CS489/689
Privacy, Cryptography, Network and Data Security

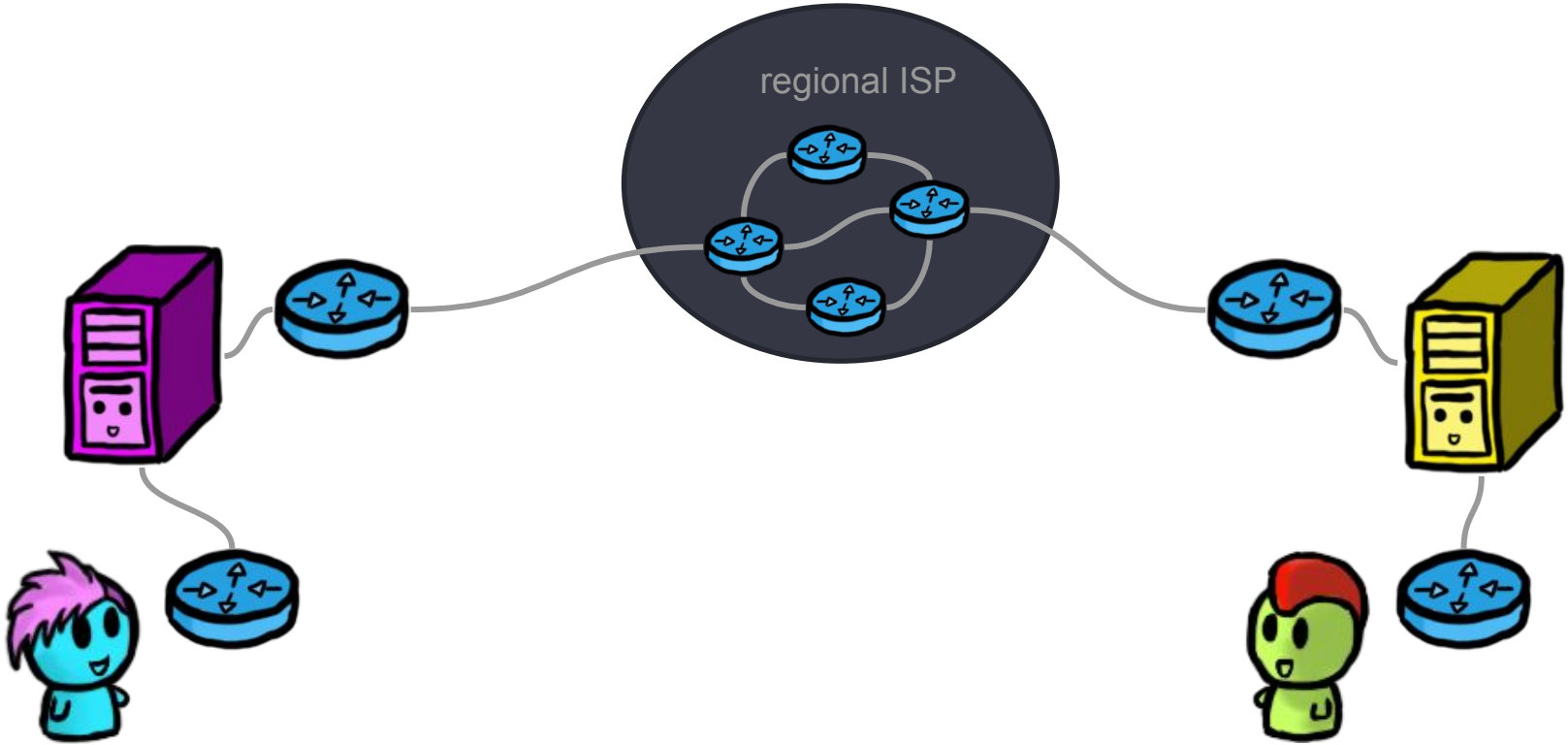
Winter 2023, Tuesday/Thursday 8:30-9:50am

Today: Authentication

- Recap:

Authenticity: Prevent Mallory from **impersonating** Alice

Our Model: Who is talking to whom?



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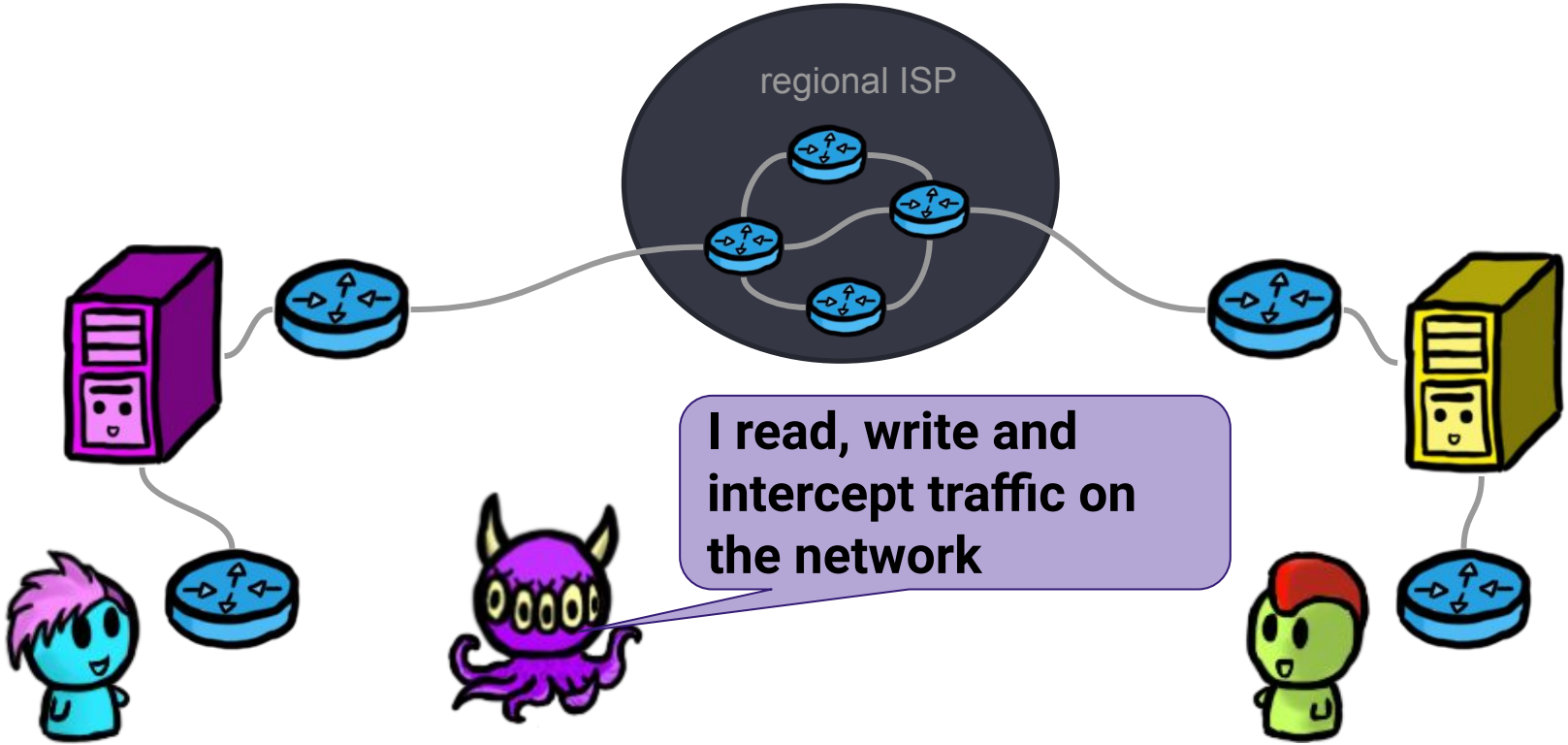
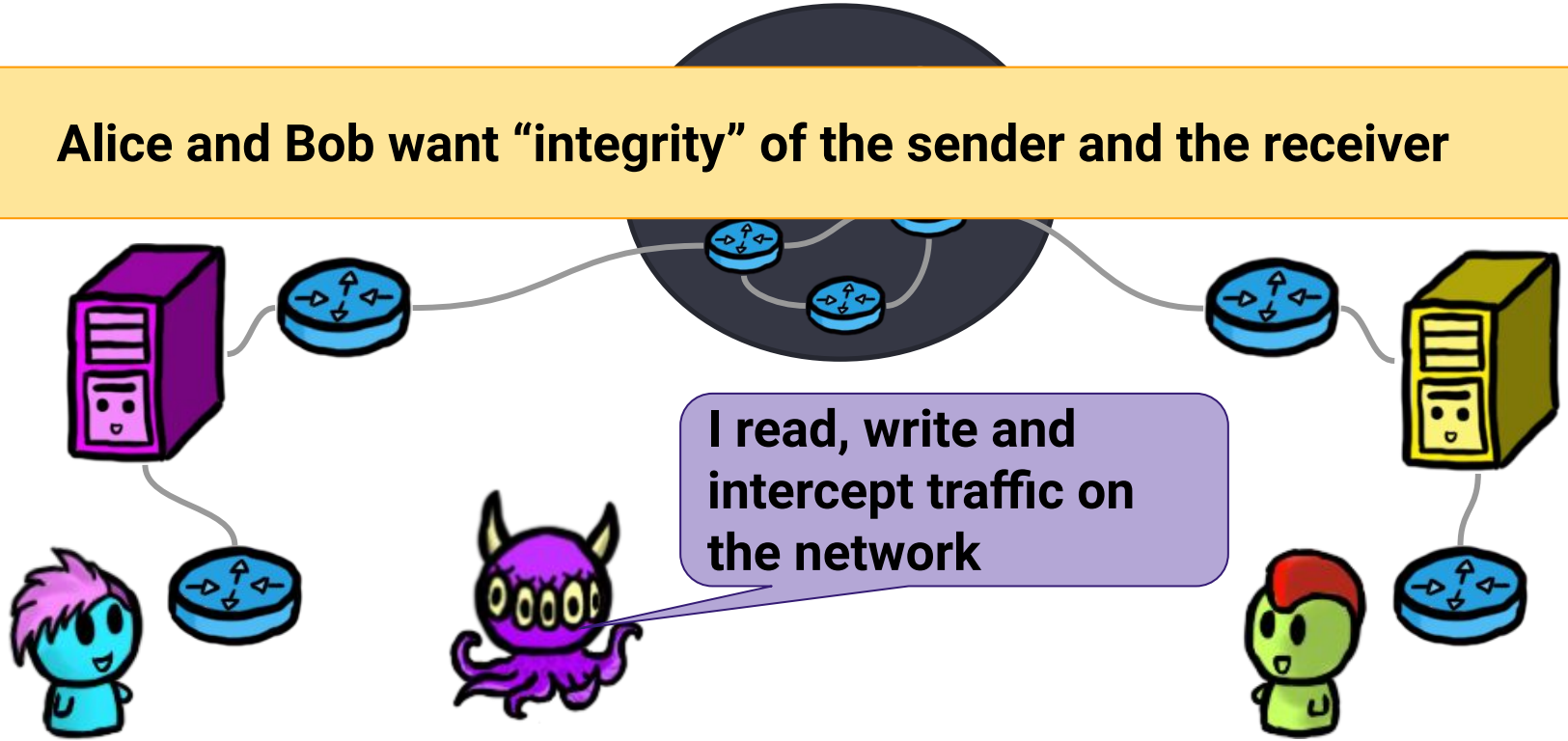


