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Systems Security

COMSM1500

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Network Security

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Plan

- OSI Model
- TCP/IP Model
- Type of attacks
  - Traffic Analysis
  - Message Disclosure
  - Masquerade
  - Message Modification
  - Replay
  - Topology Disclosure
  - Unauthorized Access
  - Denial of Service
- TCP Syn related attacks
- DNS poisoning
- Slow Loris attack

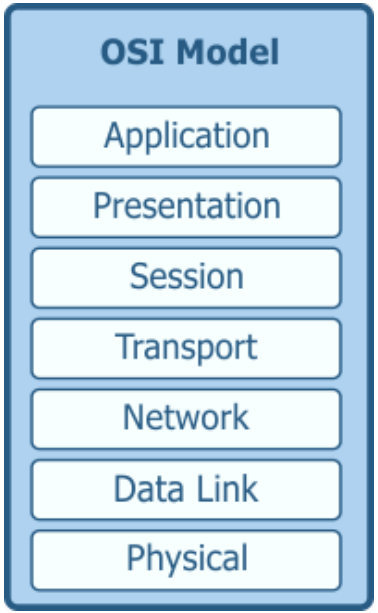
OSI Model

Layer	Description
Application Layer	High-level APIs. e.g. resource sharing, remote file access etc…
Presentation Layer	Translates data between the application and the network service. e.g. compression, encryption/decryption
Session Layer	Manages transmissions between two nodes across multiple messages.
Transport Layer	Supports and organises data transfer between nodes. e.g. segmentation, acknowledgment, multiplexing etc…
Network Layer	Handles addressing, routing and traffic control.
Data Link layer	Handles reliable data transmissions between two nodes connected by a physical layer.
Physical Layer	Transmission and reception of raw bits over a physical medium.

OSI Model

- This is just a model
- It does not quite fit reality
- … but it is a good mental model

OSI Model vs TCP/IP Model



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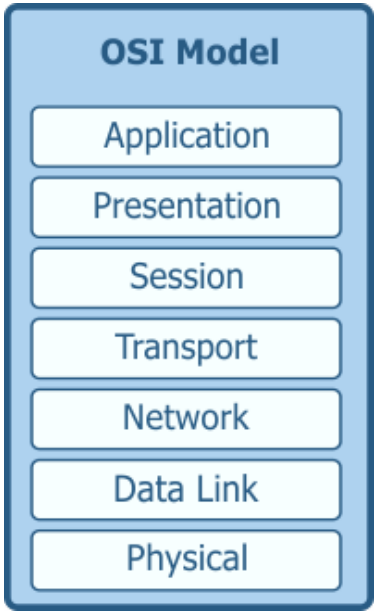

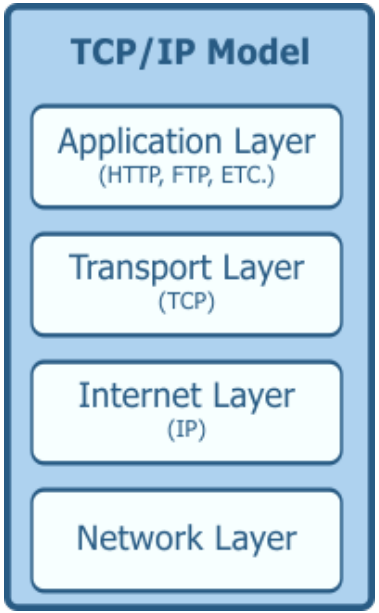

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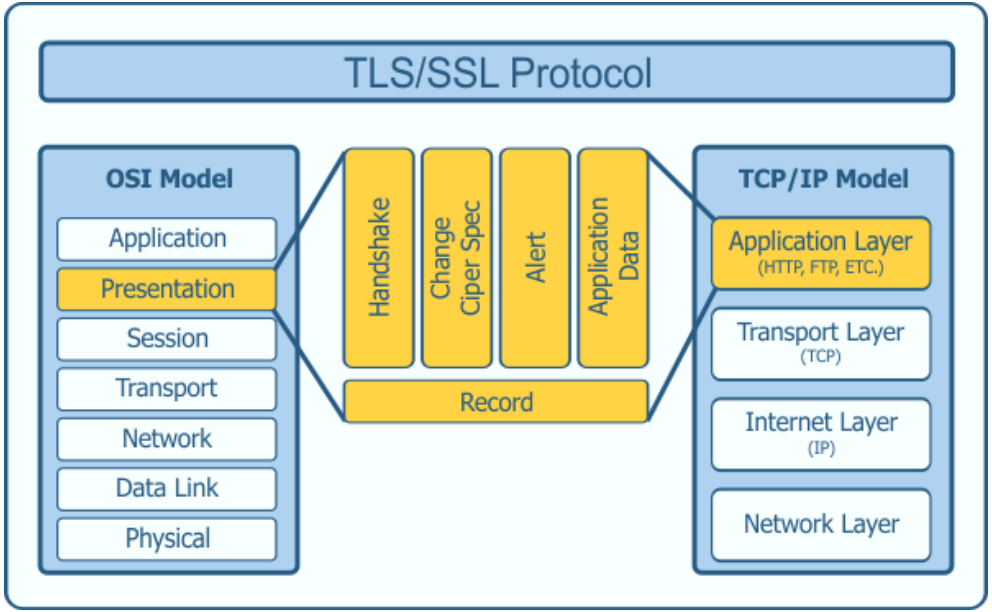
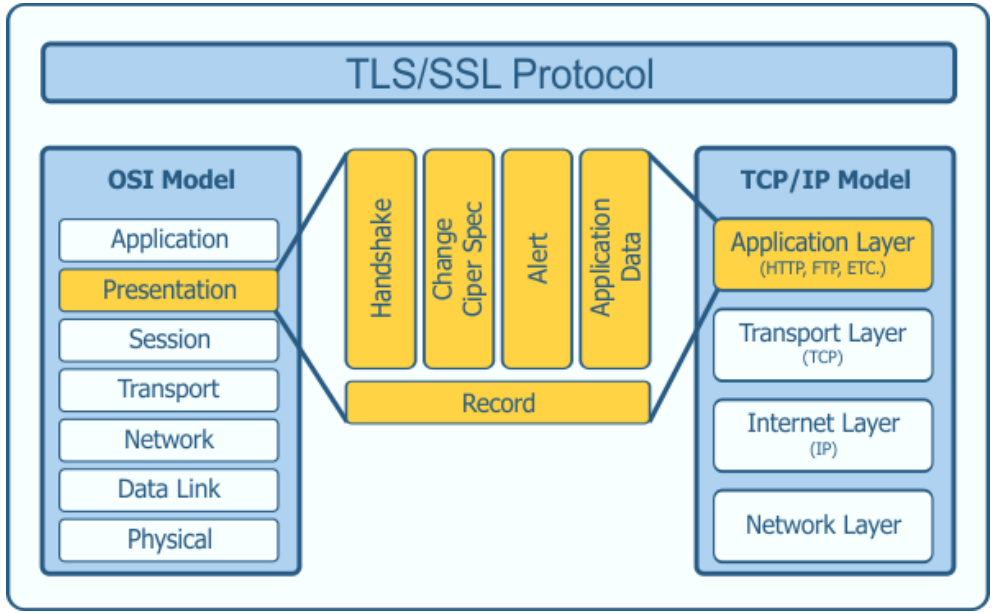


