UE PRIP
Principes des réseaux informatiques par la pratique
Introduction

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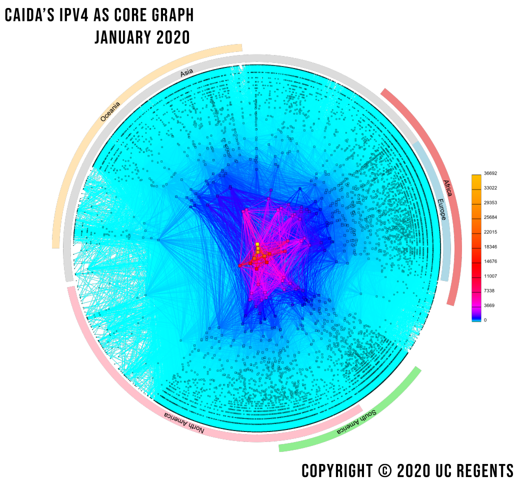
2022

Notes:



source https://www.caida.org/projects/as-core/2020/

Notes:

Today's objective

- get "feel" and some terminology
- more depth and detail later in course

Approach:

1. Introductory course using Internet as example
2. Individual quizz
3. Labs/TPs

Notes:

Today's roadmap

1. what's the Internet?
2. what's a protocol?
3. network edge: hosts, access net, physical media
4. network core: packet/circuit switching
5. protocol layers, service models, encapsulation
6. Internet's structure

Notes:

1. What's the Internet?

Notes:

What's the Internet?

A. "Construction" point of view (describing elements)
B. Service point of view

Notes:

What's the Internet?

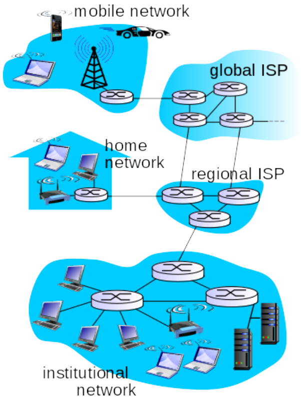
A. "Construction" point of view (describing elements)

- millions of connected computing devices: hosts running network apps
- communication links: fiber, copper, radio, satellite transmission rate: *bandwidth*
- routers: forward packets (chunks of data)

Notes:

What's the Internet?

A. "Construction" point of view (describing elements)



Notes:

What's the Internet?

A. A "construction" point of view (describing elements)

Some characteristics:

- Internet: "network of networks" loosely hierarchical
- protocols e.g., TCP, IP, HTTP, Skype, Ethernet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force
  - IEEE

Some questions:

Q public or private?

Q who governs Internet?

Notes:

What’s the Internet?

B. A services view

- A “thing” that allows as to use distributed applications
  - **Q** where do these applications run?
  - **Q** what are these applications?
- To use this “thing”, we have to respect some “rules ”
  - analogy: mail (physical)
  - APIs and Protocols (next slides)

thing = communication infrastructure
“rules” = APIs and protocols

Notes:

2. What’s a protocol?

Notes:

What’s a protocol?

Human protocols:

- introductions “what’s the time?” “I have a question”
- specific msgs sent
- specific actions taken when msgs received, or other events

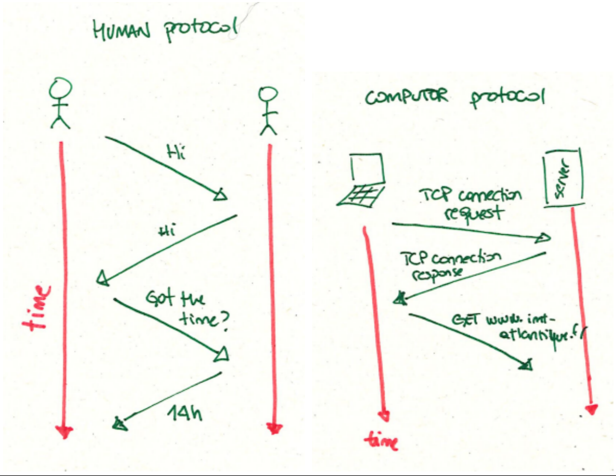
Network protocols:

- analogue to human protocols but
- machines rather than humans
- all communication activity in Internet governed by protocols

Notes:

What's a protocol?

