CS 3251- Computer Networks 1:

Security Protocols (2)

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11/26/13

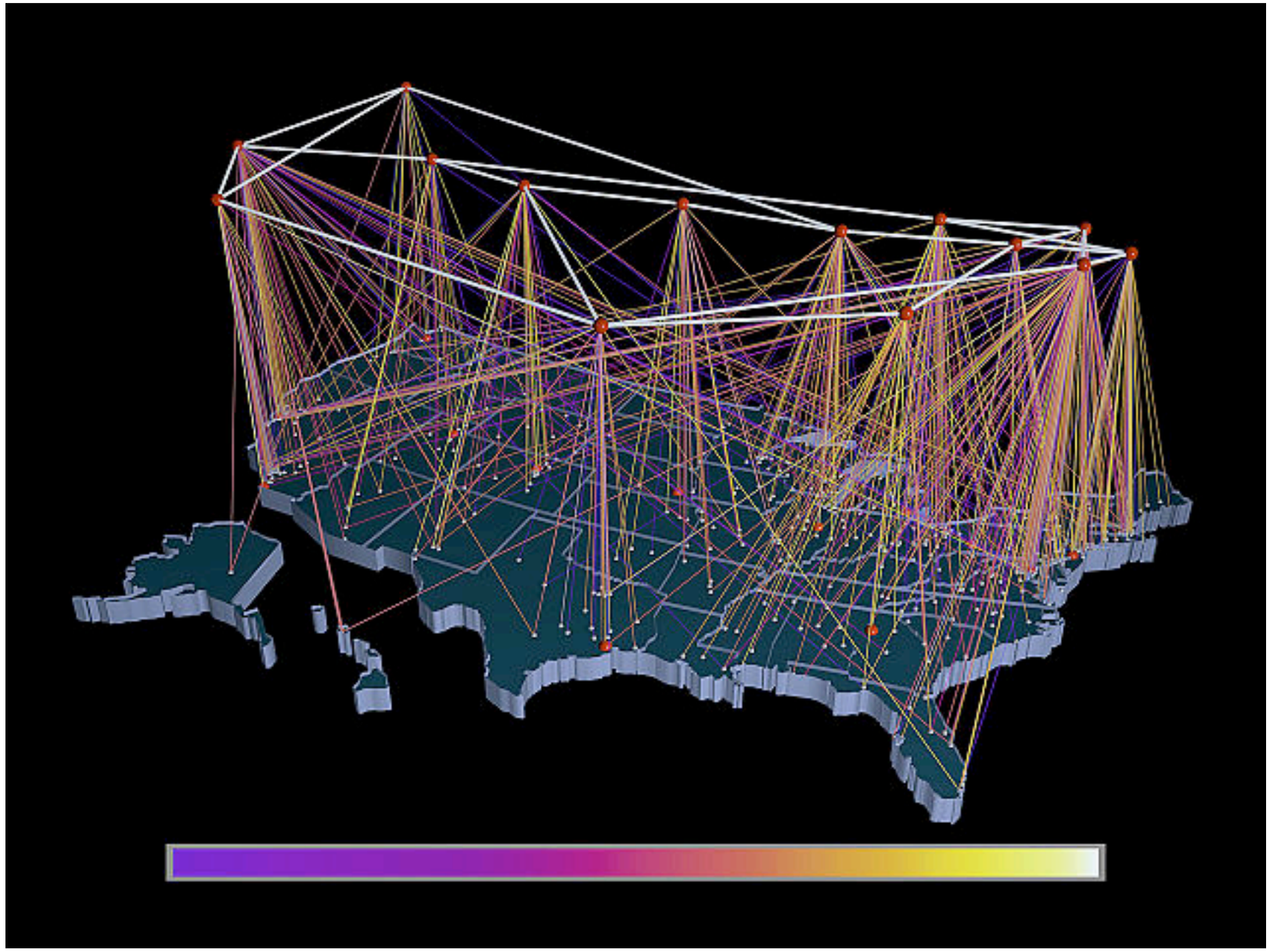
Lecture 27

Announcements

- Project 4
  - Due Thursday at 5pm

- That's it!
  - ... except for the final exam

In the News...



