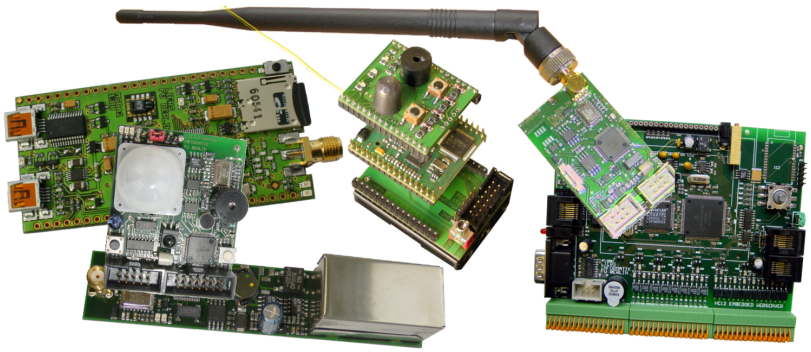

19531 - Telematics

1st Tutorial - Terminology & Basics

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Outline

1. ISO/OSI model
2. Path selection
3. Physical layer
4. Routing Schemes
5. Overhead
6. Services in a Layered Communication System
7. Latency and Bandwidth
8. Protocol Overhead
9. Asynchronous vs. Synchronous
10. Connection Properties
11. Terminology
12. Terminology 2
13. Race of Technologies
14. Networks in the Real World
15. The Core of the Internet

ISO/OSI model

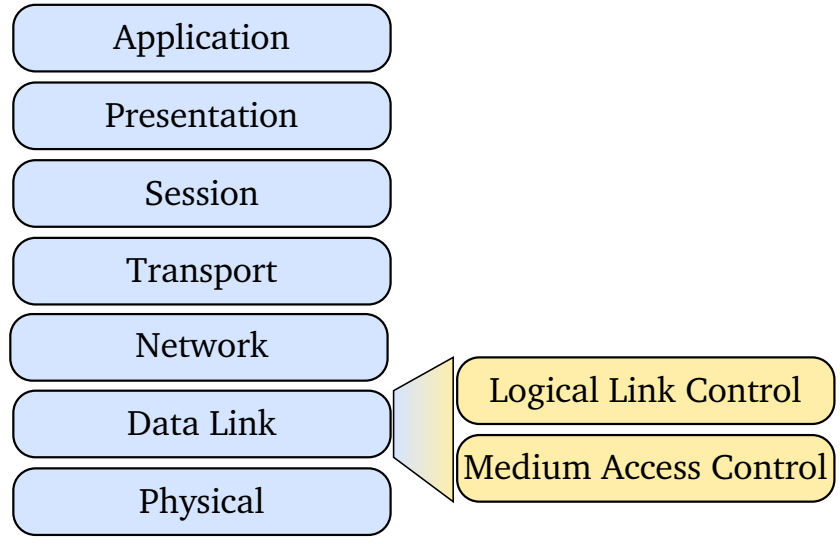
- Name the layers of the ISO/OSI model starting from the top and their general functions.

Memorize one of these sentences:

"**A**ll **P**eople **S**eem **T**o **N**eed **D**ata **P**rocessing."

"**P**lease **D**o **N**ot **T**hrow **S**ausage **P**izza Away"

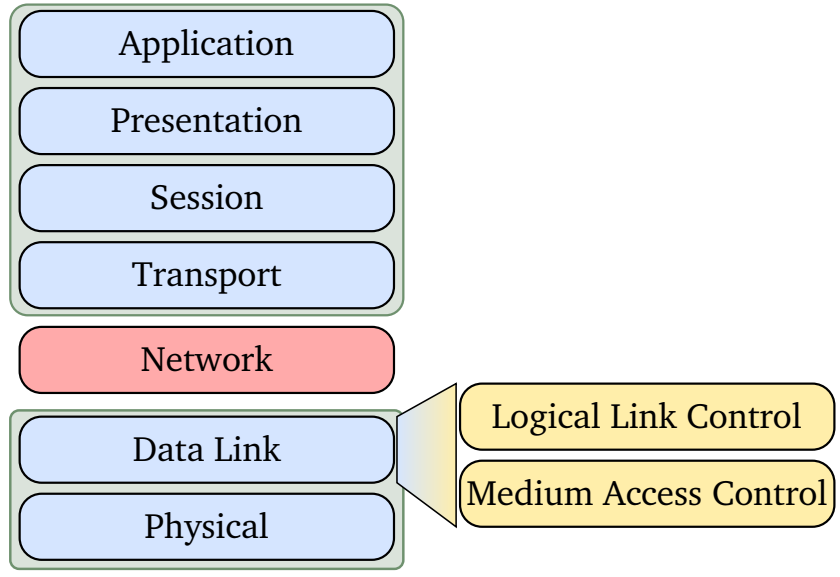
"**P**lease **D**o **N**ot **T**ell **S**ales **P**eople **A**nything"



