

# Advanced Network Architectures & Wireless Systems

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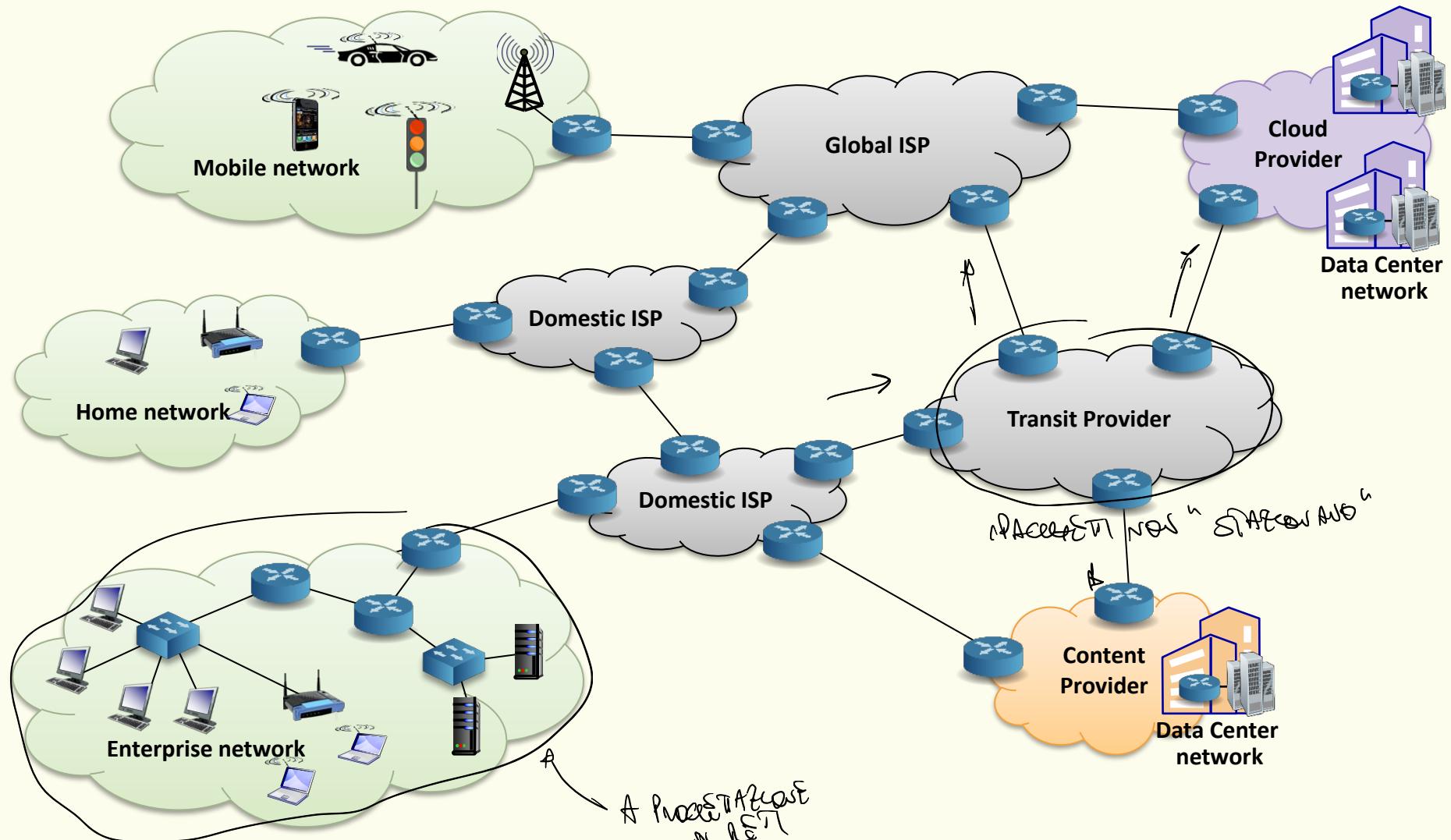
L.M. Computer Engineering

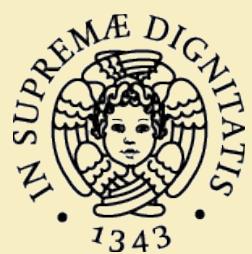
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# Internet stakeholders



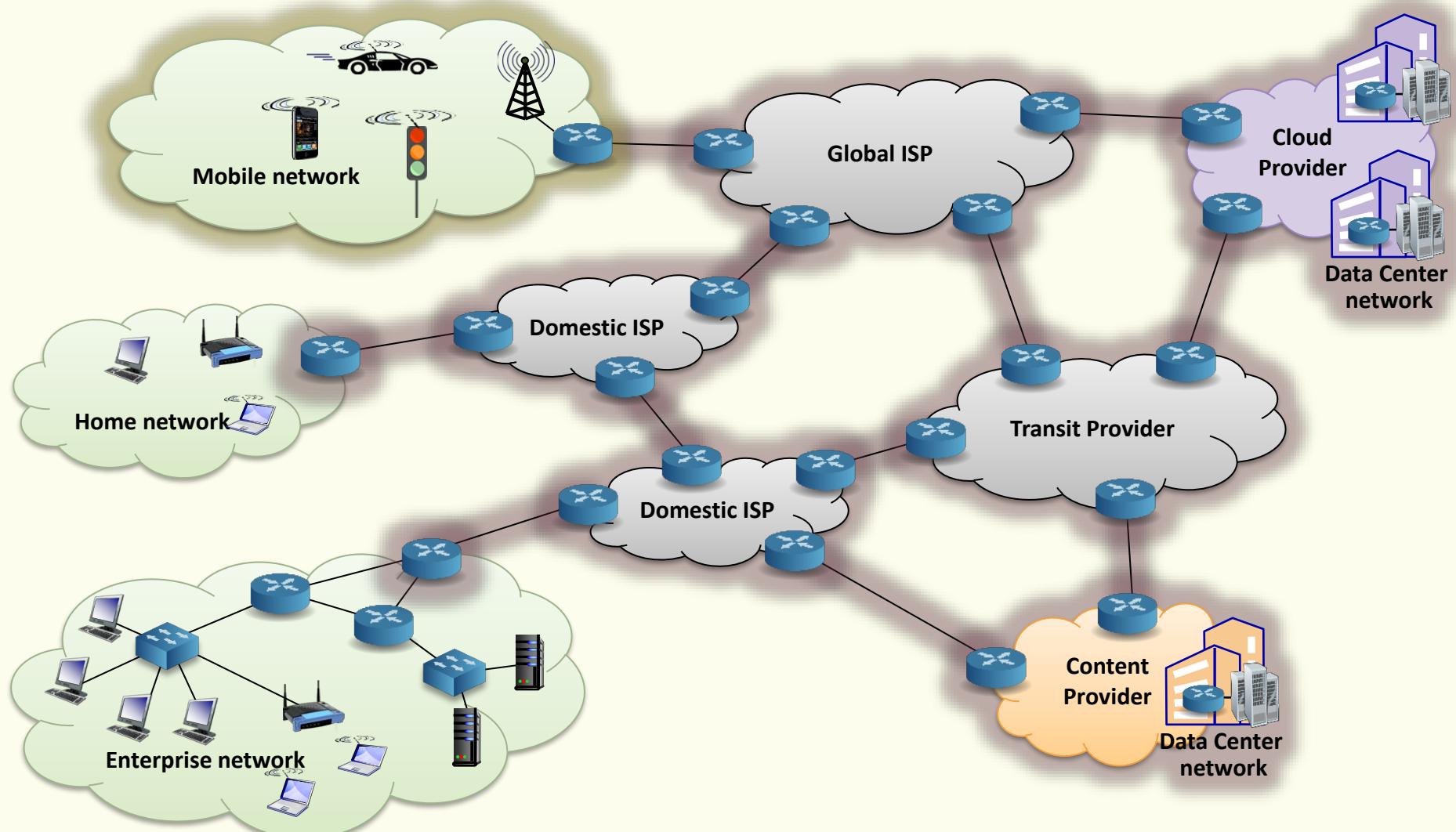


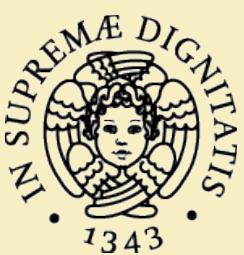
# Internet-connected devices





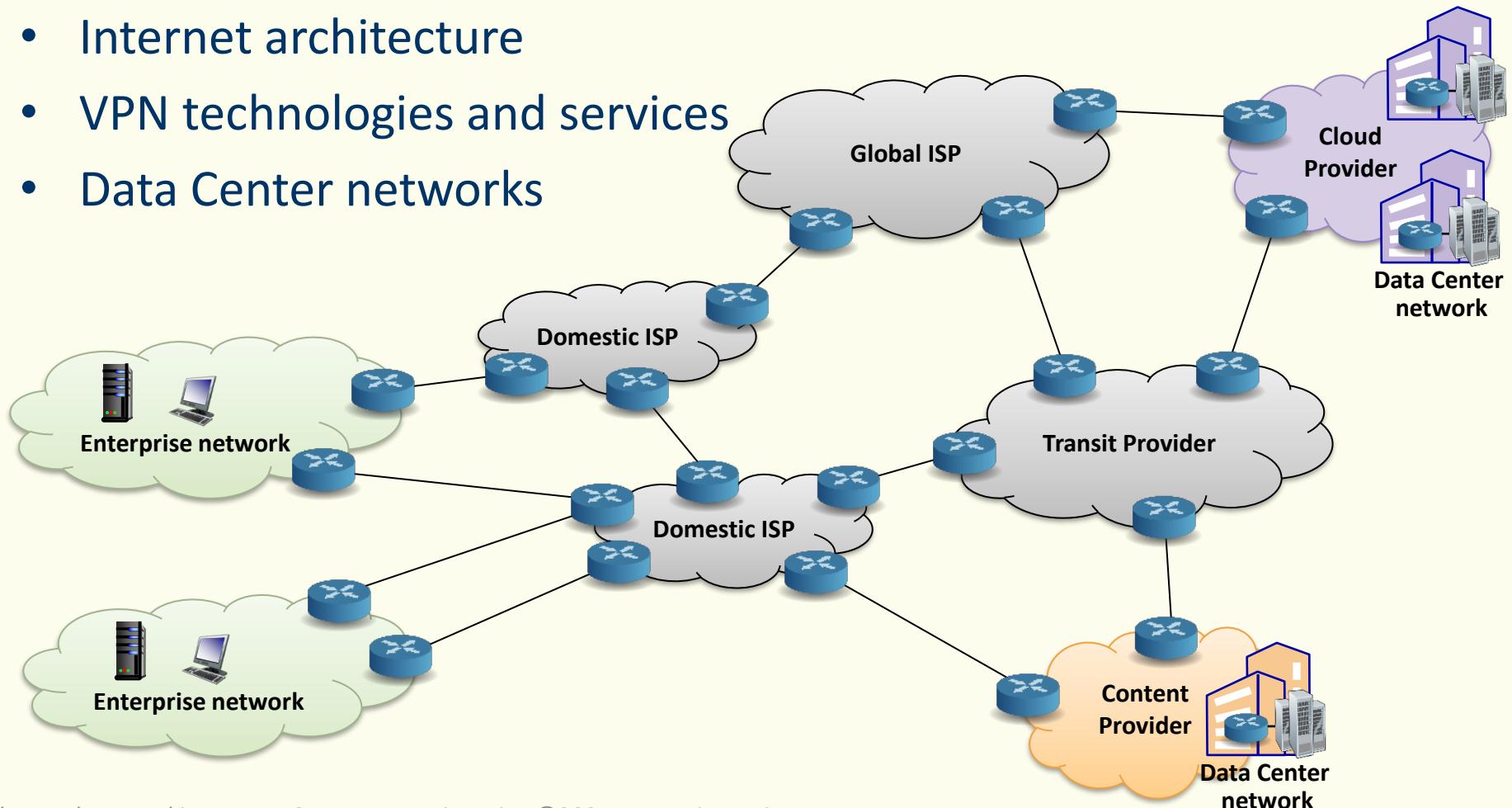
# How it works behind the scenes?