Examples



Notes:

What's a protocol?

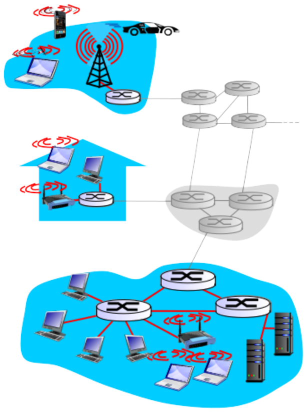
> Protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission and reception.

Notes:

3. Network edge

Notes:

Network Edge



Notes:

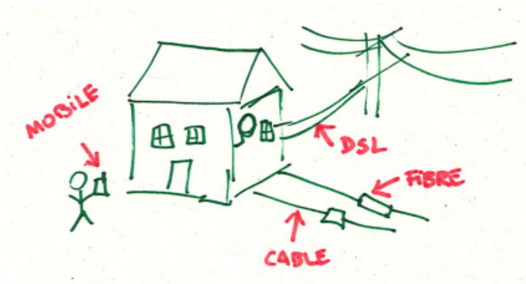
Network Edge

What is in the networks' edge?

- end systems
  - run applications (e.g. email, web,..)
- access networks
  - residential
  - institutional
  - mobile
- access technologies
  - physical media: wireless, wired, fiber
  - evolutions e.g. 1G, 2G .. VDLS, VDSL2, IEEE 802.11 a, b ... ax

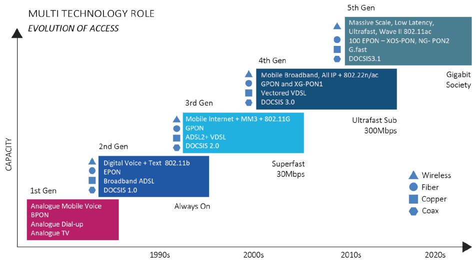
Notes:

Broadband access technologies



Notes:

Broadband access technologies



Source: ADTRAN relayed by `http://reports.broadbandcommission.org/`

Keep in mind! Bandwidth (bps)? dedicated or shared?

Notes:

Physical media

Copper, Coax, Fiber, Air

Twisted Pair (copper), RJ45 connector for twisted pair, RJ45 and Coaxial connectors, Ethernet NIC (RJ45), Coaxial NIC, Fiber connectors

Notes:

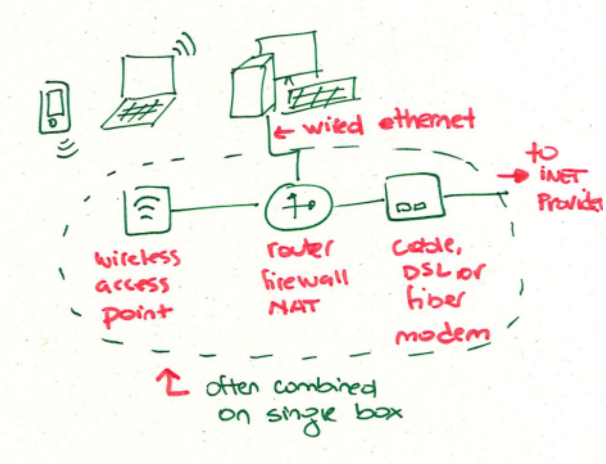
Access networks

Mobile access

Notes:

