

Advanced Network Architectures & Wireless Systems

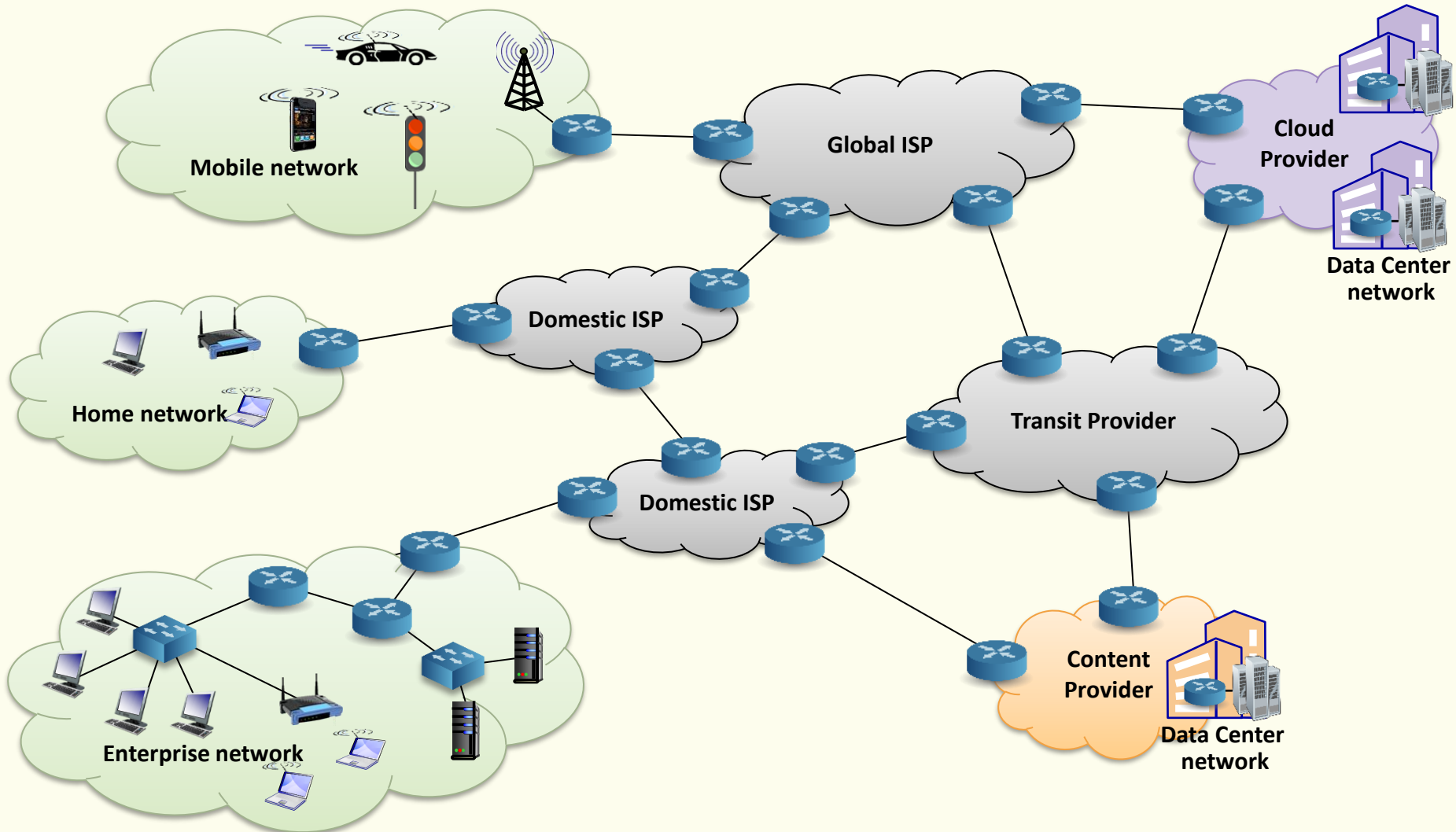
L.M. Computer Engineering

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Internet stakeholders



Internet-connected devices



Amazon Echo



Internet refrigerator



IP picture frame



Pacemaker & Monitor



Tweet-a-watt:
monitor energy use



Security Camera



Slingbox: remote
control cable TV



Web-enabled toaster +
weather forecaster



AR devices



cars



bikes



scooters



Internet phones



Gaming devices

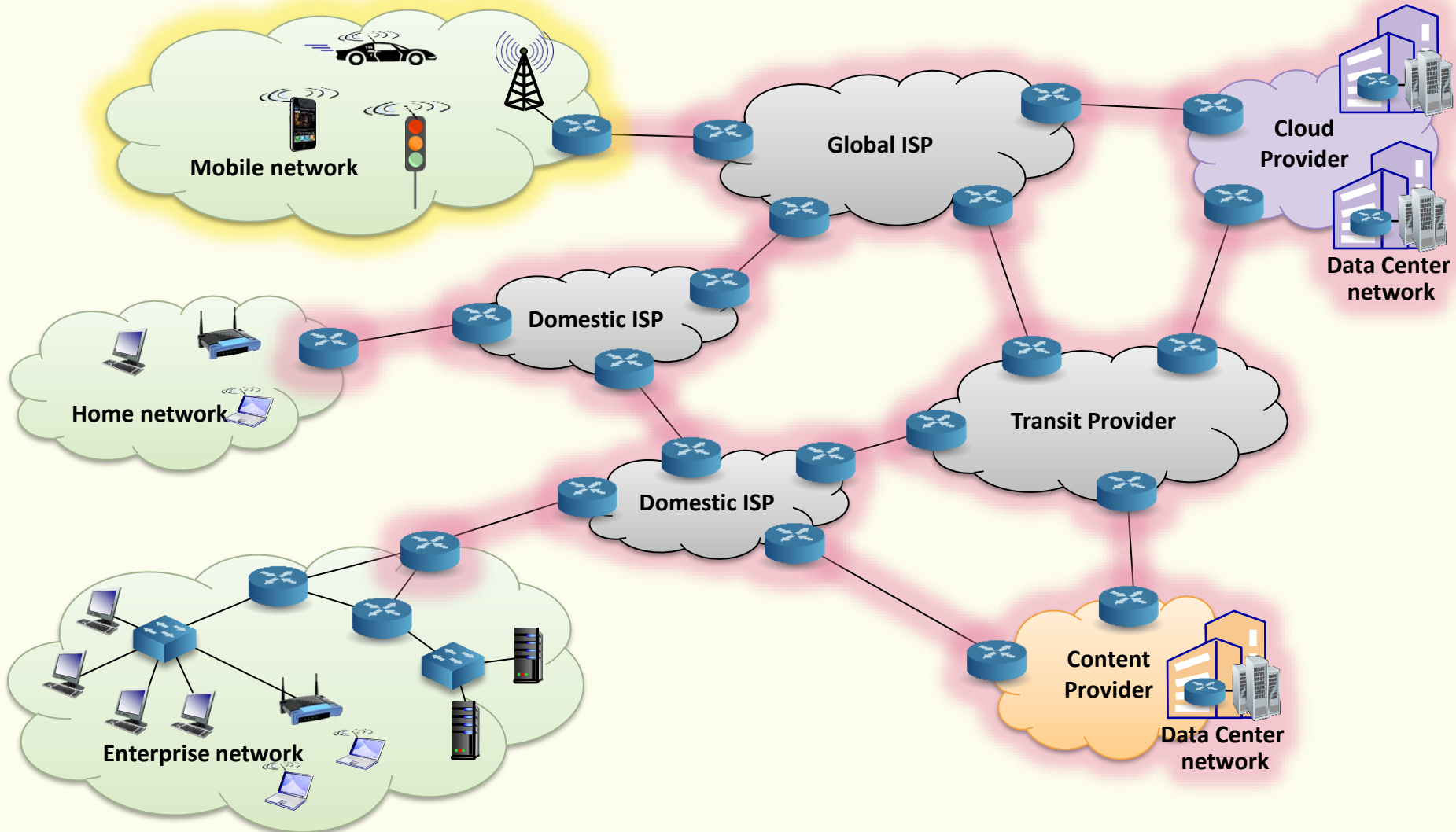


sensorized,
bed
mattress



Fitbit

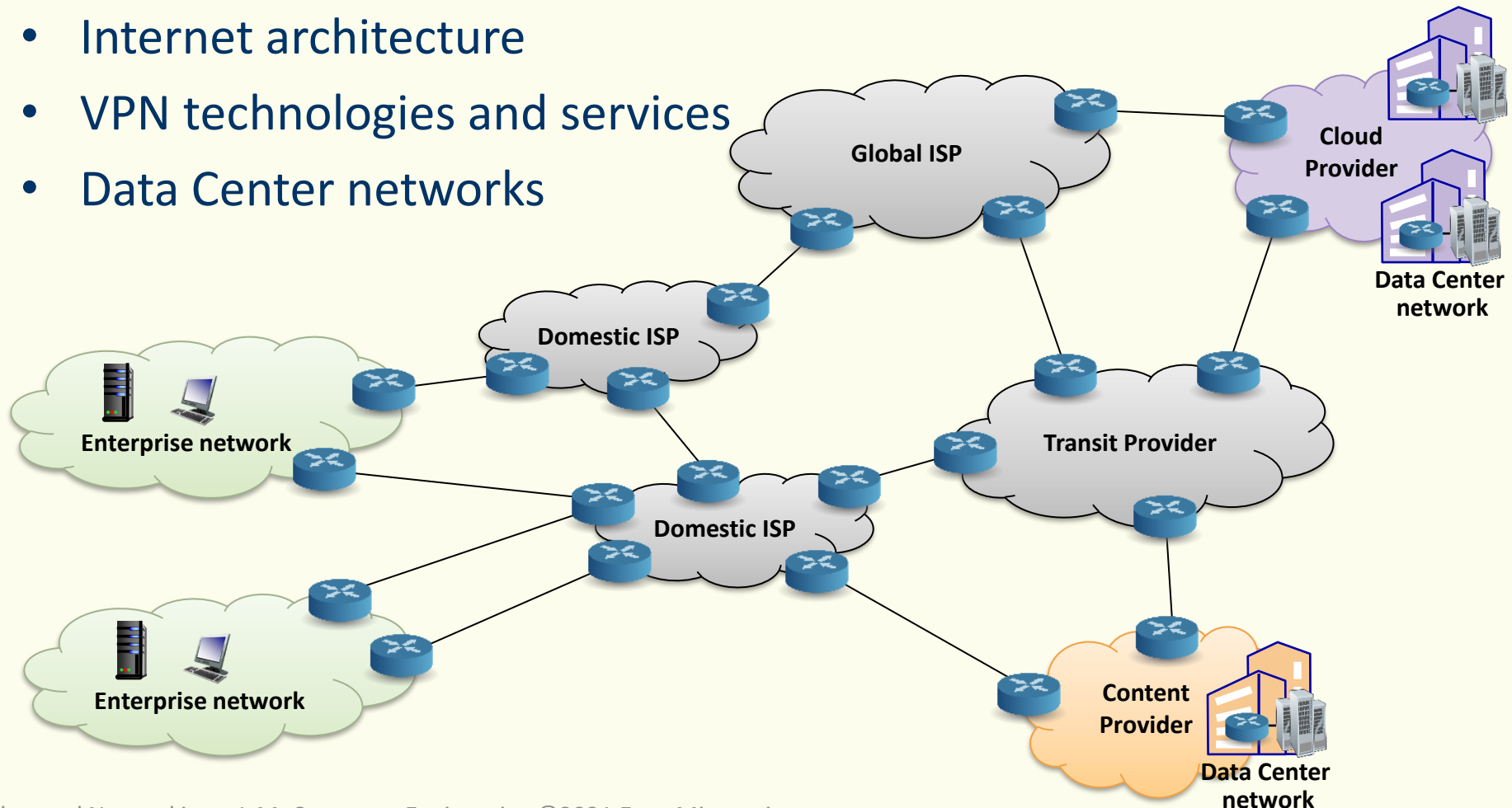
How it works behind the scenes?