Path selection

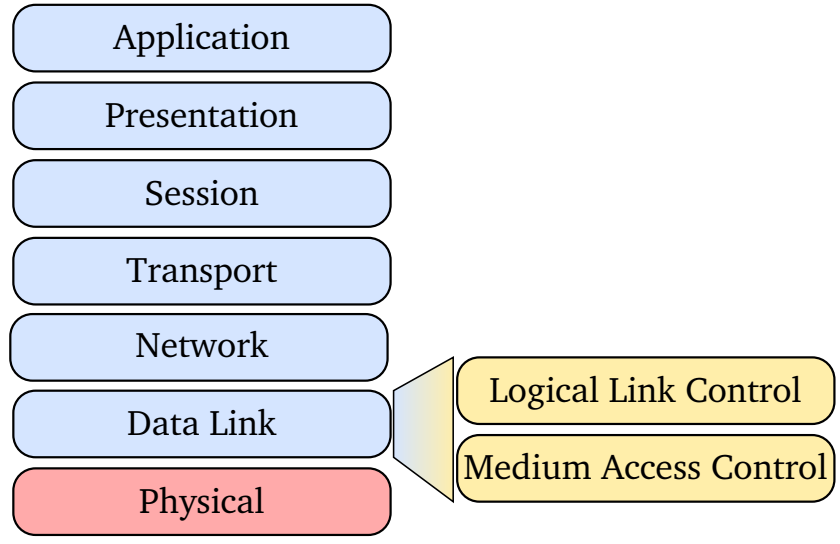
- Which layer has the task of path selection in an inter-network?

- Answer: Layer 3, the network layer
- Layer 1-2
  - Local communication
  - Nodes in same network segment
  - Point-to-point, (direct) link
  - Host-to-network layer
- Layer 4-7
  - Host specific
  - Communication between hosts over a network
  - Nodes in the network (usually) will only implement and evaluate data from layer 1-3 protocols



- What does the physical layer define?

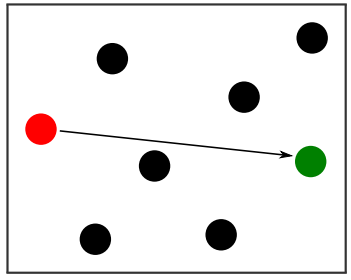
- Type of media
- Maximum transmission distances
- Physical connectors
- Voltage levels
- Time of voltage changes
- Physical data rates
- ...



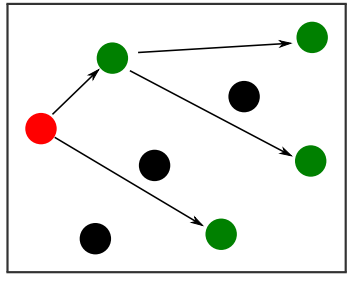
Routing Schemes

- Explain the differences of **unicast**, **multicast**, **anycast**, and **broadcast** transmissions.
- Give an example application for each transmissions type.
- Do you know what a **concast** and **geocast** is? What is the difference between a broadcast and **flooding**?