Access networks

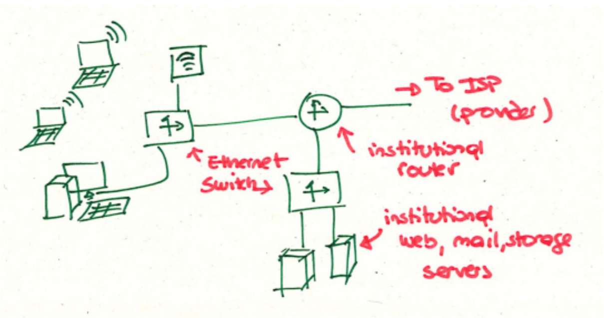
Home/ Residential network



Notes:

Access networks

Institutional network



Notes:

End hosts

End host:

- takes applications' message and breaks it into chunks of data (packets) of say length L bits
- sends the packet through a network interface at transmission rate R bps
  - transmission rate also known as bandwidth also known as capacity

Transmission delay (D) is thus given by L and R.
$D = \frac{L \text{ (bits)}}{R \text{ (bits/second)}}$

! There are other sources of end-to-end delay: propagation, queuing, processing, we'll see it later!

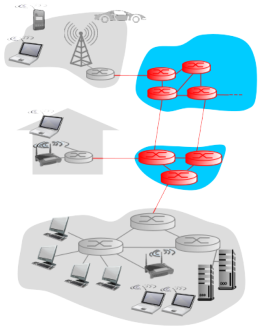
Notes:

4. Network Core

Notes:

Network Core

Packet switching core



- we usually talk of aggregation network and core network, but today we are simplifying
- mesh of interconnected *routers*

Notes:

4. Network Core

Routers forward packets from *one router to the next*, across links based on packet destination, each packet transmitted at full link capacity

Notes:

How is the *next router* determined?

Some key vocabulary: routing and forwarding

Routing function: determines source-destination route taken by packets on a *per-hop* basis

- The routing function, thanks to a routing algorithm, determines the routing table.

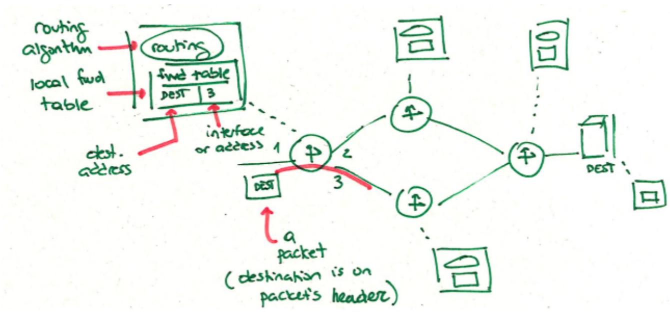
Forwarding function: moves packets from router's input interface to appropriate router outputs interface

- The forwarding function, uses such table to decide through which output interface send the packet

! Both functions performed at each router.

Notes:

Routing and Forwarding functions



Notes:

Store-and-forward packet-switching

Store and forward: entire packet must arrive at router before it can be transmitted on next link

! introduces a delay of $D = L/R$ seconds at each *hop* (where as before L is the length of the packets in bits and R the interface's capacity in bps)

! This is how Internet works nowadays

Notes:

Alternative Core: Virtual circuit

End-end resources allocated to, reserved for, "call" between source, dest.

- dedicated resources: no sharing
  - circuit-like (guaranteed) performance
  - resource piece remains idle if not used by owning call (no sharing)
- dividing link bandwidth into "pieces"
  - frequency division
  - time division

Example: telephony network

Notes:

Circuit-switched vs Packet switching networks

Analogy: restaurant with and without reservations.

Restaurant with reservations:
☺You arrive and are served immediately
☹You have to call and reserve before going
☹If you don't show, the restaurant wastes a table

Restaurant without reservations:
☹You might have to wait on arrival
☺You don't have to call in advance to reserve
☺Restaurant doesn't take the risk of wasting a table

Notes:

Statistical multiplexing

Packet switching allows more users to use network!

Example

- 1 Mbps link
- each user is active (i.e. sends data) 10% of the time
- each user when active sends data at rate 100kbps

Q How many users can be supported?