Encapsulation/Decapsulation

encapsulation

decapsulation



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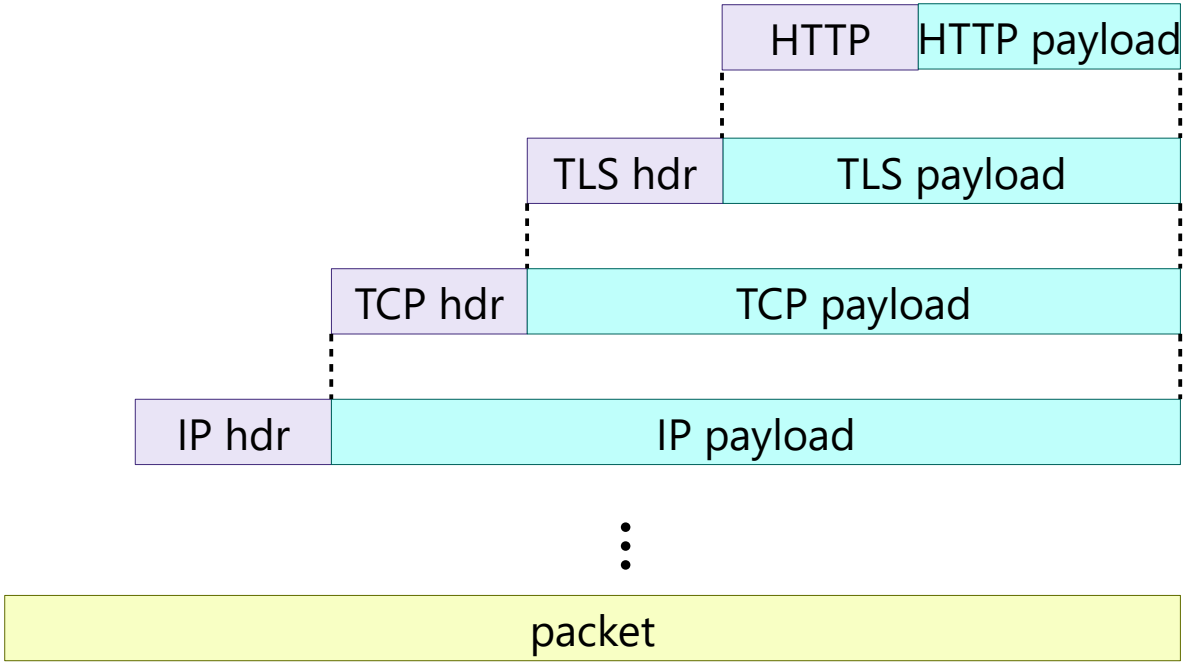
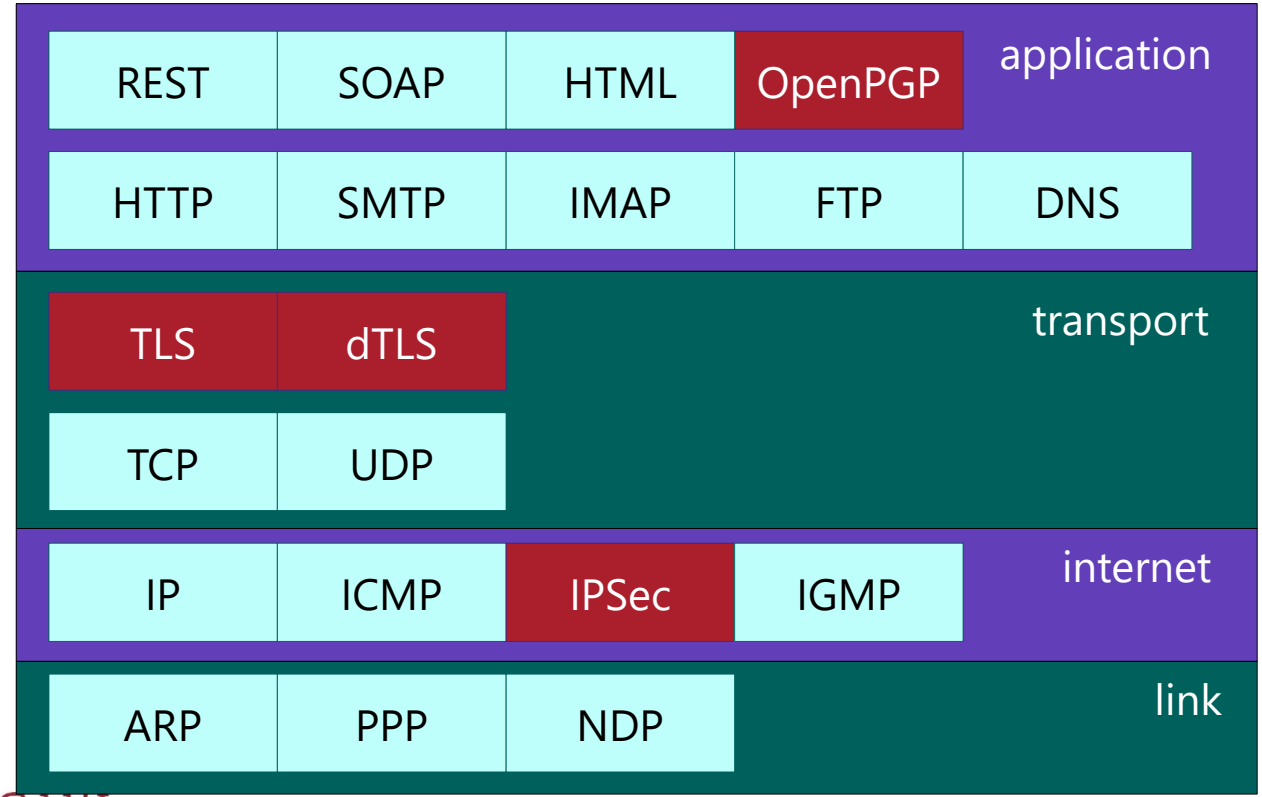