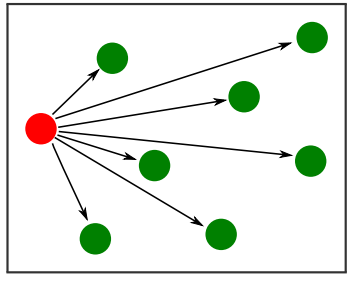
- Unicast
  - Transmission from one source to one destination
  - Source knows address of destination
  - Example: web server access



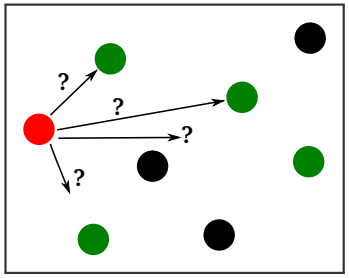
- Multicast
  - Transmission from one source to many hosts
  - Hosts register to receive the data from a source
  - Often tree structures for routing
  - Source does not know destination hosts
  - Example: video streaming



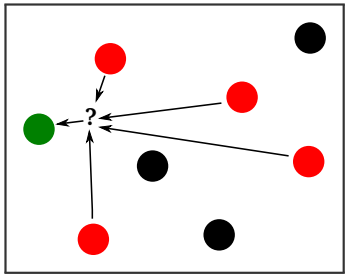
- Broadcast
  - Transmission from one source to every station (on the local network segment)
  - Source sends to dedicated broadcast address
  - Wireless communication always implies physical layer broadcast
  - Example: service discovery, layer 3 to layer 2 address resolution (ARP)



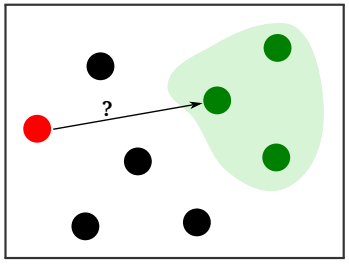
- Anycast
  - Transmission from one source to “best” candidate, e.g. closets, destination
  - All potential destinations offer the same specific service
  - Who is the best service provider has to be determined by the network/protocol
  - Used to provide high availability and load balancing for stateless services
  - Example: distributed DNS



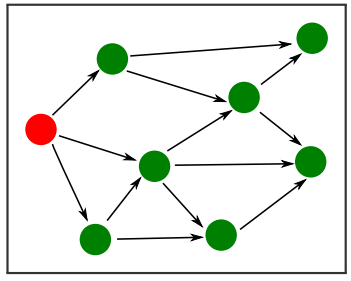
- Concast
  - “Inverse multicast”
  - Transmission from many sources to one destination
  - Network merges packets (aggregation)
  - Sources appear as one group for the destination
  - Reduction of bandwidth consumption
  - Example: Report-in, client-multiserver scenarios



- Geocast
  - Transmission to a group in a specific geographic region
  - Special kind of multicast
  - Example: Location Based Services



- Flooding
  - “Multi-hop broadcast”
  - Transmission from one source to every station in the network
  - Receiver forwards received packets by broadcast
  - Over multiple network segments / physical layer broadcast domains
  - Example: Route discovery in wireless networks
  - Please note: There are different definitions of broadcast and flooding!



Overhead

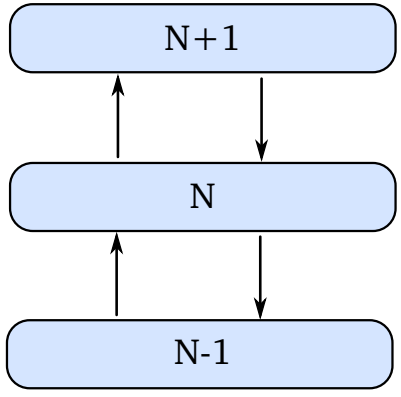
- Explain which service type has more overhead: connection-oriented or connection-less?

Overhead

- Connection-oriented communication has higher overhead due to
  - Connection setup
  - Connection termination
  - Usually flow and/or congestion control
- Data can just be transmitted with connection-less communication
- Connection-oriented and connection-less communication can be found on different layers of the protocol stack
  - Transport layer: TCP vs. UDP
  - Network layer: IPv4 vs. ST2 (RFC 1819)
  - Host-to-network: Ethernet vs. Frame Relay

1. Explain why the layers of a n-level communication system should never use or supply services of/to other layers other than ones below resp. above?
2. Which alternative does exist to a layered communication model? Name an application where this model is more useful.