Chapter 8 roadmap

8.1 What is network security?

8.2 Principles of cryptography

8.3 Message Integrity, Authentication

8.4 Securing e-mail

8.5 Securing TCP connections: SSL

8.6 Network layer security: IPsec

8.7 Securing wireless LANs

8.8 Operational security: firewalls and IDS

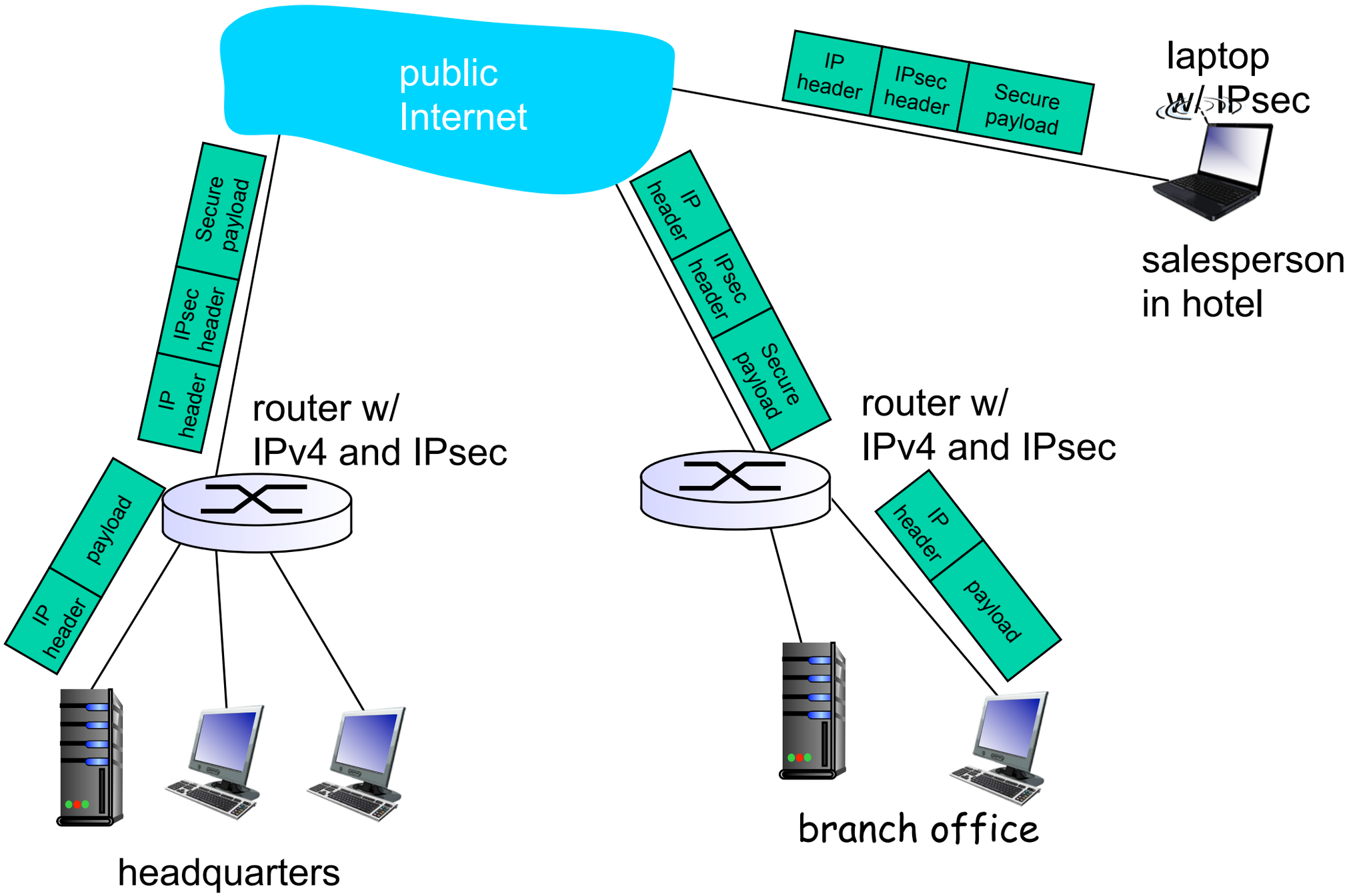
What is network-layer confidentiality?