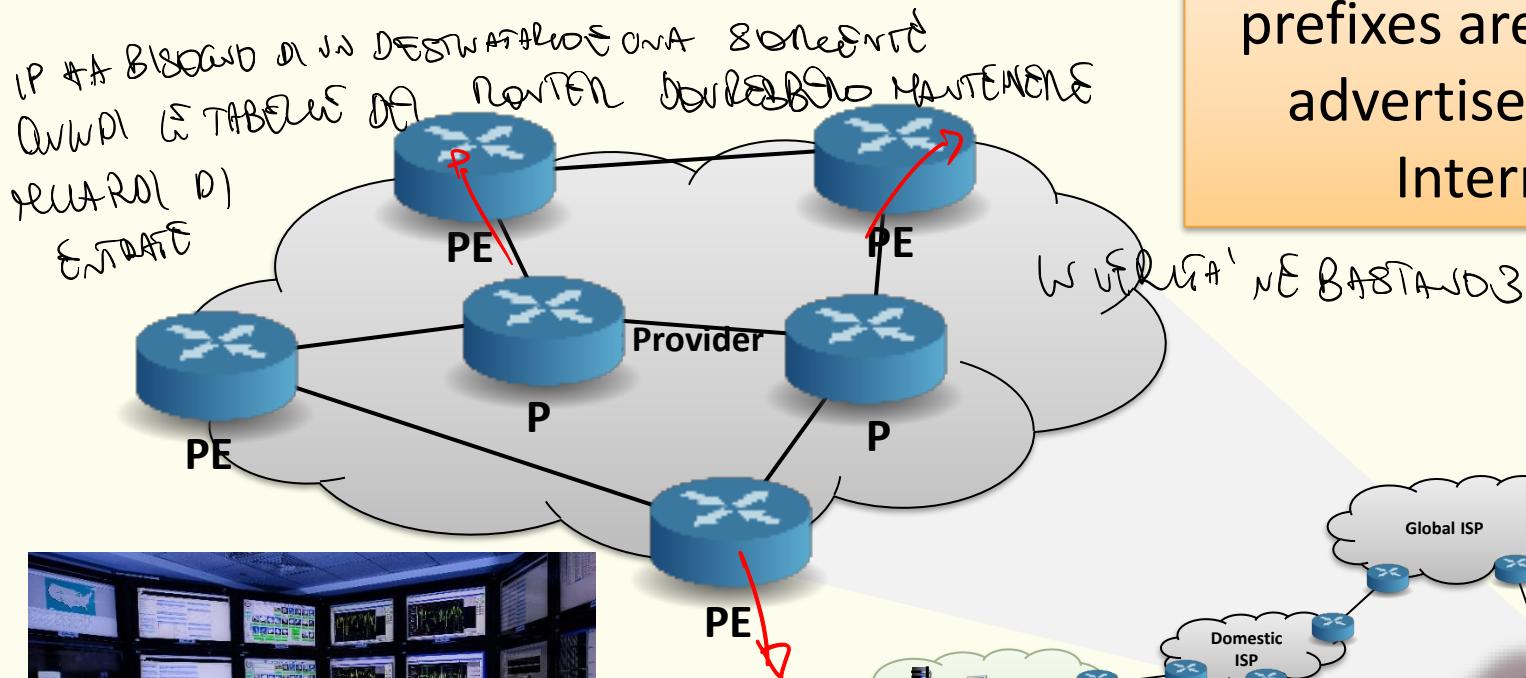
# Our main focus

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

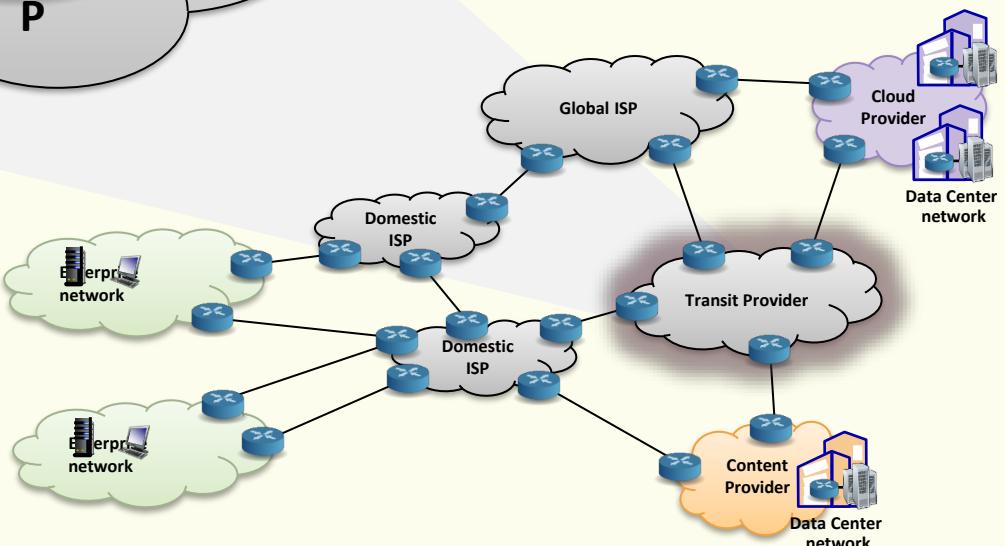


# Multi-Protocol Label Switching

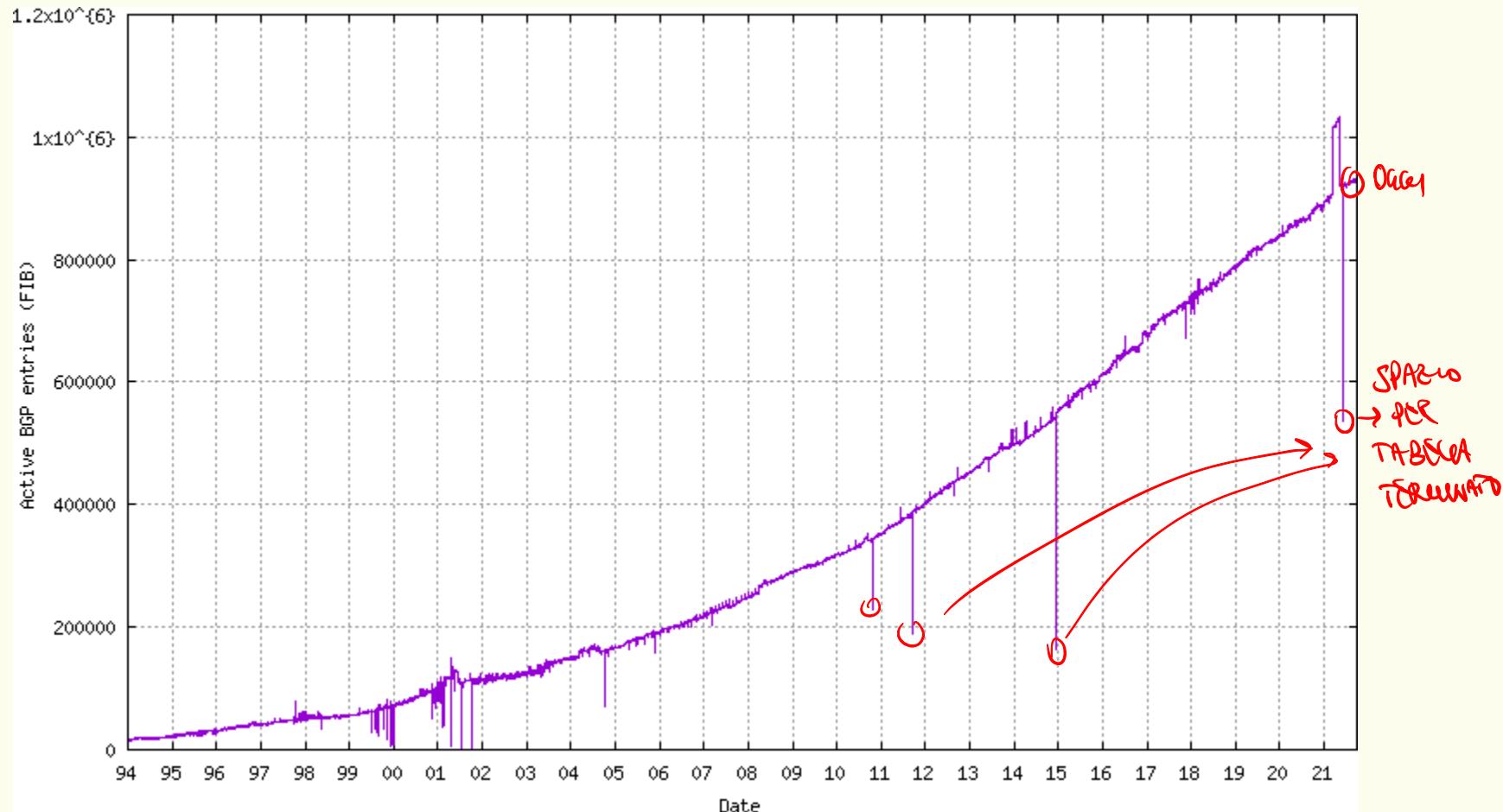
- Routing scalability



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

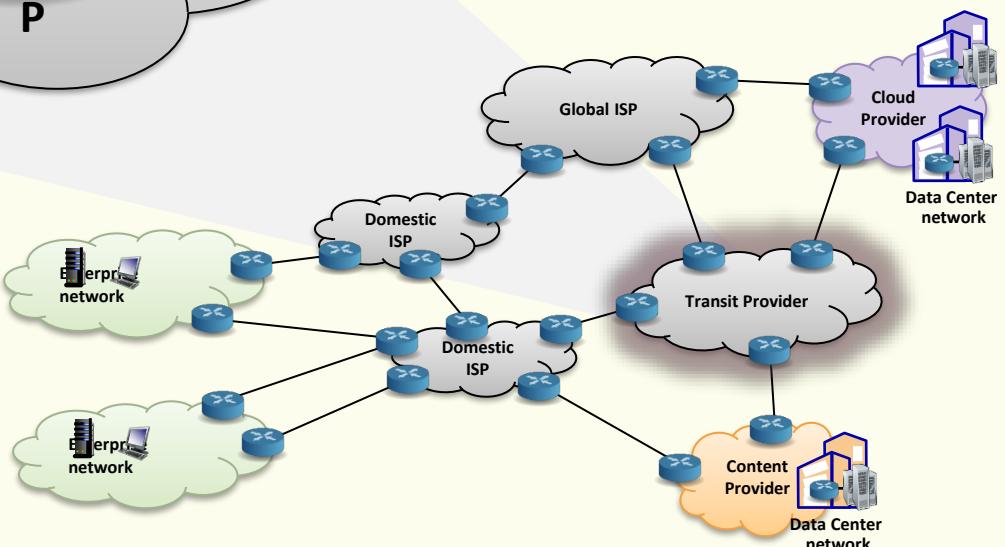
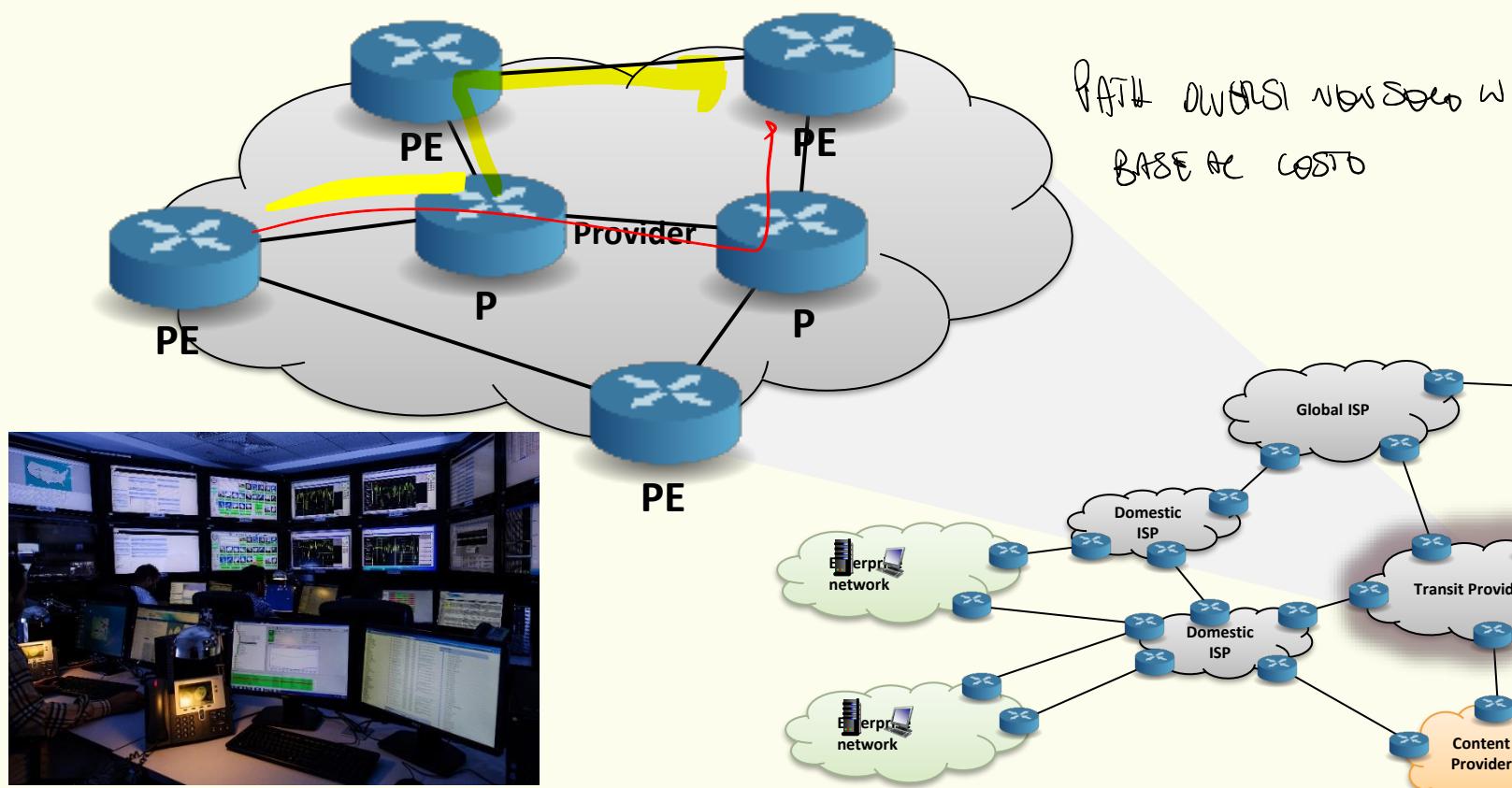