1. Reasons for a layered architecture:
   - Interchangeability of layer implementations
   - Specific Service Access Points (SAPs), less restrictive than an API
   - Abstraction, lower layers as a “black box”
   - Security, information hiding
   - . . .
2. Cross-layering
   - No layered and modular protocol stack, layers use services of any other layer
   - More useful when optimized solutions are required
   - Example: wireless sensor networks $\rightarrow$ energy efficiency achieved by optimizing all layers and sharing information



The terms *latency* and *bandwidth* have been introduced in the lecture. Discuss in which of the following application scenarios latency, bandwidth, or both are most important.

1. FTP (file transfer)
2. SSH (shell access)
3. Pay-TV video streaming
4. Remote controlled emergency shut-off system
5. Telemedicine in the surgery
6. Access to the world wide web
7. E-Mail

Latency and Bandwidth

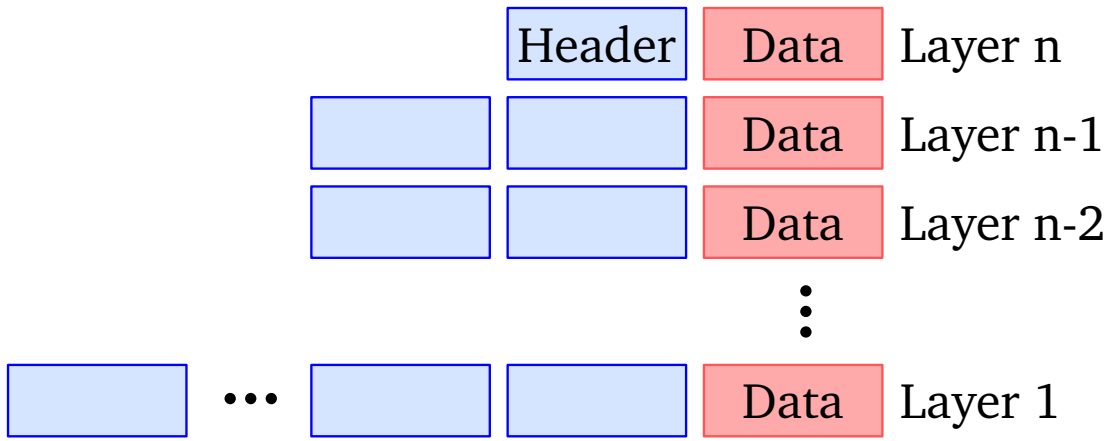
1. FTP: bandwidth
2. SSH: secure shell, therefore terminal environment $\rightarrow$ latency; when using ssh based files services, like secure copy (SCP) $\rightarrow$ bandwidth
3. Pay-TV video streaming: bandwidth; especially with large buffers; no real time aspect
4. Remote controlled emergency shut-off system: latency; bandwidth not important as the messages are usually small
5. Telemedicine in der surgery: both properties are important; high resolution video needs high bandwidth and picture has to be updated in real time
6. Access to the world wide web: both properties are important; website are quite large today and user does not want to wait
7. E-Mail: with attachments $\rightarrow$ bandwidth; usually depends on user and client what is more important

Protocol Overhead

- Consider a layered network architecture with *n* levels.
- Each protocol on a level adds a header of *h* bytes.
- What fraction of the network bandwidth is lost due to the overhead when *m* bytes are generated by an application on the top-most layer?

Protocol Overhead

- $n \times h$ bytes are prepended to the data of m bytes
- $m + n \times h$ bytes will be transmitted over the medium
- A fraction of $\frac{n \times h}{m + n \times h}$ of the bandwidth is lost for application layer data transmission



Asynchronous vs. Synchronous

- Name the advantages and disadvantages of asynchronous and synchronous timing schemes in the context of data transmission.

