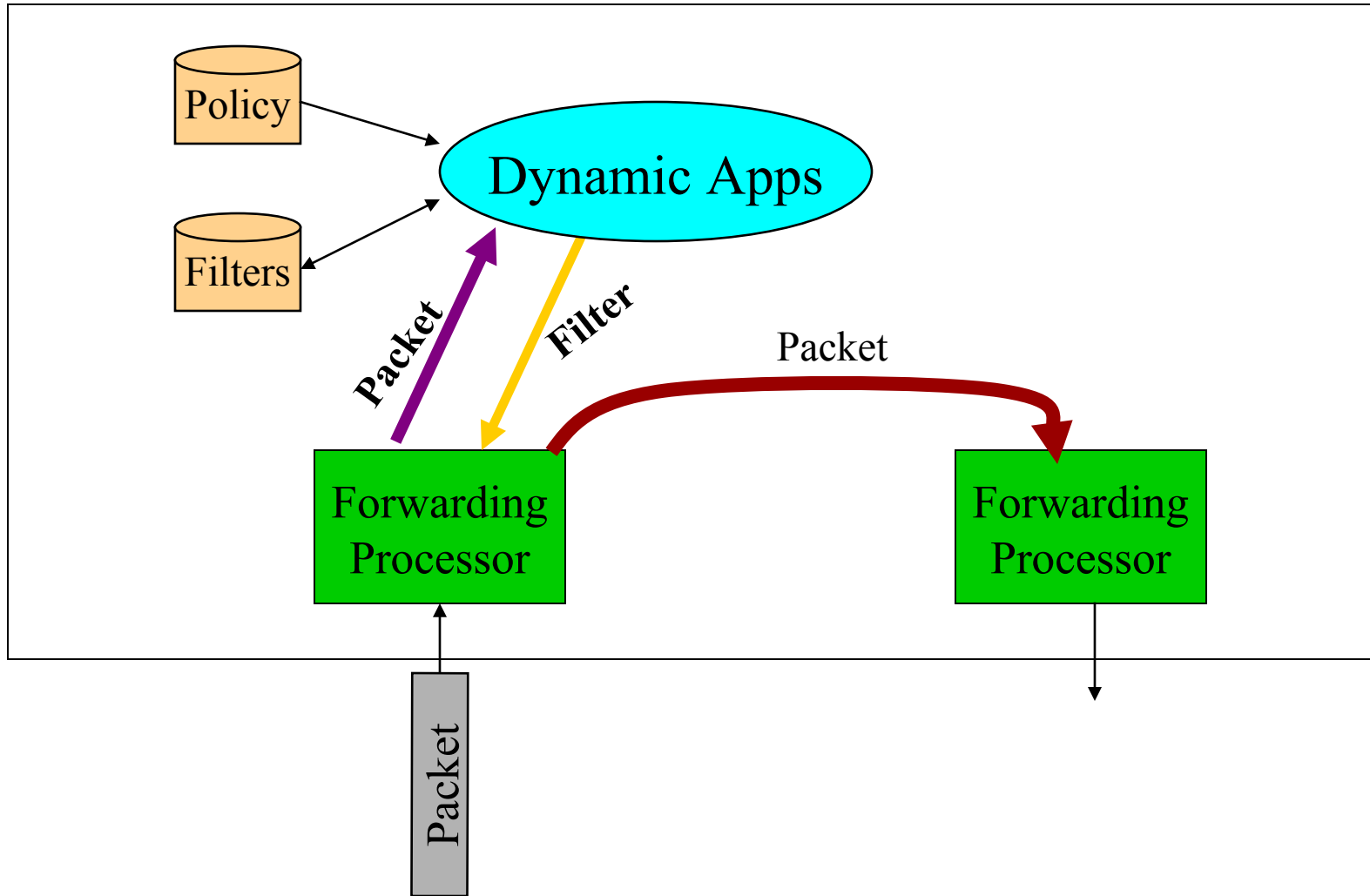   – Protocol type
  - DSField: DSCP
  - Interface ports

✦ **Traffic profile**
  - Average rate and bucket size
  - Peak rate and bucket size

✦ **Action**
  - Marking then forwarding
    – 3-color marker: R/Y/G,RFC 2697
    – new DSCP
  - Dropping

On-the-fly configuration

What's an Oplet?