# Active BGP entries as of Sept. 26, 2021



# MPLS-based Traffic Engineering

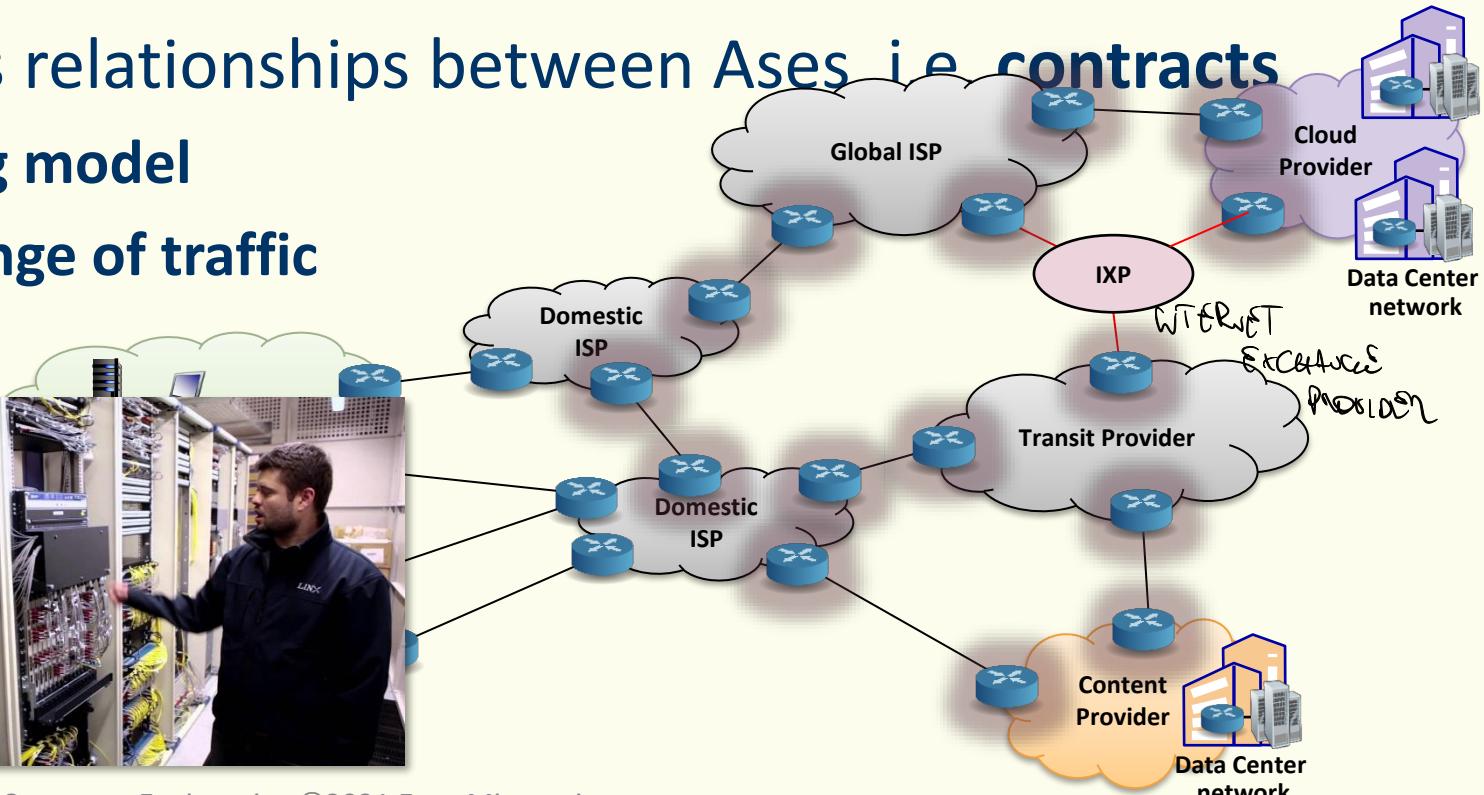
- Routing flexibility





# InterAS routing

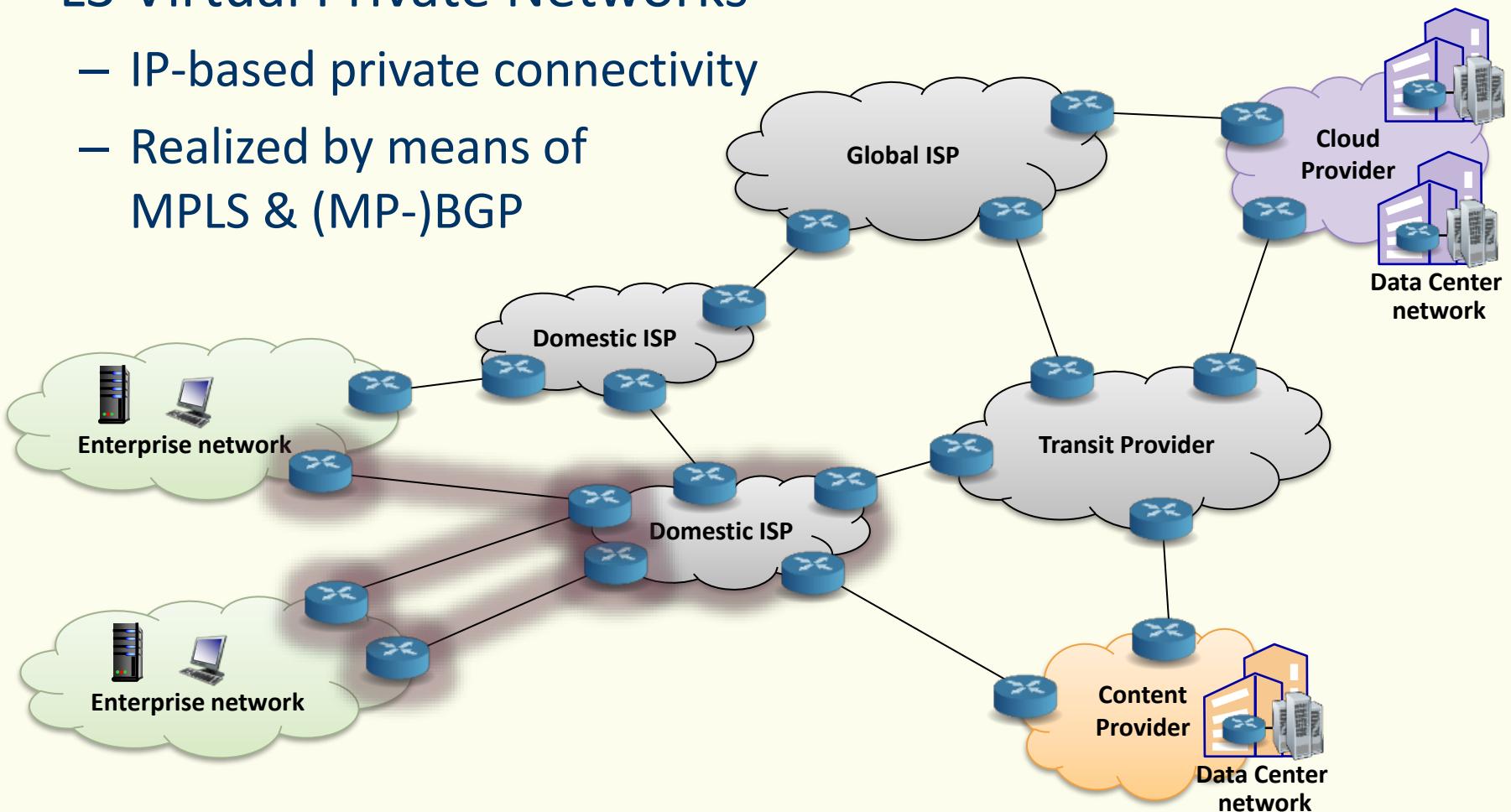
- Global connectivity ensured by peering between Autonomous Systems (AS)
  - Border Gateway Protocol (BGP-4)
- Business relationships between Ases i.e. contracts
  - pricing model
  - exchange of traffic