Security at different layers



Problems

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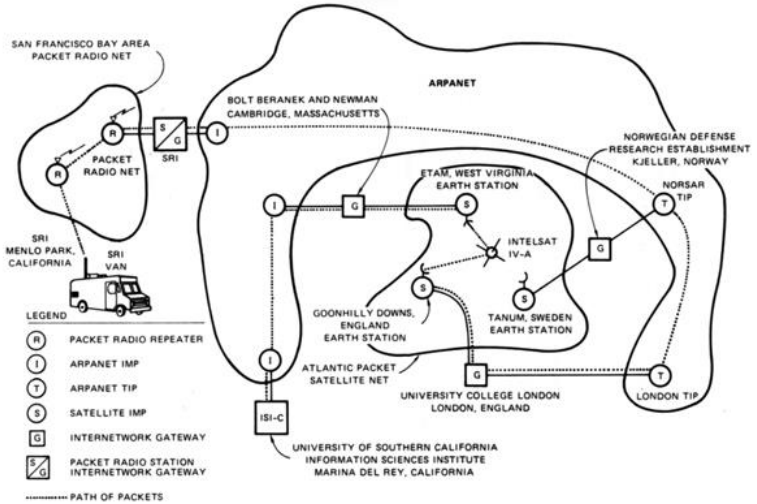
  - e.g. 1975 TCP/IP test between Stanford and UCL



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- … but also in the protocol themselves

Problems

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- Moved to a world where we know there is malign element in the network
- Issues in implementations
- … but also in the protocol themselves
- Need to improve security without disturbing the old
  - Lead to optional extra security, extra layers etc…
  - Takes a lot of time to move forward (e.g. IPv6)

Problems

Homework/potential exam question:
Discuss why securing network protocols is proving difficult in practice

- Size of the network have grown exponentially since most of the protocols were designed
- Moved to a world where we know there is malign element in the network
- Issues in implementations
- … but also in the protocol themselves
- Need to improve security without disturbing the old
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Type of attacks

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Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Understanding attacks
  - What and How

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- Understanding attacks
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- Two targets
  - Network Data
  - Systems Connected to the Network or Within the Network (e.g. switches)

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- Understanding attacks
  - What and How
- Two targets
  - Network Data
  - Systems Connected to the Network or Within the Network (e.g. switches)
- Passive and Active attacks

Type of attacks

	Passive	Active
Network Data	Traffic Analysis Message Disclosure	Masquerade Message Modification Replay
System	Topology disclosure Unauthorized access Denial of Service	

Type of attacks

- Traffic Analysis
  - Attacker can see who is exchanging messages
  - Number, time, pattern
  - e.g. timing analysis (seen in previous lecture, also check SSH timing attack on github)
- Message Disclosure
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
  - The attacker can read the content or some content of exchanged message
  - Countermeasure encryption
  - Although size can leak information
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
  - Pretending to be someone else
  - We have seen several examples in past lecture
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
  - Man in the middle
  - Receive message from Alice
  - Modify Message
  - Send it to Bob
  - Need to block traffic between Alice and Bob; and to Masquerade as Alice
  - See example in Browser Security Lecture
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
- Replay
  - Data maliciously retransmitted
  - e.g. Send “pay 100$” multiple times
  - We have seen example last week
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
  - Discover nodes connected to a network
  - Discover services running on those nodes
  - Example: port scan discussed several times during lectures (browser security lecture and Morris Worm)
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
  - Attacker try to break in another system
  - Many possible way to do so
  - Social Engineering, Phishing, Brute Force
  - See Lecture on Password
- Denial of Service

