C1
Rețele de calculatoare

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Cuprinsul cursului

1. Aspecte organizatorice și prezentarea cursului
2. Scurtă istorie a internetului și a modului în care funcționează

Echipa

Sergiu Nisioi

Curs

Andrei Ciobanu

Laborator
231, 232

Liviu Pîslaru

Laborator
233, 234

Mihăiță Drăgan

Laborator
24X, 25X

Notarea

Examen de curs în sesiune - 50%

Laborator - 50% (notare diferită în funcție de profesorul de laborator)

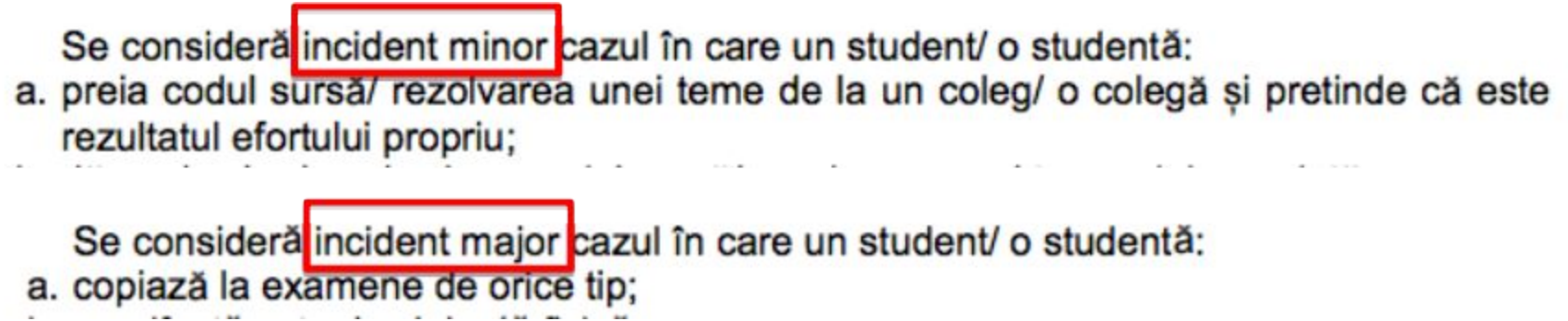
- teme și/sau test

La restanță

- se păstrează punctajul obținut la una din cele două examinări **timp de un an**
- folosim **același model de examen** ca în sesiune, cu excepția laboratorului
- **test de laborator** (dacă pici laboratorul, dai test, indiferent dacă nota în timpul semestrului a fost obținută pe bază de teme)

Regulament de integritate

*preluat din regulamentul intern



Se consideră incident minor cazul în care un student/ o studentă:

a. preia codul sursă/ rezolvarea unei teme de la un coleg/ o colegă și pretinde că este rezultatul efortului propriu;

Se consideră incident major cazul în care un student/ o studentă:

a. copiază la examene de orice tip;

3 incidente minore = un incident major = exmatriculare

Recomandări

- **NU există întrebări greșite**
- puneți întrebări ori de câte ori nu se înțelege ceva
- dacă e nevoie de o pauză la jumatea orei, trebuie doar să spuneți
- la această materie **este încurajat dialogul**
- în cazul meu, folosiți numele să vă adresați (Sergiu Nisioi), nu dom’ profesor

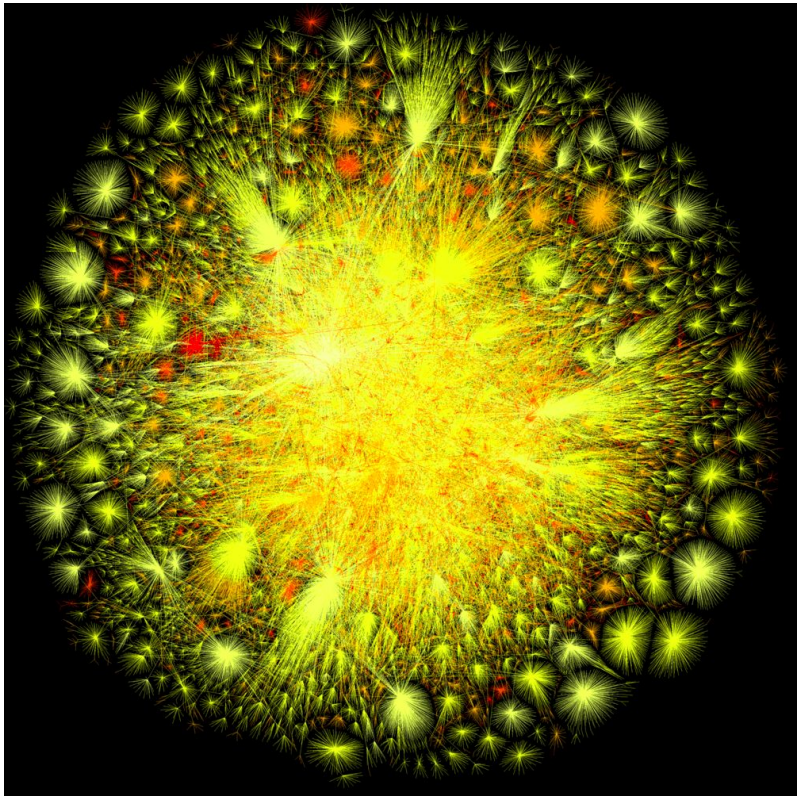
Ce vom învăța la această materie?

- TCP/IP, DNS, HTTP, 802.11
- cum funcționează internetul
- rețele din perspectiva programării
- vulnerabilități și securitate
- exemple de cod (la curs)

Nu este neapărat despre:

- CCNA
- sisteme distribuite
- comunicații

opte.org



Materiale / Bibliografie

- https://github.com/senisioi/computer-networks
- https://book.systemsapproach.org/foundation.html
- https://gaia.cs.umass.edu/kurose_ross/index.php

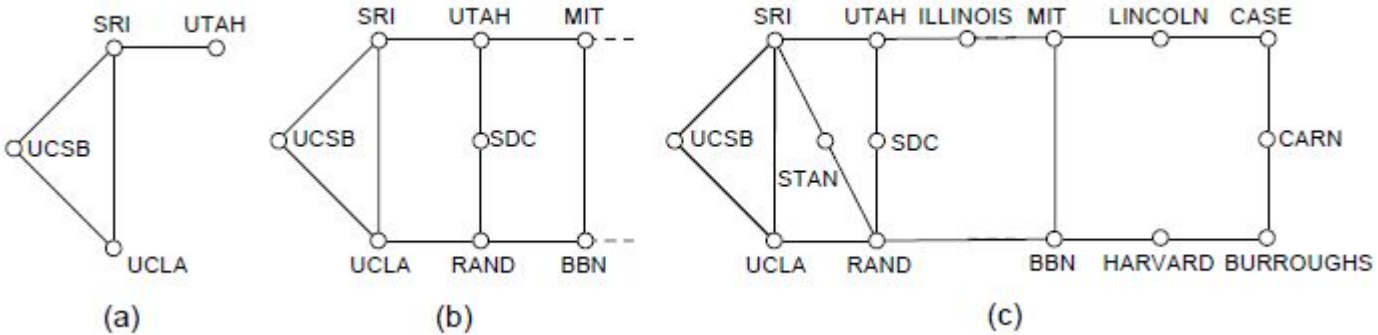
Alte cărți:

- https://bit.ly/biblio_retele

Istorie

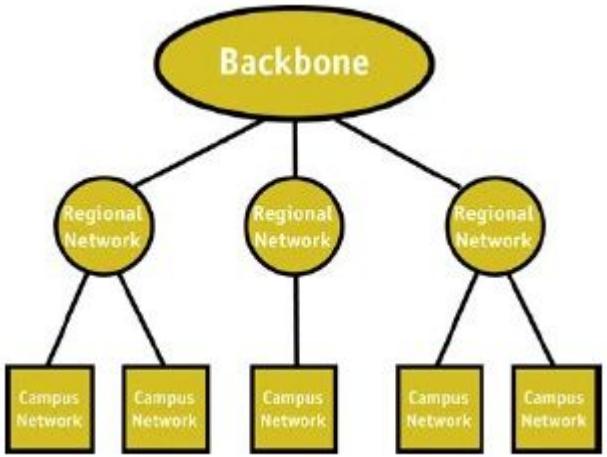
https://www.nsf.gov/news/special_reports/nsf-net/index.jsp