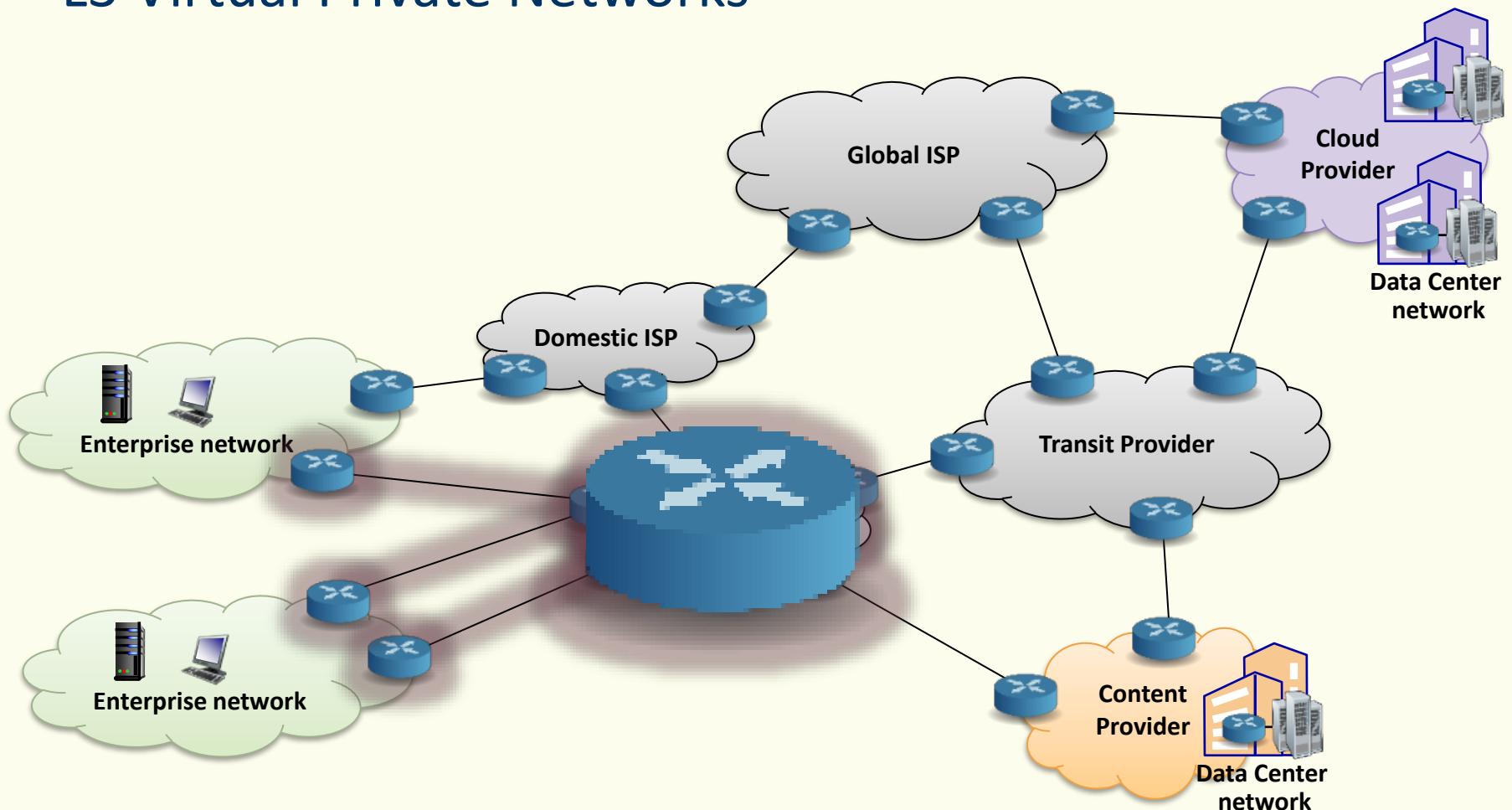
# Network virtualization

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



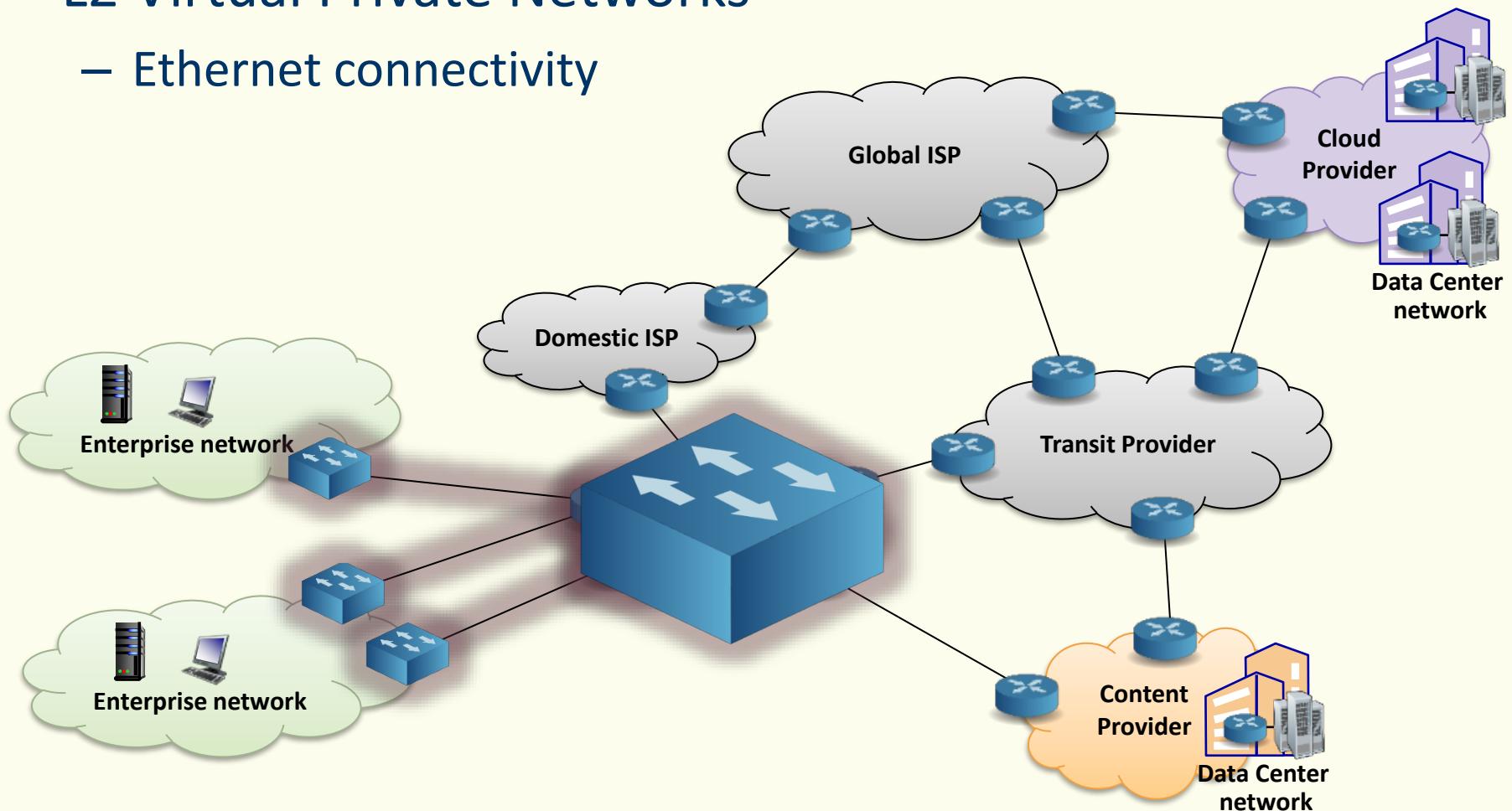
# Network virtualization

- L3 Virtual Private Networks



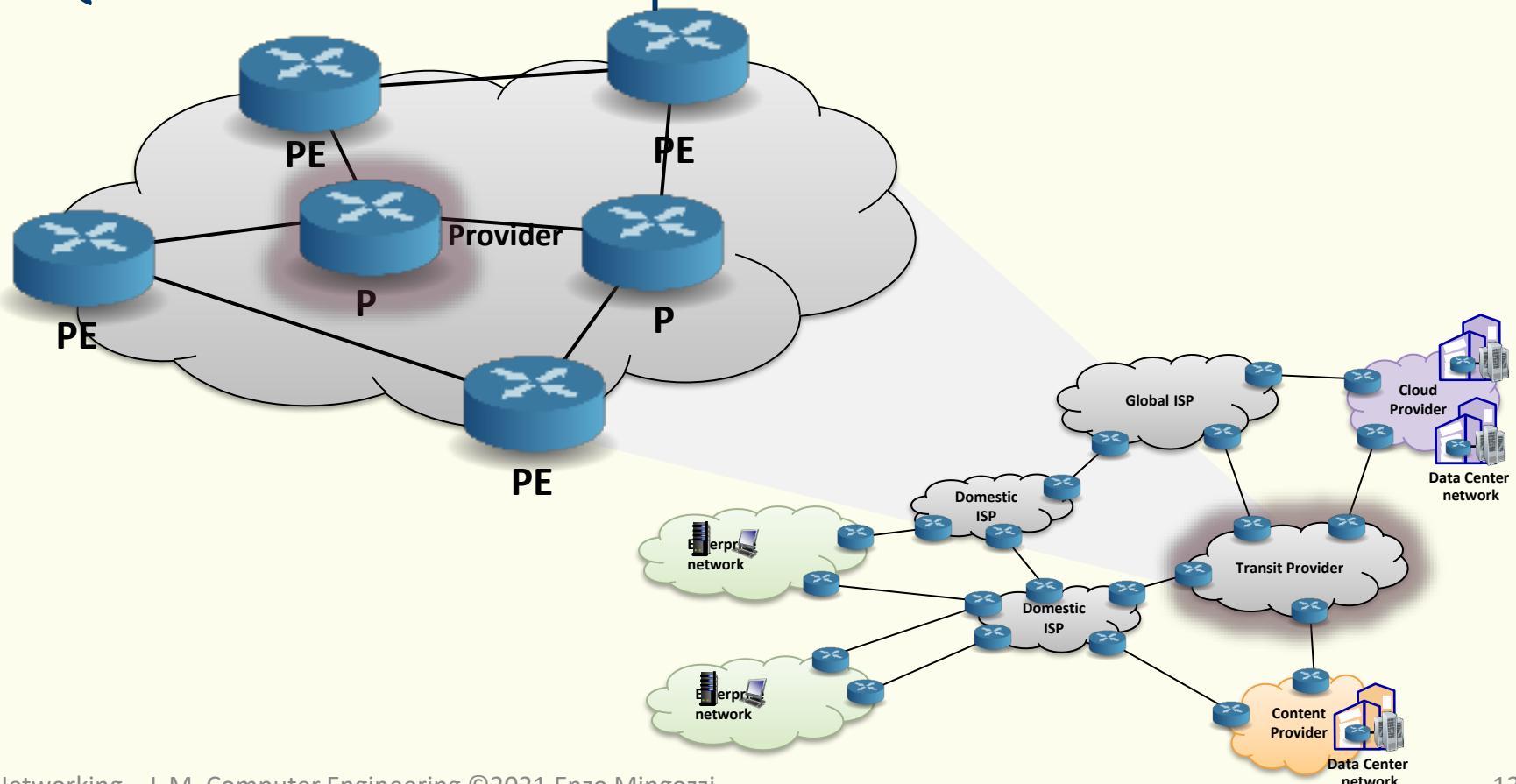
# Network virtualization

- L2 Virtual Private Networks
  - Ethernet connectivity



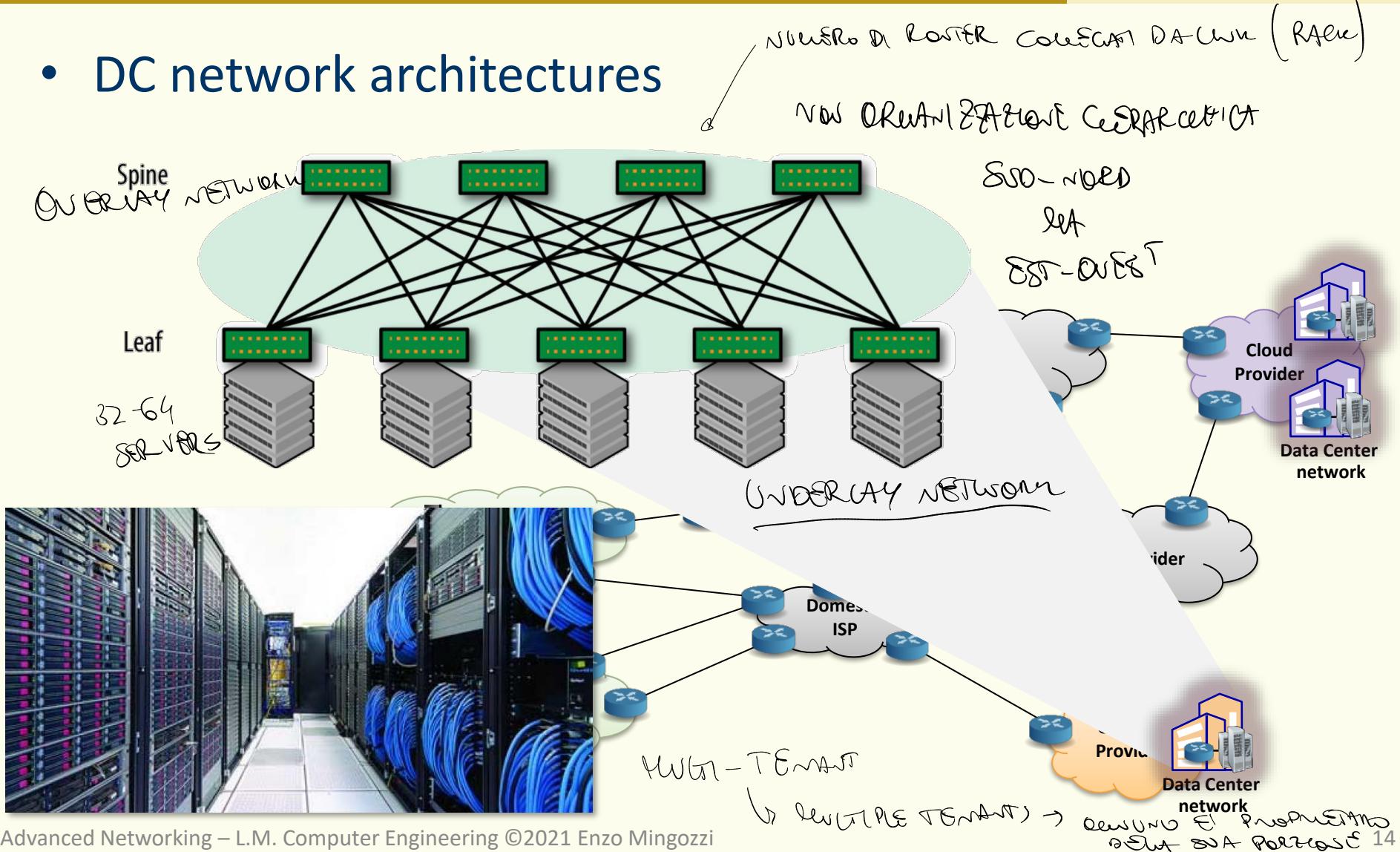
# QoS/QoE

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