Type of attacks

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service
  - Attacker want to block usage of network resources (end nodes, routers etc…)
  - e.g. overload a server with very large number of request

Type of attacks

Homework/potential exam question:
Explain succinctly X type of attack

- Traffic Analysis
- Message Disclosure
- Masquerade
- Message Modification
- Replay
- Topology Disclosure
- Unauthorized Access
- Denial of Service

Type of attacks

- Traffic Analysis
  - We will discuss Tor and the like in a future lecture
- Message Disclosure
- Masquerade
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Vulnerability examples

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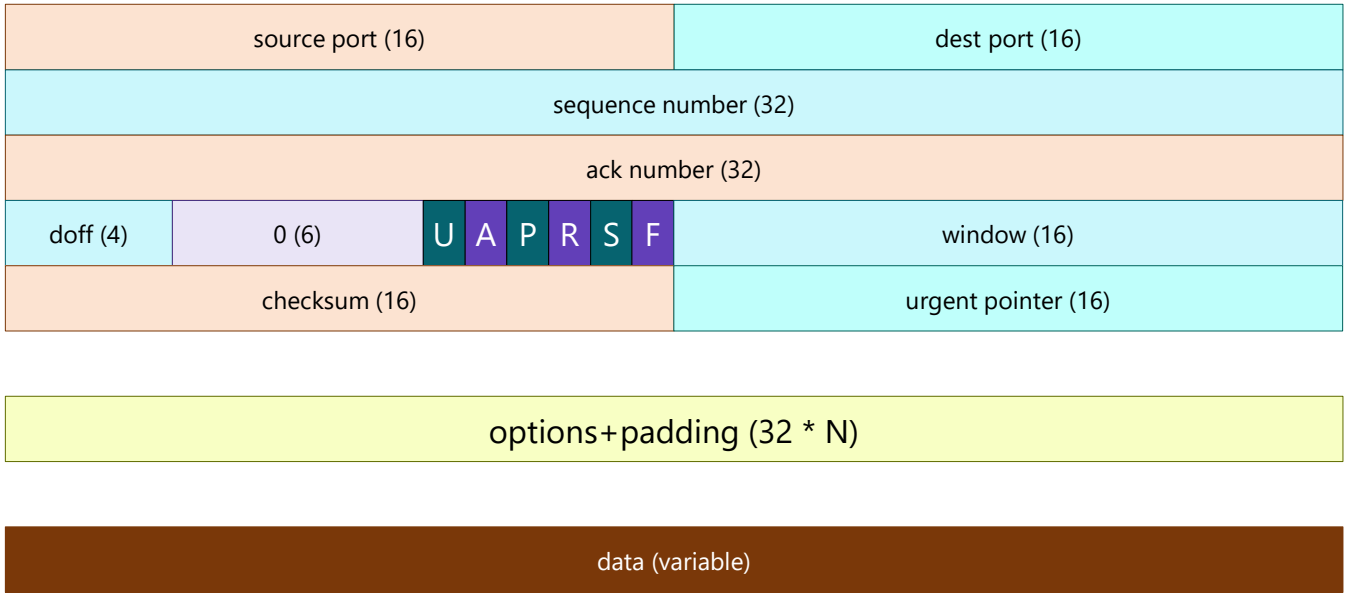
TCP


= 1 bit
source port (16)
dest port (16)
sequence number (32)
ack number (32)
doff (4)
0 (6)
U
A
P
R
S
F
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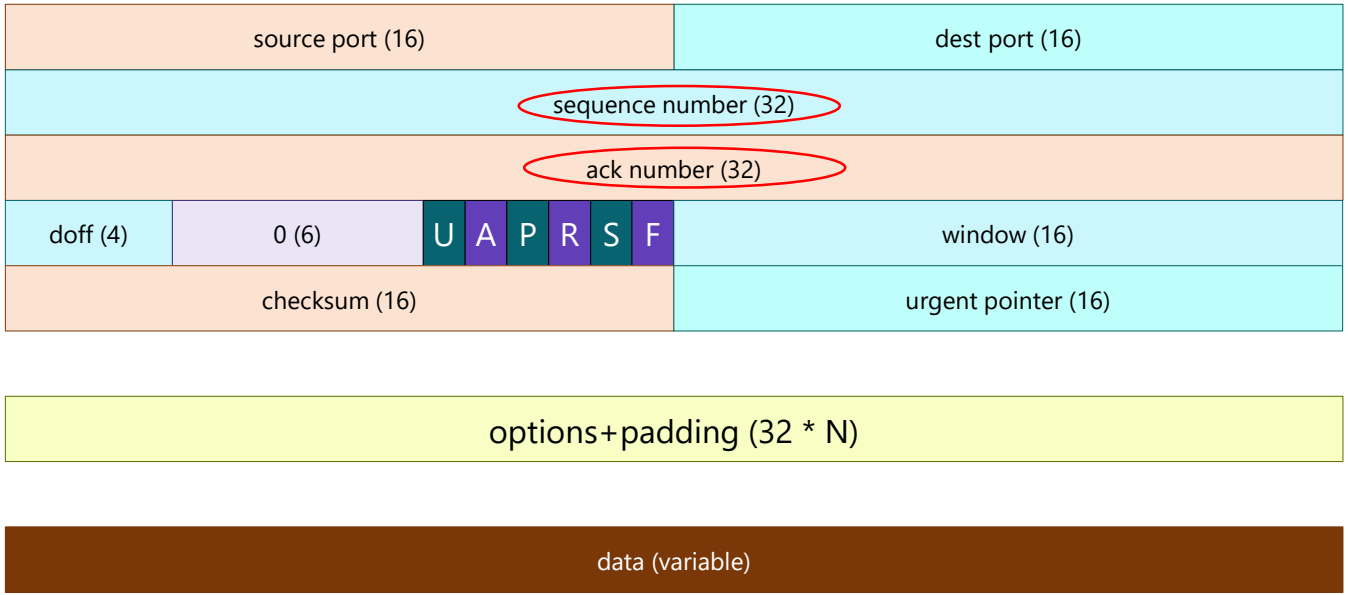
urgent pointer (16)
options+padding (32 * N)
data (variable)