Our Model: Who is talking to whom?

Alice and Bob want “integrity” of the sender and the receiver



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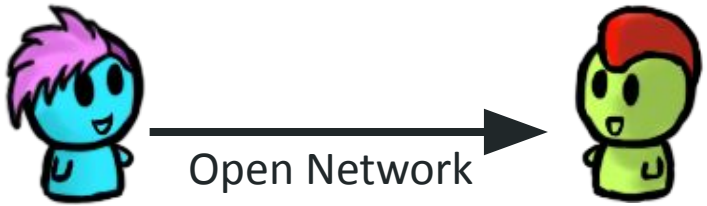
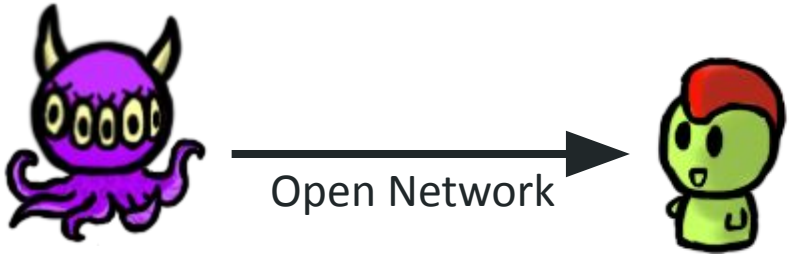
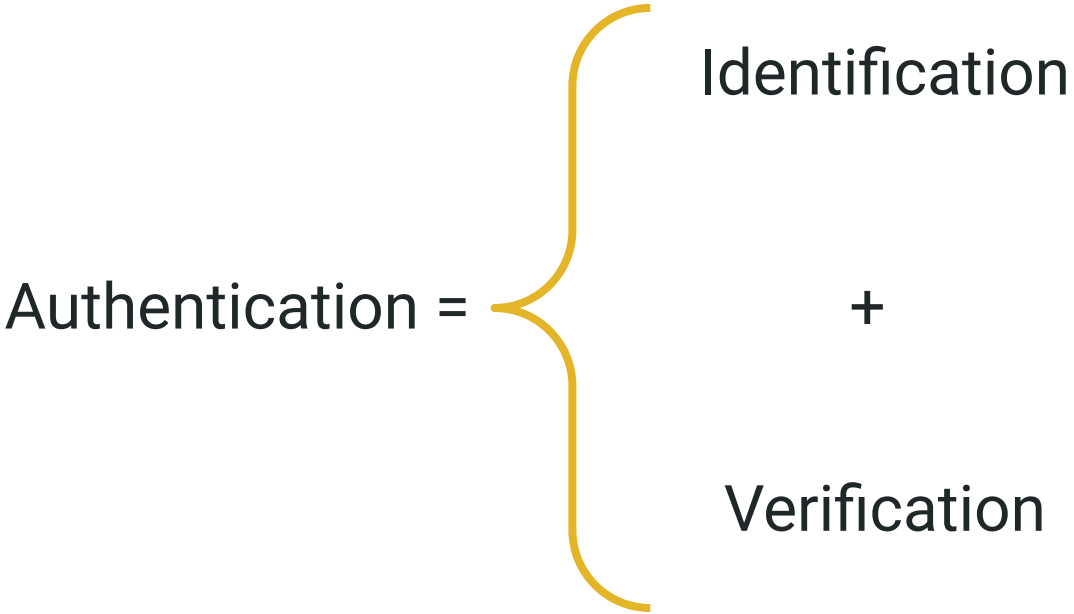




Goal: distinguish who you are talking to and confirm it

Definition of Authentication



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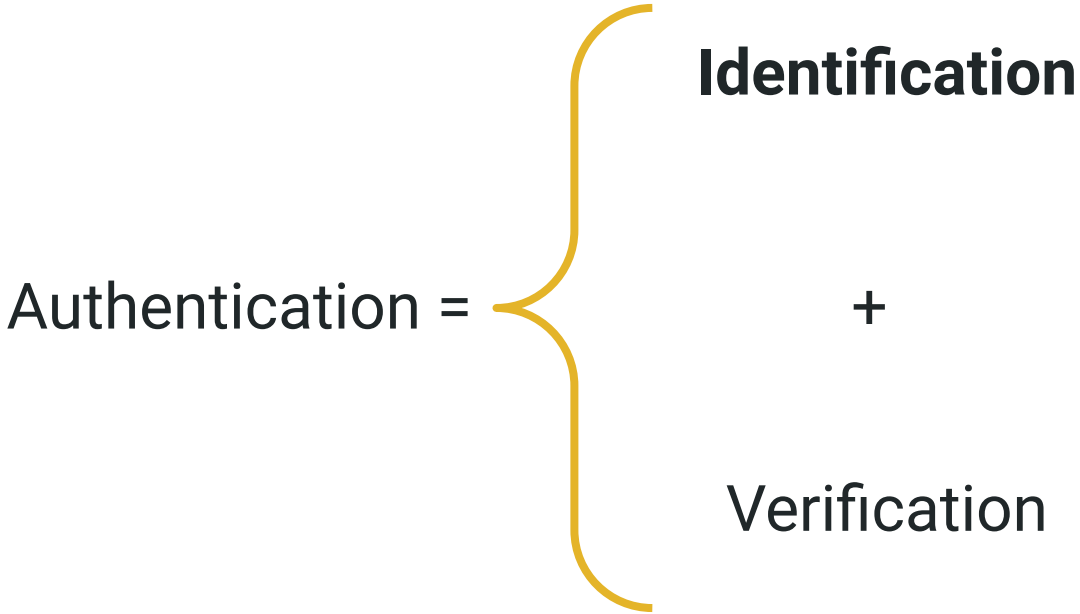
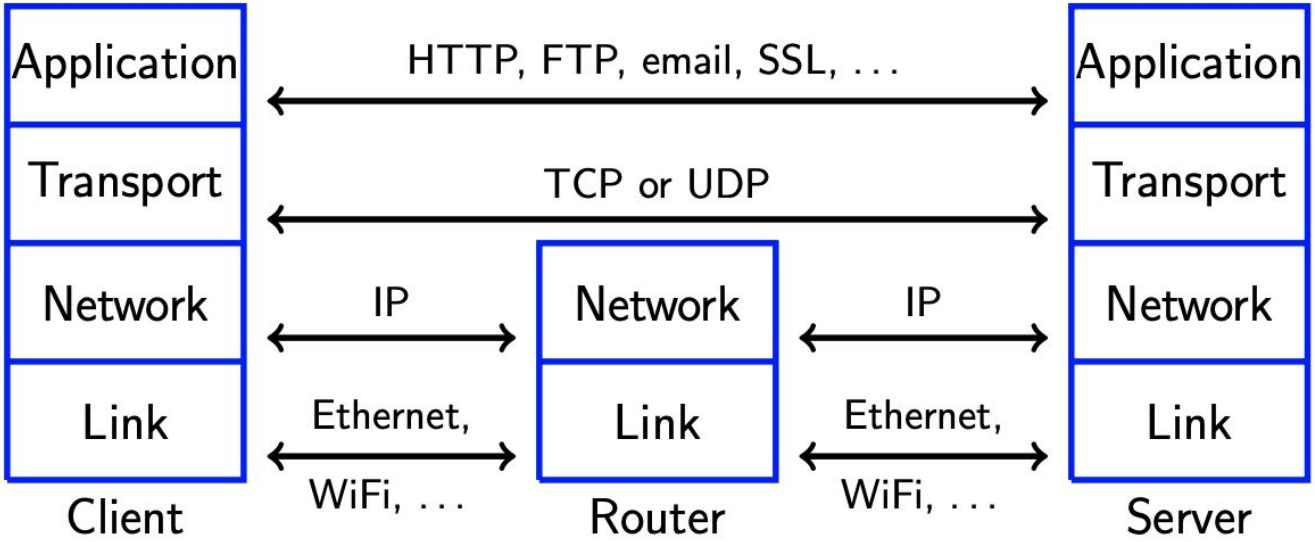