Our main focus



- Core backbone architecture and protocols
- Internet architecture
- VPN technologies and services
- Data Center networks

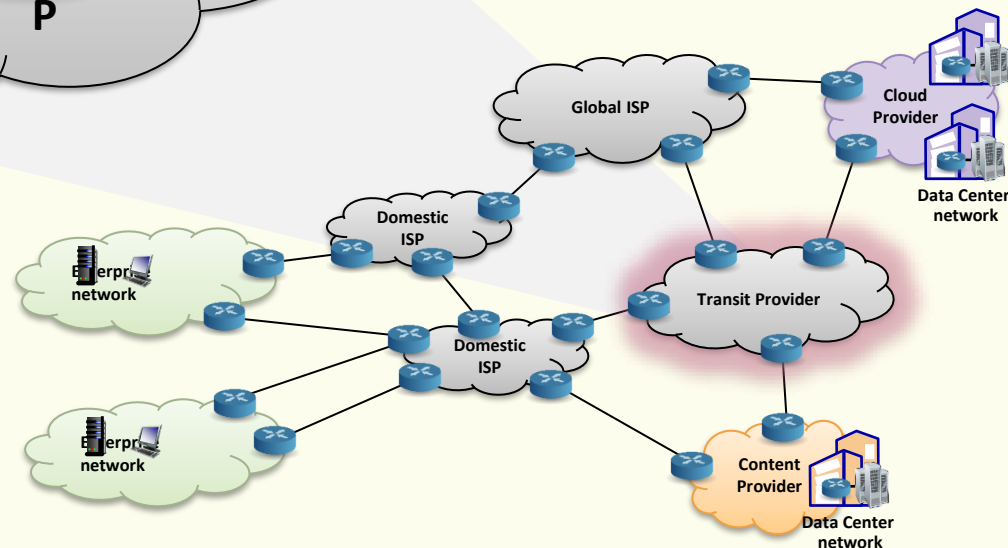
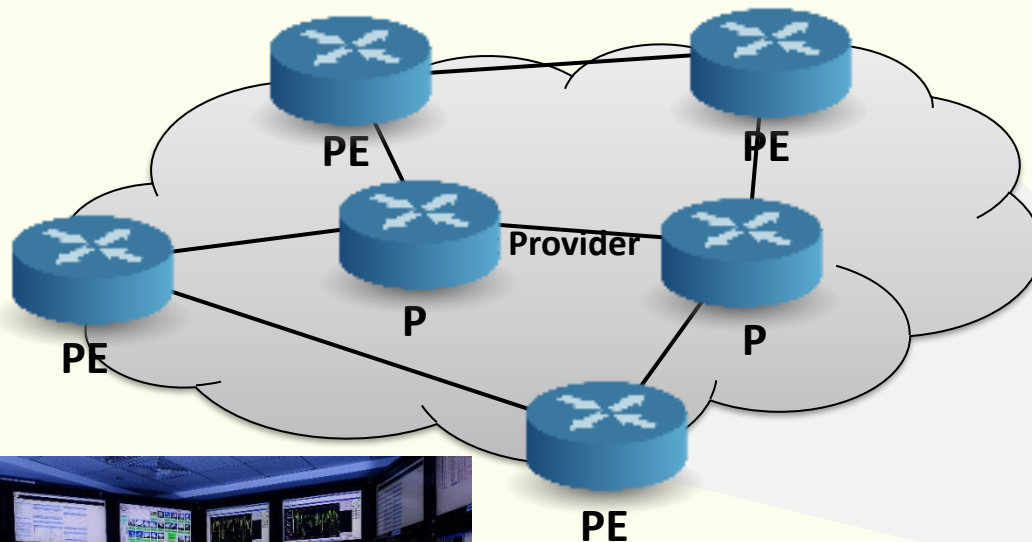


Multi-Protocol Label Switching

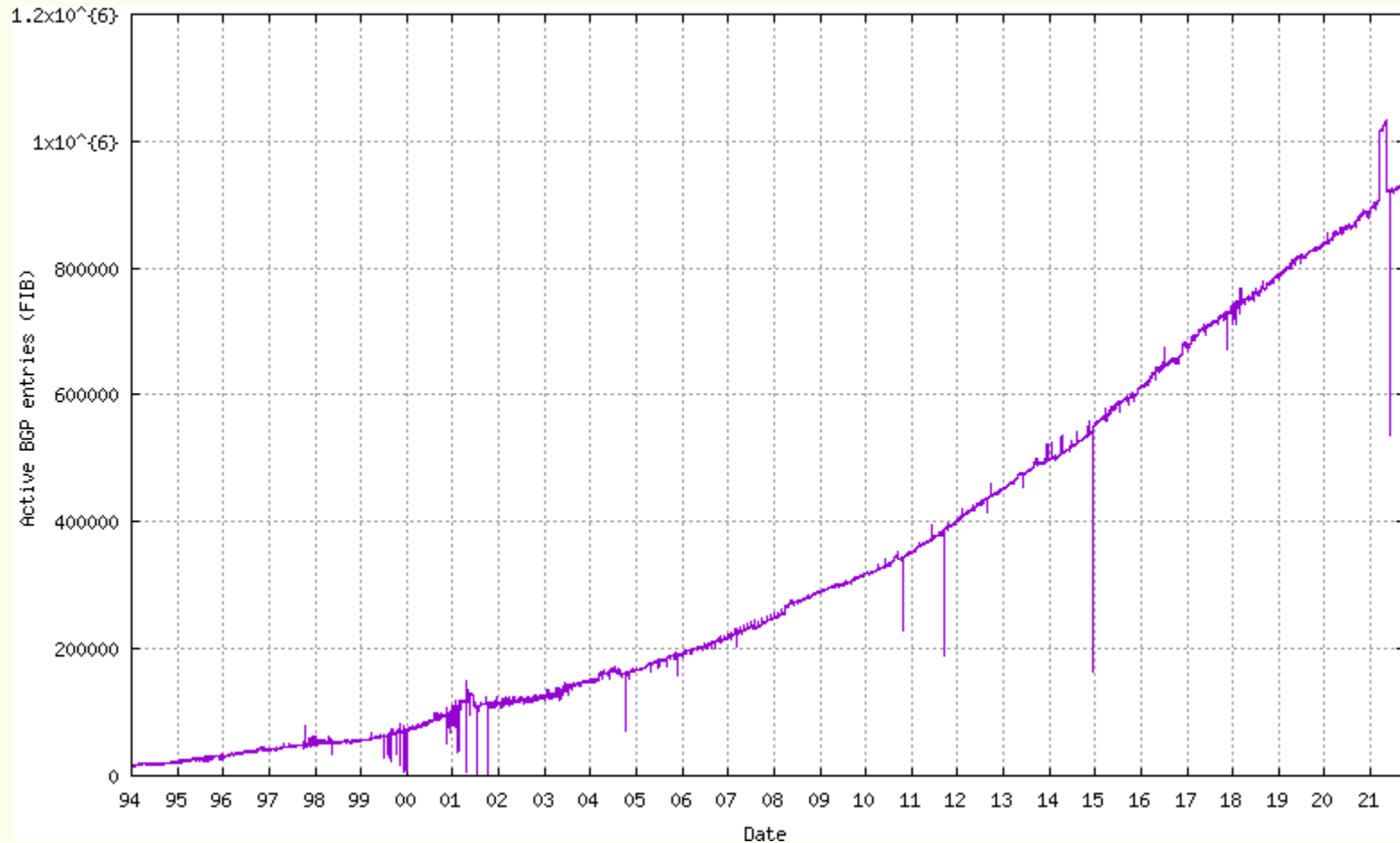


- Routing scalability

how many IP(v4)
prefixes are currently
advertised on the
Internet?