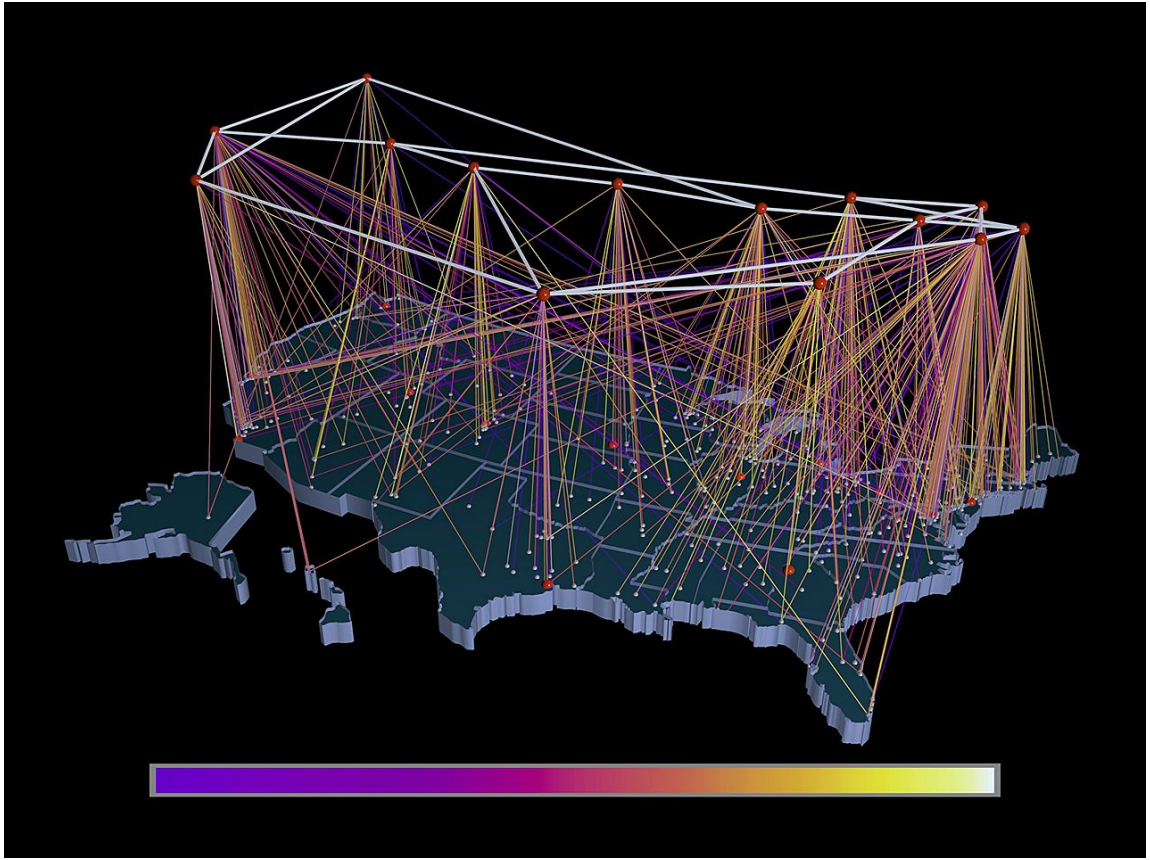
ARPANET



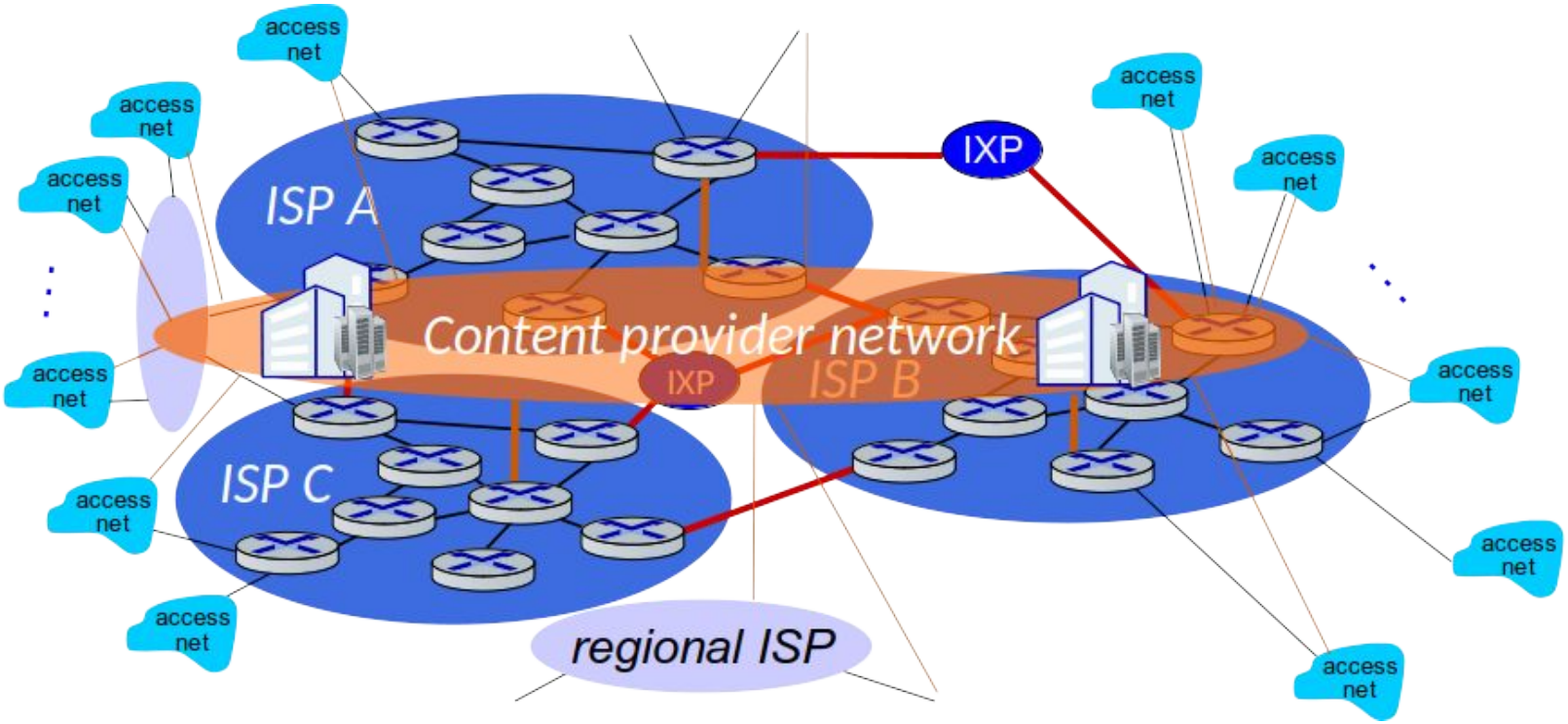
1969 - 1970 - 1971

NSFNET 1985 - 1995





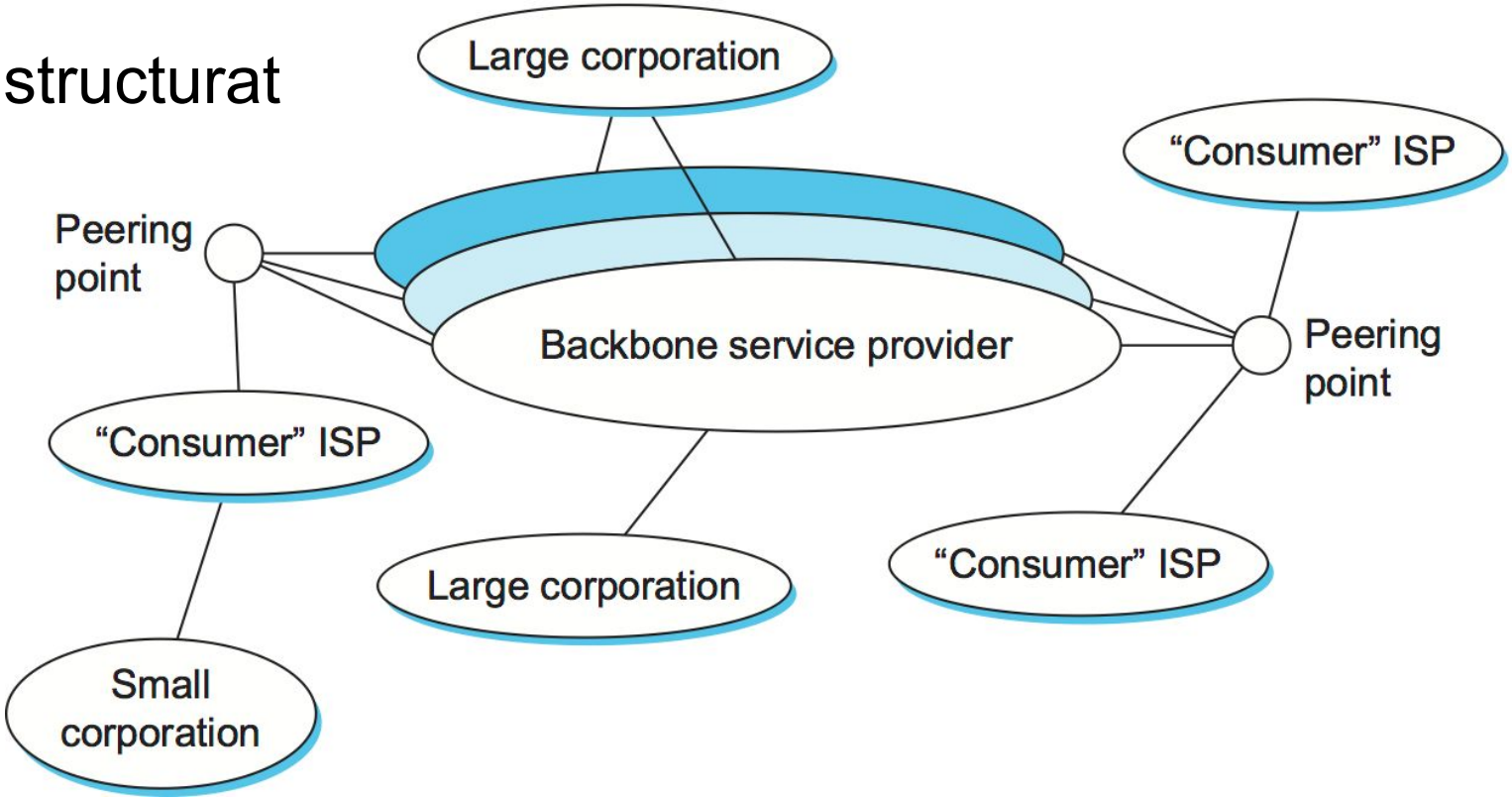
Internetul în prezent



Modern internet

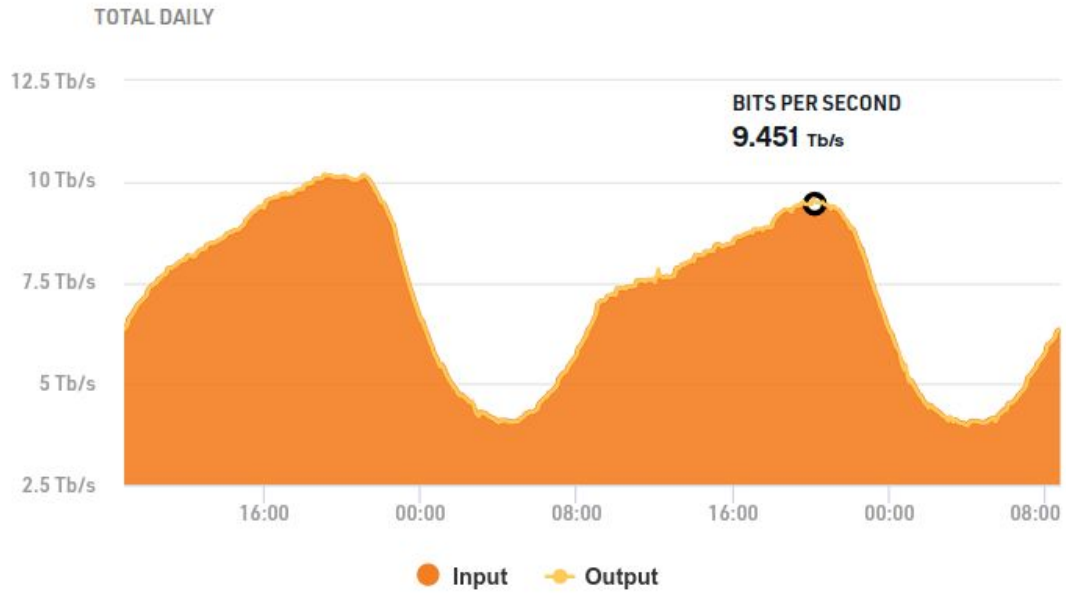
- ISP networks serve as the Internet backbone
- ISPs connect or peer to exchange traffic at IXPs
- Within each network routers switch packets
- Between networks, traffic exchange is set by business agreements
- Customers connect at the edge by many means (Cable, DSL, Fiber-to-the-Home, 3G/4G wireless, dialup)
- Data centers concentrate many servers (“the cloud”)
- Most traffic is content from data centers (esp. video)
- The **architecture continues to evolve**

Mai structurat



Vint Cerf:
https://www.internetsociety.org/internet/history-internet/brief-history-internet-related-networks/