- **Oplet**: *a self-contained downloadable unit*
  - Encapsulates one or more service objects
  - Contains service attributes, e.g., names
  - Eases secure downloading and service installation
  - Use other service oplets
  - Examples
    - Active Networks services: EE
    - Java Forwarding services: JFWD
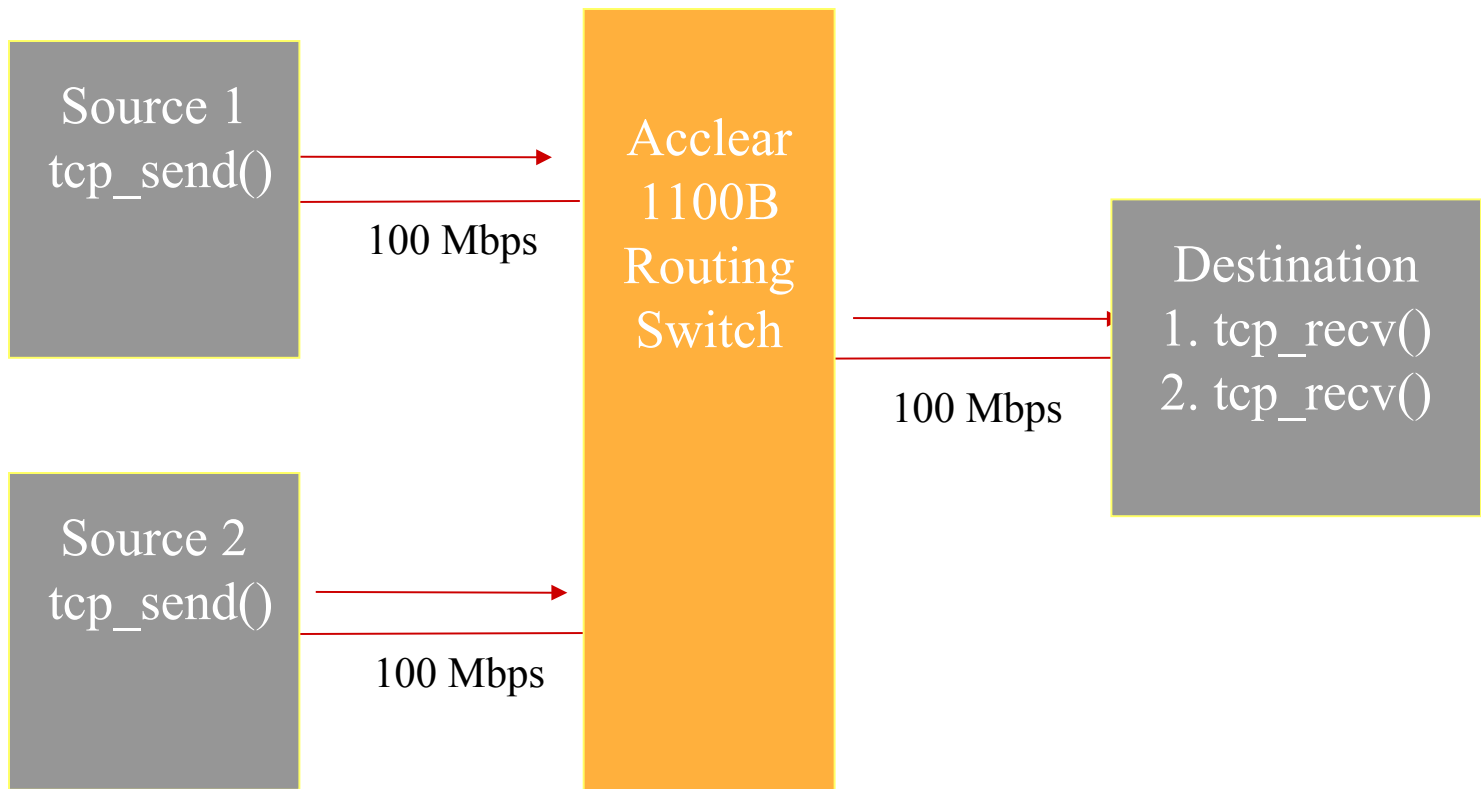   - Base services: ODK

How a service is deployed?

✦ **Service design and coding**
- Regular Java programming

✦ **Service package**
- Oplets by ODK
- JAR files
- Uploading to downloading servers

✦ **ORE start at Passport**

✦ **Service activation by ORE**
- Downloading, start and stop
  - Startup service
  - Shell service

✦ **Service execution**

Dynamic Classification

★ **Objectives**

- **Implement flow performance enhancement mechanisms**

- without **introducing software into data forwarding path**

- **Service defined packet processing in a silicon-based forwarding engine**

- **packet classifier**

Experimental Setup

Throughput Results