Identification on Network



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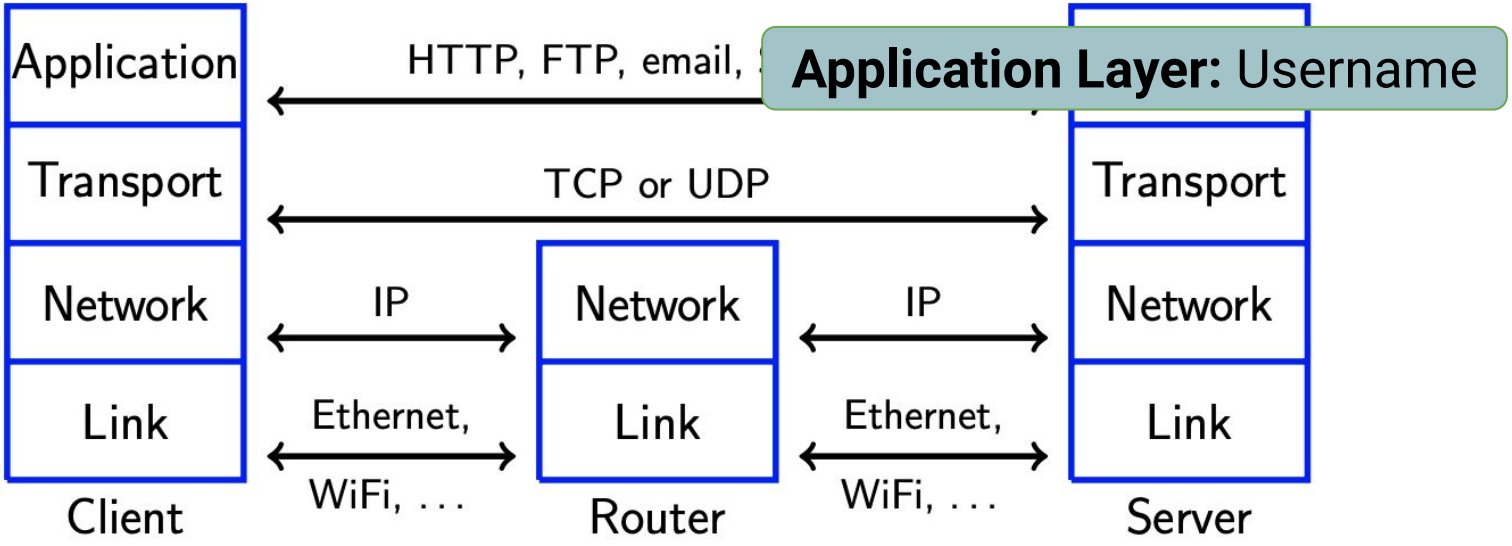

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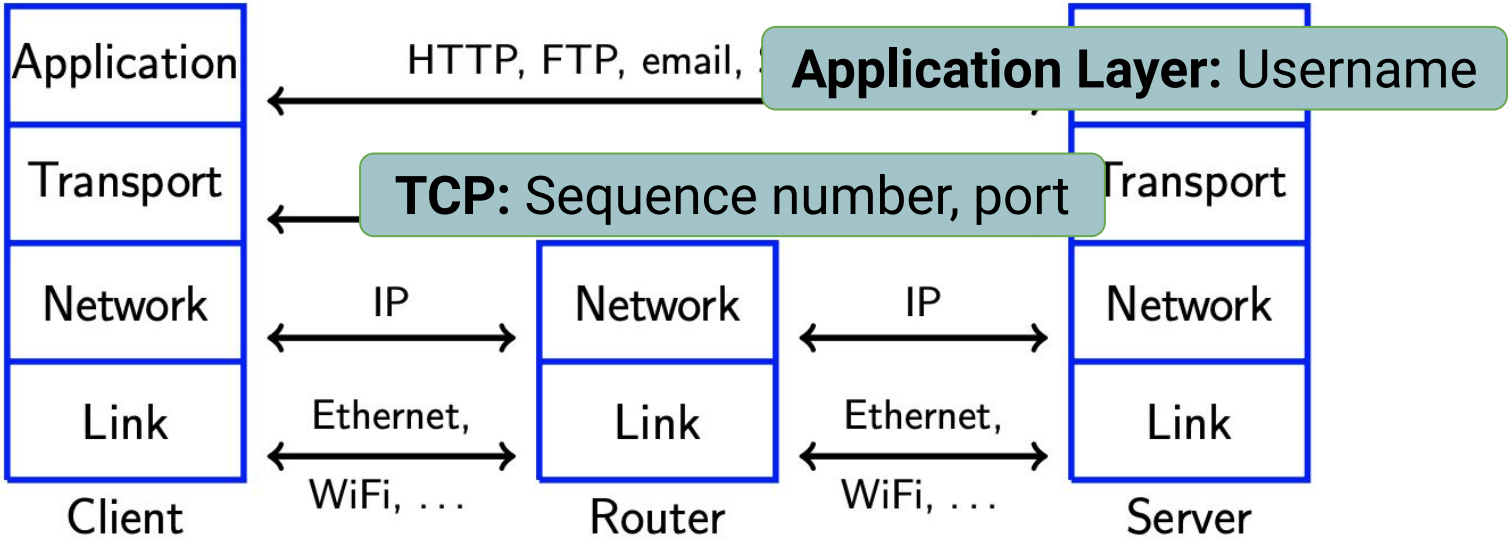