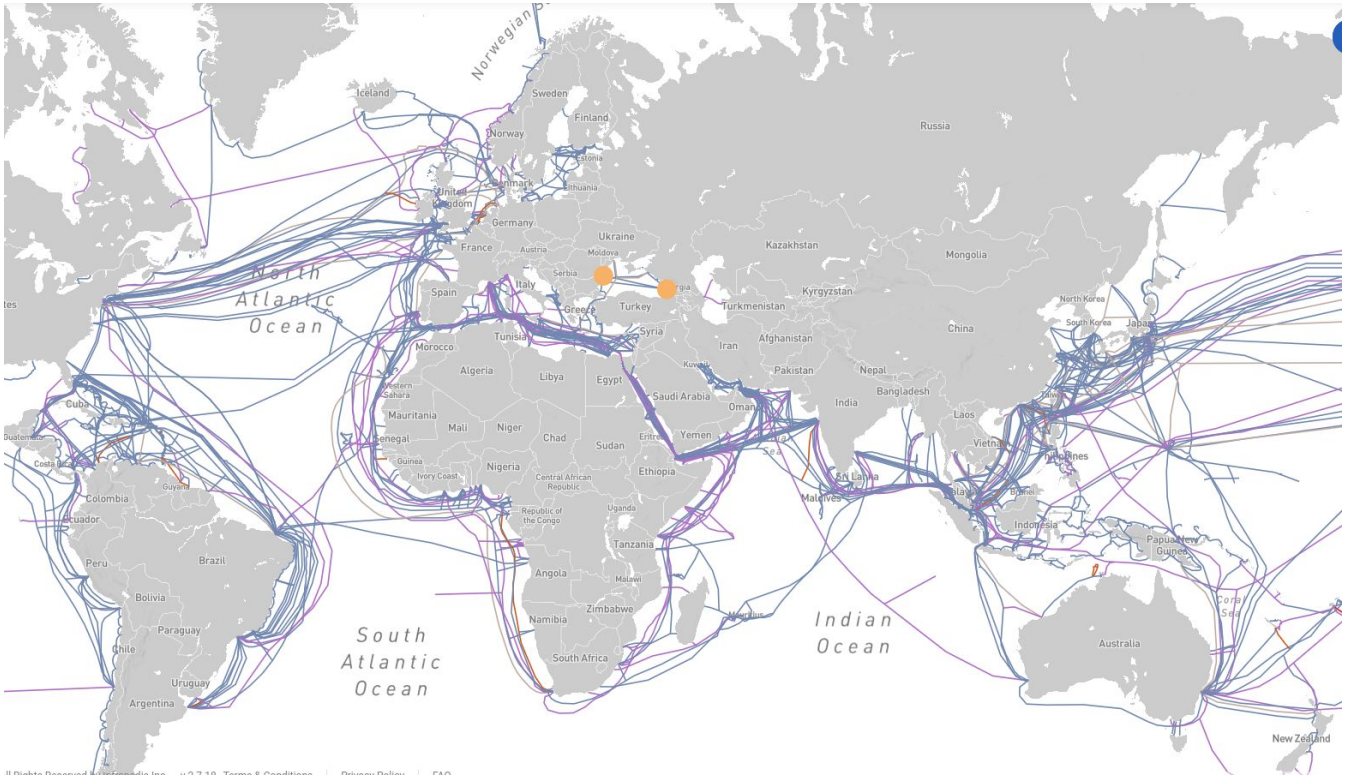
Amsterdam Peering Exchange ams-ix.net



PEAK IN	PEAK OUT
10.157 Tb/s	10.184 Tb/s
AVERAGE IN	**AVERAGE OUT**
7.168 Tb/s	7.185 Tb/s
CURRENT IN	**CURRENT OUT**
6.32 Tb/s	6.337 Tb/s

infrapedia.com/app

An elderly Georgian woman was scavenging for copper to sell as scrap when she accidentally sliced through an underground cable and cut off internet services to all of neighbouring Armenia (2011)

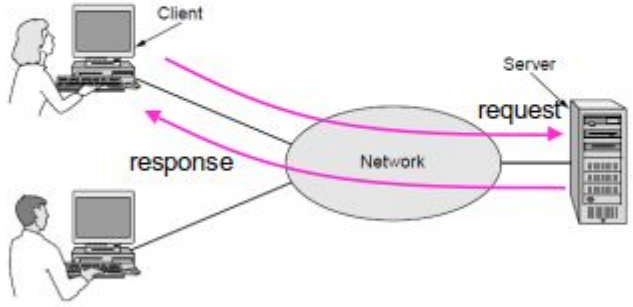


Arhitectură client - server

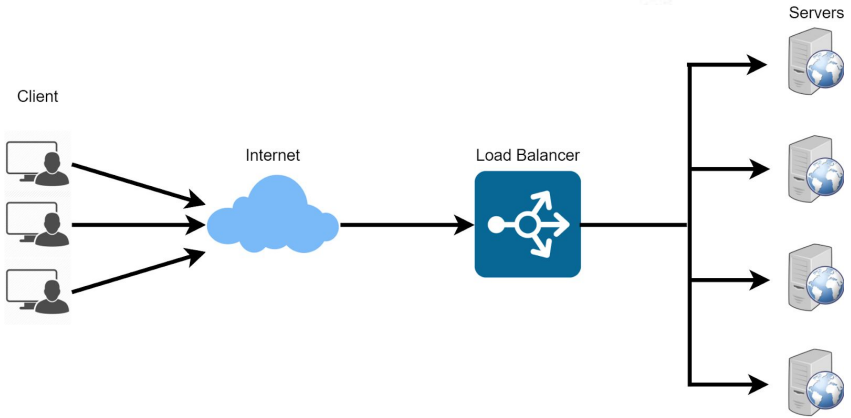
- în cazul cel mai simplu, avem 1 server
- când vrei să deservești clienți pe tot globul cu latență scăzută, 1 server nu va fi de ajuns (vezi slide-ul anterior)
- server-ul devine un grup de servere
- server uneori înseamnă **mașina fizică**, uneori, **aplicația software**