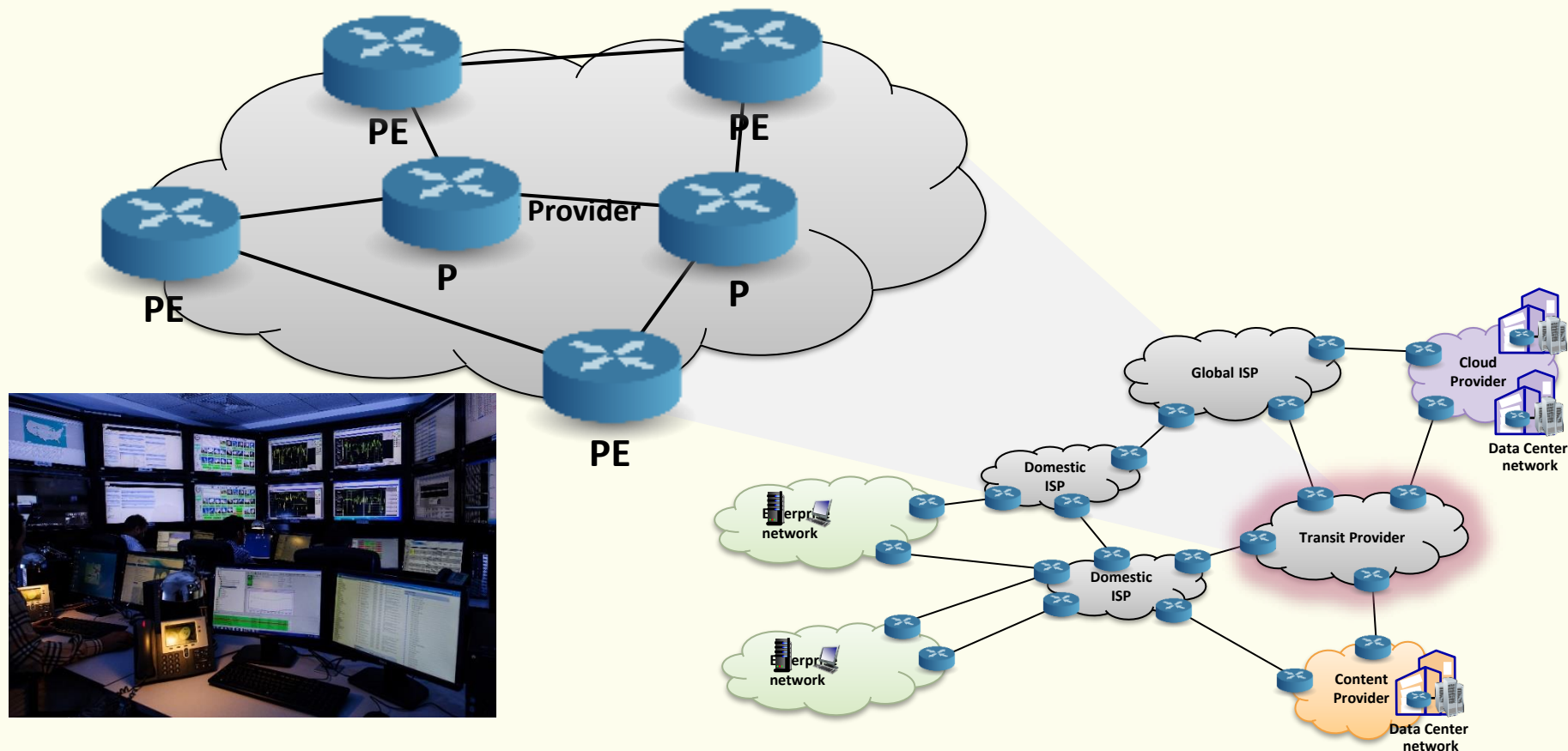
Active BGP entries as of Sept. 26, 2021



MPLS-based Traffic Engineering

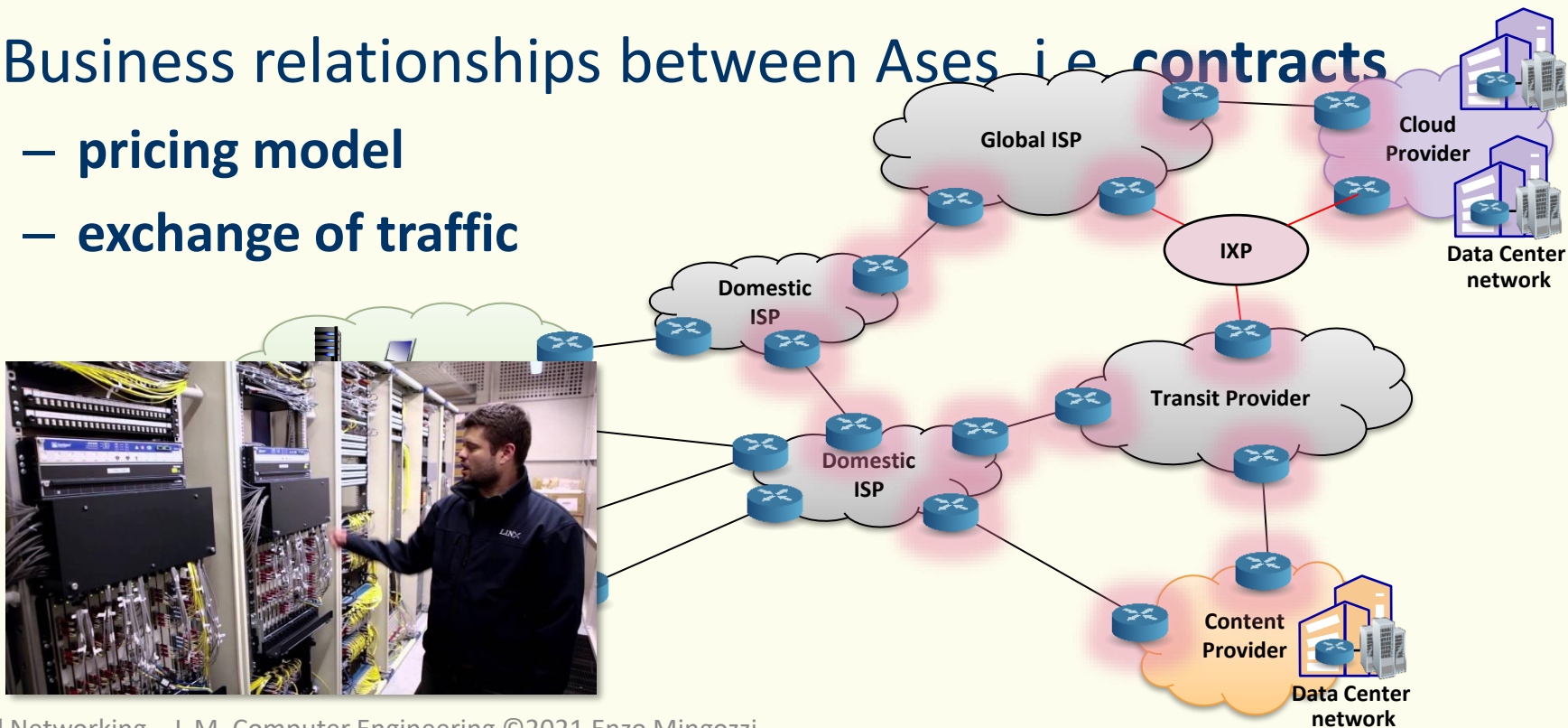


- Routing flexibility



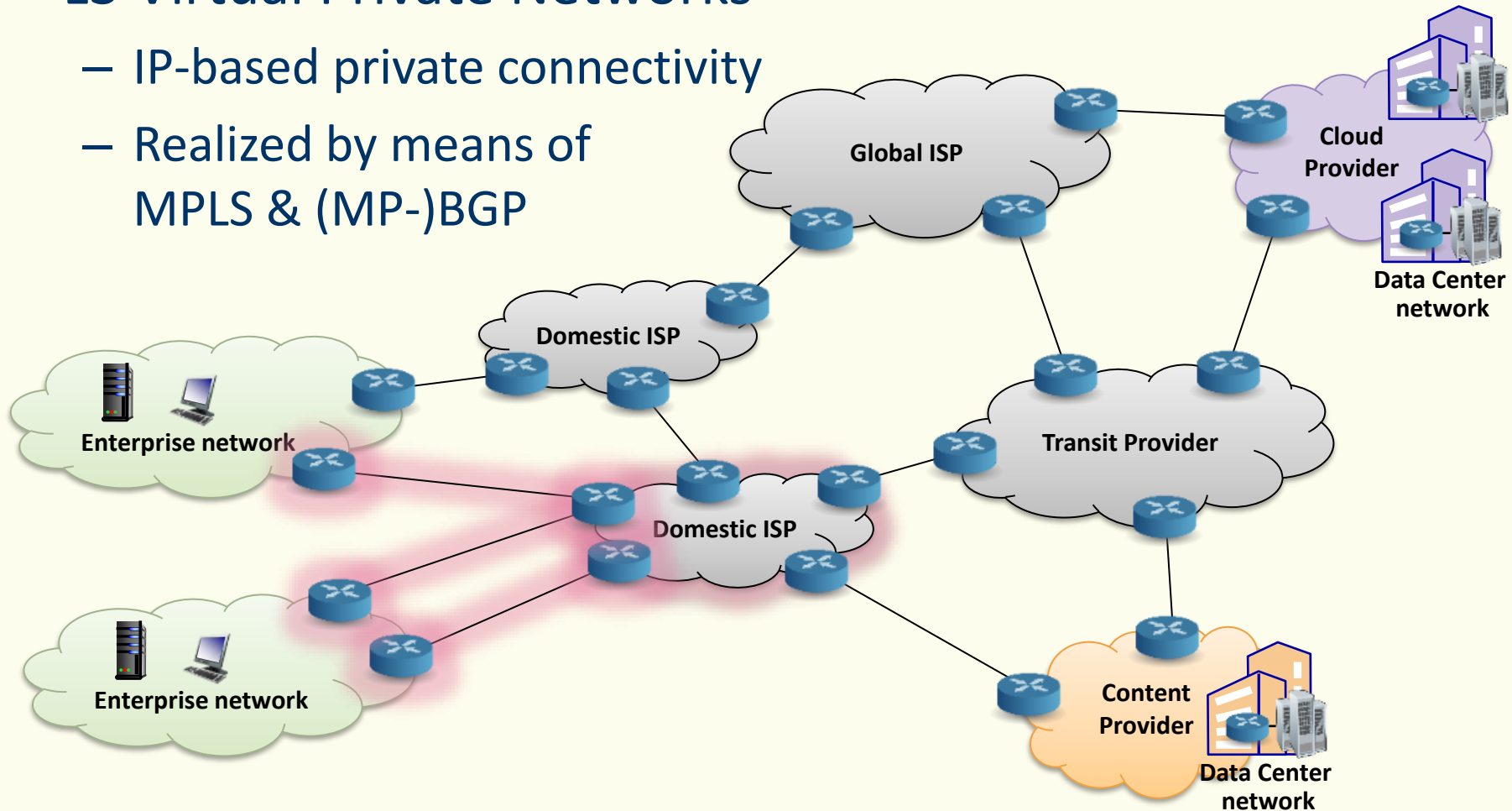
InterAS routing

- Global connectivity ensured by peering between Autonomous Systems (AS)
 - Border Gateway Protocol (BGP-4)
- Business relationships between Ases i.e. **contracts**
 - **pricing model**
 - **exchange of traffic**



Network virtualization

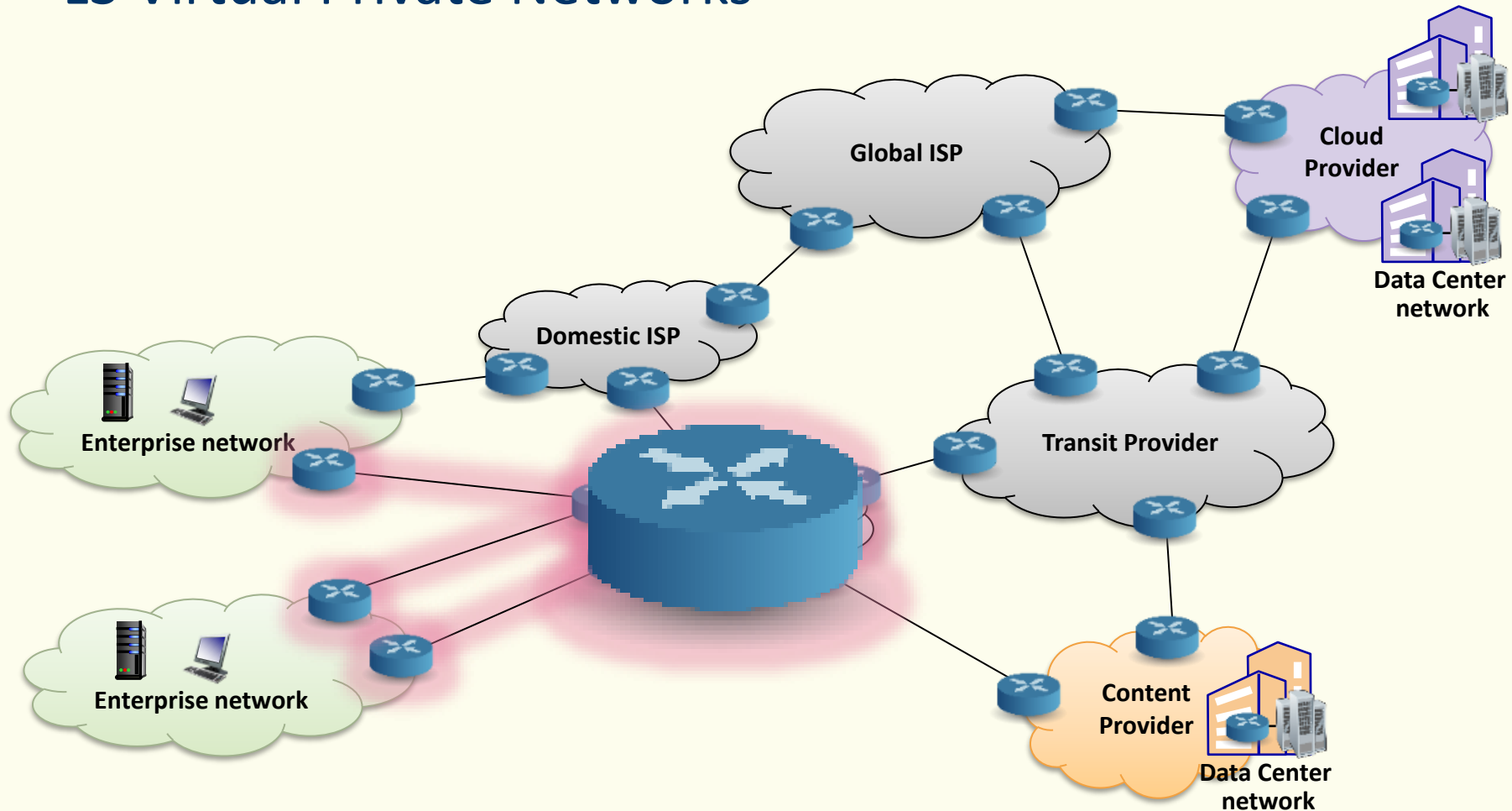
- L3 Virtual Private Networks
 - IP-based private connectivity
 - Realized by means of MPLS & (MP-)BGP