# Data Center networking

- DC network architectures

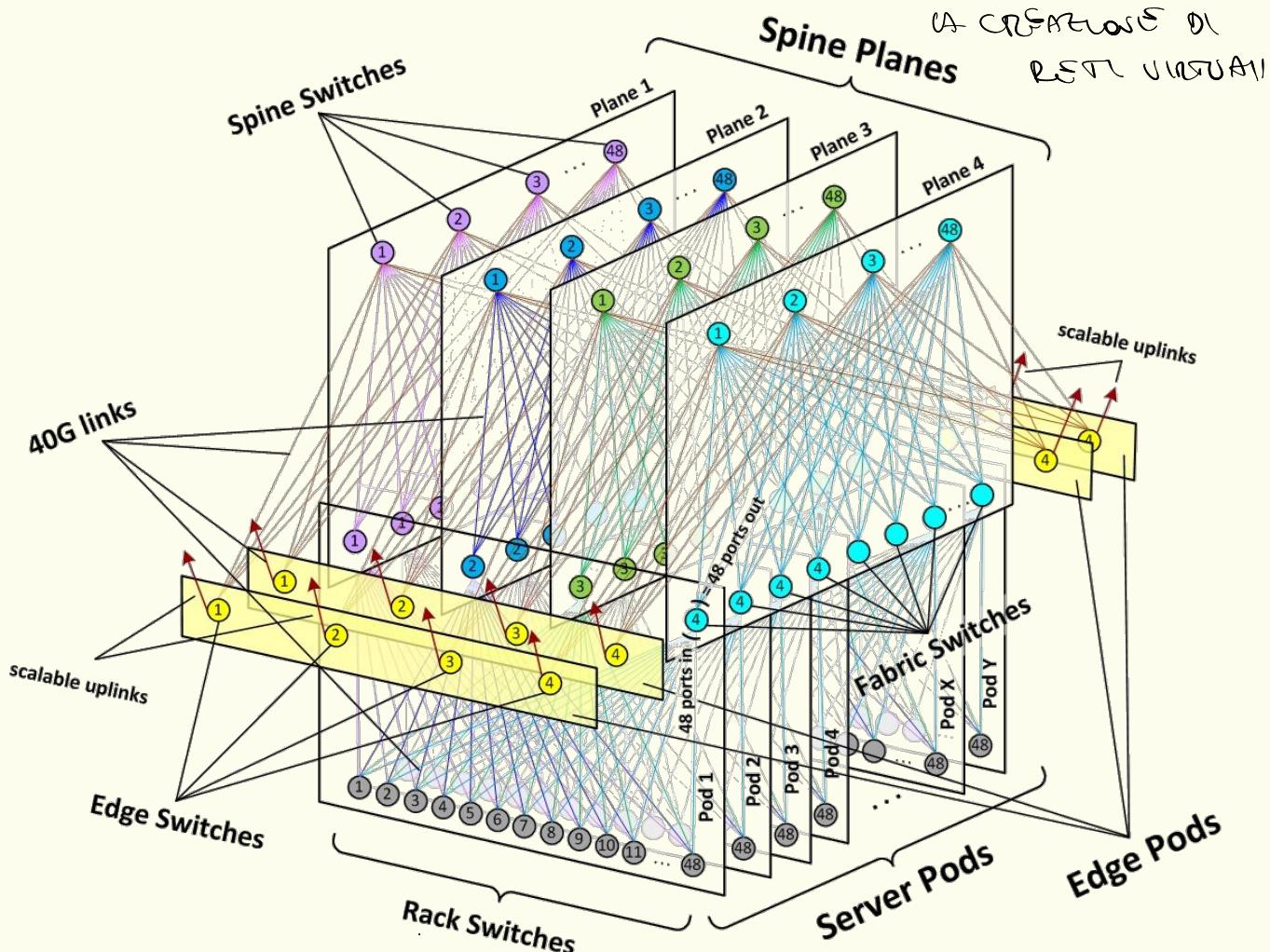


A PROSESSES UN PAFFWITI SOFTWARE PER AUTOMATIZZARE ALCUNI PROCESSI

MA AL VUELS CONSEGNE AL FELICITATIONE DI RETE

# Data Center networking

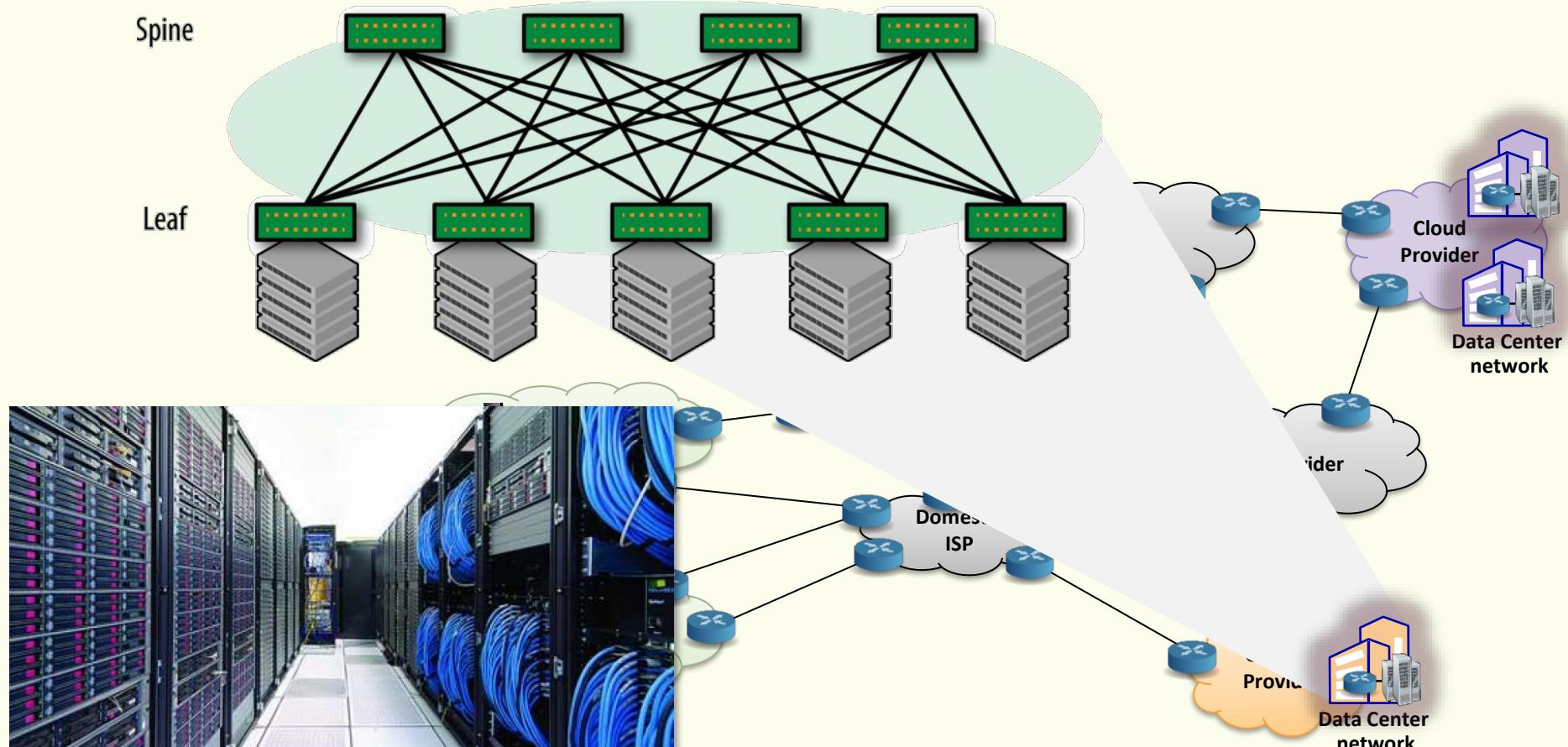
↳ TO ESSERE  
MESSO IN SERVIZIO  
TRAMITE SOFTWARE



[Introducing data center fabric, the next-generation Facebook data center network - Facebook Engineering \(fb.com\)](#)