Client makes requests

Server gives answers

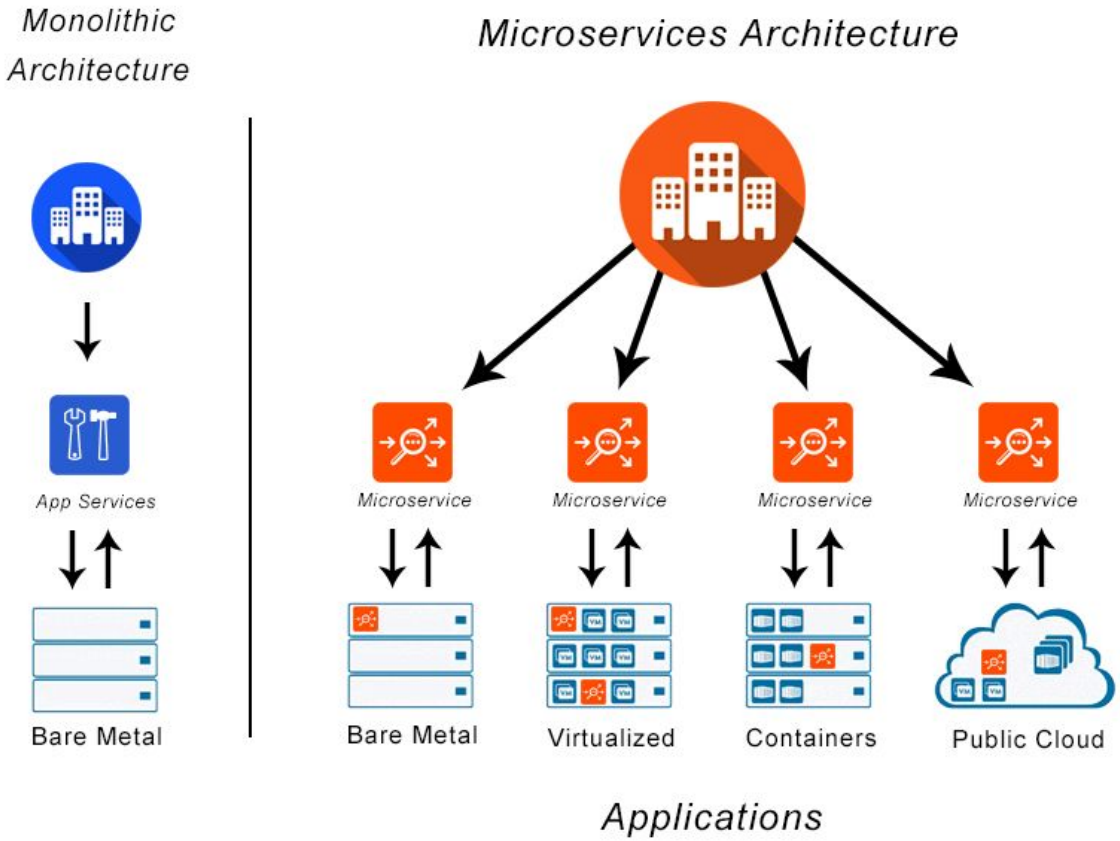


Other popular uses are communication, e.g., email, VoIP, and e-commerce



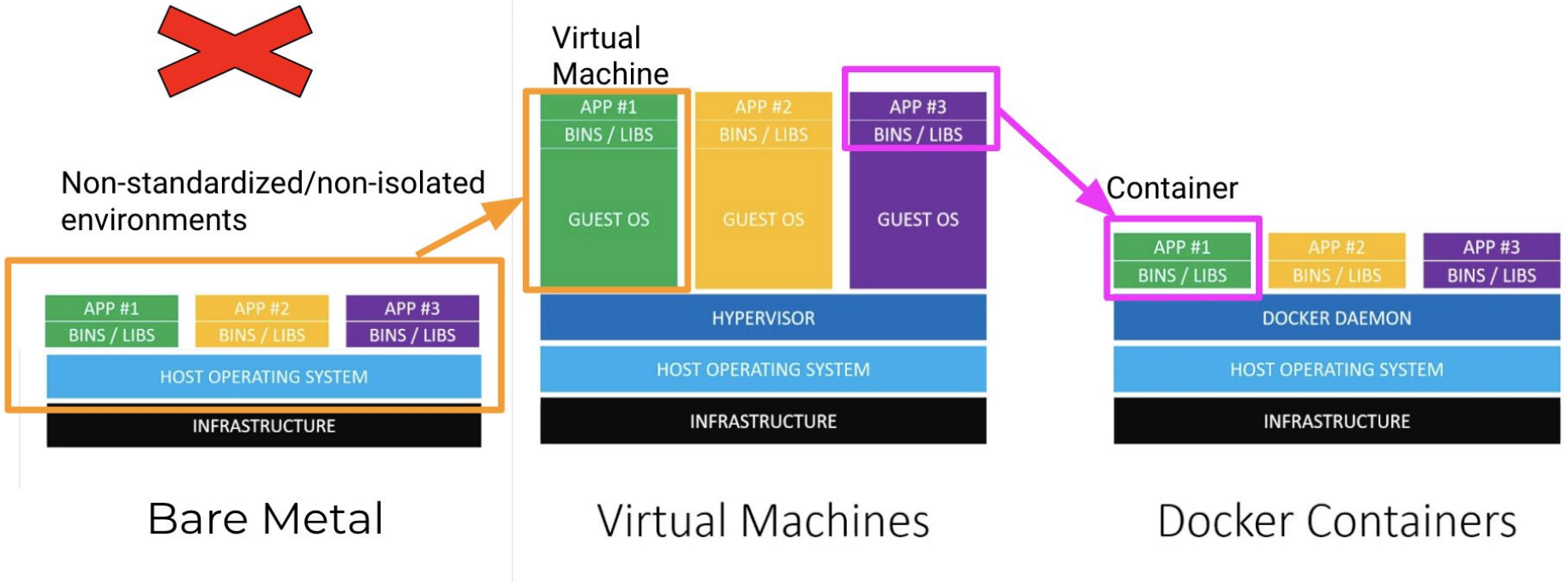
Containere docker

- ca metaforă a rețelelor
- perspectiva software
- arhitectură actuală

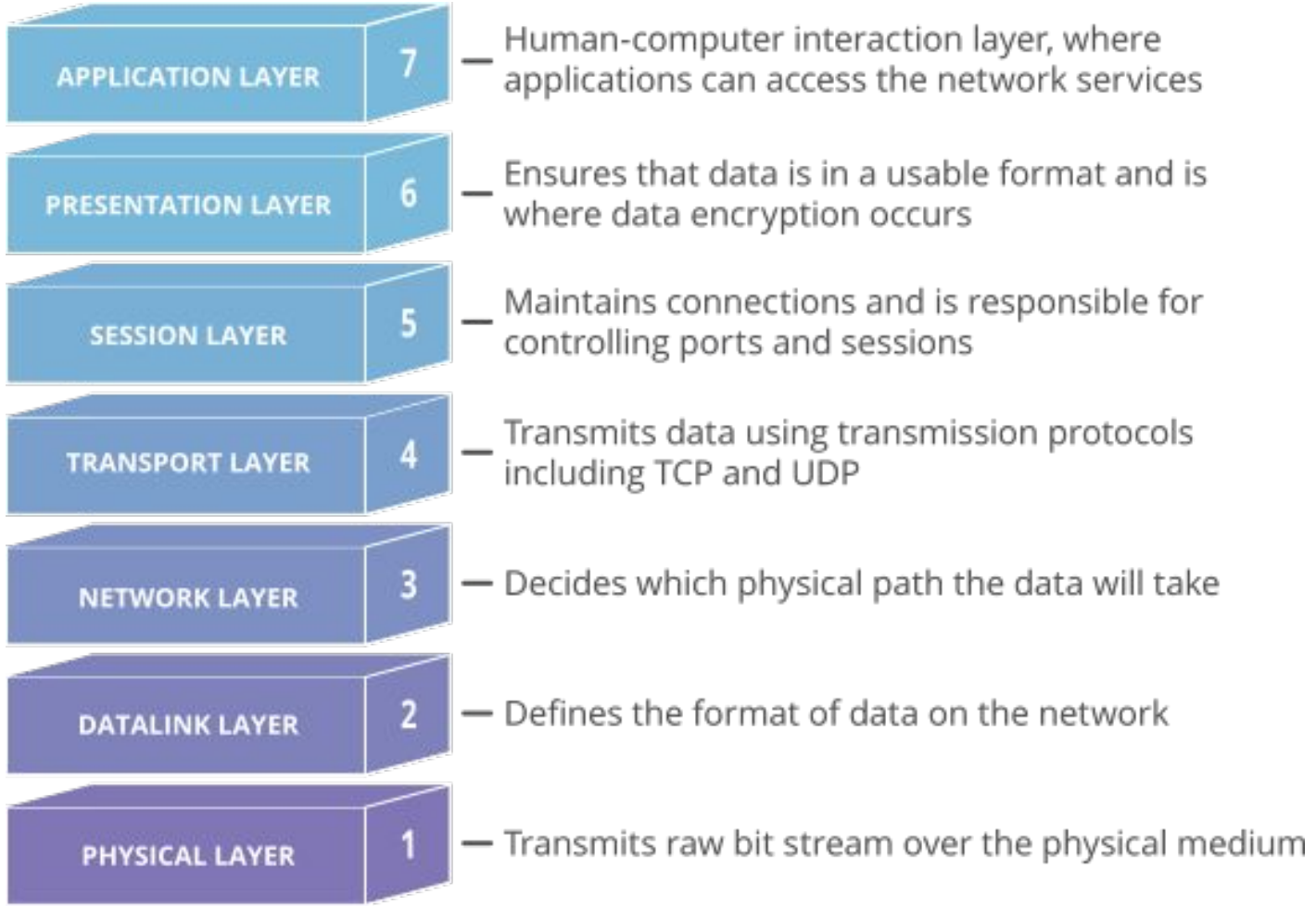


Containere docker

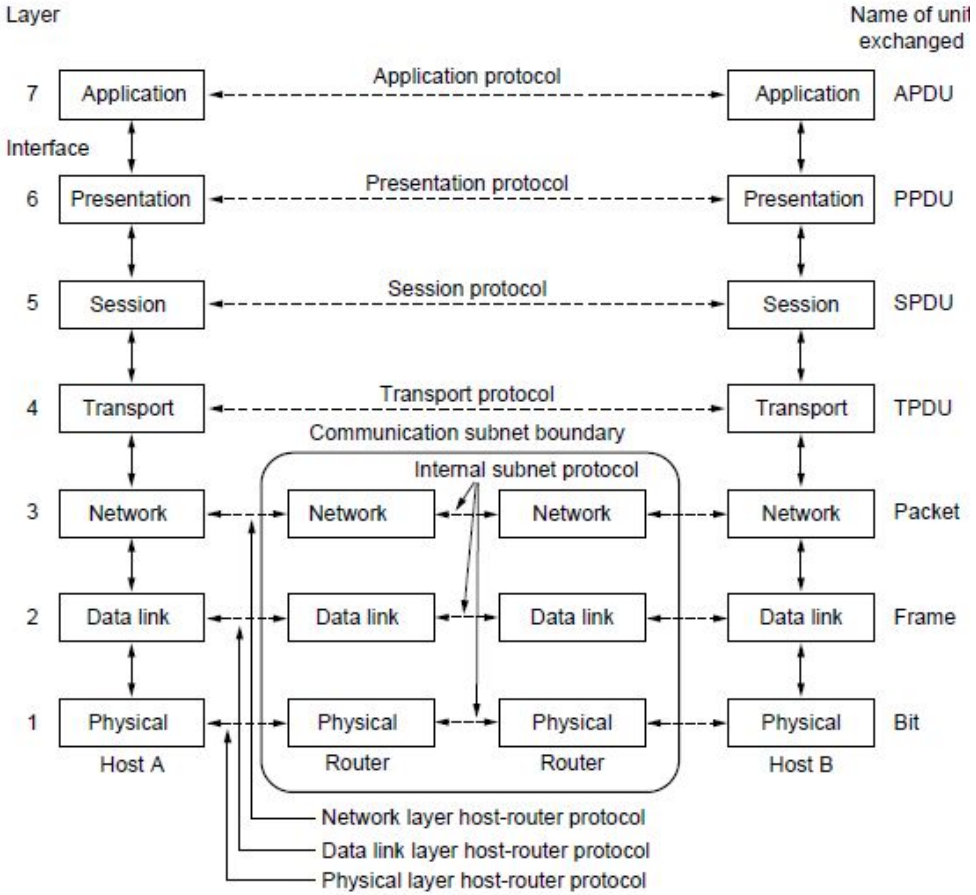
https://github.com/senisioi/computer-networks/tree/2022/capitolul0



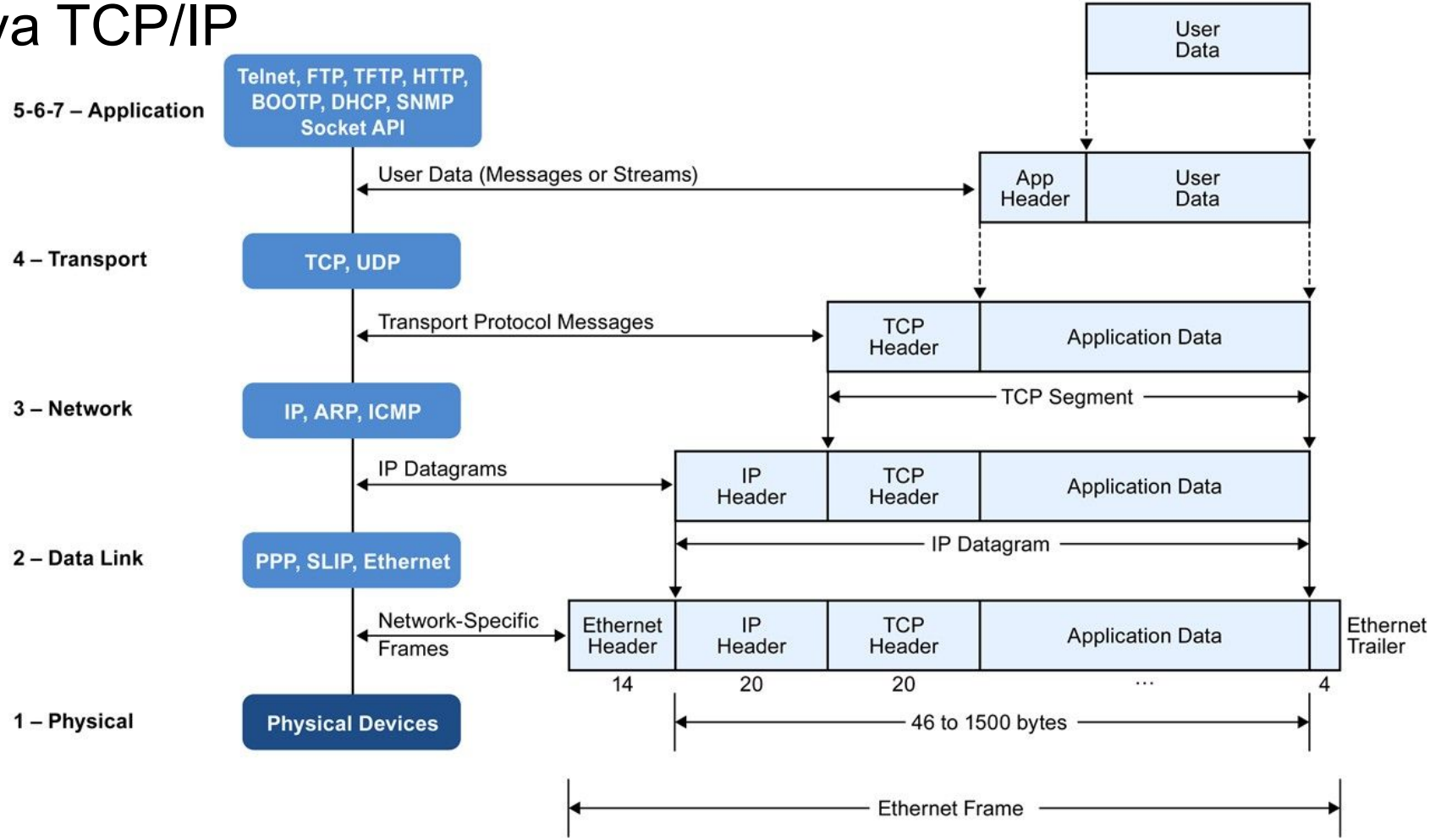
Stiva OSI


APPLICATION LAYER
7
Human-computer interaction layer, where applications can access the network services
PRESENTATION LAYER
6
Ensures that data is in a usable format and is where data encryption occurs
SESSION LAYER
5
Maintains connections and is responsible for controlling ports and sessions
TRANSPORT LAYER
4
Transmits data using transmission protocols including TCP and UDP
NETWORK LAYER
3
Decides which physical path the data will take
DATALINK LAYER
2
Defines the format of data on the network
PHYSICAL LAYER
1
Transmits raw bit stream over the physical medium