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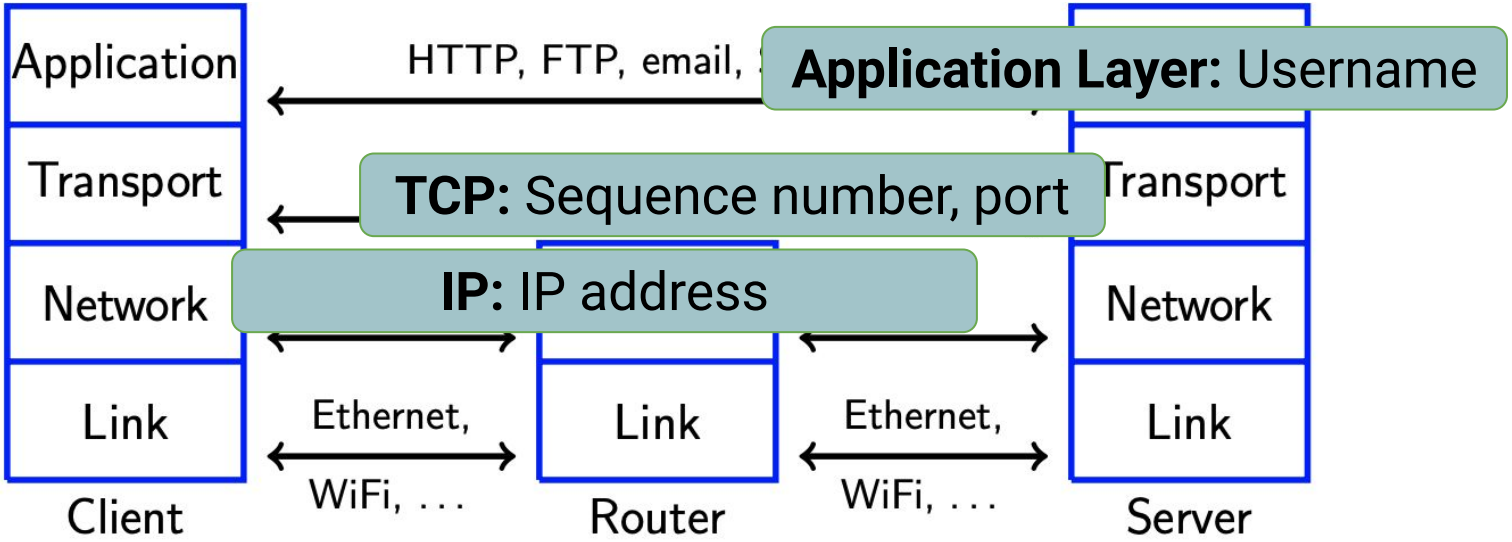

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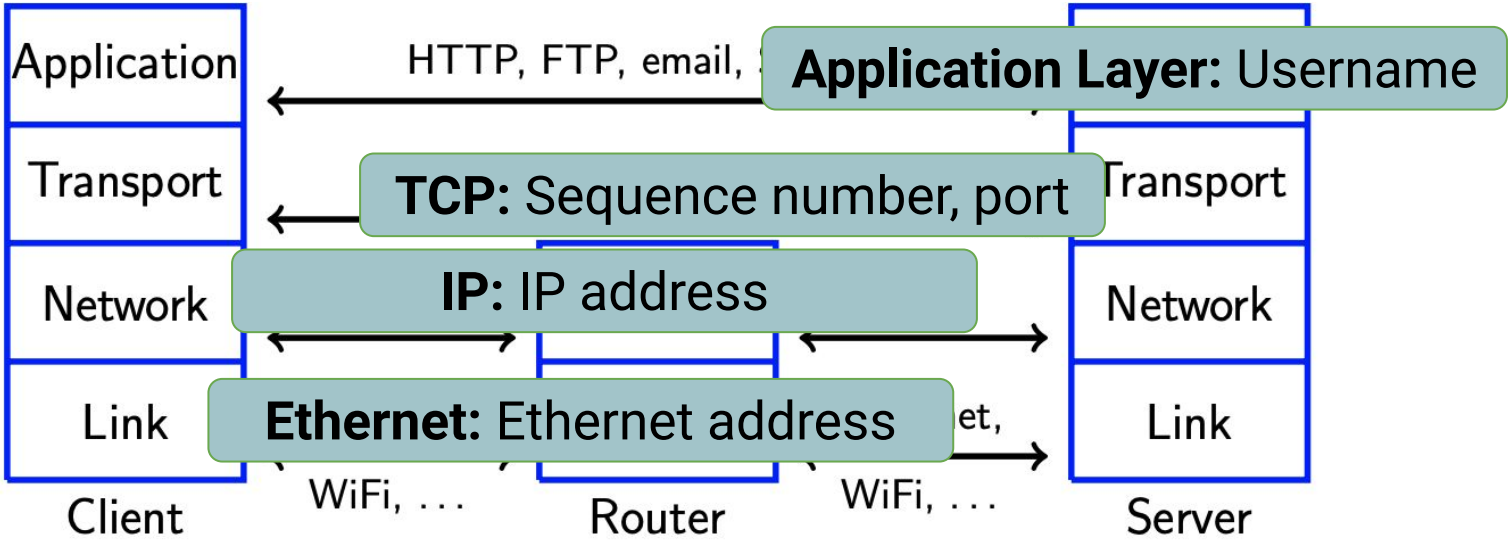


Returning to Authentication

Authentication =

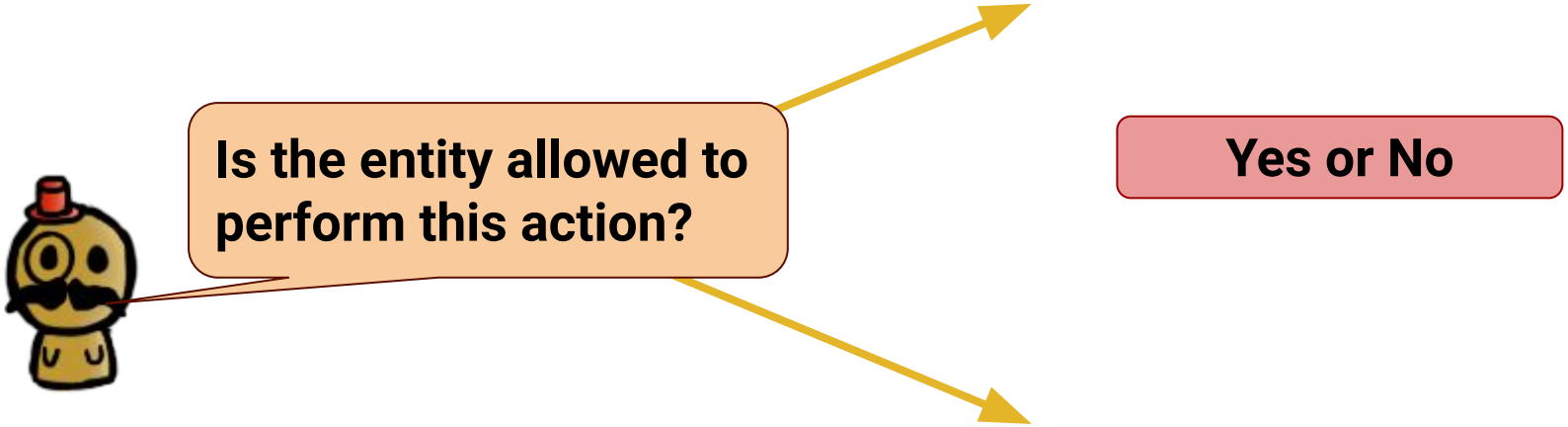
Identification

+

Verification

Need both: for example, to achieve access control

Access Control



Access Control

Is the entity allowed to perform this action?

Doesn't matter…unless you can verify the entities **identity**

Port Scan: **Identification** at the IP Layer

- Server offers services at different port (TCP state listening)

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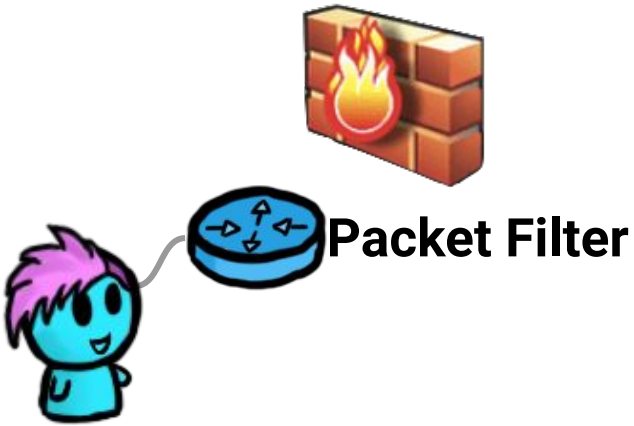
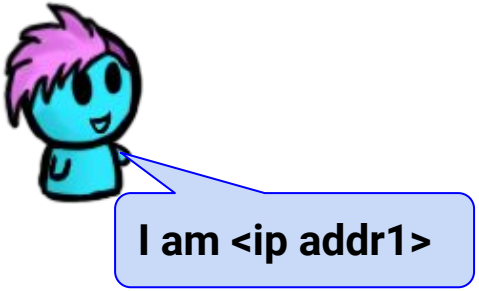
- Client learns services offered by server
  - Information for further attacks

Firewall (for Access Control)



- Only allows packets from IP address “A.B.C.D”
- Access control on source IP address (identification)
- IP address is not verified

IP spoofing



Client's can set their source IP….