Asynchronous vs. Synchronous

Please note: The terms asynchronous and synchronous have many slightly different meanings in different domains of computer science

- Asynchronous
  - simple and inexpensive to implement (e.g. serial ports)
  - start- and stopbit for every character → higher overhead
  - typically used with low transfer rates

Idle	Start bit	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Stop bit	Idle

- Synchronous
  - more complex and expensive to implement (e.g. Ethernet)
  - more efficient, one start- and stopfield for multiple characters

Flag	Control	Bytes 0..n	Control	Flag

In this context, *efficiency* is defined as follows:

$$\text{efficiency} = \frac{\text{data transmitted}}{\text{bits sent}} \quad (1)$$

Assume an asynchronous transmission scheme requires 1 start bit and 1 stop bit (2 bits overhead per byte of data). 20 kB of data are transmitted.

$$20\ kB = 160\ kbits \quad (2)$$

$$160\ kbits + 40\ kbits = 200\ kbits \quad (3)$$

$$\frac{160\ kbits}{200\ kbits} * 100 \Rightarrow 80\%\ \text{efficiency} \quad (4)$$

In contrast, assume a synchronous transmission scheme with 3 byte overhead:

$$3\ Byte = 24\ bit \quad (5)$$

$$160\ kbits + 24\ bit = 160.024\ kbits \quad (6)$$

$$\frac{160\ kbits}{160.024\ kbits} * 100 = 99.985\%\ \text{efficiency} \quad (7)$$

Connection Properties

- Explain the terms **simplex**, **duplex**, and **half-duplex**.
- Name an example medium of each type.

Connection Properties

- Simplex
  - Fire detector and other sensors
  - Pager
  - Monitor and TV
  - Media without reverse channel

- Duplex
  - Telephone
  - Ethernet cable (CAT-5 or better)

- Half-duplex
  - Walkie-talkie
  - GSM mobile phone
  - Basically all technologies with a shared medium

Terminology

- Explain the terms **signal**, **data**, and **information** in the context of Telematics.

- Data: representation of facts, concepts, or statements; cannot be transmitted without transformation into signals

- Signal: physical representation of data; can be transmitted and received

- Information: data interpreted by a human; leads to increased knowledge

Terminology 2

- Explain what the terms **throughput**, **goodput**, and **packet delivery ratio** describe in the context of computer networks.

- Throughput: transmitted data per time unit

$$\text{throughput} = \frac{\text{bits transmitted}}{\text{time}} \tag{8}$$

- Goodput: application layer data transmitted per time unit without the protocol, management, and connection establishment/termination overhead contained in throughput

$$\text{goodput} = \frac{\text{bits received on the application layer}}{\text{time}} \tag{9}$$

$$\text{goodput} \leq \text{throughput} \tag{10}$$

- Packet Delivery Ratio (PDR): fraction of the received packets and the transmitted packets

$$\text{PDR} = \frac{\text{packets received}}{\text{packets sent}} \tag{11}$$

Race of Technologies

- A carrier pigeon can reach speeds of up to 100 km/h and carry an USB mass storage device with 256 GByte.
- Up to which range has the pigeon a higher data rate than a 1 Gbps data line?
- Assume that the pigeon can keep this speed indefinitely.