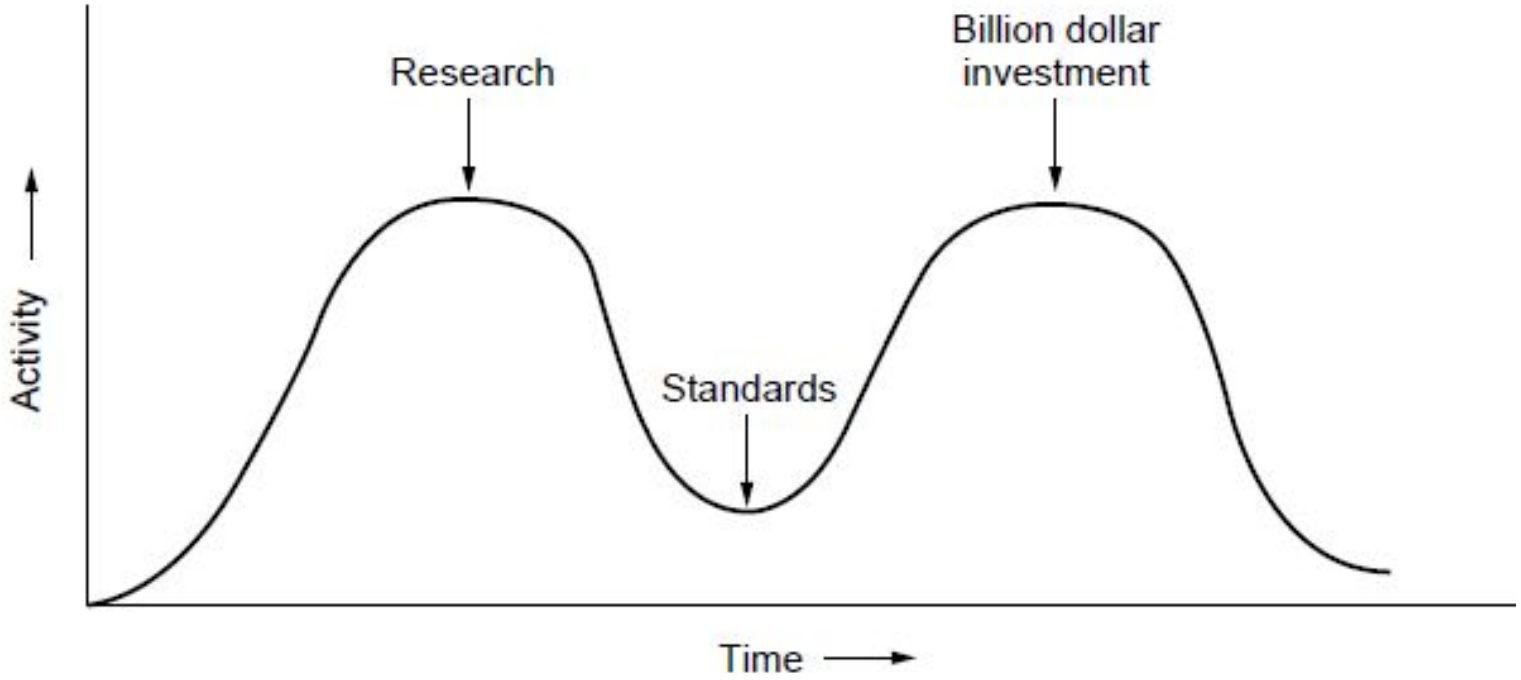
Stiva OSI


Layer
Name of unit exchanged
7
Application
Application protocol
Application
APDU
Interface
6
Presentation
Presentation protocol
Presentation
PPDU
5
Session
Session protocol
Session
SPDU
4
Transport
Transport protocol
Transport
TPDU
Communication subnet boundary
Internal subnet protocol
3
Network
Network
Network
Network
Packet
2
Data link
Data link
Data link
Data link
Frame
1
Physical
Physical
Physical
Physical
Bit
Host A
Router
Router
Host B
Network layer host-router protocol
Data link layer host-router protocol
Physical layer host-router protocol

Stiva TCP/IP


5-6-7 – Application
Telnet, FTP, TFTP, HTTP, BOOTP, DHCP, SNMP Socket API
User Data
User Data (Messages or Streams)
App Header
User Data
4 – Transport
TCP, UDP
Transport Protocol Messages
TCP Header
Application Data
TCP Segment
3 – Network
IP, ARP, ICMP
IP Datagrams
IP Header
TCP Header
Application Data
IP Datagram
2 – Data Link
PPP, SLIP, Ethernet
Network-Specific Frames
Ethernet Header
IP Header
TCP Header
Application Data
Ethernet Trailer
14
20
20
...
4
1 – Physical
Physical Devices
46 to 1500 bytes
Ethernet Frame

Modelul OSI


Research
Billion dollar
investment
Standards
Activity
Time

Conform Andrew Tanenbaum

- The standards were drawn up by large committees
- Everything but the kitchen sink was included
- The resulting standards were enormously complex
- initial implementations were huge, slow, buggy
- Soon people thought: OSI = bad quality
- TCP/IP was already good quality

Q: What do you get when you cross a mafia gangster with an international standard?

A: Someone who makes you an offer you can’t understand

Standardizarea

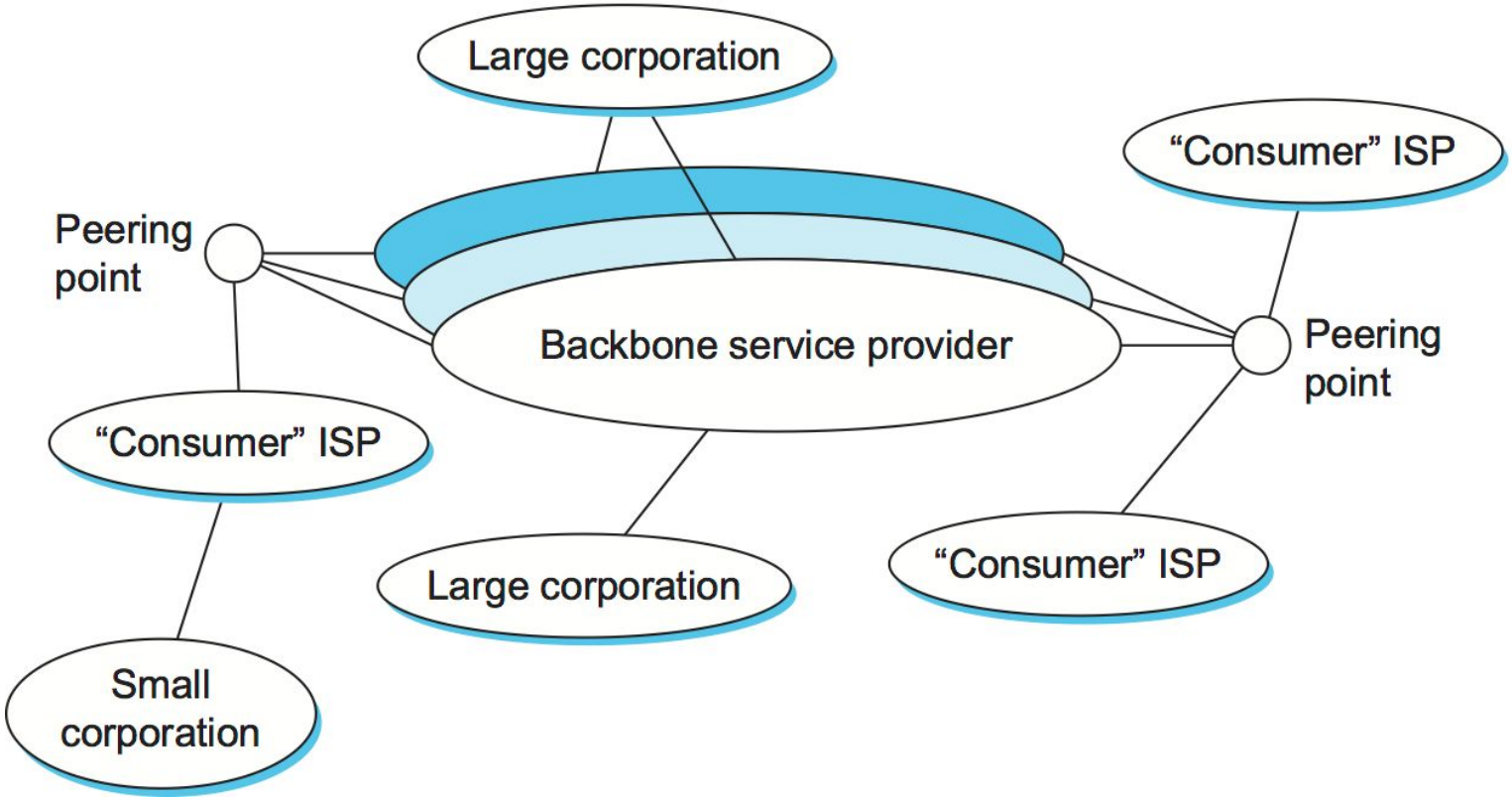
Body	Area	Examples
ITU	Telecommunications	G.992, ADSL H.264, MPEG4
IEEE	Communications	802.3, Ethernet 802.11, WiFi
IETF	Internet	RFC 2616, HTTP/1.1 RFC 1034/1035, DNS
W3C	Web	HTML5 standard CSS standard

IETF RFC https://www.ietf.org/standards/rfcs/

Grupuri IEEE 802 en.wikipedia.org/wiki/IEEE_802

IEEE 802.11	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)	Active
IEEE 802.15.4	Low-Rate wireless PAN (e.g., ZigBee, WirelessHART, MiWi, etc.)	Active
IEEE 802.1	Higher Layer LAN Protocols Working Group	Active
IEEE 802.15	Wireless PAN	Active
IEEE 802.3	Ethernet	Active