- between two network entities:
  - sending entity encrypts datagram payload, payload could be:
    - TCP or UDP segment, ICMP message, OSPF message ….
- all data sent from one entity to other would be hidden:
  - web pages, e-mail, P2P file transfers, TCP SYN packets …
- "blanket coverage"

Virtual Private Networks (VPNs)

- *motivation*:
  - institutions often want private networks for security.
    - costly: separate routers, links, DNS infrastructure.
  - VPN: institution's inter-office traffic is sent over public Internet instead
    - encrypted before entering public Internet
    - logically separate from other traffic

Virtual Private Networks (VPNs)



IPsec services

- data integrity
- origin authentication
- replay attack prevention
- confidentiality
- two protocols providing different service models:
  - AH
  - ESP

Two IPsec protocols

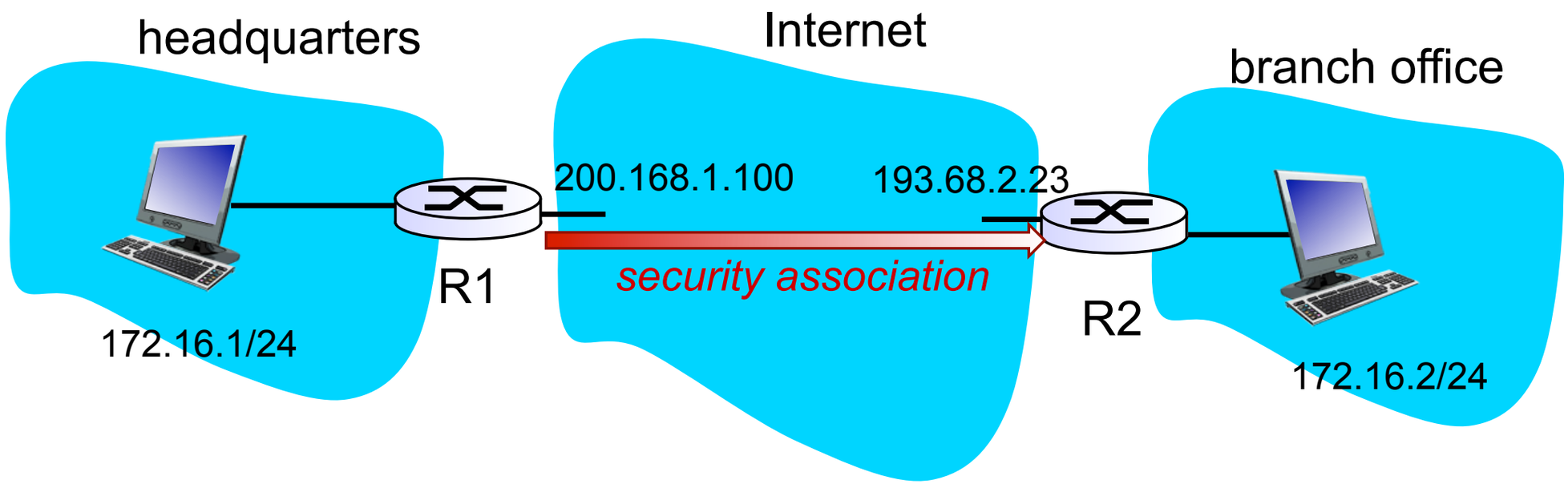
- Authentication Header (AH) protocol
  - provides source authentication & data integrity but not confidentiality
- Encapsulation Security Protocol (ESP)
  - provides source authentication, data integrity, and confidentiality
  - more widely used than AH

Security associations (SAs)

- before sending data, "security association (SA)" established from sending to receiving entity
  - SAs are simplex: for only one direction
- ending, receiving entitles maintain state information about SA
  - recall: TCP endpoints also maintain state info
  - IP is connectionless; IPsec is connection-oriented!
- how many SAs in VPN w/ headquarters, branch office, and n traveling salespeople?