TCP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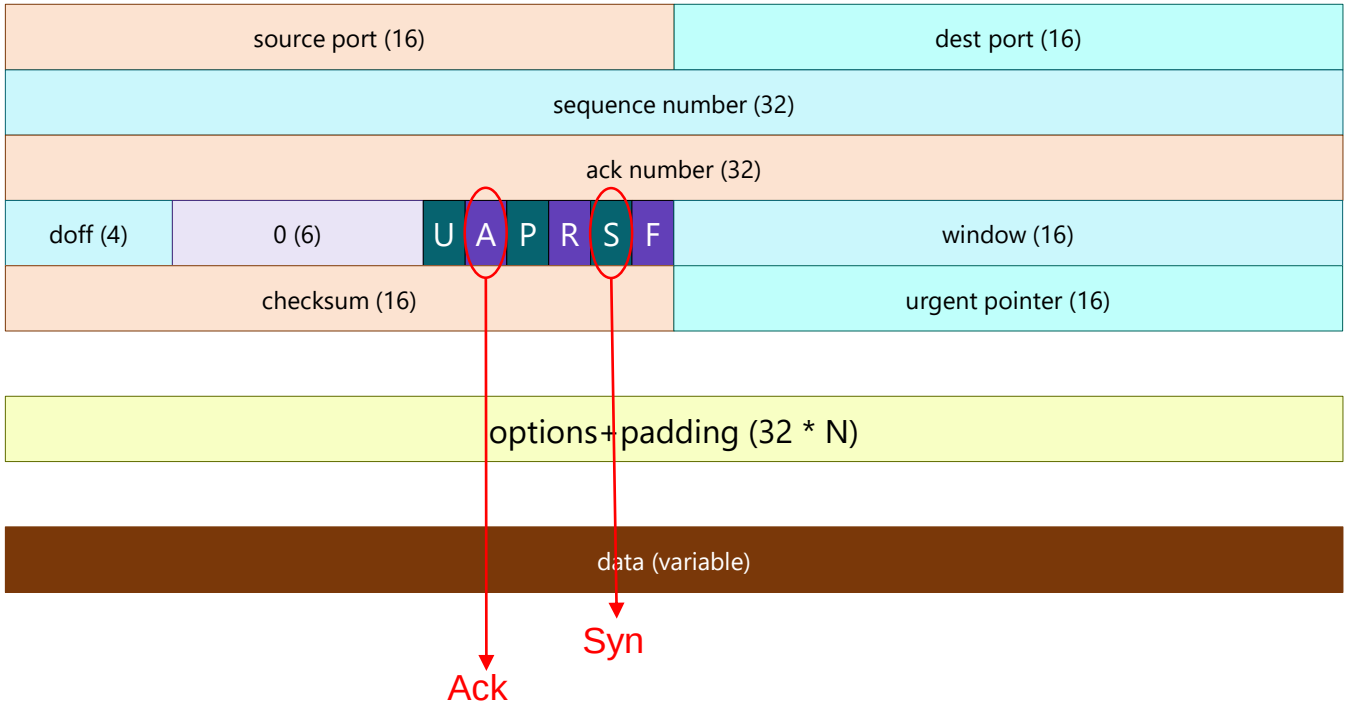
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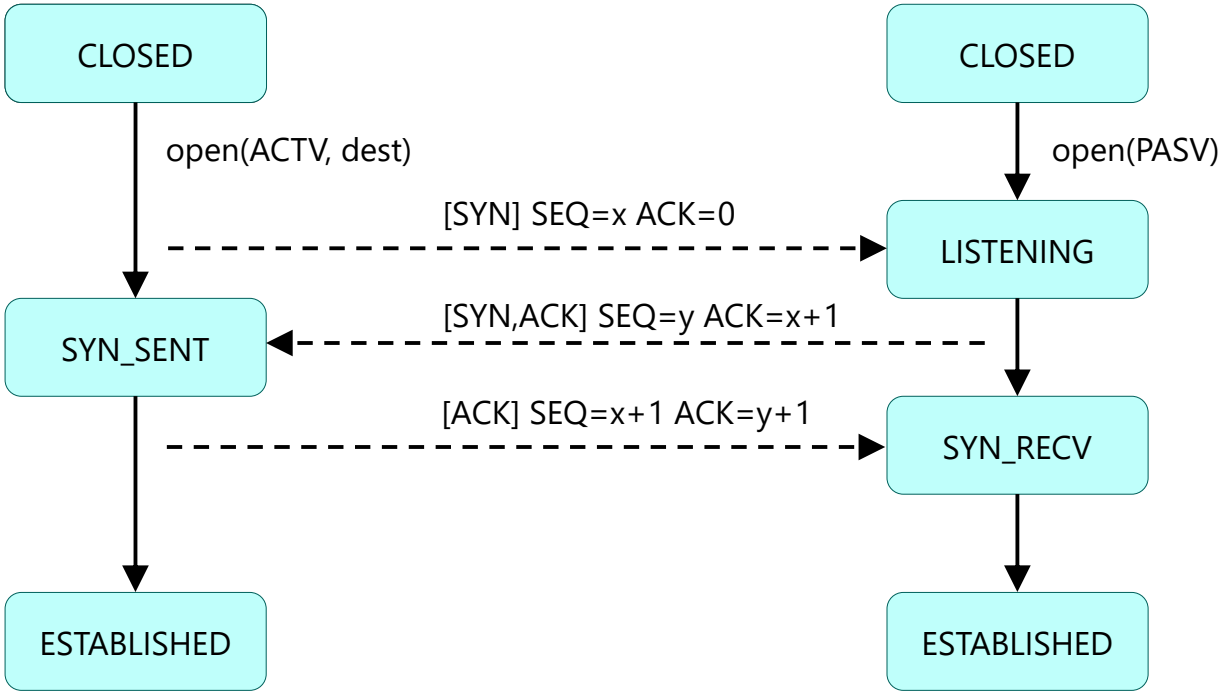
data (variable)
Syn
Ack