Network virtualization



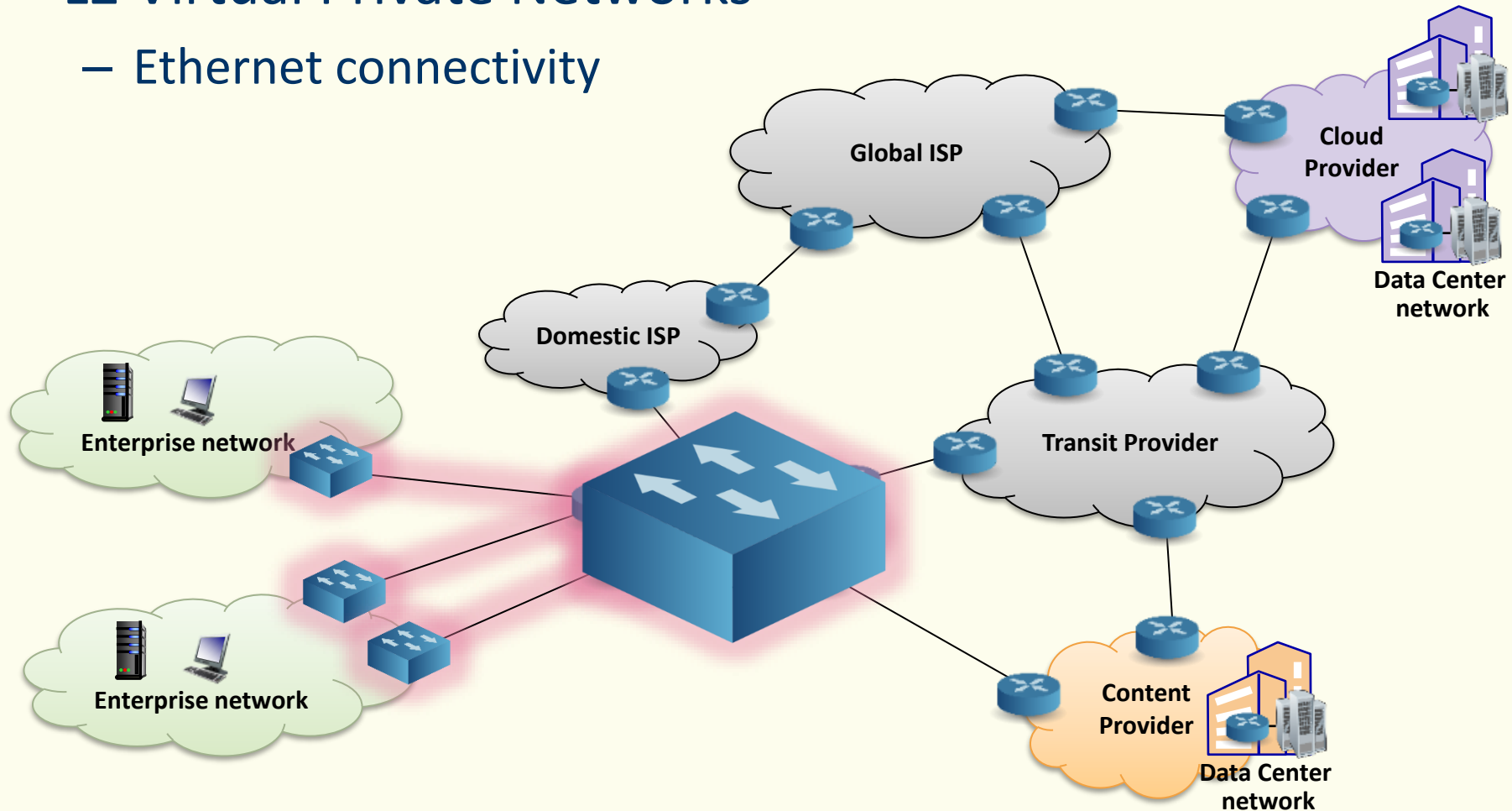
- L3 Virtual Private Networks



Network virtualization



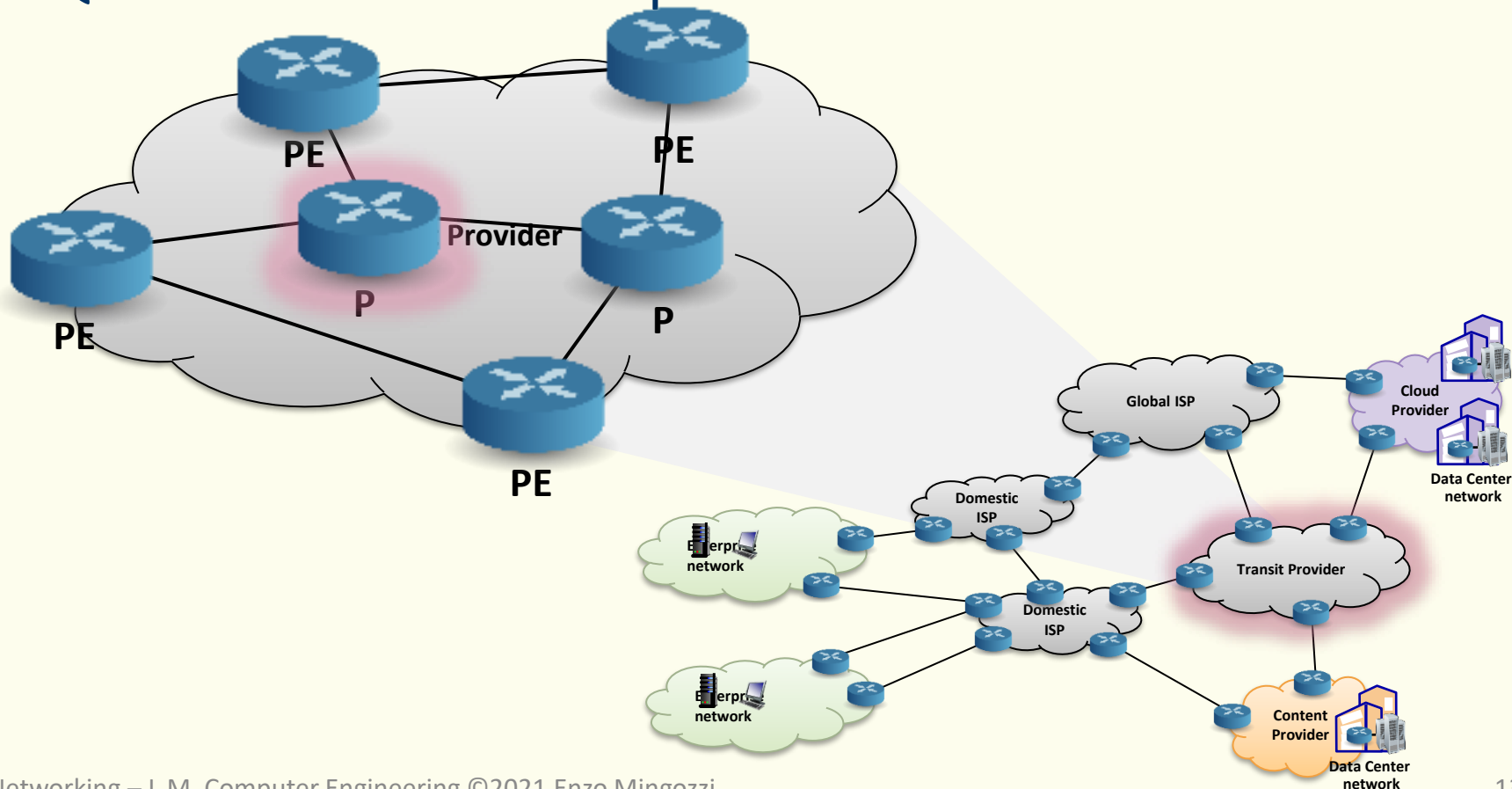
- L2 Virtual Private Networks
 - Ethernet connectivity