Try spoofs using attack simulator at: https://cs.uwaterloo.ca/~m2mazmud/netsim/

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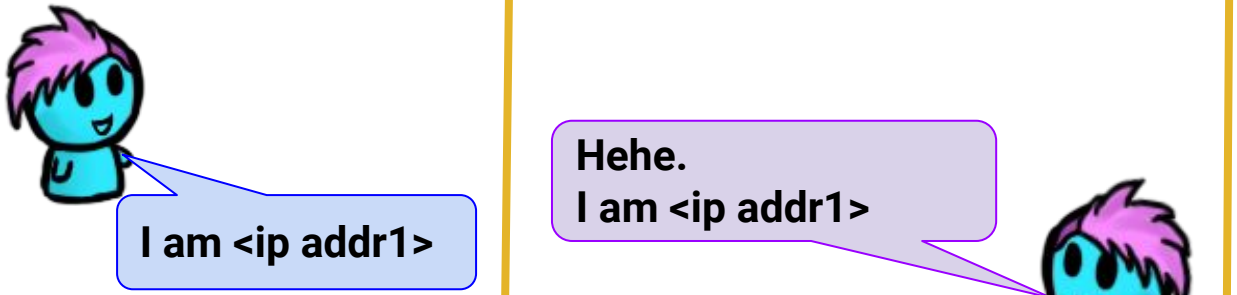

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IP spoofing

PROBLEM: Response packets routing for the spoofing/spoofed client

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Reflected Port Scan: Spoofing + Ports

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Server's response?

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Server responds SYN+ACK to A.B.C.D

A.B.C.D replies RST, so IP ID increases by 1

Attacker observes increases in ping replies

A Very Simple Public-Key Authentication Protocol

Client connects to the server and asks it to authenticate

Server reads a time T and sends a signature $Sign_S(T)$

Client reads a time T', verifies the signature and checks that T' is close to T

Attack 1: Adversary Authenticates as the Server

- Find an attack such that the adversary can authenticate as the server

Solution: Attack 1

- Mal connects to the server at time T and obtains $Sign_S(T)$

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- Client wants to connect to server at time T” 
- Mal redirects request 
- Mal manipulates the time at the client (e.g. Internet time protocol) to T’ 
- Mal responds with $Sign_S(T)$ 
  - Replay attack
- Client reads time T’, verifies signature and accepts 
- The information signed must be *fresh*

Simple Public-Key Authentication Protocol 2

Client sends a random challenge r

Server responds with signature $Sign_S(r)$

Client verifies signature

Attack 2: Adversary Authenticates as the Server

- Find an attack such that Ingrid can authenticate as the server S

Solution: Attack 2

- Client sends a random challenge r up server

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- Client sends a random challenge r up server 
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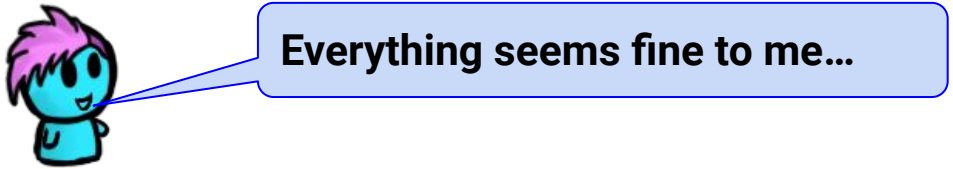
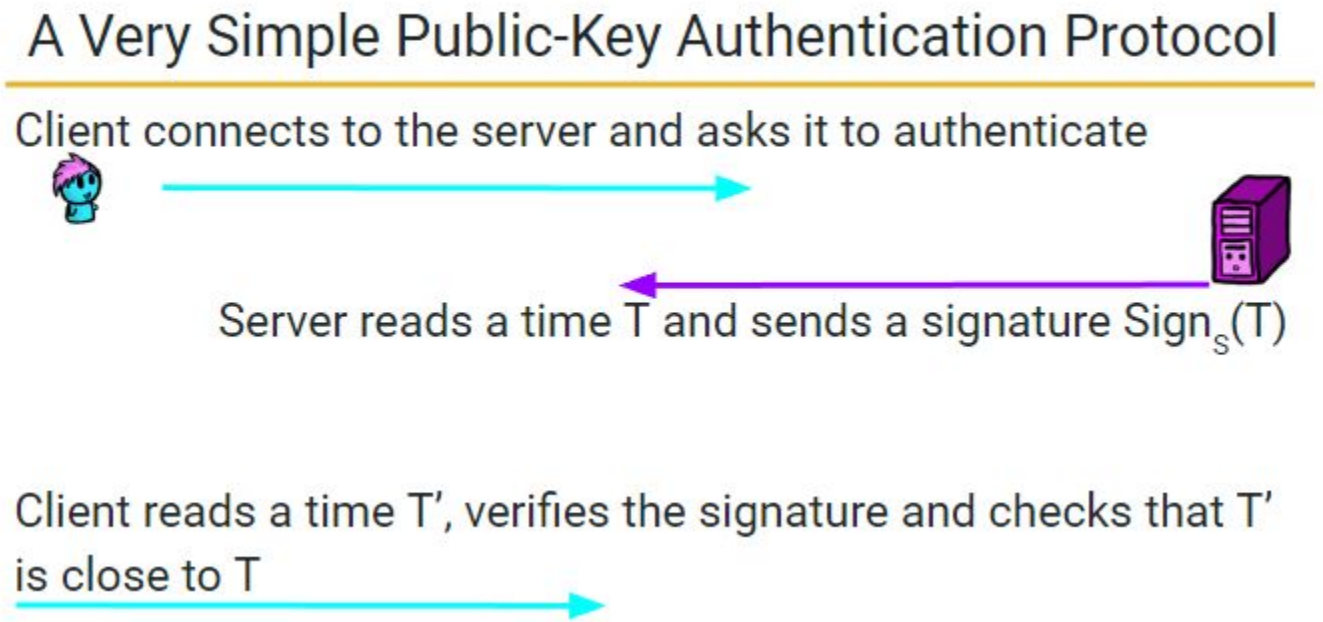
- Mal sends the request to server with ***same*** r 
- Server responds $Sign_s(r)$ to Mal 
- Mal forwards response to client 
- Client accepts



Question

- Provide a fix to the simple authentication protocol (first one)



Solution

- The server signs the message S|C|r
- Then Ingrid cannot forward S|I|r to the client and have it accept
- The problem existed in an early version SSL (now TLS)
- Challenge information needs to be *complete* (including communicating entities)

Verification, in a few slides

Verification Methods

- Something you know

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- Something you know
  - Password
- Something you have

Verification Methods

- Something you know
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- Something you have
  - Mobile Phone
  - Cryptographic Key
- Something you are
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- Something you know
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  - Biometric
- 2-factor authentication
  - Using two of the above

Curious about some cool research in this space? Look up “Shatter Secrets”

Verification Setup

- Verification requires trusted setup phase
  - Attacker cannot modify the authentication information delivered
    - Mallory-in-the-middle attack
  - Identity can be established
- In a distributed system this implies a secure channel

Authentication Information Needs to Be Protected

- Password
  - Hashed with Salt
- Public Key
  - Doesn’t allow inference of private key
- Biometric Template
  - Open Problem (Crypto?)

No Verification **does not imply** Anonymity (No ID)

- Implicit identifiers
  - IP address
    - Your Internet provider knows your IP address
  - Browser fingerprint
    - Fonts, browser capabilities (JavaScript, etc.), …
  - Web Cookies
  - Behavior
    - Typing, Walking, …
  - Location (Trajectory)
- Communication parties can identify each other without explicit identification
  - Servers can track your browser fingerprint (cookies)

Web Cookies

- Set in the HTTP protocol and stored on the browser
  - Session vs. permanent
- Stored cookies are automatically transferred on each request to the same domain
- Used for authentication
- Used for tracking
  - Third-party cookies
    - Cookies set for different domains (option in HTTP protocol)
    - Cookies set by loaded objects (JavaScript, Images, etc.)

Recommended: Web tracking activity

- Launch the Labtainer VM
- In the terminal type: **`labtainer webtrack`** and hit enter
- Open the lab manual
- Complete the lab

Verification, what’s the catch?

Verification: May Imply Leakage

Verification is binary

Yes or No

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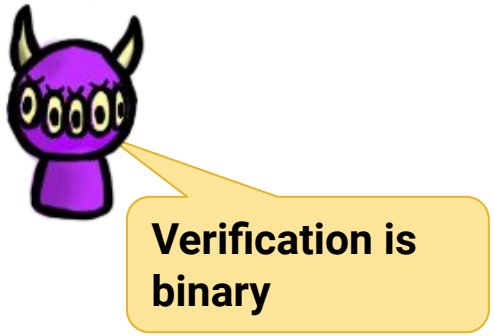

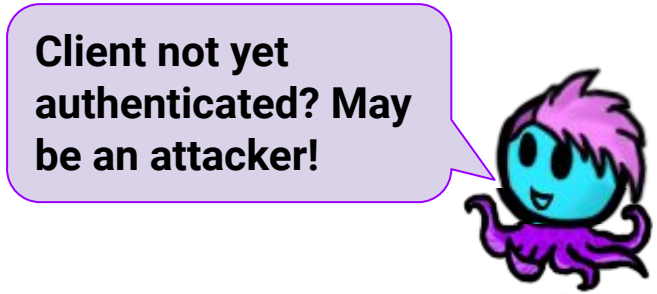

Yes or No

Verification: May Imply Leakage

Verification is binary

Verification is given to the client…which could be me.