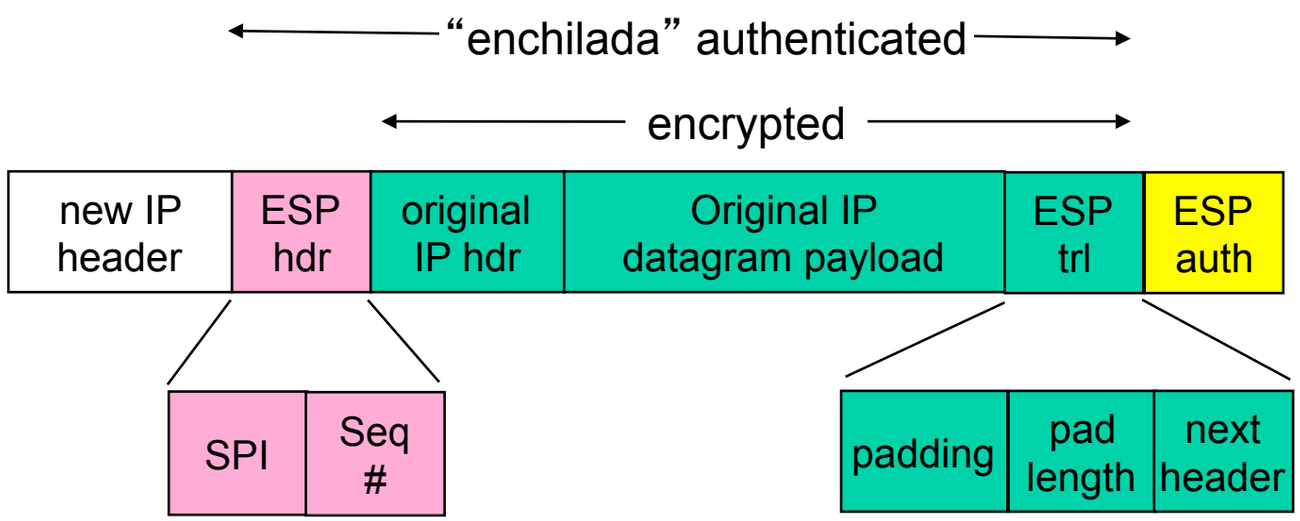
Example SA from R1 to R2

- *R1 Stores:*
  - 32-bit SA identifier: Security Parameter Index (SPI)
  - origin SA interface (200.168.1.100)
  - destination SA interface (193.68.2.23)
  - type of encryption used (e.g., 3DES with CBC)
  - encryption key
  - type of integrity check used (e.g., HMAC with MD5)
  - authentication key



IPsec datagram

- focus for now on tunnel mode with ESP



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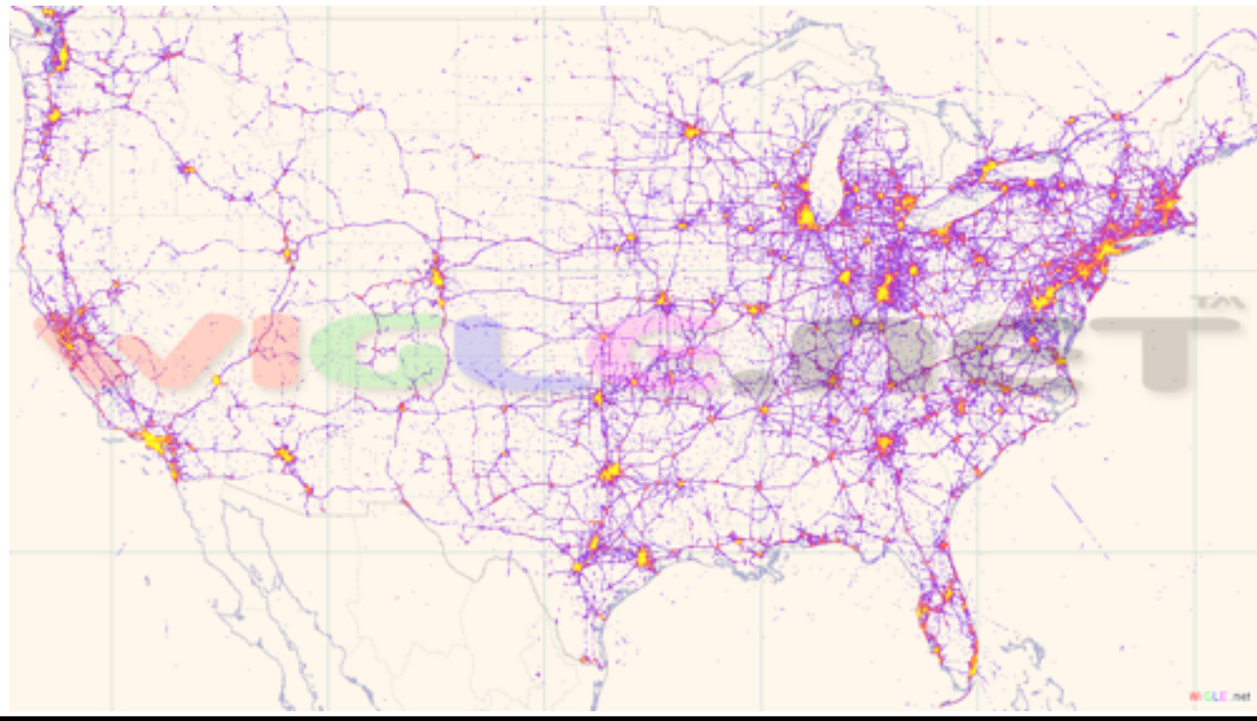
IEEE 802.11 security