Să revenim la partea de rețea



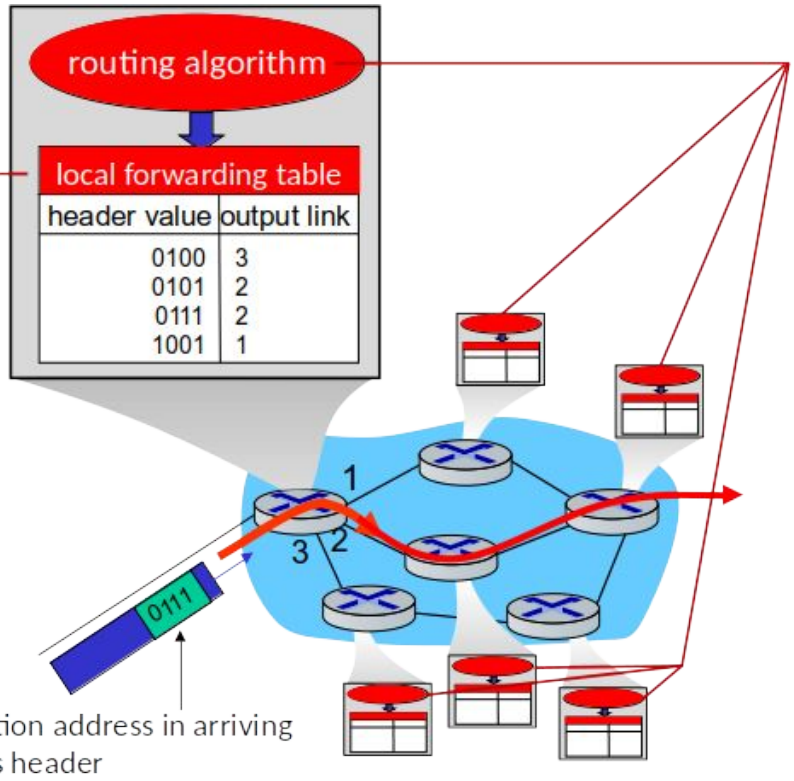
În interiorul ISP-urilor

- există o topologie de dispozitive intercontectate
- funcționează un proces numit **packet-switching**
- rețeaua redirecționează pachetele de la un dispozitiv la altul, prin diferite tipuri de legături (links) către destinație

Routing vs. Forwarding

Forwarding:

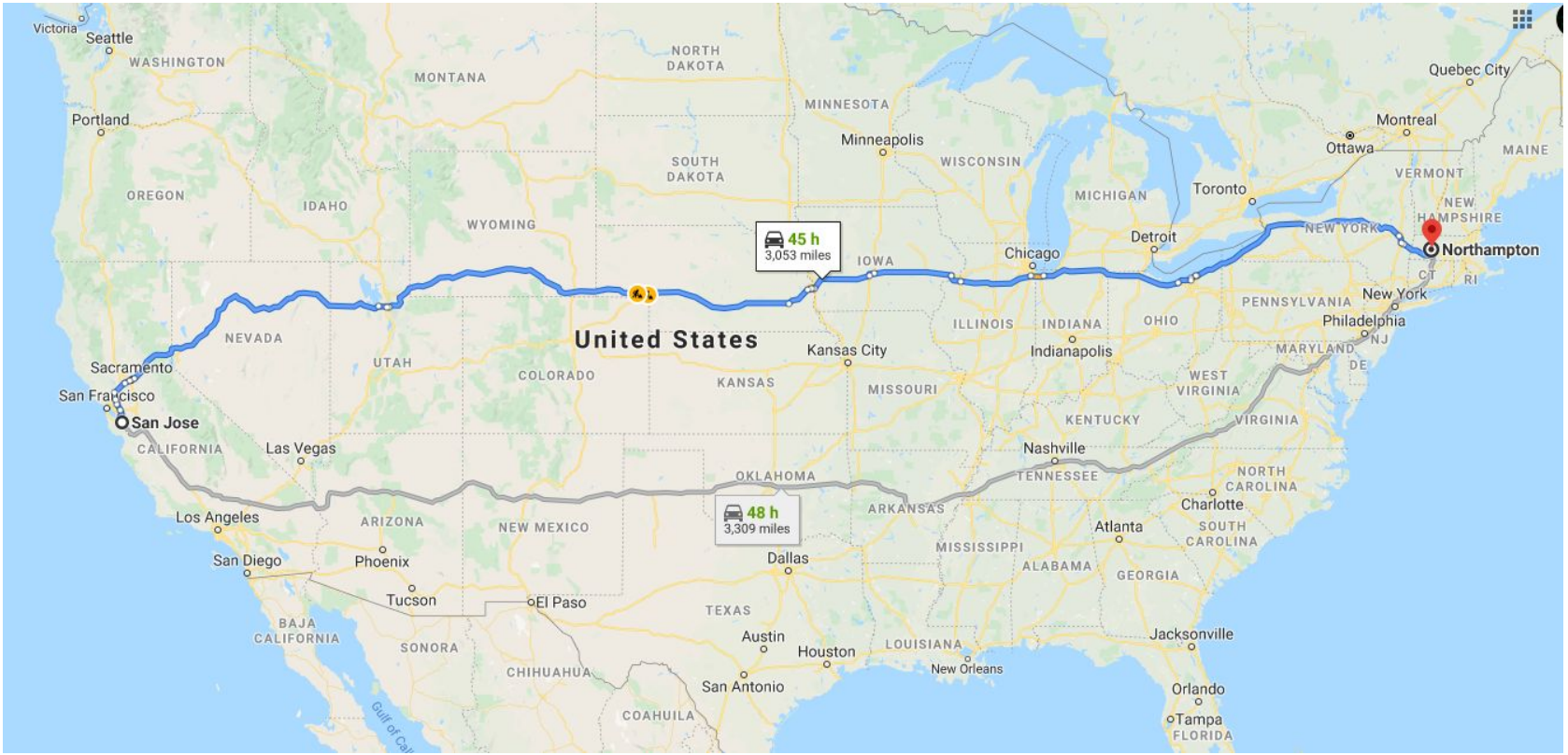
- aka "switching"
- *local* action: move arriving packets from router's input link to appropriate router output link



Routing:

- *global* action: determine source-destination paths taken by packets
- routing algorithms

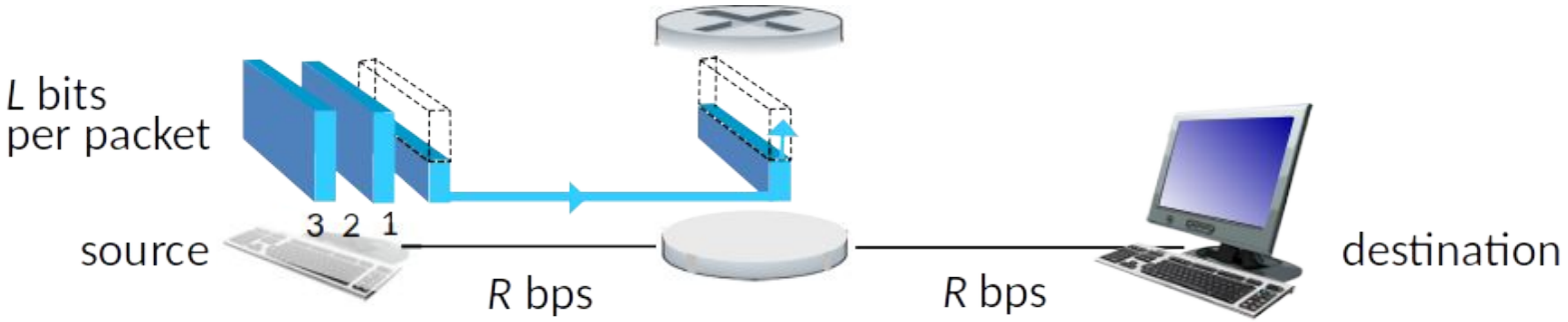
Routing


45 h
3,053 miles
48 h
3,309 miles
San Jose
Northampton
United States
Victoria
Seattle
WASHINGTON
Portland
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEVADA
UTAH
COLORADO
Sacramento
San Francisco
CALIFORNIA
Las Vegas
Los Angeles
San Diego
ARIZONA
Phoenix
Tucson
El Paso
NEW MEXICO
BAJA CALIFORNIA
SONORA
CHIHUAHUA
COAHUILA
TEXAS
Austin
Houston
San Antonio
Dallas
OKLAHOMA
KANSAS
Kansas City
MISSOURI
IOWA
MINNESOTA
Minneapolis
WISCONSIN
ILLINOIS
Chicago
MICHIGAN
Detroit
INDIANA
Indianapolis
OHIO
KENTUCKY
Nashville
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
LOUISIANA
New Orleans
ARKANSAS
Atlanta
Charlotte
NORTH CAROLINA
SOUTH CAROLINA
Jacksonville
Orlando
Tampa
FLORIDA
Toronto
Ottawa
Montreal
Quebec City
MAINE
VERMONT
NEW HAMPSHIRE
NEW YORK
PENNSYLVANIA
New York
Philadelphia
NJ
MARYLAND
DE
WEST VIRGINIA
VIRGINIA
CT
RI