QoS/QoE



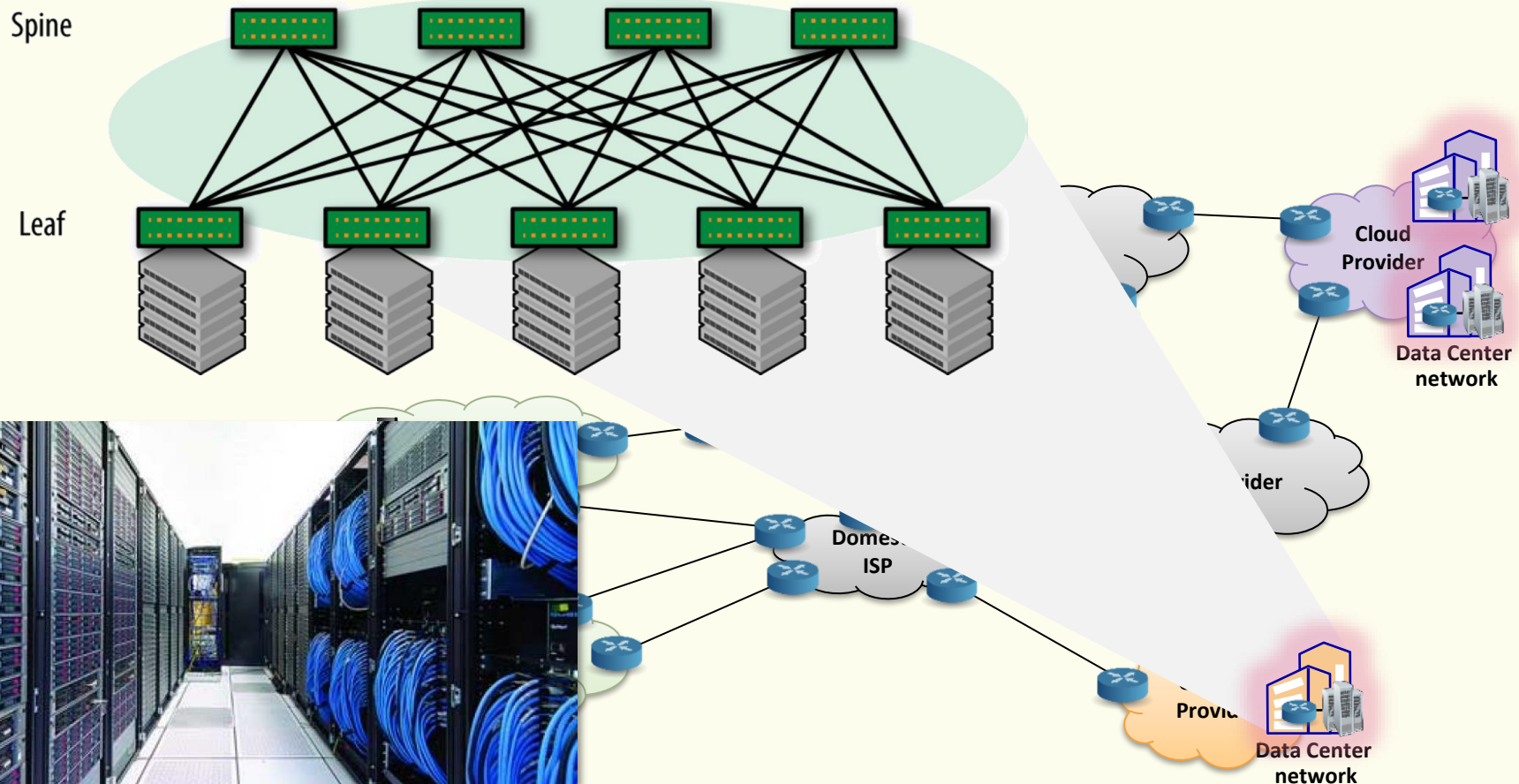
- Multimedia data characterization and requirements
- IP QoS architectures and protocols