- *war-driving:* drive around Bay area, see what 802.11 networks available?
  - More than 9000 accessible from public roadways
  - 85% use no encryption/authentication
  - packet-sniffing and various attacks easy!

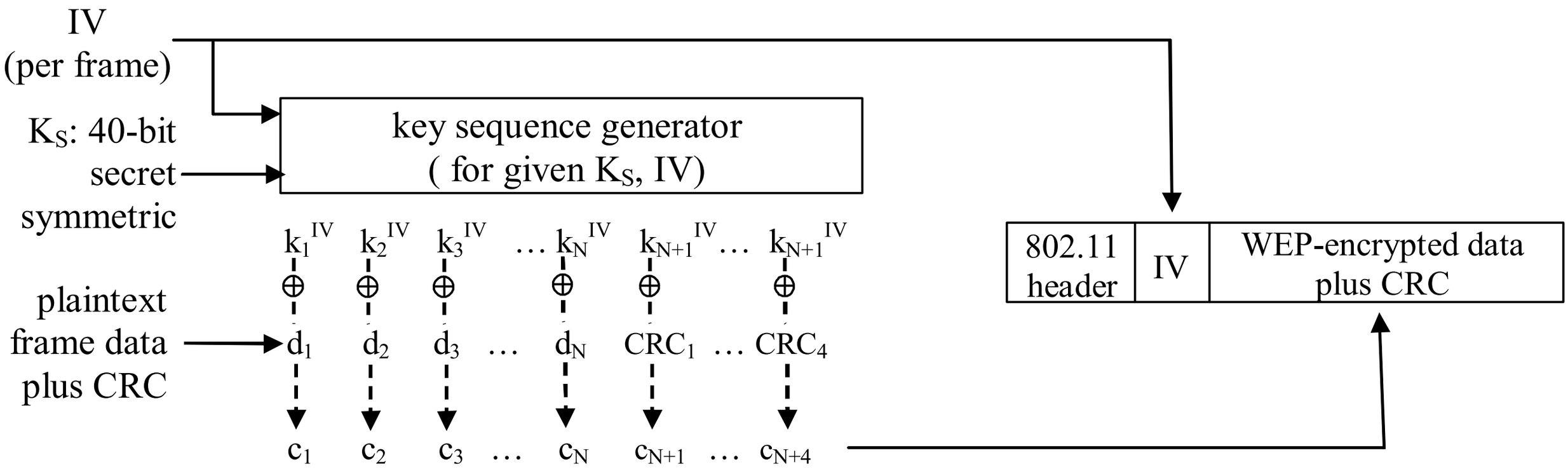
- securing 802.11
  - encryption, authentication
  - first attempt at 802.11 security: Wired Equivalent Privacy (WEP): a failure
  - current attempt: 802.11i



Wired Equivalent Privacy (WEP):

- authentication as in protocol *ap4.0*
  - host requests authentication from access point
  - access point sends 128 bit nonce
  - host encrypts nonce using shared symmetric key
  - access point decrypts nonce, authenticates host
- no key distribution mechanism
- authentication: knowing the shared key is enough

802.11 WEP encryption



Sender-side WEP encryption

Breaking 802.11 WEP encryption

security hole:

- 24-bit IV, one IV per frame, -> IV's eventually reused
- IV transmitted in plaintext -> IV reuse detected
- attack:
  - Trudy causes Alice to encrypt known plaintext d_1 d_2 d_3 d_4 …
  - Trudy sees: $c_i = d_i$ XOR k_i^{IV}
  - Trudy knows c_i d_i, so can compute k_i^{IV}
  - Trudy knows encrypting key sequence k_1^{IV} k_2^{IV} k_3^{IV} …
  - Next time IV is used, Trudy can decrypt!