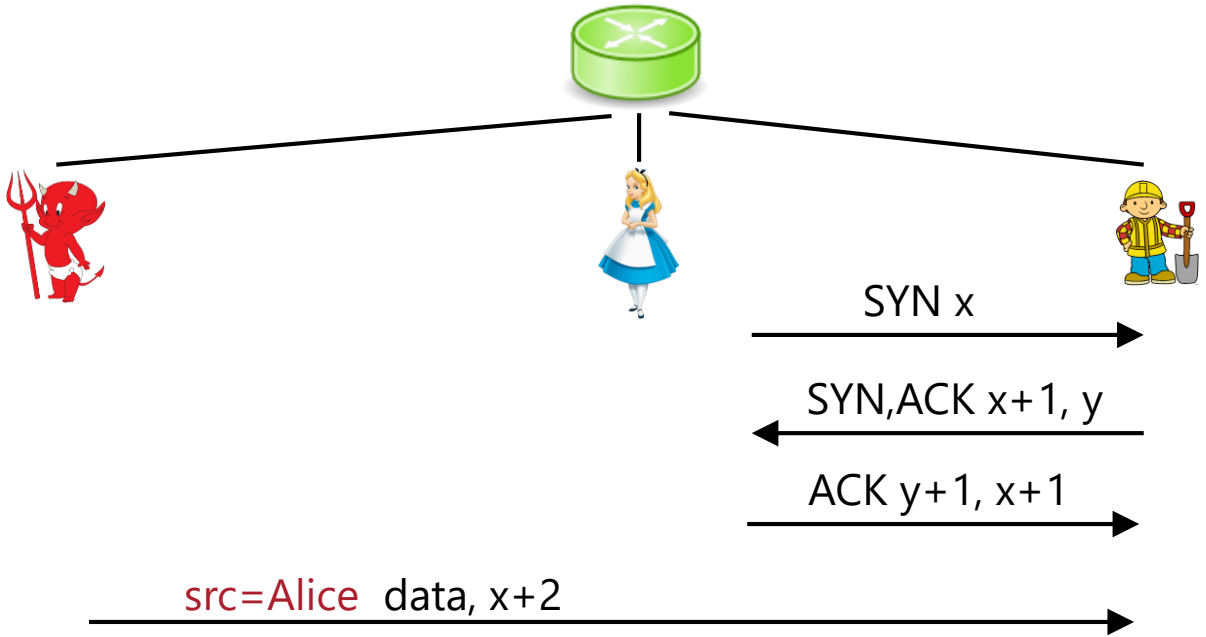
TCP handshake



Problem

- Sequence number are not random
- They were designed to prevent collision
- But things can go wrong
- Attack can guess sequence numbers!

Session Hijacking

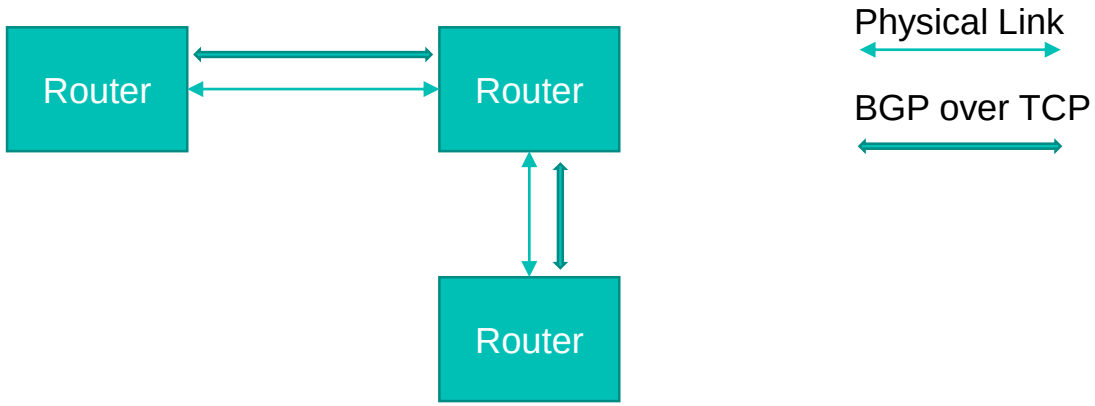


Problem

- IP-based authorization (do not this! this is bad!)
  - Masquerade + Unauthorized Access