Client not yet authenticated? May be an attacker!

Verification attempts can leak information.

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Q: Consider a failed login attempt. What could it reveal?

Yes or No

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Verification attempts can leak information.

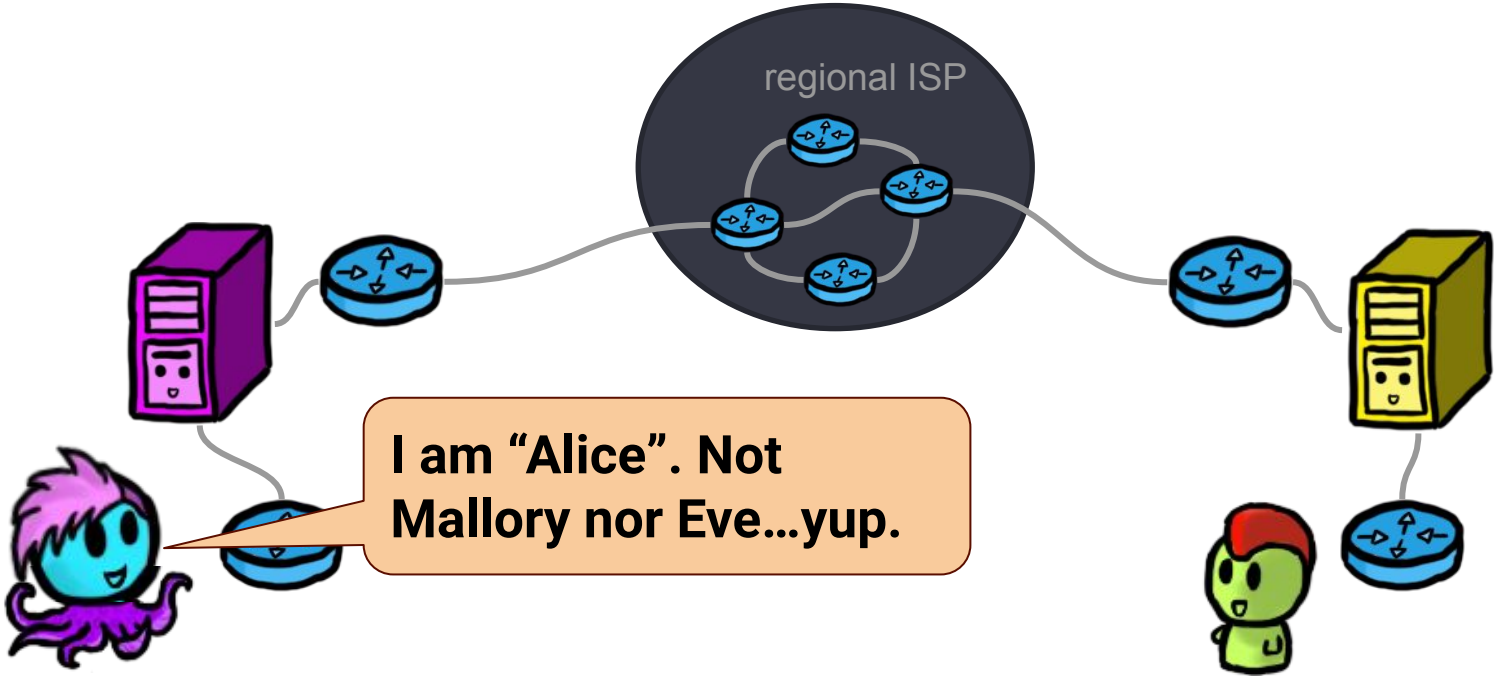
Client not yet

Q: Consider a failed login attempt. What could it reveal?

Yes or No

A: wrong user name, wrong password

Verification may be abused



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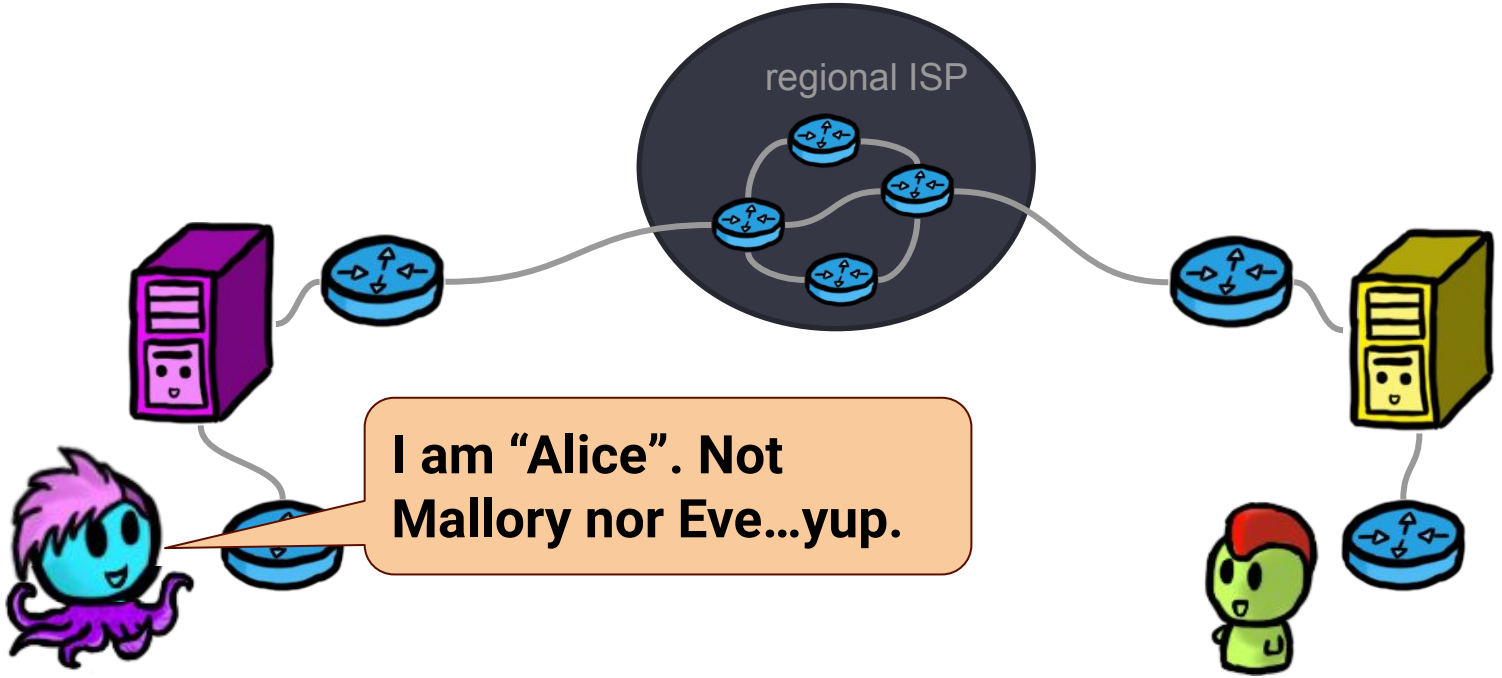

Identification/Authentication information may be supplied by attacker

Impersonation attacks go both ways…

- Client
  - MAC spoofing
  - IP spoofing
  - Session hijacking
  - Guessed password login
  - Spam

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- Client
  - MAC spoofing
  - IP spoofing
  - Session hijacking
  - Guessed password login
  - Spam
- Server
  - Broadcast networks (Ethernet bridge poisoning)
  - Rerouting attacks (ARP, ICMP redirect, RIP/BGP)
  - DNS cache poisoning
  - Phishing

DNS cache poisoning

- Victim and Attacker share common DNS server (cache)

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- Attacker queries my.attack.home
  - Attacker colluded with my.attack.home authoritative DNS server
  - Attacker queries its DNS server for my.attack.home
  - my.attack.home DNS server replies with
    - my.attack.home A.B.C.D
    - www.yourbank.ca A.B.C.E
  - Victim queries its DNS server for www.yourbank.ca
  - DNS server replies from cache with A.B.C.E
  - Victim communicates with A.B.C.E