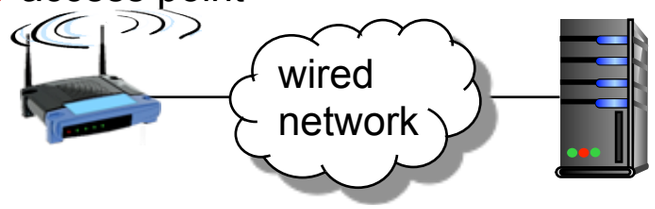
802.11i: improved security

- numerous (stronger) forms of encryption possible
- provides key distribution
- uses authentication server separate from access point

802.11i: four phases of operation

STA: client station

AP: access point



AS: Authentication server

1. Discovery of security capabilities

2. STA and AS mutually authenticate, together generate Master Key (MK). *AP serves as "pass through"*

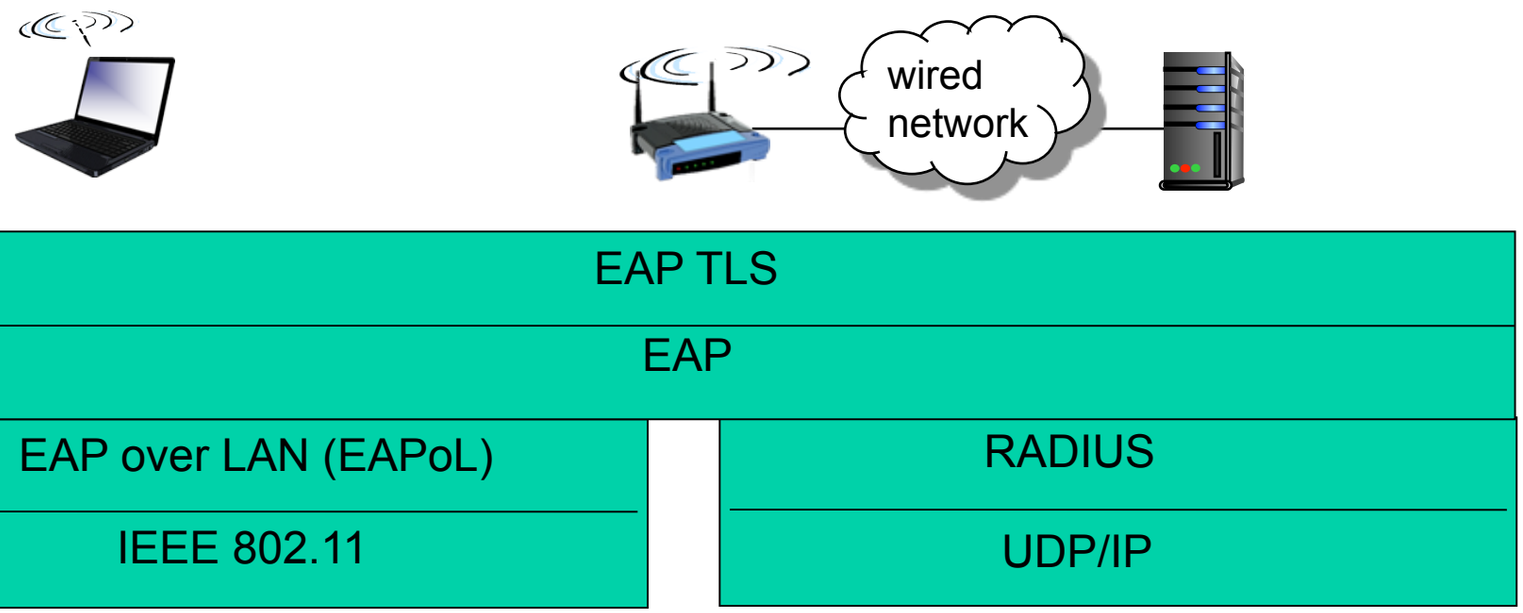
3. STA derives Pairwise Master Key (PMK)