Forwarding

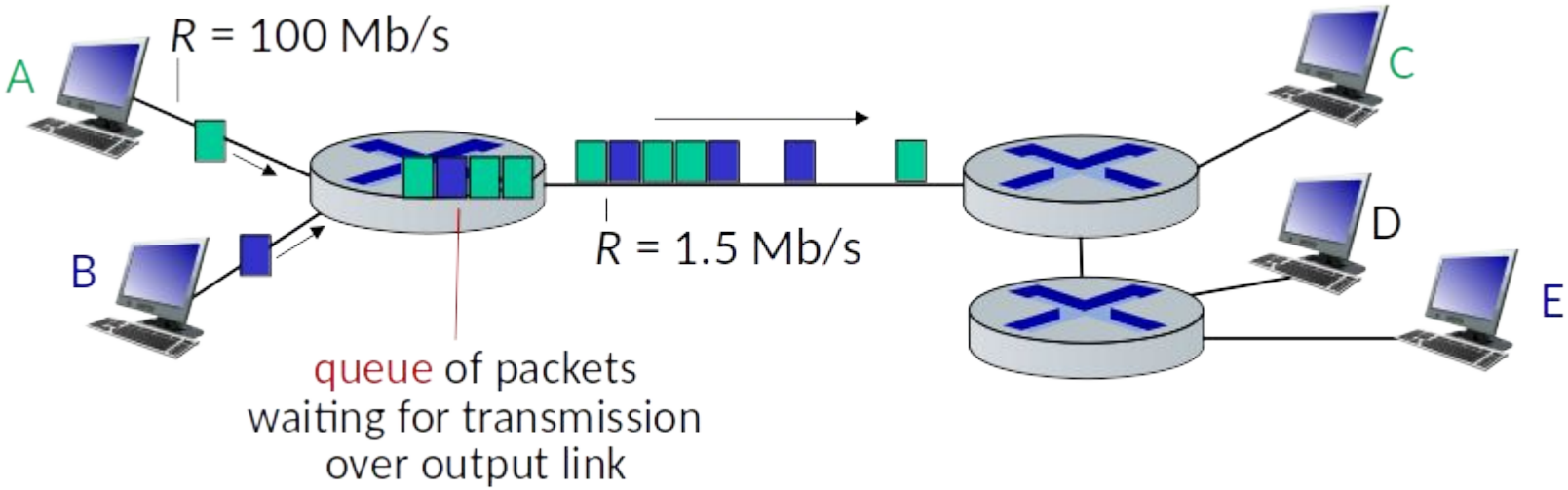

forwarding
forwarding
45 h
3,053 miles
48 h
3,309 miles
United States
Victoria
Seattle
WASHINGTON
Portland
NORTH DAKOTA
MINNESOTA
Minneapolis
SOUTH DAKOTA
WISCONSIN
MICHIGAN
Toronto
Quebec City
Montreal
Ottawa
MAINE
VERMONT
NEW HAMPSHIRE
Northampton
WYOMING
IOWA
Chicago
Detroit
ILLINOIS
INDIANA
OHIO
Kansas City
Indianapolis
COLORADO
KANSAS
MISSOURI
San Francisco
San Jose
CALIFORNIA
Las Vegas
KENTUCKY
Nashville
TENNESSEE
OKLAHOMA
ARKANSAS
Atlanta
Los Angeles
ARIZONA
NEW MEXICO
MISSISSIPPI
ALABAMA
San Diego
Phoenix
Dallas
Tucson
El Paso
TEXAS
BAJA CALIFORNIA
SONORA
Austin
Houston
LOUISIANA
New Orleans
CHIHUAHUA
San Antonio
COAHUILA
Tampa
FLORIDA
Cleveland

Packet-switching: store-and-forward



- packet transmission delay: takes L/R seconds to transmit (push out) L-bit packet into link at R bps
- *store and forward: entire* packet must arrive at router before it can be transmitted on next link

Switching - queueing



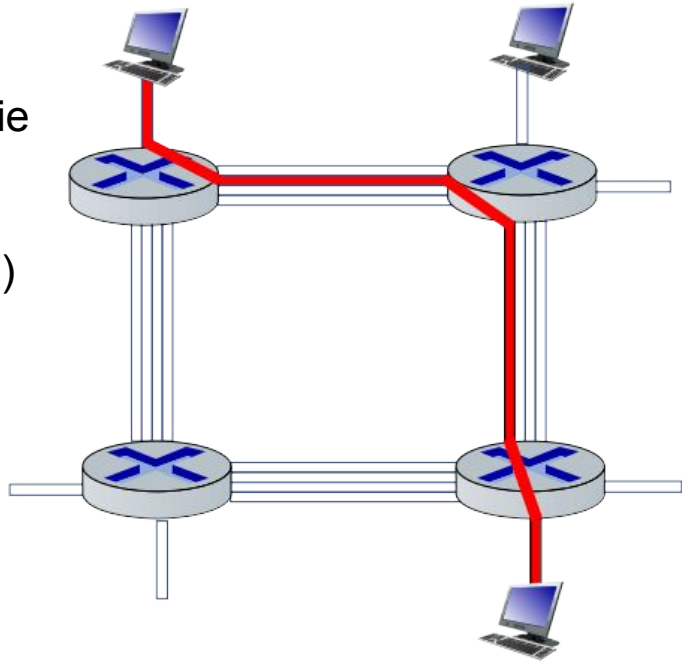
if arrival rate (in bps) to link exceeds transmission rate (bps) of link for some period of time:

- packets will queue, waiting to be transmitted on output link
- packets can be dropped (lost) if memory (buffer) in router fills up

Switching pe bază de circuit

- resurse alocate end-to-end între sursă și destinație
- resurse dedicate: **no sharing**
- circuit-like (guaranteed) performance
- circuit segment idle if not used by call (no sharing)

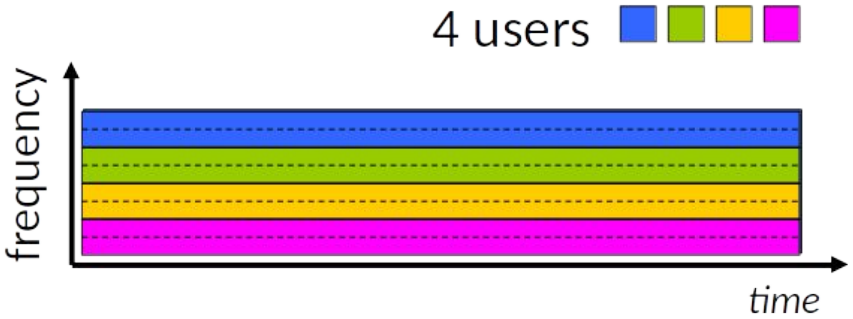
sursa: https://bit.ly/extra_retele



Multiplexarea: FDM and TDM

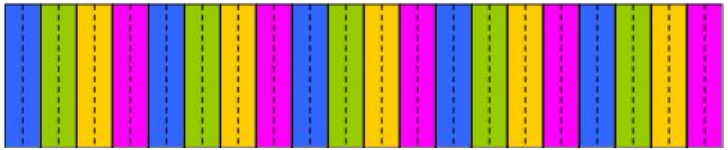
Frequency Division Multiplexing (FDM)

- optical, electromagnetic frequencies divided into (narrow) frequency bands
- each call allocated its own band, can transmit at max rate of that narrow band



Time Division Multiplexing (TDM)

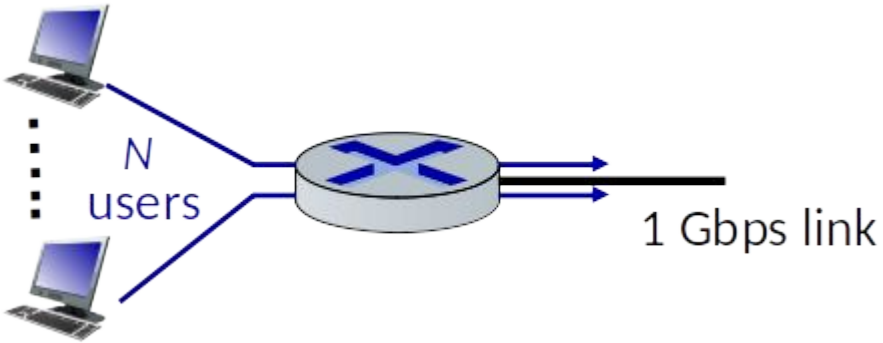
- time divided into slots
- each call allocated periodic slot(s), can transmit at maximum rate of (wider) frequency band (only) during its time slot(s)



Packet switching vs Circuit switching

example:

- 1 Gb/s link
- each user:
  - 100 Mb/s when “active”
  - active 10% of time



Q: câți utilizatori pot folosi concomitent această rețea pentru cele 2 tipuri de switching?

- circuit 10
- N avem în vedere o distribuție binomială https://en.wikipedia.org/wiki/Binomial_distribution
- soluția explicată și aici