# Data Center networking

- DC network virtualization



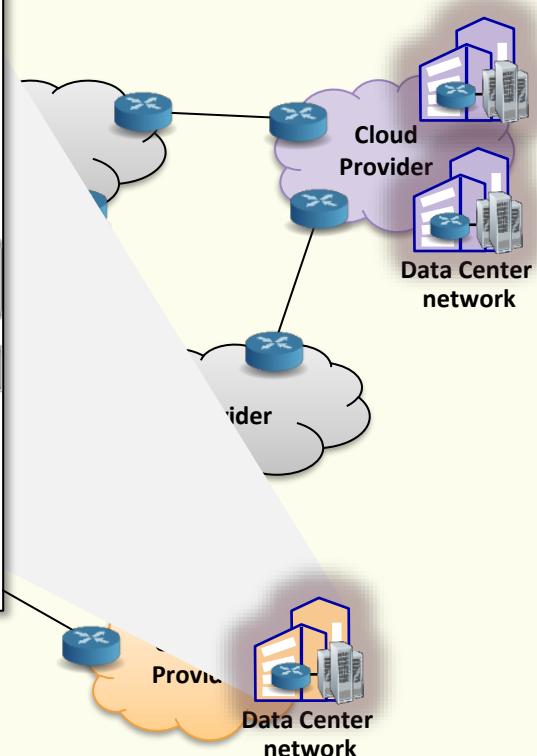
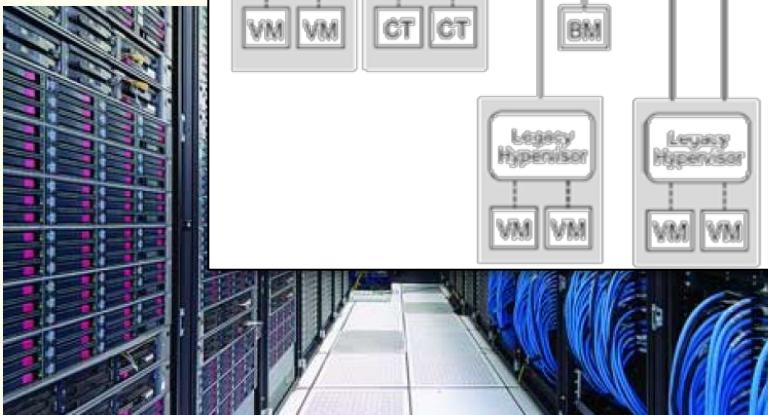
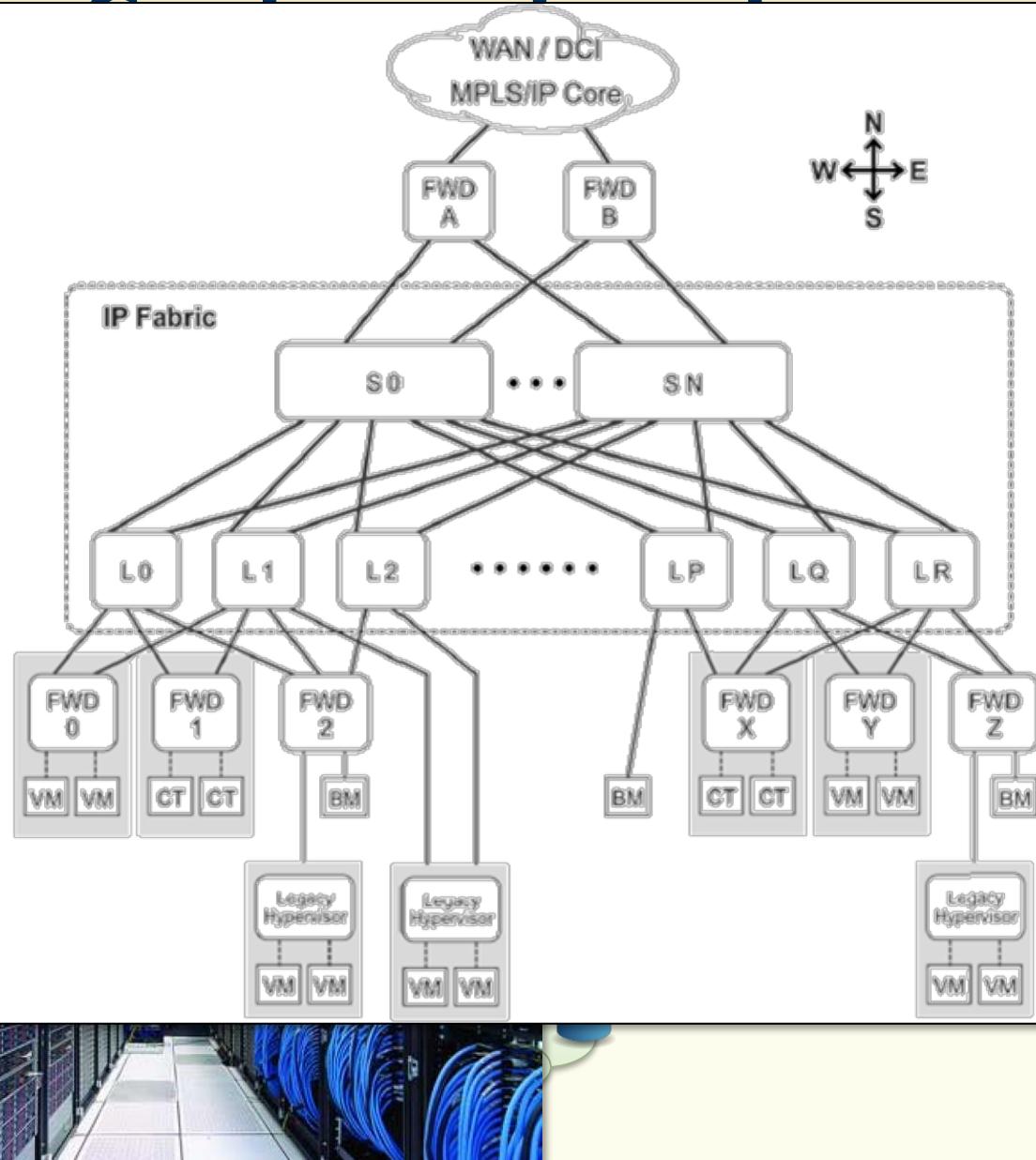


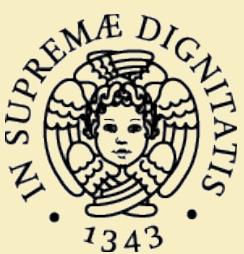
# Data Center

## DC

Spin

Leaf





# Network programmability

Sorriso: Precaumentata osse lutea

## PROBLEM: NETWORK AGILITY

Not Much has Changed in the Last 20 Years

Ho presentato a liste, ha bisogno di una certa serie di funzionalità  
↳ configurazioni

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>

Bisognerebbe  
essere  
Veloci

Disporsi di

rete esclusivo

disponibile

con relazioni

a reconfigurazione

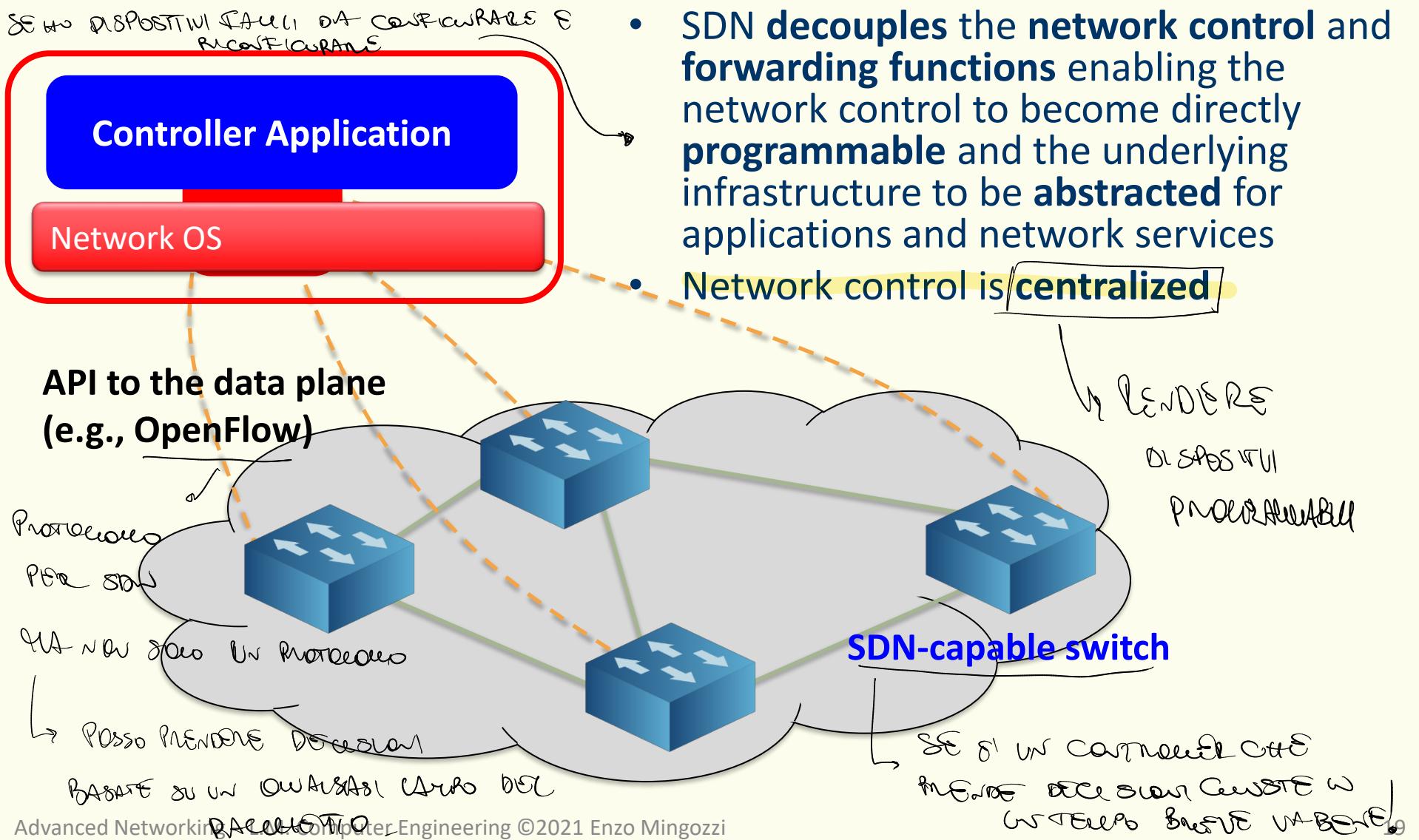
Terminal Protocol: **Telnet**

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  
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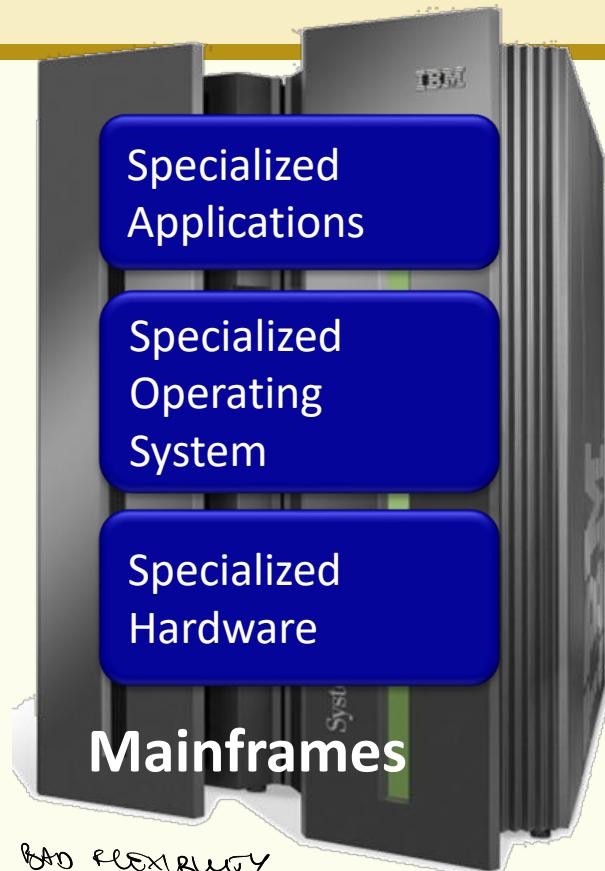
Terminal Protocol: **SSH**