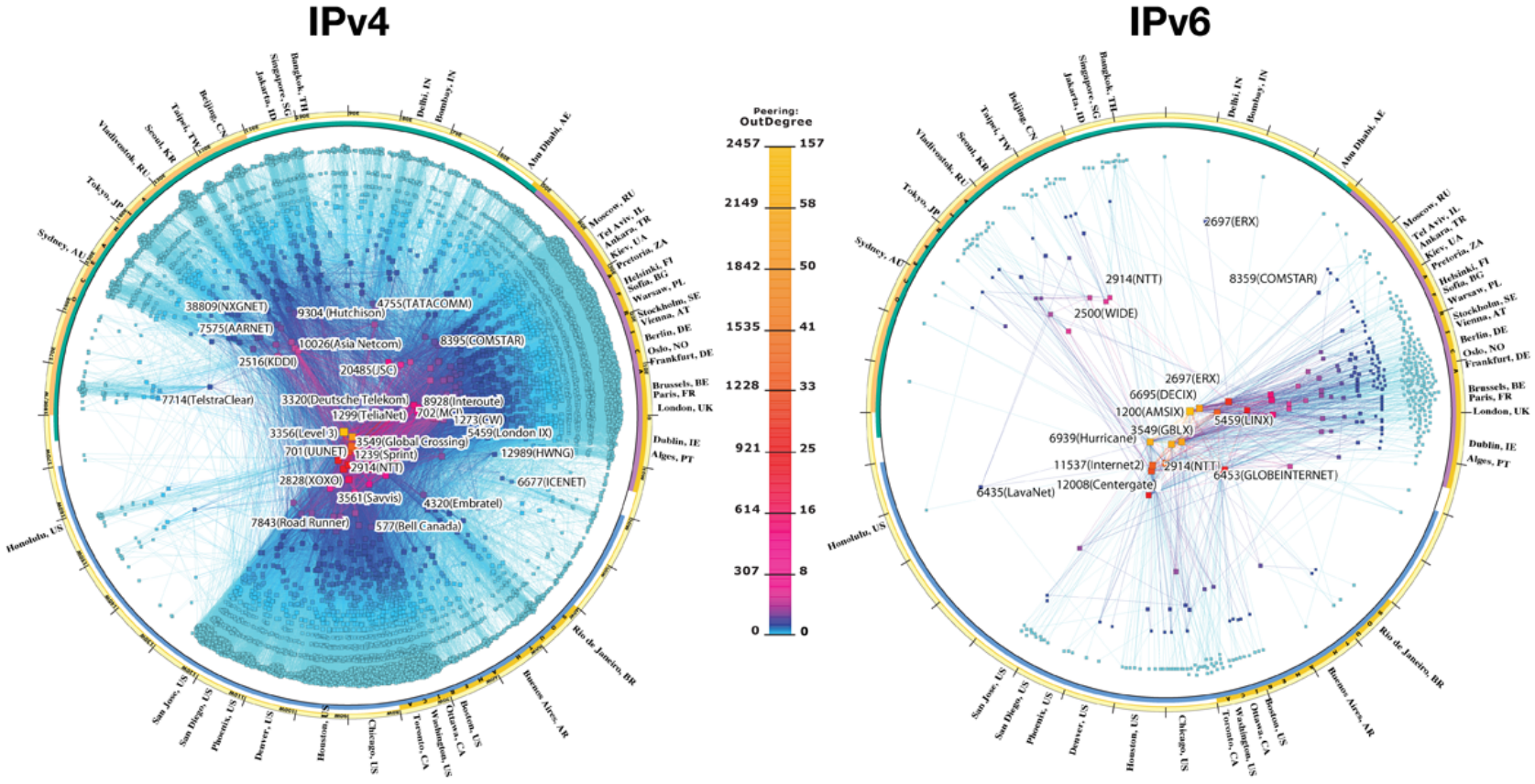
- The pigeon carries 256 GByte = $2,048$ Gbit
- 100 km/h = 27.78 m/sec
- The pigeons reaches a destination in distance d meter after $\frac{d}{27.78}$ sec = $0.036 \times d$ sec
- The pigeon's data rate is $\frac{2{,}048 \text{ Gbit}}{0.036 \times d \text{ sec}} = \frac{56{,}888.88}{d}$ Gbps
- 1 Gbps $\geq \frac{56{,}888.88}{d}$ Gbps $\Rightarrow d = 56,888.88$ meter
- Only for ranges larger than 56,888.88 meter, the data line has a higher data rate.

- Discuss where you find computer networks in our daily life and which types of networks do you know?
- Have you heard of the “Internet of Things”?

- Computer networks are basically ubiquitous today: Ethernet, GSM, UMTS, . . .
- Technologies like WiMax and Wireless LAN made clients mobile
- Future wireless technologies will allow a media independent handover; “always best connected” principle
- As computers become miniaturized even more things of our daily life will contain them
- “Smart things” create networks that result in the “Internet of Things”

The Core of the Internet

- Visit the following website
  http://www.caida.org/research/topology/as_core_network/
  and have a look at the data and media they provide.
- Discuss the existence of an Internet core.



$$radius = 1 - \log\left(\frac{outdegree(AS) + 1}{maximum.outdegree + 1}\right) \quad (12)$$

$$angle = \text{longitude of the AS's BGP prefixes in netacq} \quad (13)$$

- Internet consists of many *autonomous systems* (AS)
- Each AS managed by one entity: corporations, individuals, states
- Some AS with high node degree can be considered the core
- Failing AS does not lead to total breakdown
- *Default free zone* (DFZ) is sometimes considered as core

Thank you for your attention.

Questions?