Denial of service

- Client requests more resources than server / network can deliver

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- Examples
  - IP bandwidth: Ping flood
  - IP state: fragmentation attacks, routing attacks (blackhole)
  - TCP state: SYN flood, hash table attacks on stateful firewalls
  - TCP/IP Implementation error: Smurf, XMas, Ping of death, …

Attempts at Retrofitting Authentication

Challenge: Resource Allocation in Networks

- Difficult due to distributed nature

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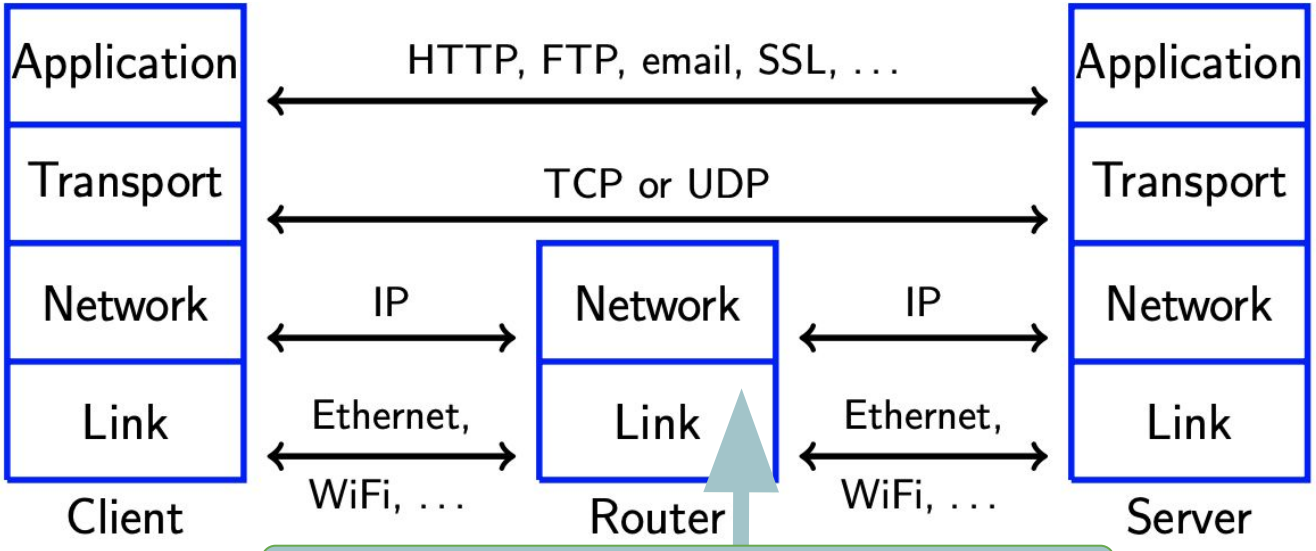
- Often no authentication of clients
  - Resource allocation can be foiled
- Clients can be remote controlled / abused
  - Botnet (Storm, Mirai)
  - Reflectors (Ping with spoofed source)
  - Amplifiers (SNMP)

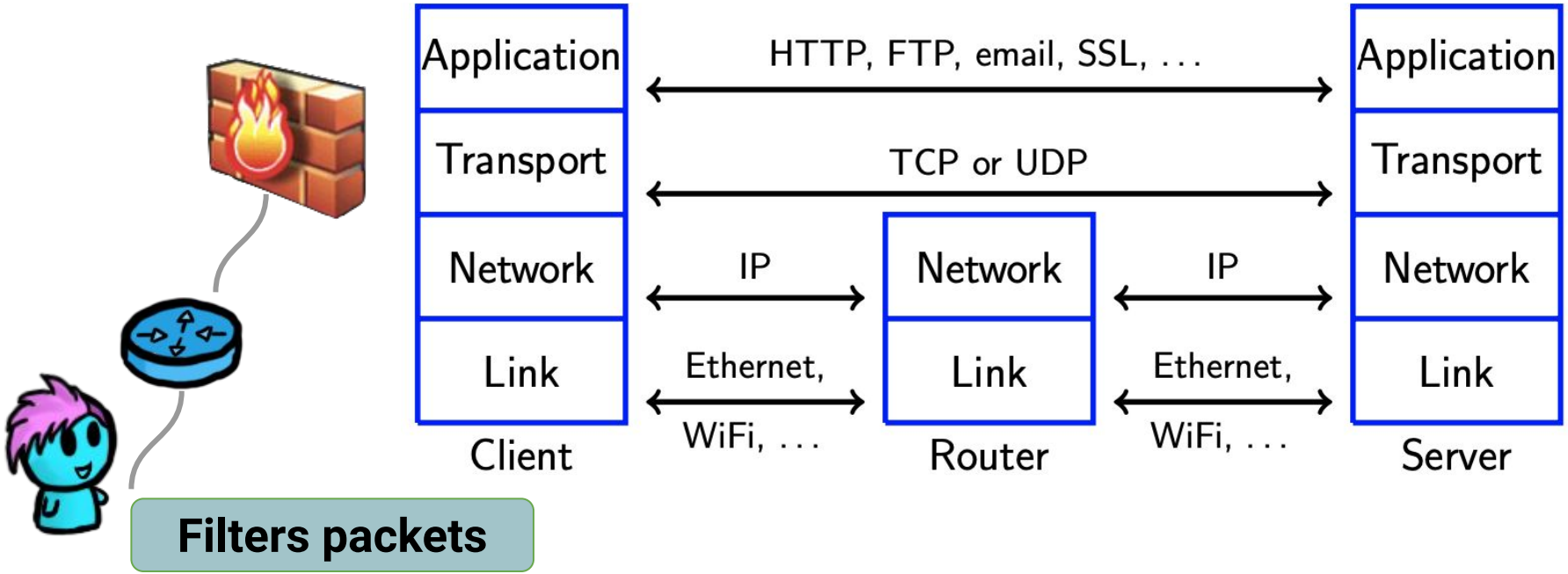
Retrofitting Authentication: WPA2



Wi-Fi Protected Access (Feb 14)

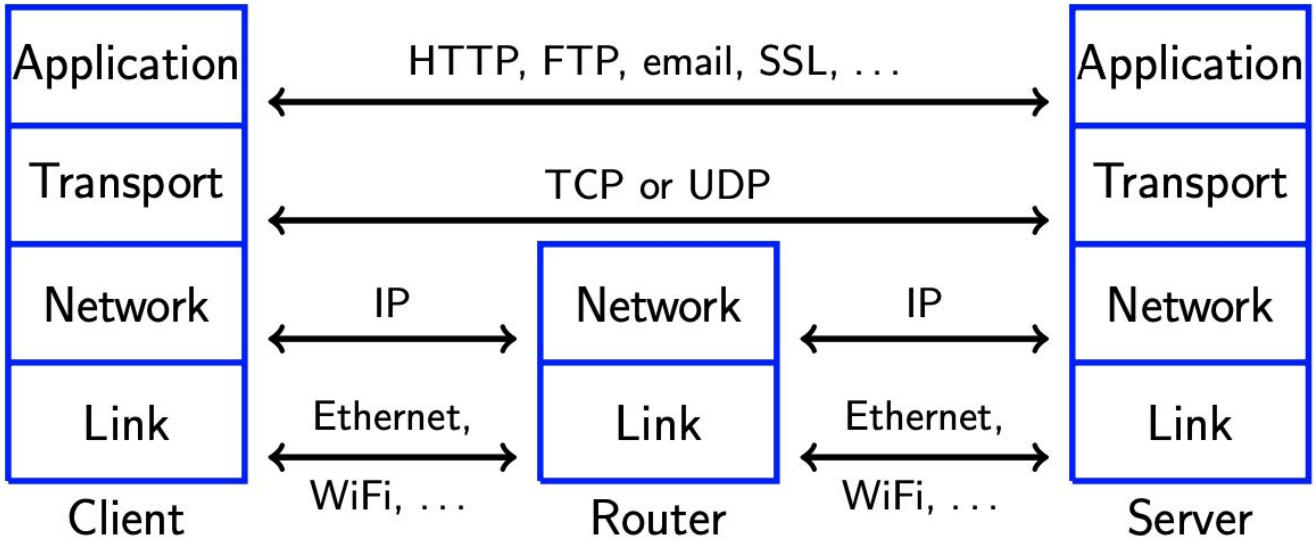
Cryptographic protection at the wireless data link layer