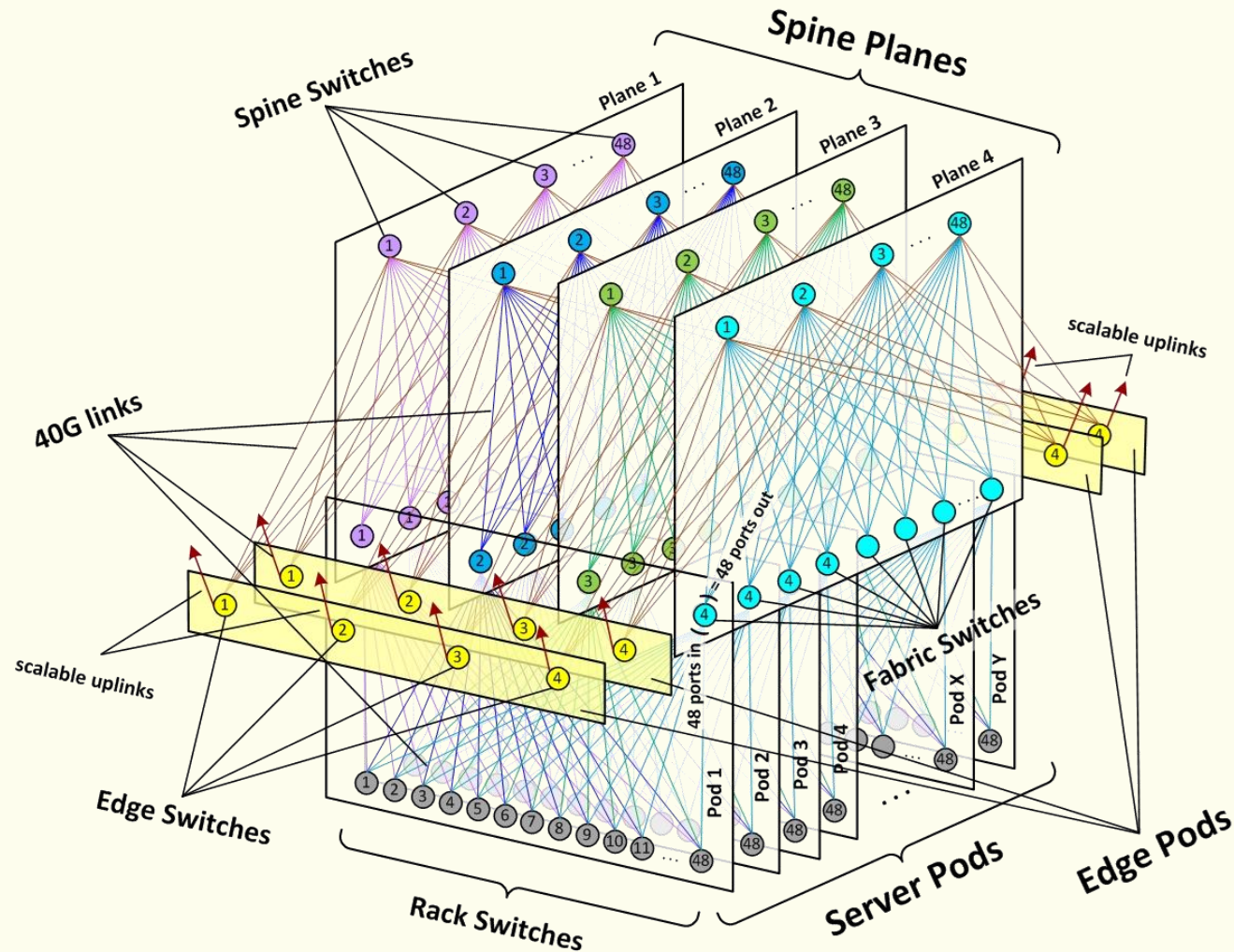
Data Center networking



- DC network architectures

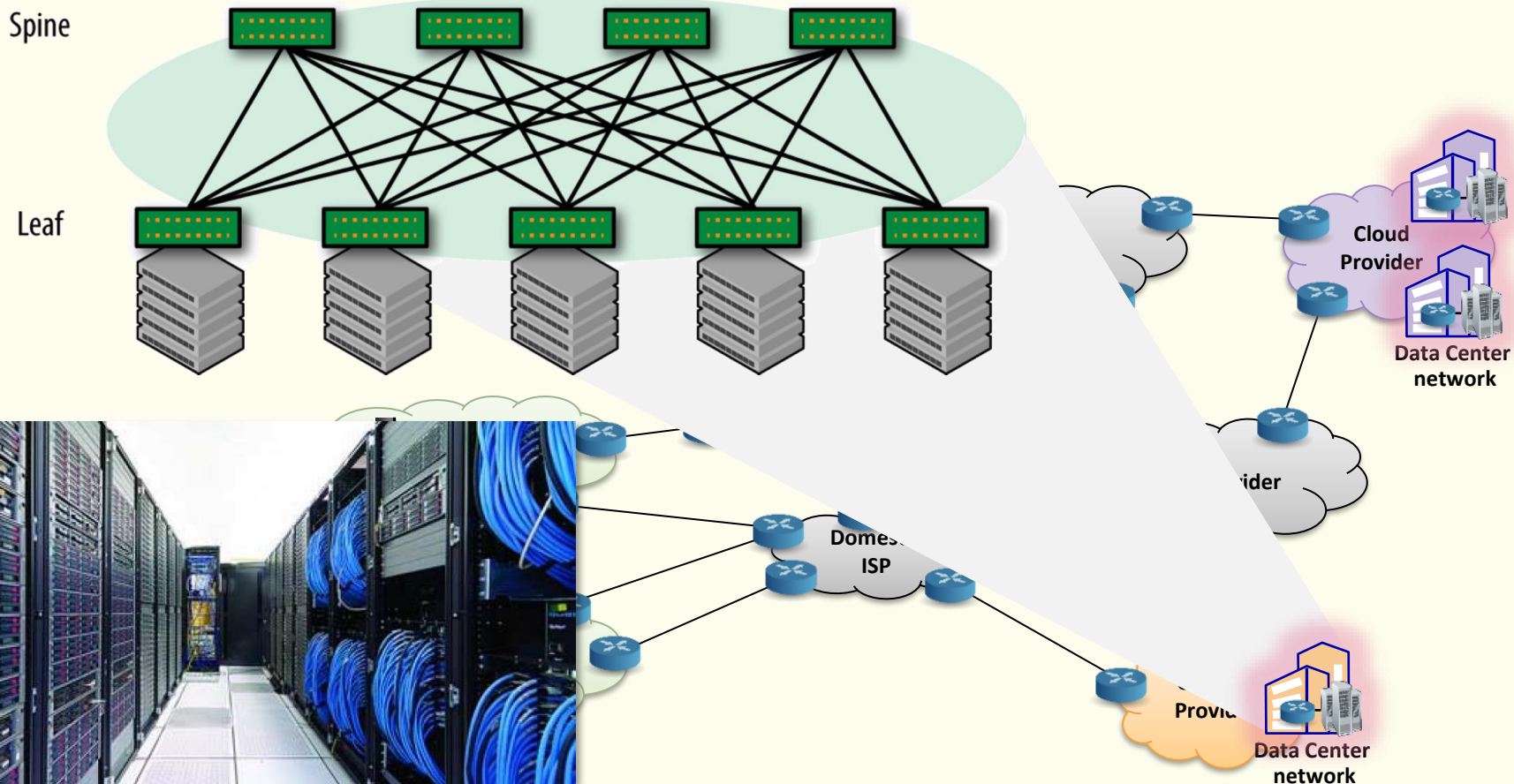


Data Center networking



Data Center networking

- DC network virtualization

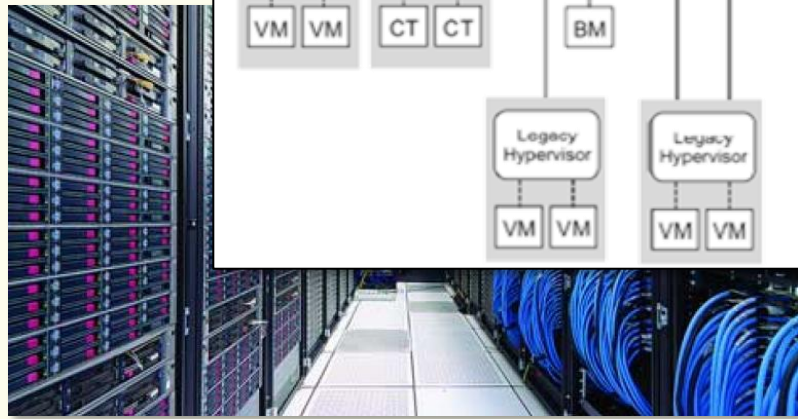
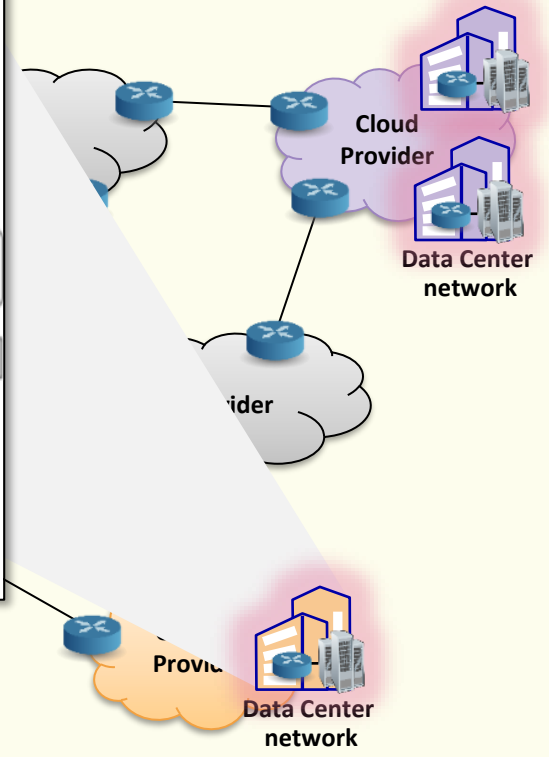
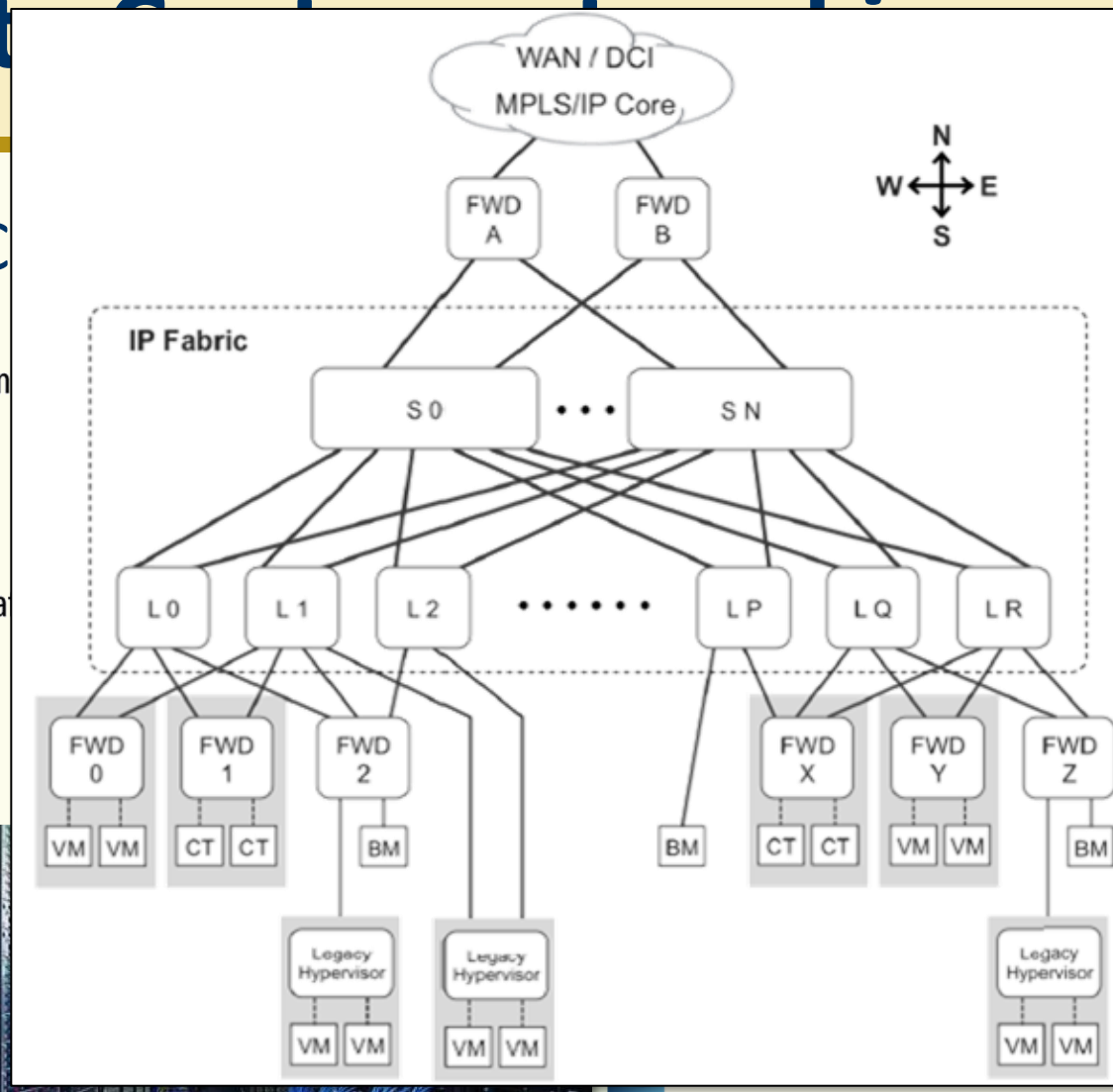


Data Center

- DC

Spin

Leaf



Network *programmability*



PROBLEM: NETWORK AGILITY

Not Much has Changed in the Last 20 Years

1994

```
Router> enable
Router# configure terminal
Router(config)# enable secret cisco
Router(config)# ip route 0.0.0.0 0.0.0.0 20.2.2.3
Router(config)# interface ethernet0
Router(config-if)# ip address 10.1.1.1 255.0.0.0
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# interface serial0
Router(config-if)# ip address 20.2.2.2 255.0.0.0
Router(config-if)# no shutdown
Router(config-if)# exit
Router(config)# router rip
Router(config-router)# network 10.0.0.0
Router(config-router)# network 20.0.0.0
Router(config-router)# exit
Router(config)# exit
Router# copy running-config startup-config
Router# disable
Router>
```