3. AS derives same PMK, sends to AP

4. STA, AP use PMK to derive Temporal Key (TK) used for message encryption, integrity

EAP: extensible authentication protocol

- EAP: end-end client (mobile) to authentication server protocol
- EAP sent over separate "links"
  - mobile-to-AP (EAP over LAN)
  - AP to authentication server (RADIUS over UDP)



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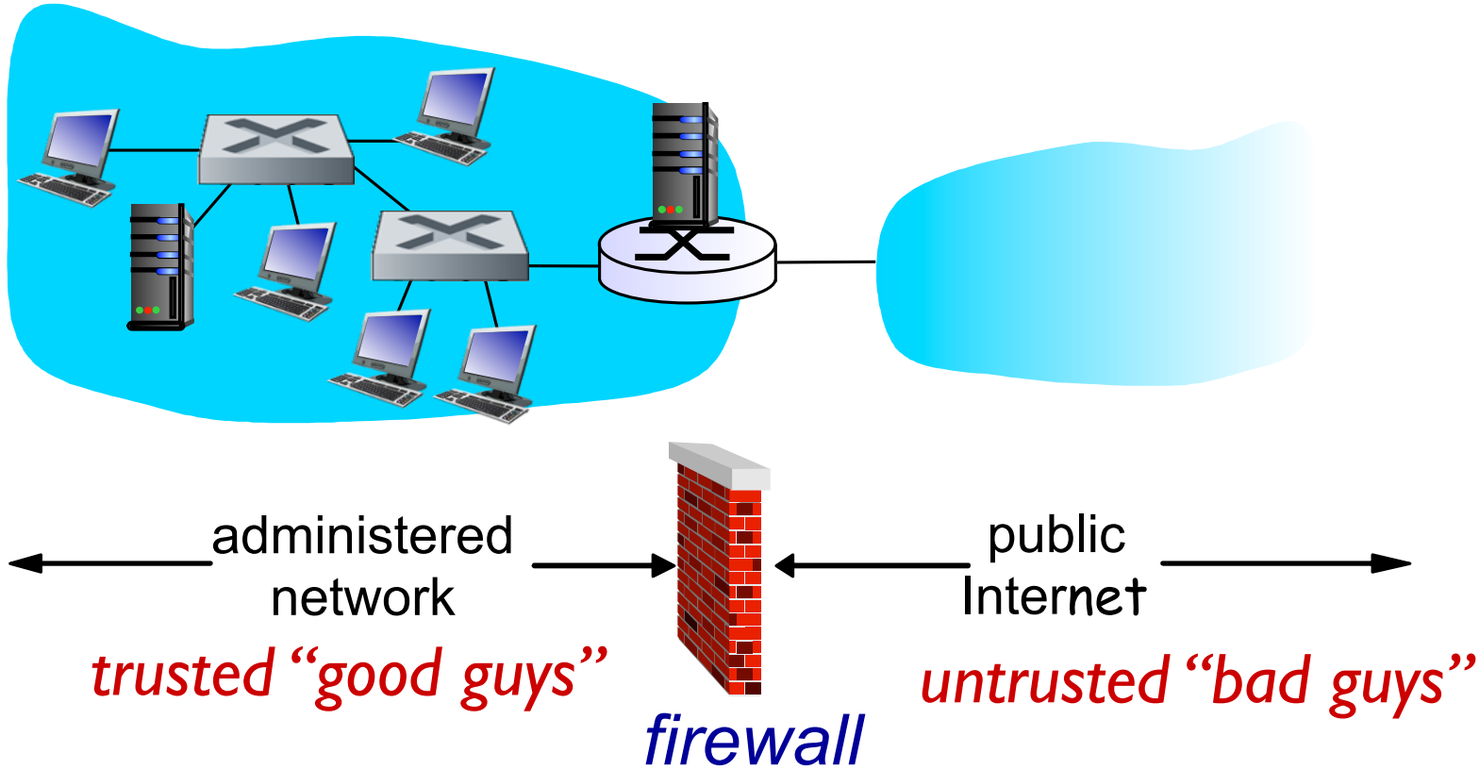
Firewalls