Problem

- IP-based authorization (do not this! this is bad!)
- Reset attack



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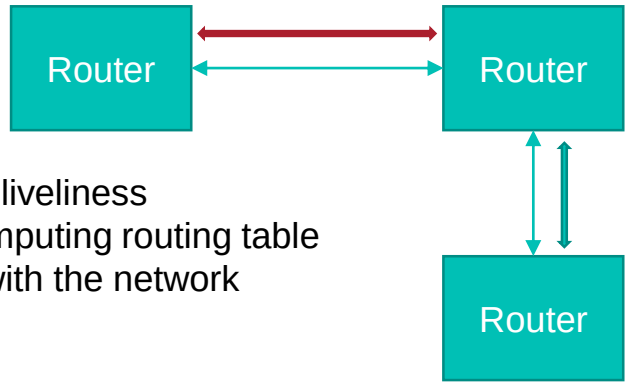

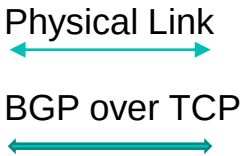

Use connection to infer liveliness
If lost connection, recomputing routing table
Attacker can mess up with the network
Denial of Service

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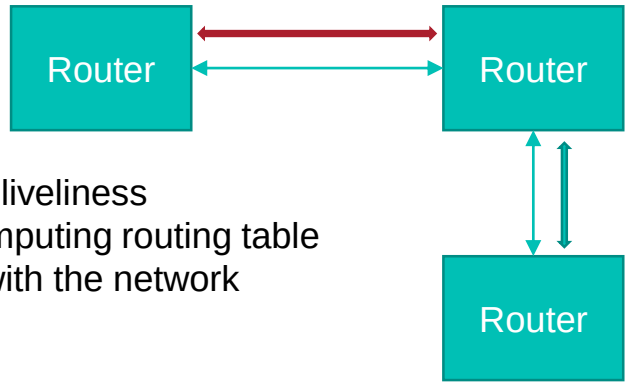

Physical Link

BGP over TCP

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Fix: enforce TTL 255 (max value)

Problem

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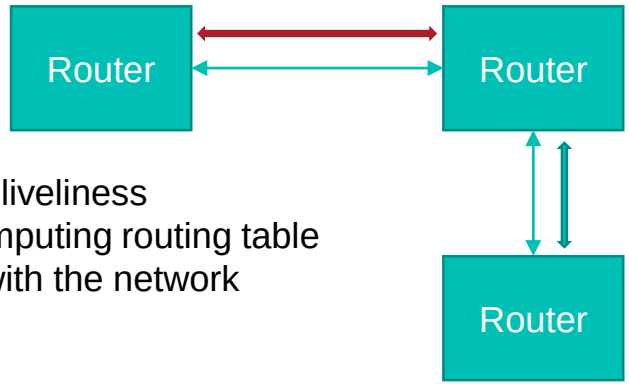

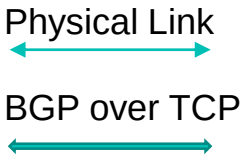

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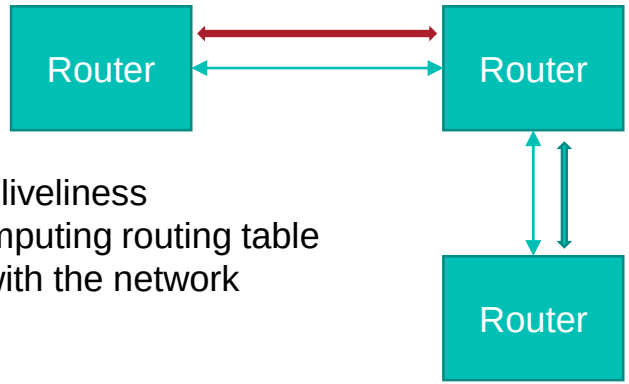
Problem

Homework/potential exam question:
Give an example of DOS attack

- IP-based authorization (do not this! this is bad!)
- Reset attack (Masquerade + DOS)



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  - Break application relying on long-lived connection
- Data injection
  - Wait application level authentication have been achieved
  - Insert packet that will be treated as coming from the users

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Problem

Homework/potential exam question:
Look at SYN flood attack type

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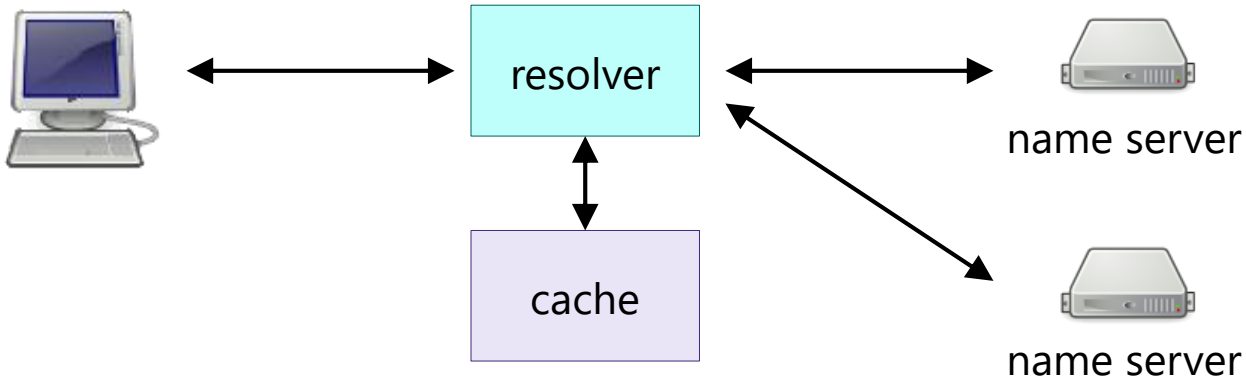
DNS resolver & cache