Terminal Protocol: **Telnet**

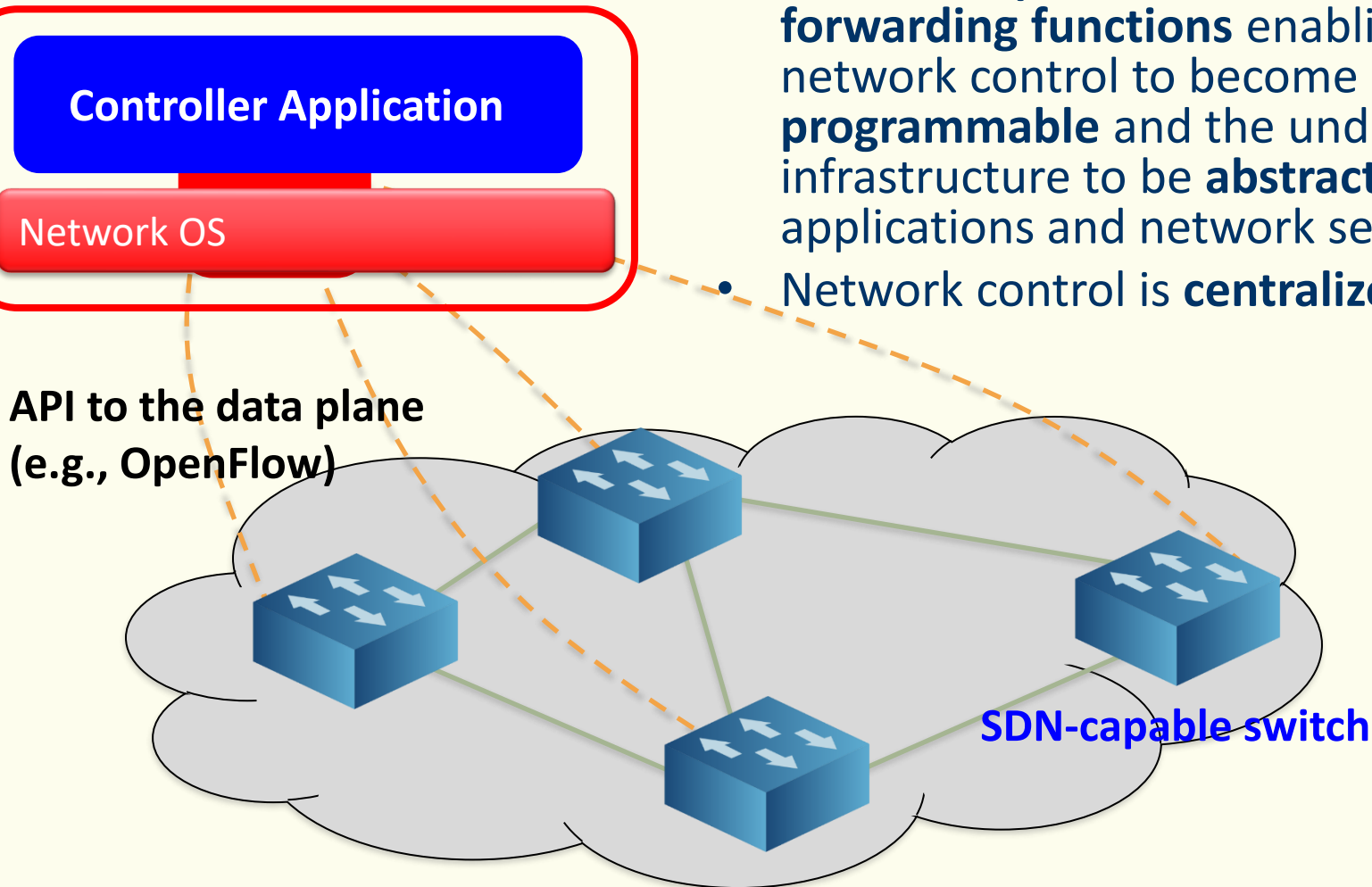
2014

```
Router> enable
Router# configure terminal
Router(config)# enable secret cisco
Router(config)# ip route 0.0.0.0 0.0.0.0 20.2.2.3
Router(config)# interface ethernet0
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```

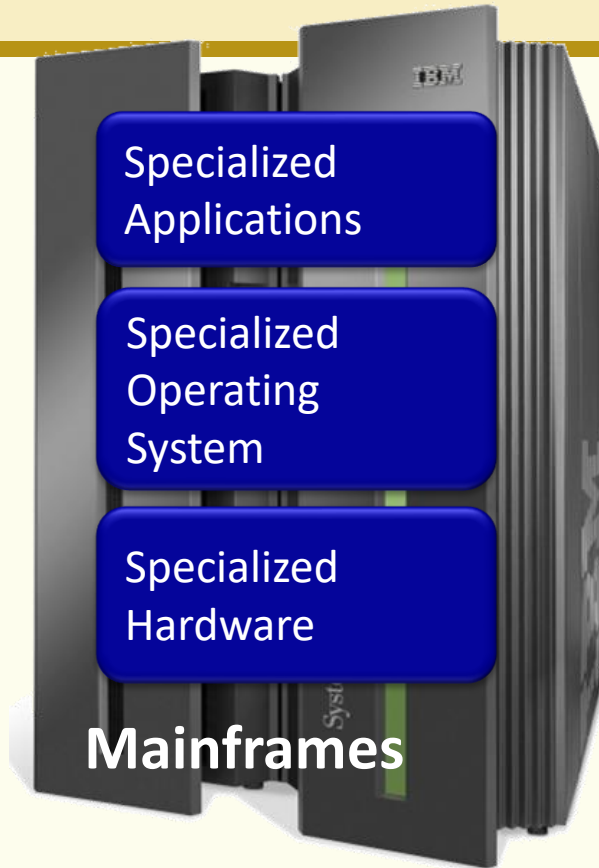
Terminal Protocol: **SSH**

Software Defined Networking

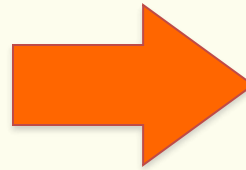
- SDN decouples the **network control** and **forwarding functions** enabling the network control to become directly **programmable** and the underlying infrastructure to be **abstracted** for applications and network services
- Network control is **centralized**



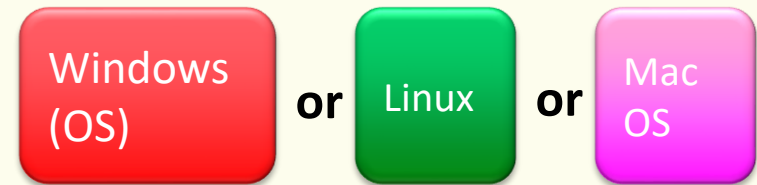
Software Defined Networking



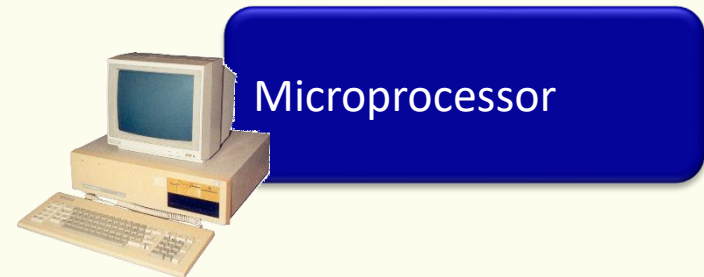
Vertically integrated
Closed, proprietary
Slow innovation
Small industry



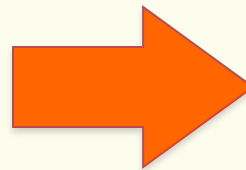
— Open Interface —



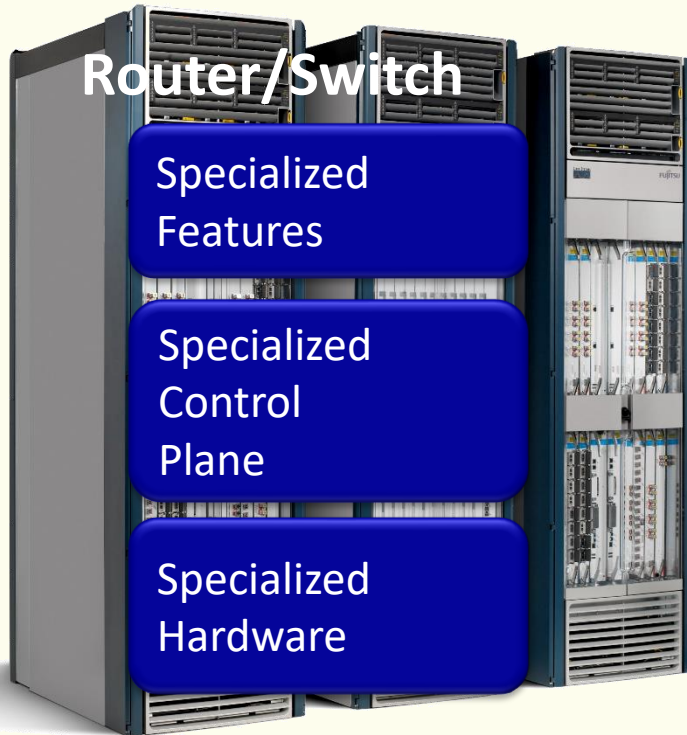
— Open Interface —



Horizontal
Open interfaces
Rapid innovation
Huge industry



Software Defined Networking

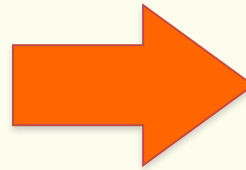


Router/Switch

Specialized
Features

Specialized
Control
Plane

Specialized
Hardware



App

— Open Interface —

Control
Plane

or

Control
Plane

or

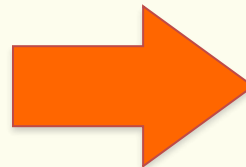
Control
Plane

— Open Interface —

Merchant
Switching Chips

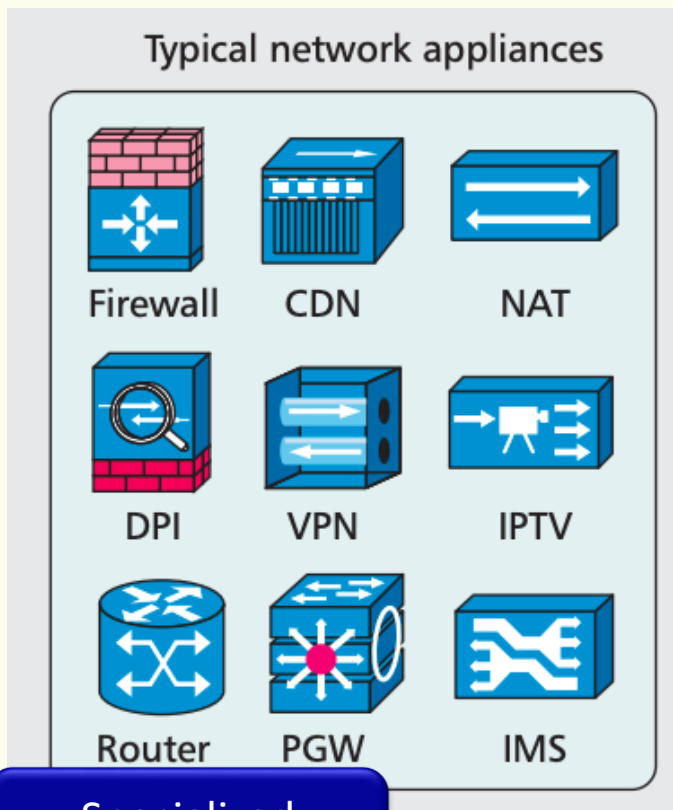


Vertically integrated
Closed, proprietary
Slow innovation



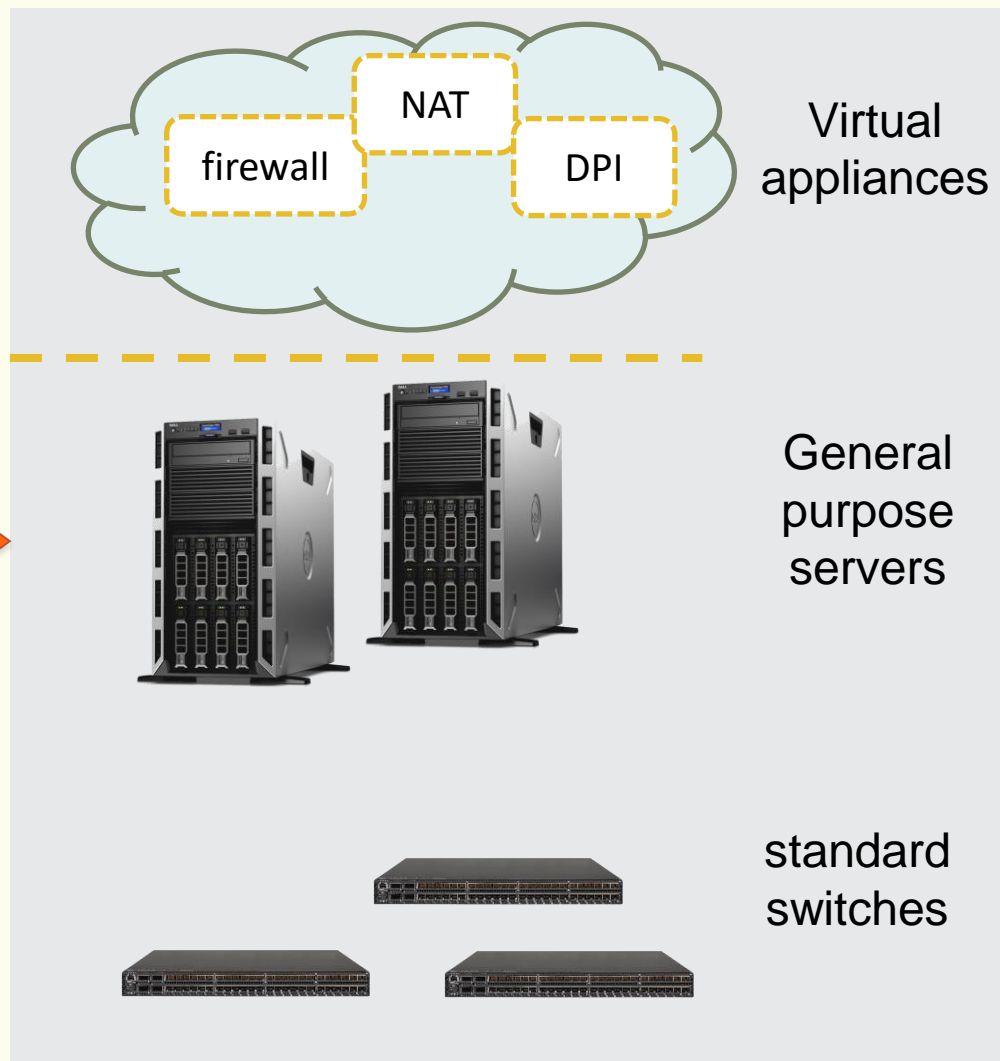
Horizontal
Open interfaces
Rapid innovation

Network Function Virtualization



Specialized
Features

Specialized
Hardware

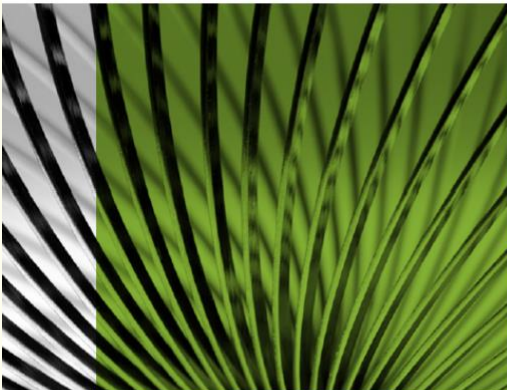


Network Function Virtualization



JUNIPER
NETWORKS | Engineering
Simplicity

Data Sheet 



Product Overview

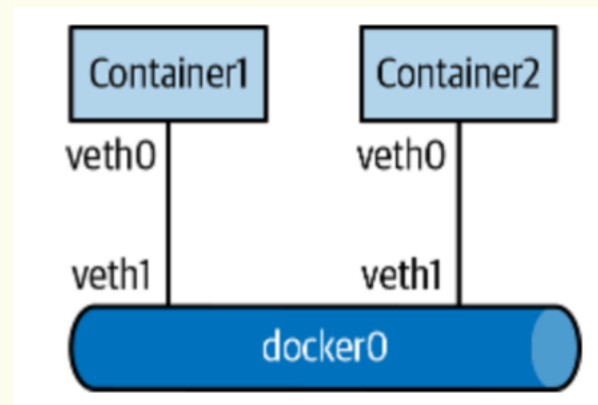
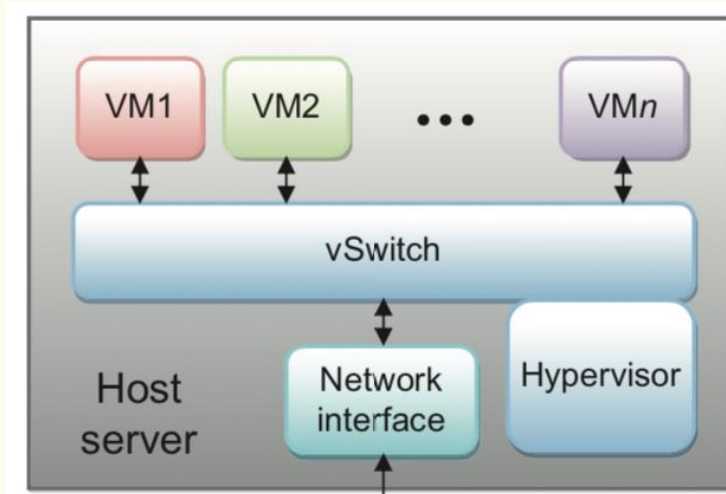
vMX VIRTUAL ROUTER

Product Description