Retrofitting Authentication: Egress Filtering



Firewall at source verifying source IP

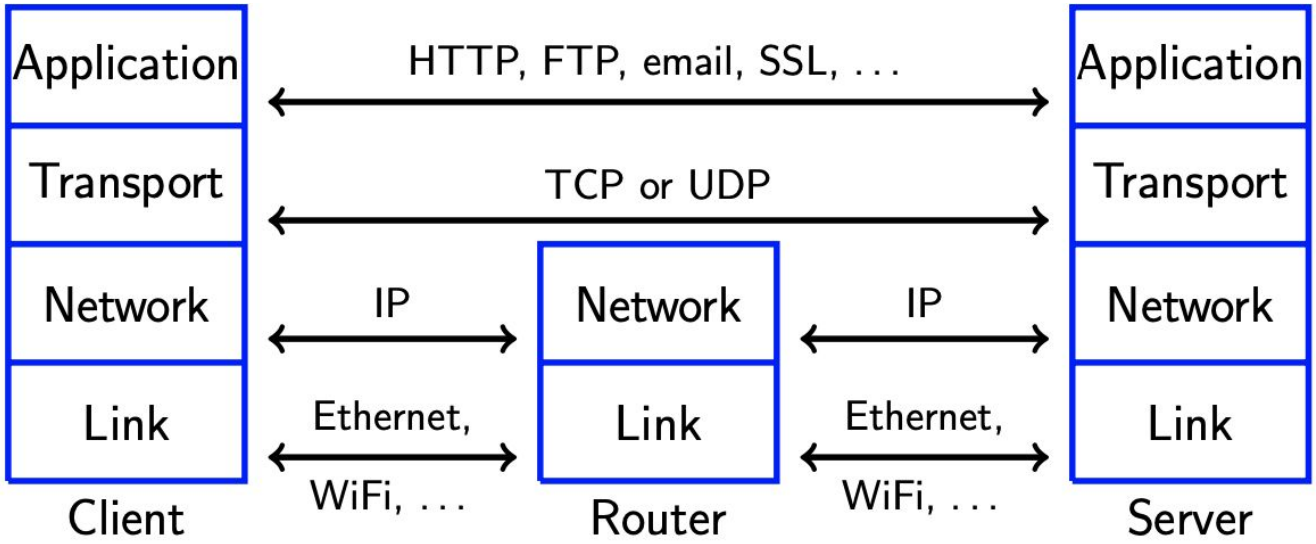
Retrofitting Authentication: IPSEC



Feb 7 (ish)

Cryptographic protection (MAC, symmetric encryption) at IP layer

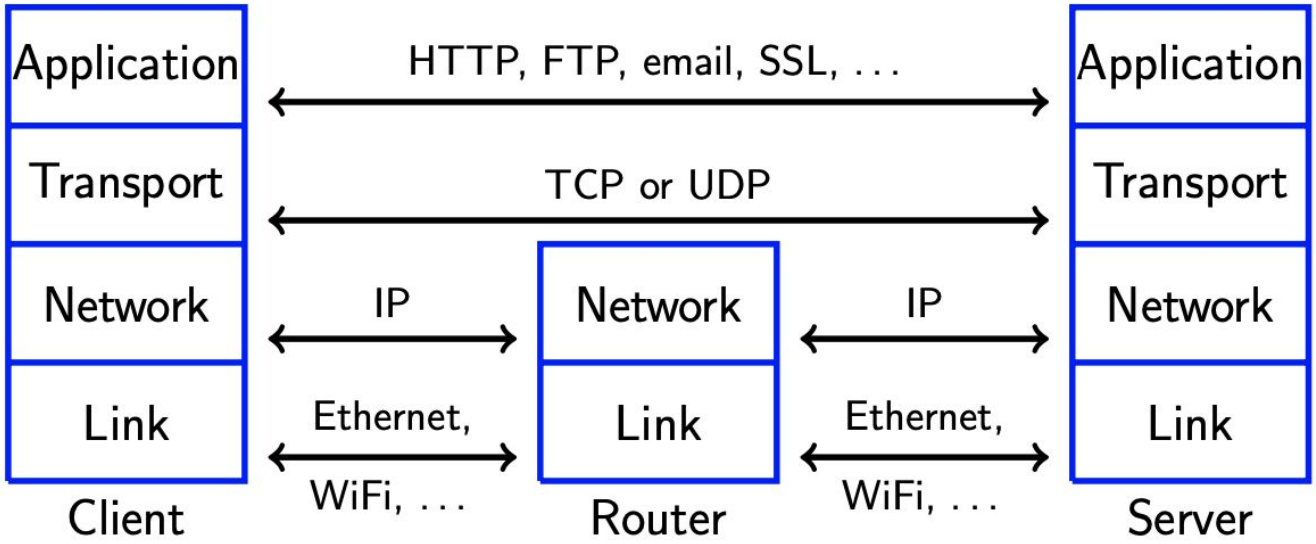
Retrofitting Authentication: DNSSEC



Feb 7

Cryptographic protection (Signature of DNS records) at DNS layer

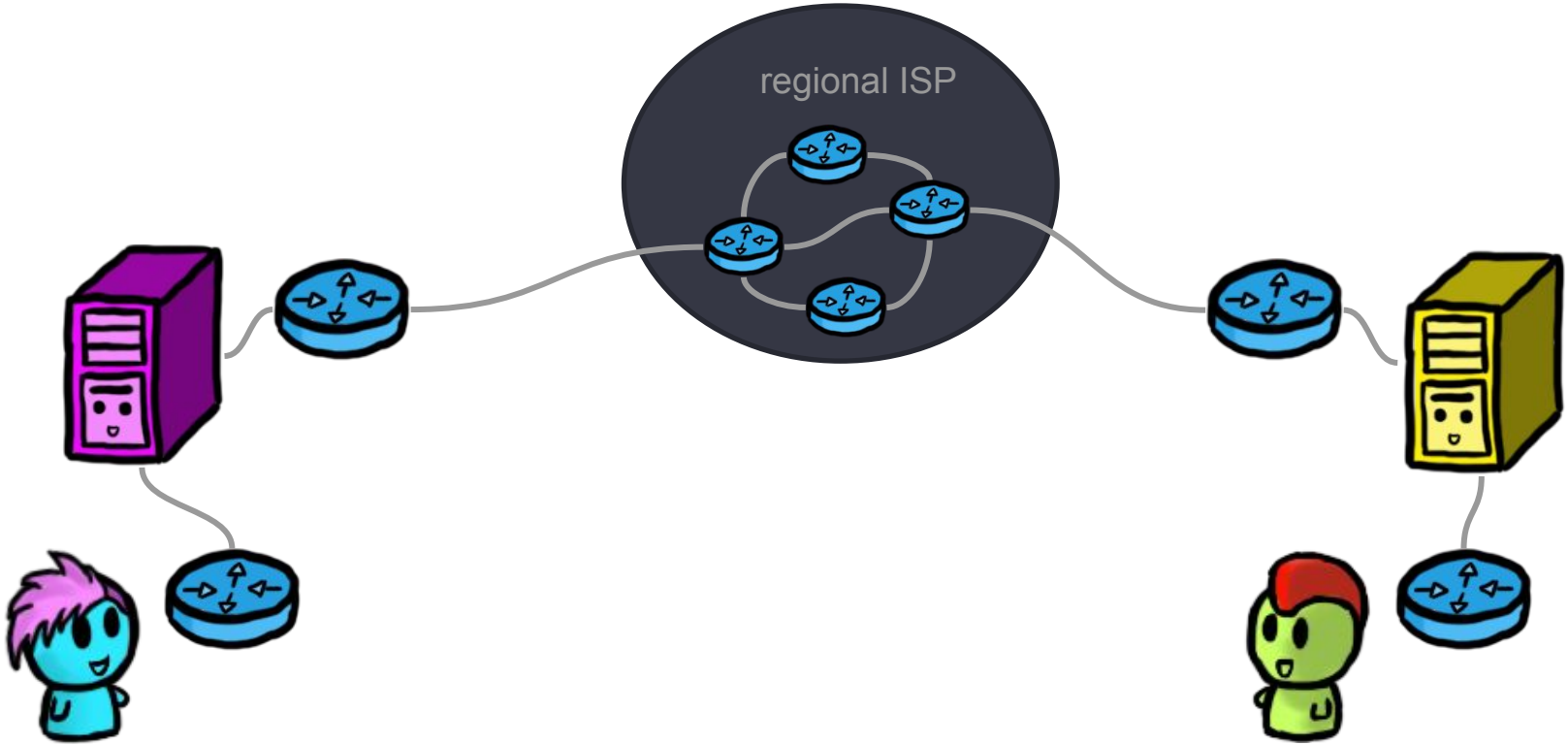
Retrofitting Authentication: TLS



Feb 14

Cryptographic protection at session (between TCP and application) layer

So now what? Actual Protocols



Next: NetSec continues…

Exercise

- Fully homomorphic encryption allows to compute any function f over encrypted data, i.e., f(E(x)) = E(f(x))
- Why does that **not** solve the biometric template protection?