# Software Defined Networking





# Software Defined Networking



Bad flexibility

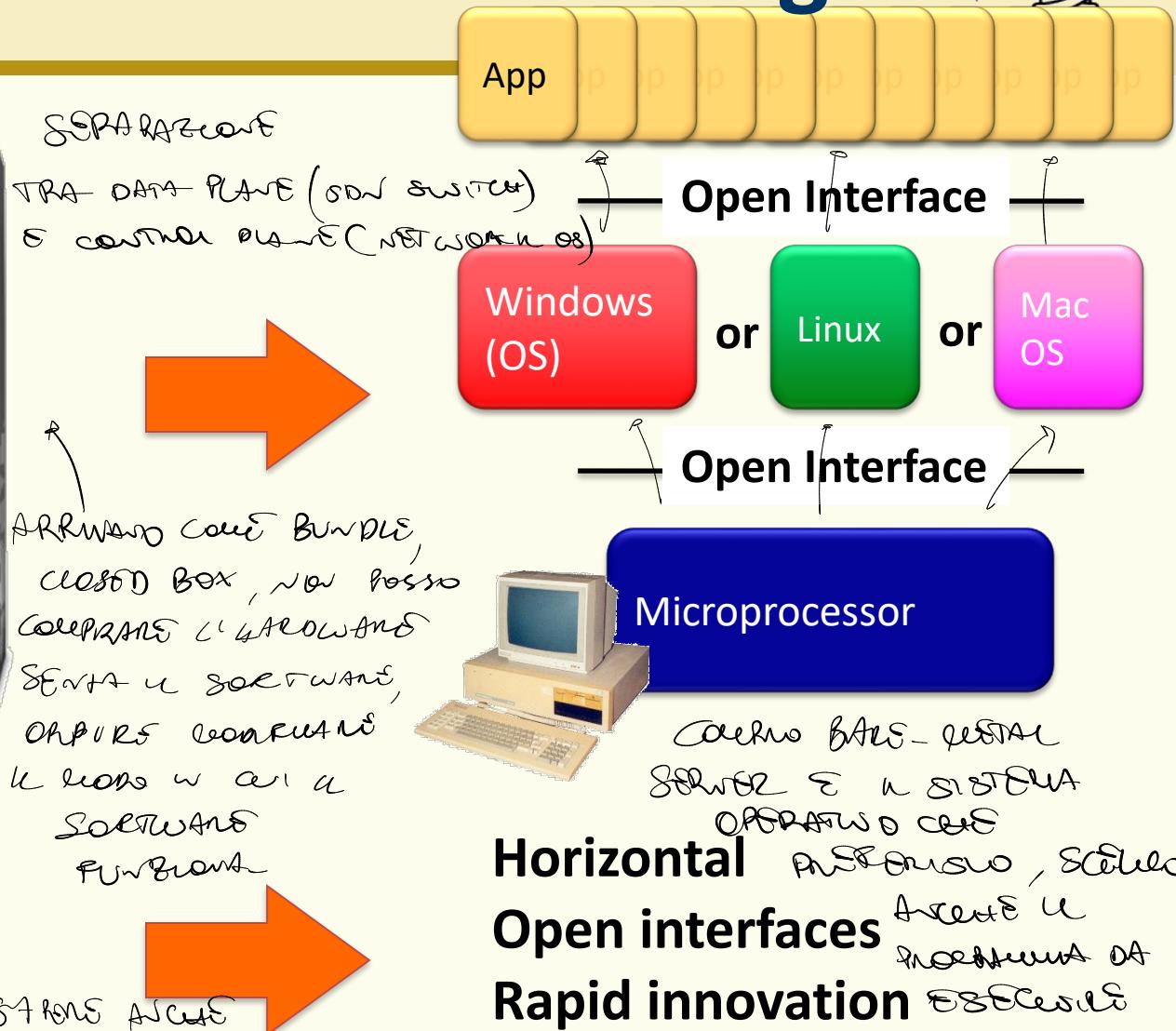
**Vertically integrated**

Closed, proprietary

Slow innovation

Small industry

Progettare le REQUISIZIONI FUTURI  
SISTEMI FUTURI - NO TECNOLOGIA  
SISTEMI FUTURI - NO TECNOLOGIA  
SISTEMI FUTURI - NO TECNOLOGIA



Carlo Basile - ESTATE  
SISTEMI E IN SISTEMA  
OPERATIVO CIE  
**Horizontal** PROSPERARE, SCHEDE  
**Open interfaces** Avere il  
**Rapid innovation** INNOVARE DA  
**Huge industry** ESTENDERSI

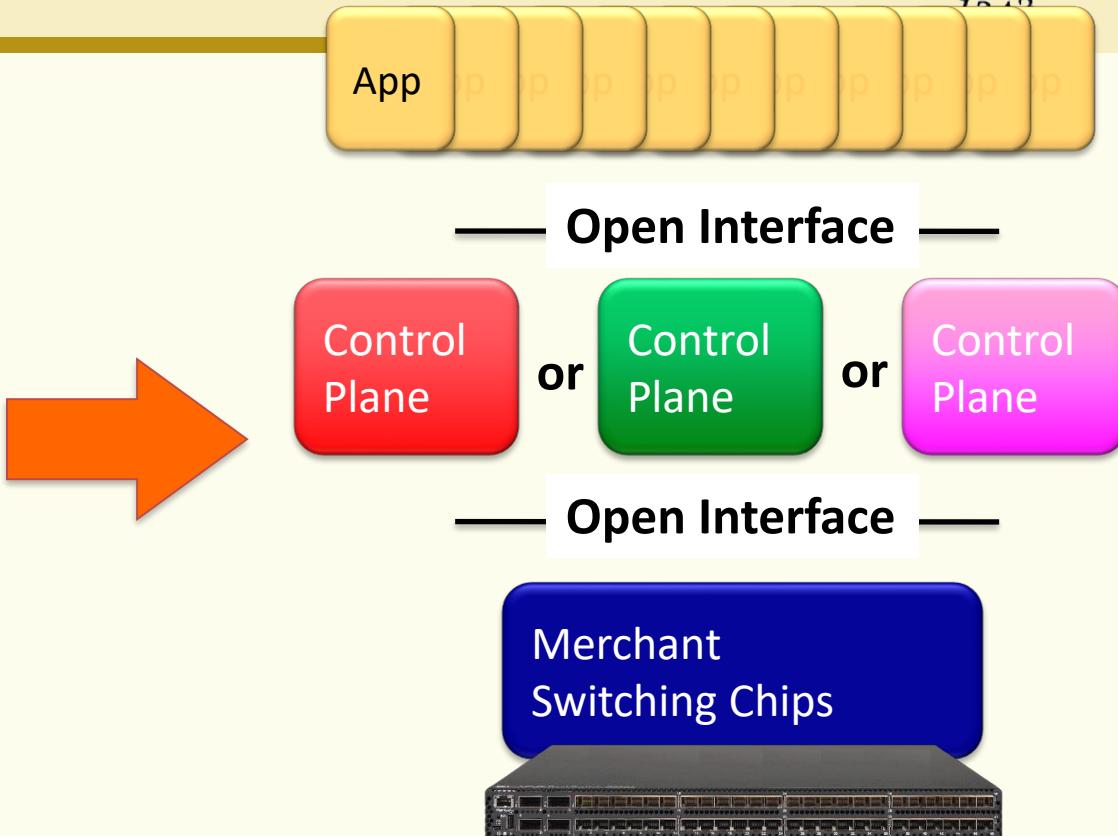
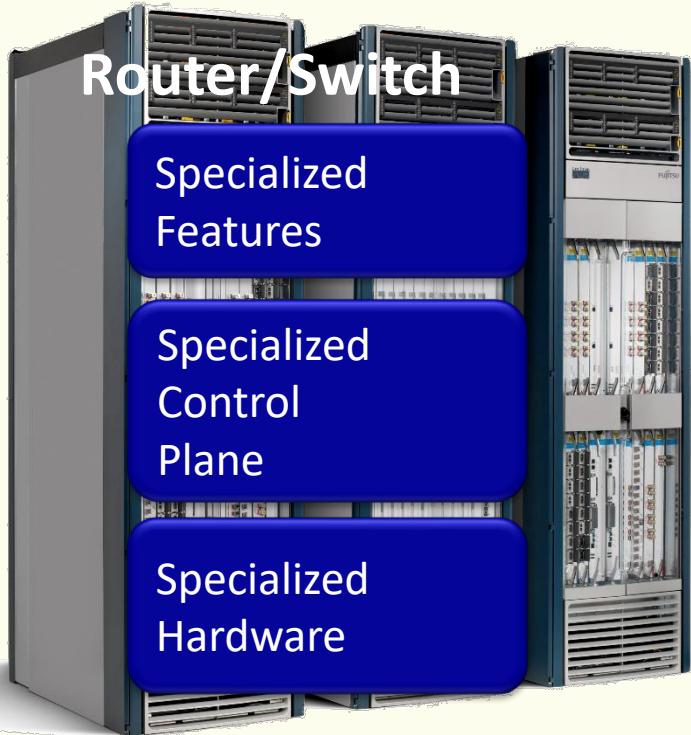
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BEST PRACTICE Software

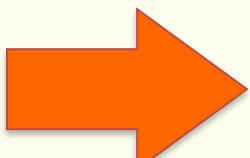
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# Software Defined Networking

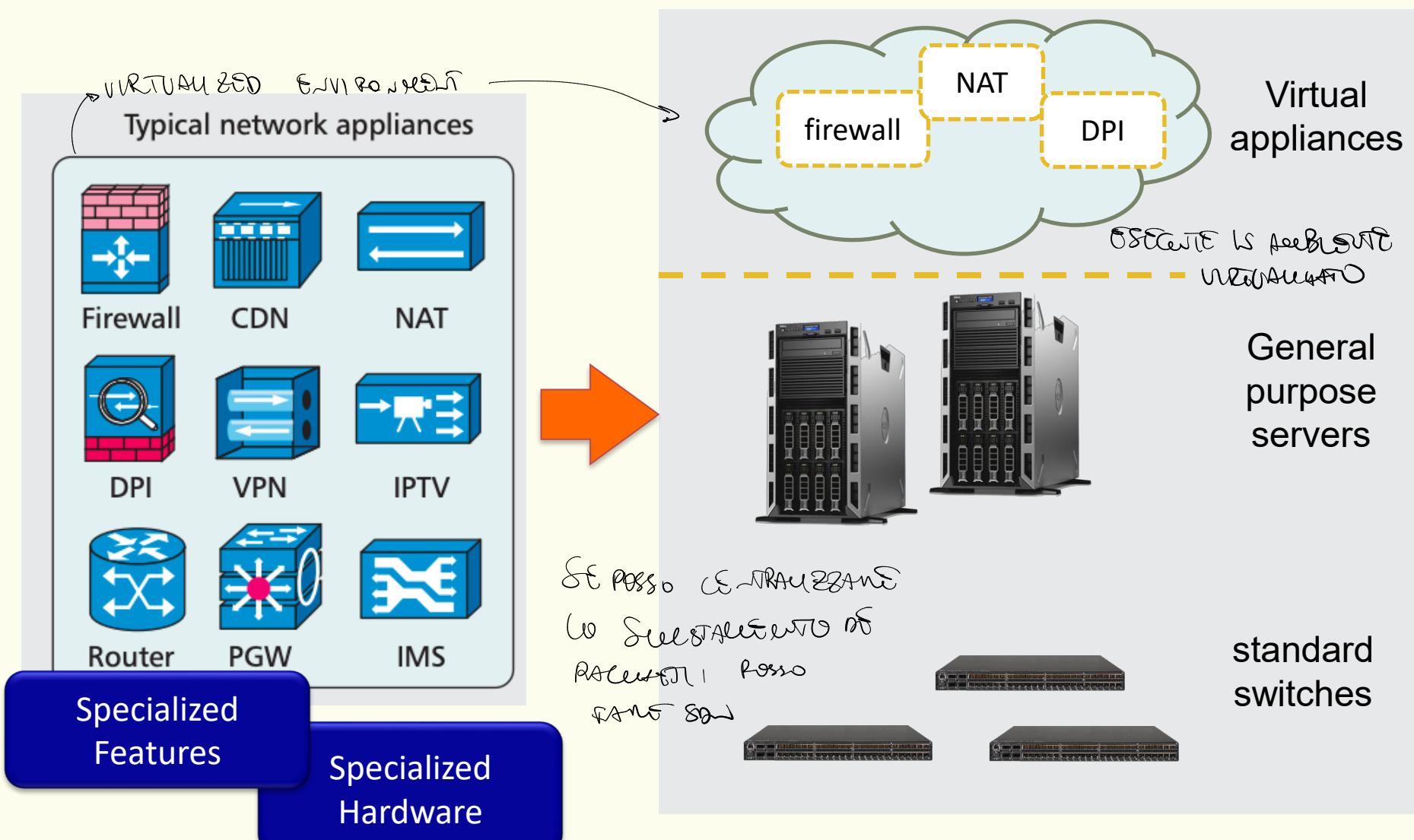


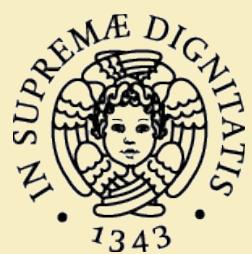
**Vertically integrated  
Closed, proprietary  
Slow innovation**



*Arquitetura interna suficiente para gerenciar a conexão diversa com razão*  
**Horizontal Open interfaces Rapid innovation**