The Juniper Networks® vMX Virtual Router, available as licensed software for deployment on x86-based servers, Amazon Web Services (AWS), AWS GovCloud, and Microsoft Azure supports a broad range of broadband, cloud, cable, mobile, and enterprise applications. The vMX control plane is powered by Juniper Networks Junos® operating system, the same OS that powers the entire Juniper Networks MX Series Universal Routing Platform portfolio, and the forwarding plane is powered by vTrio, Juniper's programmable Trio chipset microcode optimized for execution in x86 environments. With Junos OS and vTrio, the vMX

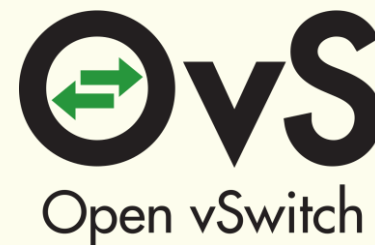
[vMX Virtual Router | Juniper Networks](#)

VM/Container networking



- “easy” networking
 - No network
 - Host-only network
 - Bridged
 - ...

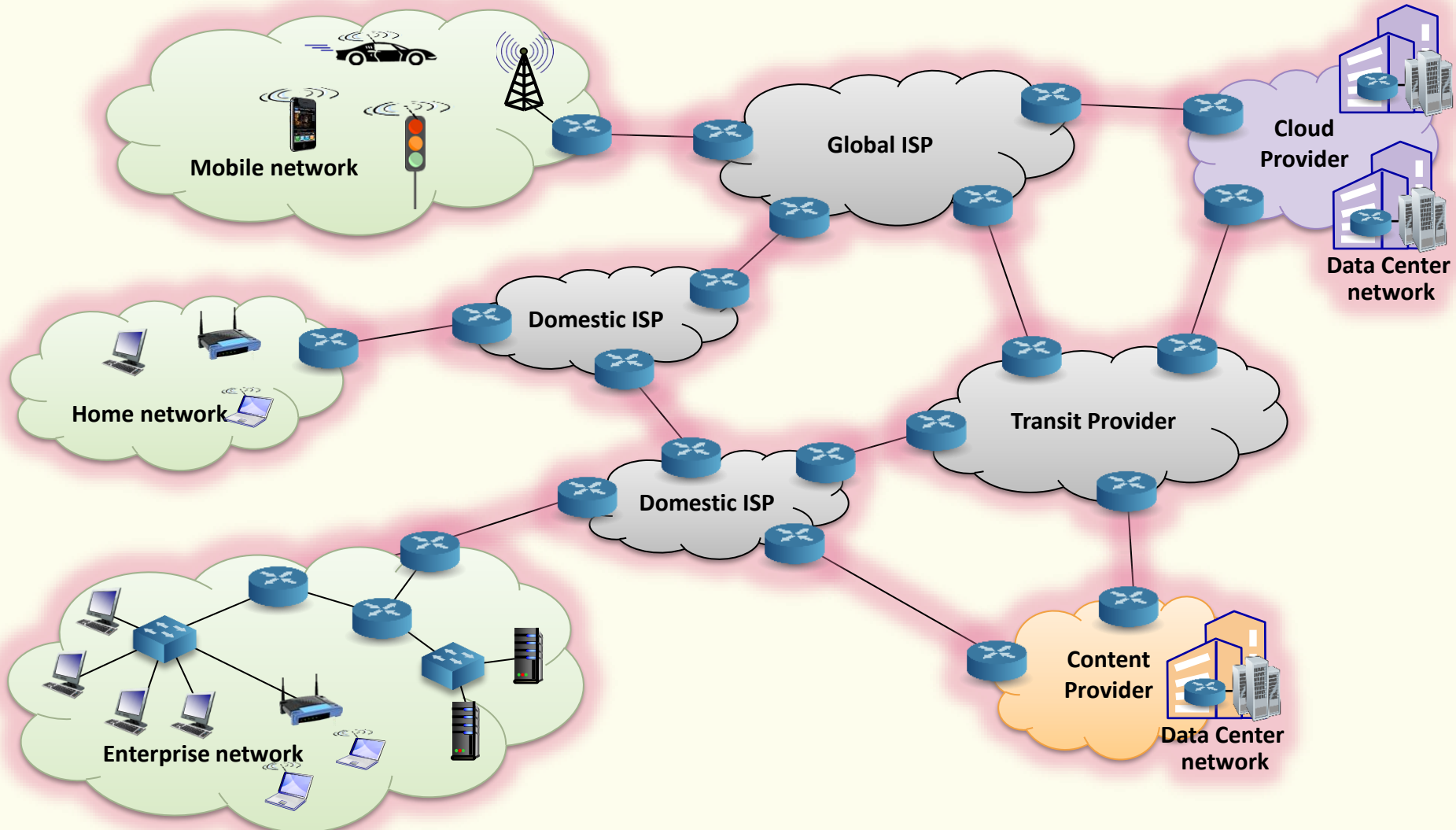
- “advanced” networking
 - custom software switches



Network automation

- Take advantage of the programmatic interfaces being exposed by modern network devices that offer an API
 - Automating the configuration of network devices
 - Automating the process of troubleshooting
 - Aid in the day-to-day operations of managing networks for data gathering and automated diagnostics
- **Intent-based networking**
 - machine learning and cognitive computing used to enable more automation and less time spent on manual configuration and management

Internet Protocol v6 (IPv6)



Course figures

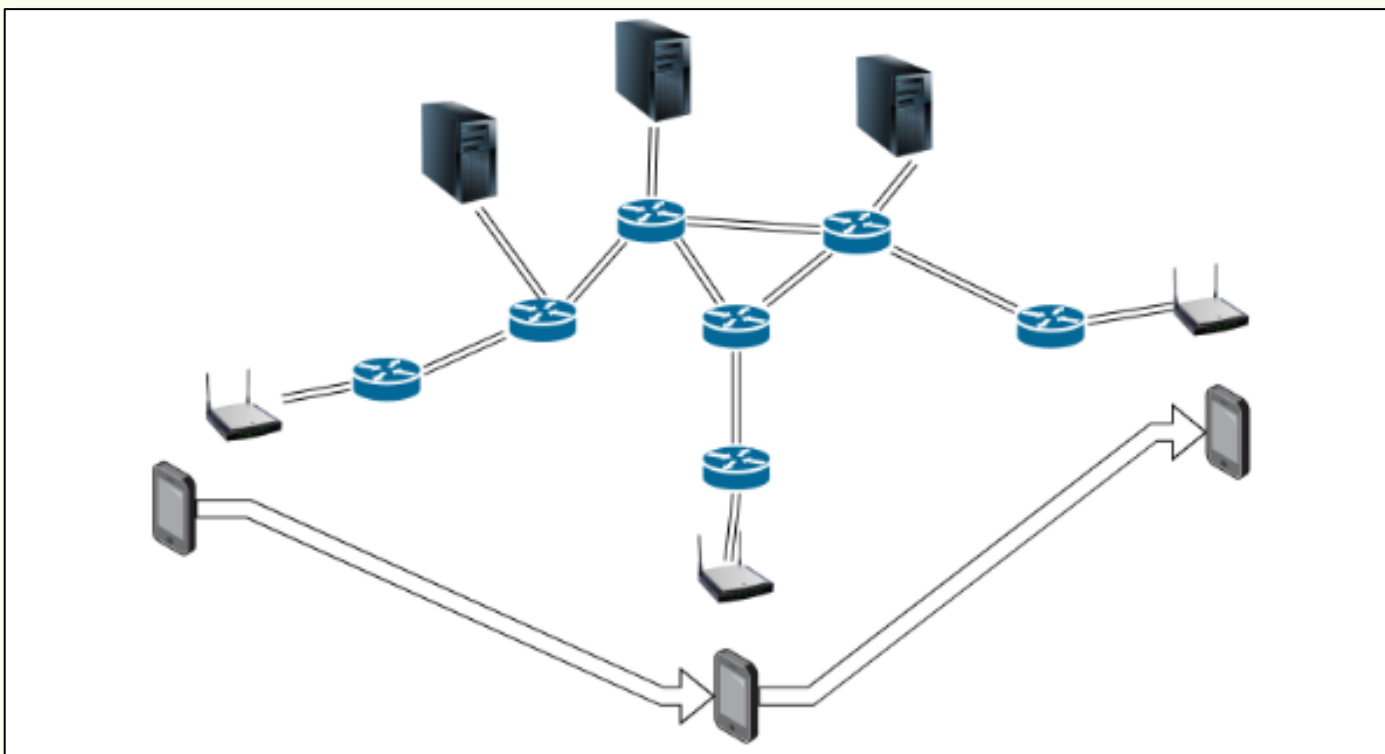
- 9 CFUs = 90 hours (~70h lessons + ~20h labs)
 - 6 CFUs with myself
 - 3 CFUs with Antonio Viridis
- Prerequisites
 - computer networking and programming
- Final exam
 - Team project (3 persons per team)
 - Oral Q&A

Course content

- **Lab activities:** hands-on labs on
 - Software Defined Networking (software)
 - Backbone router configuration (emulating software)
 - VM/Container networking

Project example: SDN

- SDN support for mobility: dynamically configure the network to allow a client to communicate with the closest server



Course material

- Microsoft Teams class
 - Syllabus, slides, readings, ...
 - Remote classes
- Web page
 - <http://www2.ing.unipi.it/~a009395/corsi/anaws/>

Contacts

- Prof. Enzo Mingozzi (enzo.mingozzi@unipi.it)
- Prof. Antonio Virdis (antonio.virdis@unipi.it)
- Dip. Ingegneria dell'Informazione
 - building A - Largo Lucio Lazzarino, 1
- Office hours for students
 - Weekly on MS Teams (day of the week TBD)