- Circuit-switching: 10 users
- Packet-switching: With 35 users probability of more than 10 users transmitting at the same time is $\sim$ 0.0004

Q How did we get value 0.0004?
Q What happens if there are more than 35 users?

Notes:

Is packet-switching *better* than circuit-switching?

☺Packet-switching is great for bursty data

- resource sharing
- simpler, no call setup

☹No performance guarantees, excessive congestion possible: packet delay and loss

- protocols needed for reliable data transfer and congestion control

Q Examples of applications generating bursty and non-bursty data?

Q How to provide bandwidth guarantees, needed for some applications, on packet-switching networks?

- several "patches" exist, but till a research problem!

Notes:

A word on end-to-end packet delay

Packet-switched networks experience different source of delays:

- **Transmission** at each node
- **Propagation** through physical media
- **Queuing** at nodes
- **Processing** at nodes

Notes:

5. Layers model

Notes:

Protocol Layers

Networks are complex!

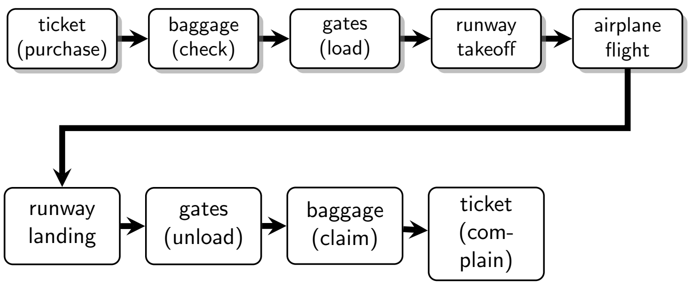
Q How can we organize the discussion to make it simpler?

Q How can we organize such systems to make them simpler, easier to develop, as little as possible prune to errors, upgradeable, scalable, ...?

Notes:

Analogy: organization of a travel

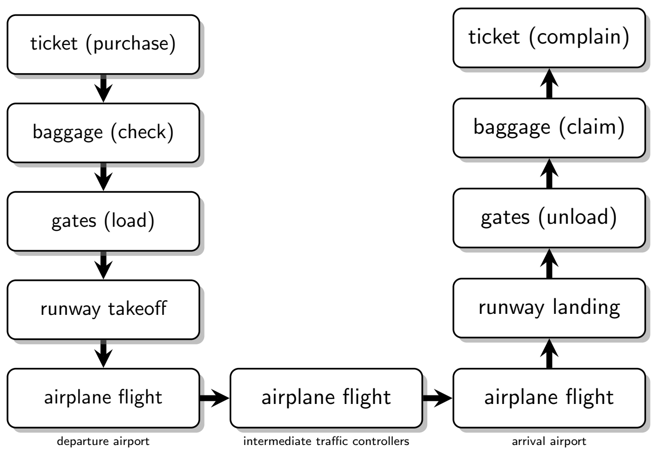
Different steps



Notes:

Analogy: organization of a travel

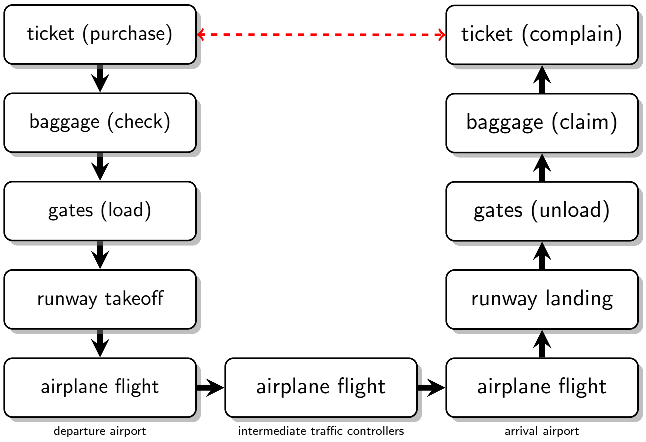
Let's arrange steps differently



Notes:

Analogy: organization of a travel

Process on different entities but of same 'layer' can 'understand' each other



Notes:

Analogy: organization of a travel

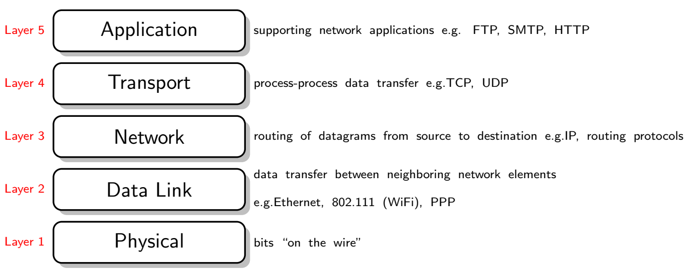
We have constructed a layered service architecture

Each layer provides a service

- via its own internal-layer actions and functions
- relying on services provided by layer below
- each layer 'talks' to its homologue

Notes:

Layered reference model in the Internet



Notes:

ISO/OSI reference model

- Application
- Presentation — allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- Session — synchronization, checkpointing, recovery of data exchange
- Transport
- Network
- Data Link
- Physical

! Internet stack "missing" two layers! ⇒ these services, if needed, must be implemented in application

Q Are they needed?

Notes:

Layers as a means to deal with complex systems

Some motivations for layering:

- ease implementation: focus on one function, rely on others for solving other 'problems'
- layered reference model for discussion
- modularization eases maintenance, updating of system
- change of implementation of layer's service transparent to rest of system e.g., change in gate procedure doesn't affect rest of system

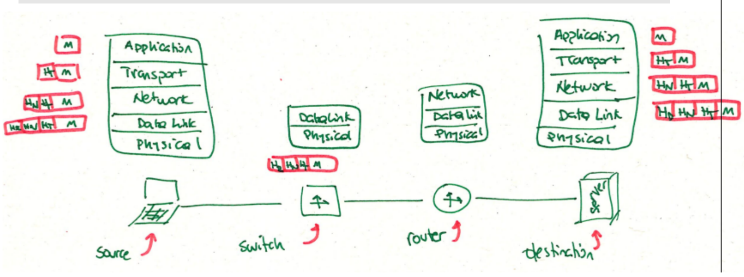
Q Can you think of any cons of layering?

Notes:

Encapsulation

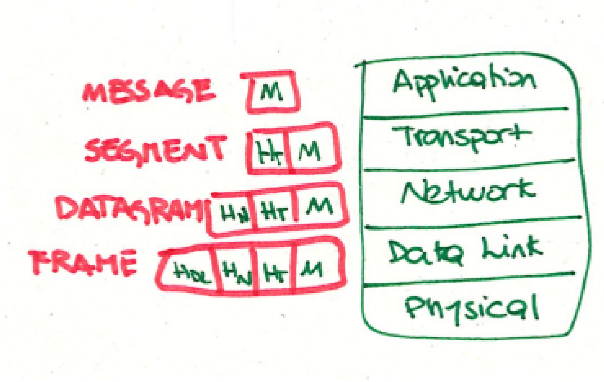
How does each process "talk" to its homologue on another equipment?

Messages are *encapsulated* i.e. extra information (known as *headers*) are added by each layer in the source, and interpreted by corresponding layers in middle equipments (e.g. switches,routers) and by the destination.



Notes:

Some vocabulary



Q Analogy between headers, encapsulation and our travel planning example?

Notes:

Summary

Make sure you have some initial idea of the following concepts! (we'll come back to them during next classes)

- Access network, Access technologies, Core network
- Packet
- Protocol
- Layers
- Delay

Notes:

Acknowledgements

The contents of these slides are partially taken from Computer Networking a Top Down approach, J. KUROSE and K. ROSS and K. KUROSE's networking course
`http://www-net.cs.umass.edu/cs453_fall_2013/`

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