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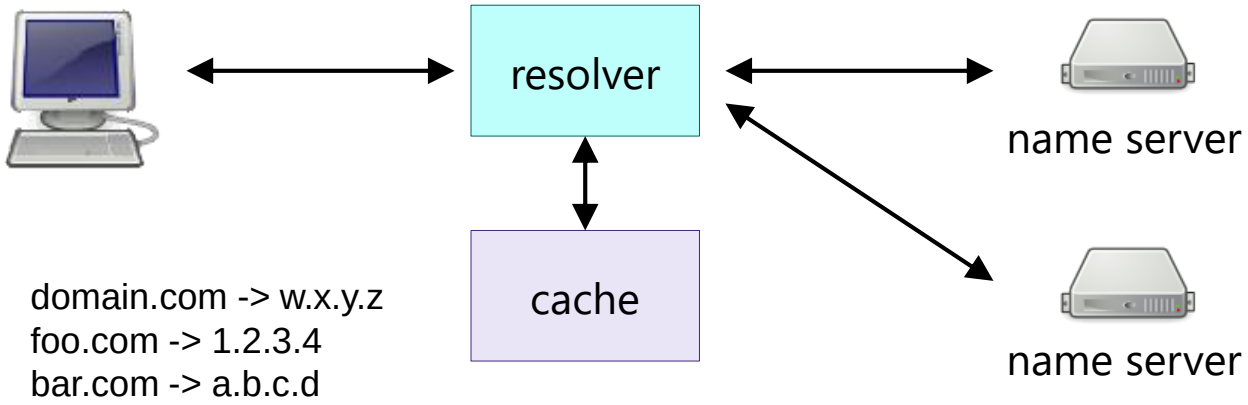
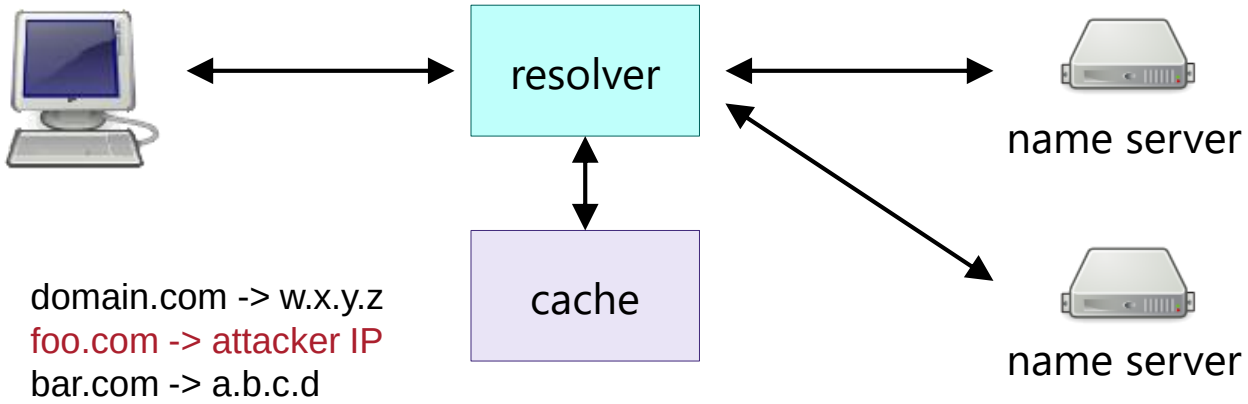


DNS poisoning



DNS poisoning

- Exploit vulnerability in the DNS resolver/server
- Man in the middle (send a fake response)
- Modify the client host file (won't make DNS request then)
- Domain high-jacking (point to a different DNS server for a particular domain)
  - Would require to gain access to a registrar
  - Getting the password (we have seen how)
  - 22/10/2016, attacker gained control of Brazilian bank website for 6h
- Masquerade type attack

Countermeasure: DNSSEC

- Simple idea: sign domain, IP pair with domain owner certificates!
  - We have seen last week:
    - How certificate work
    - How to verify signature
- NSEC: prove subdomain don't exist
  - sign an entry bar.bristol.ac.uk to foo.bristol.ac.uk
  - there exists no domain (in alpha. order), between bar… and foo…
  - Can someone spot a type of attack we could use this info for?

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Countermeasure: DNSSEC

Homework/potential exam question:
Explain how and why DNSSEC

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Slow Loris Attack

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- Usual DOS
  - Overload server computing power
  - … or available bandwidth

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  - Send the request GET XXXX
  - When the server is about to timeout…
  - Send one more character
- Totally normal usage of HTTP protocol

Slow Loris Attack

Homework/potential exam question:
Explain Slow Loris attack

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  - Overload server computing power
  - … or available bandwidth
- Slow Loris is a protocol level attack
  - Require very little computer power from the attacker
- HTTP request always finished by \n\n
- Open connection and send data very, very, very slowly
  - Send the request GET XXXX
  - When the server is about to timeout…
  - Send one more character
- Totally normal usage of HTTP protocol
- Open multiple connections, until the server ran out of threads (Apache limite #threads)
- DOS done! Very low resource required from attackers!

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- The world changes, protocols change very slowly
- Understand guarantees form underlying layers
- Never expect them to do more than this
- Always distrust external inputs
  - Buffer overflow
  - SQL Injection
  - … and lot of network related issue!

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Thank you, questions?

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