# Network Function Virtualization





# Network Function Virtualization



Engineering  
Simplicity

Data Sheet



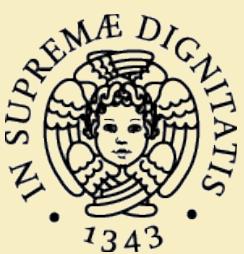
Product Overview

## vMX VIRTUAL ROUTER

### Product Description

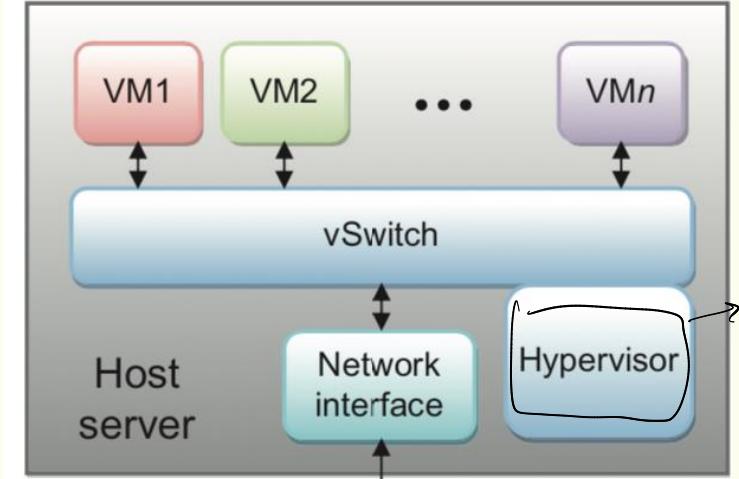
The Juniper Networks® vMX Virtual Router, available as licensed software for deployment on x86-based servers, Amazon Web Services (AWS), AWS GovCloud, and Microsoft Azure supports a broad range of broadband, cloud, cable, mobile, and enterprise applications. The vMX control plane is powered by Juniper 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**



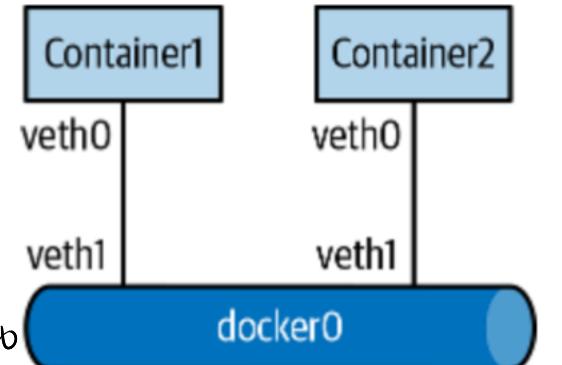
# VM/Container networking

VM devono usare lo stesso switch →



vede gli indirizzi di trasmissione e arriva con i destini

Configurazione  
comune  
per connettività  
con il esterno e  
tra di loro



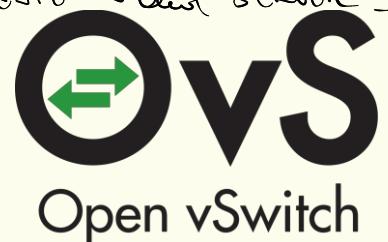
- “easy” networking
  - No network
  - Host-only network
  - Bridged
  - ...

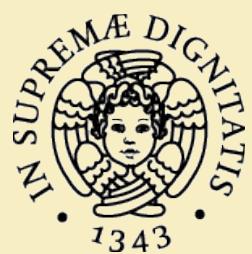
Un po' più network sono costosi  
ma hanno la possibilità di essere  
switchati

Tutti i server del rete sono connessi al “TOP OF THE RACK”

- “advanced” networking
  - custom software switches

Se ho un “TOP OF THE RACK” di 60 switch  
virtualizzati posso avere 60 server -





# Network automation

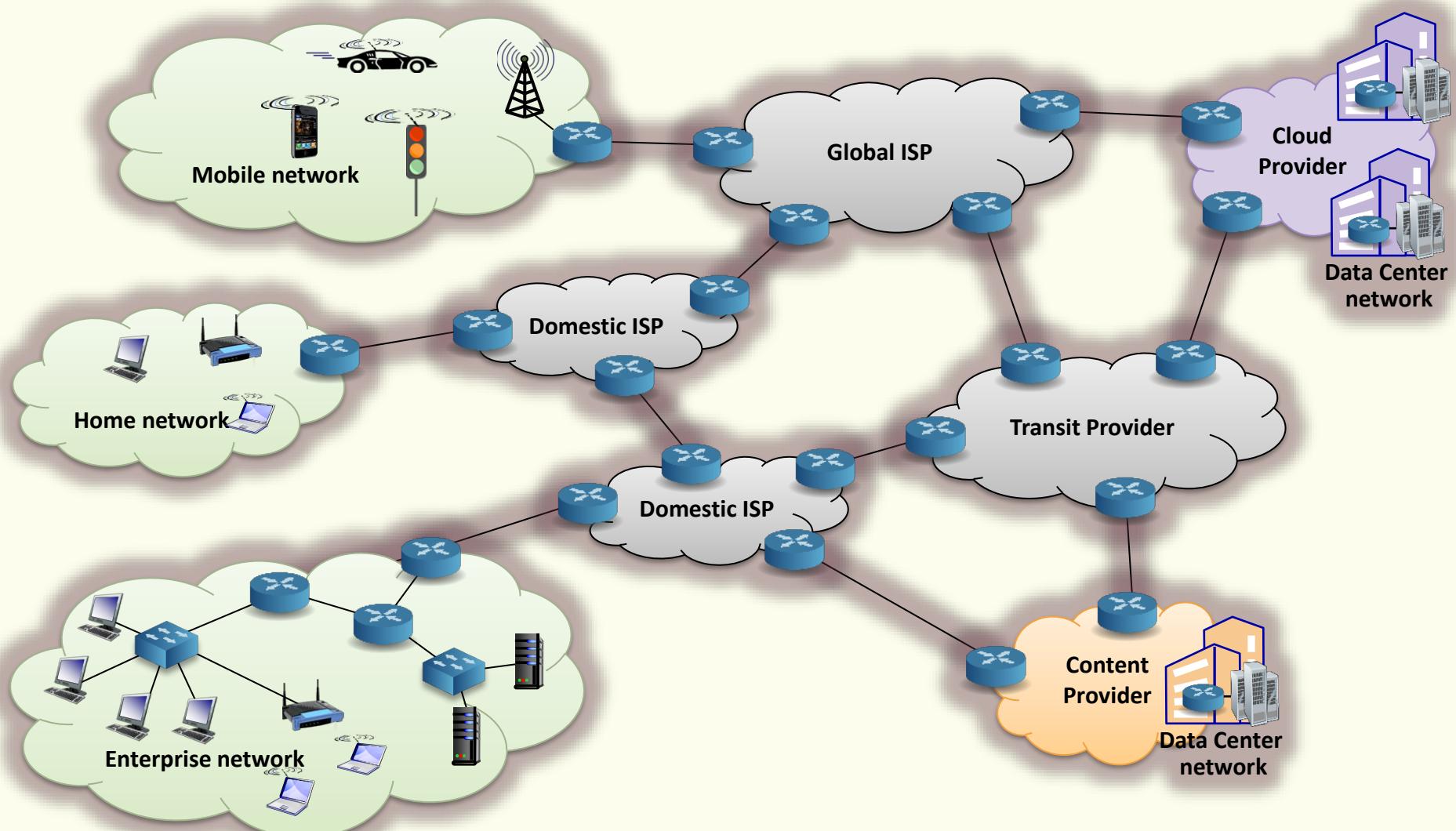
- Take advantage of the programmatic interfaces being exposed by modern network devices that offer an API
  - Automating the configuration of network devices
  - Automating the process of troubleshooting
  - Aid in the day-to-day operations of managing networks for data gathering and automated diagnostics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

→ PRODUTIVE MAINTENANCE

↳ OSARIS WIRELESS AGREEMENT FOR CONVERGENCE & SERVICES AREAS  
SOTRA INTERVENTO UNICO



# Internet Protocol v6 (IPv6)





# Course figures

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



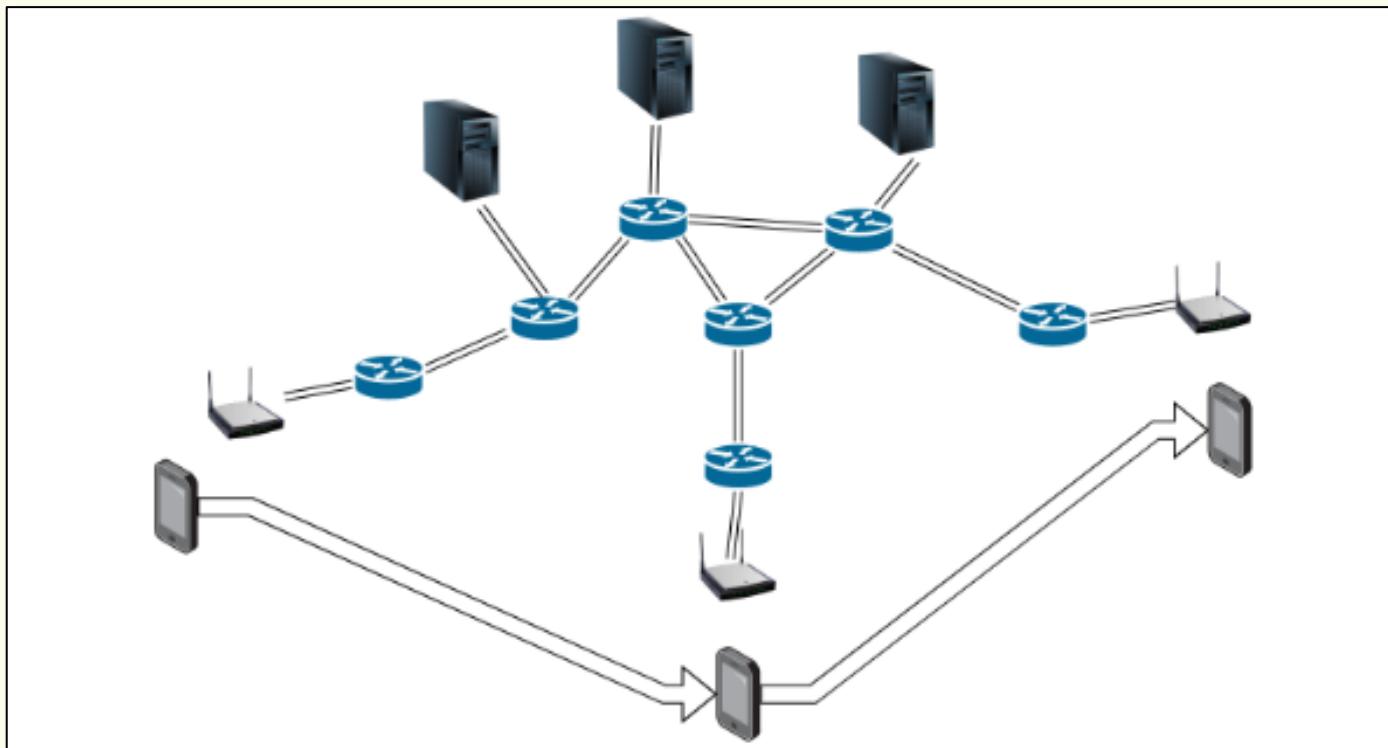
# Course content

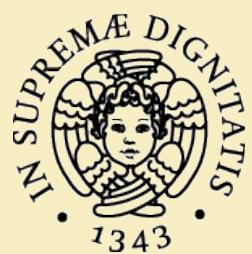
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- **Lab activities:** hands-on labs on
  - Software Defined Networking (software)
  - Backbone router configuration (emulating software)
  - VM/Container networking

# 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

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- Prof. Enzo Mingozi ([enzo.mingozi@unipi.it](mailto:enzo.mingozi@unipi.it))
- Prof. Antonio Virdis ([antonio.virdis@unipi.it](mailto: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)