firewall

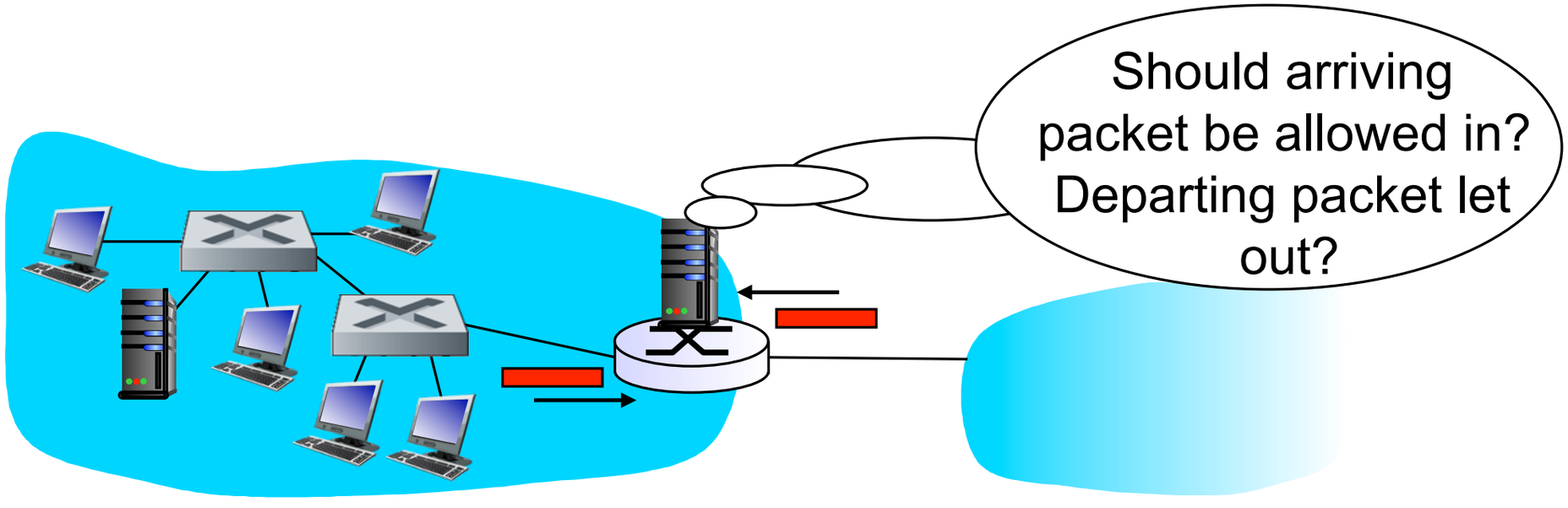
isolates organization's internal net from larger Internet, allowing some packets to pass, blocking others.



Firewalls: why

- prevent denial of service attacks:
  - SYN flooding: attacker establishes many bogus TCP connections, no resources left for "real" connections
- prevent illegal modification/access of internal data
  - e.g., attacker replaces CIA's homepage with something else
- allow only authorized access to inside network
  - set of authenticated users/hosts
- three types of firewalls:
  - stateless packet filters, stateful packet filters, application gateways

Stateless packet filtering



- internal network connected to Internet via router firewall
- router filters packet-by-packet, decision to forward/drop packet based on:
  - source IP address, destination IP address
  - TCP/UDP source and destination port numbers
  - ICMP message type
  - TCP SYN and ACK bits

Stateless packet filtering: example

- example 1: block incoming and outgoing datagrams with IP "Protocol field" = 17 and with either source or dest port = 23.
  - result: all incoming, outgoing UDP flows and telnet connections are blocked.
- example 2: Block inbound TCP segments with ACK=0.
  - result: prevents external clients from making TCP connections with internal clients, but allows internal clients to connect to outside.

Stateless packet filtering: more examples

Policy	*Firewall Setting*
No outside Web access.	Drop all outgoing packets to any IP address, port 80
No incoming TCP connections, except those for institution's public Web server only.	Drop all incoming TCP SYN packets to any IP except 130.207.244.203, port 80
Prevent Web-radios from eating up the available bandwidth.	Drop all incoming UDP packets - except DNS and router broadcasts.
Prevent your network from being used for a smurf DoS attack.	Drop all ICMP packets going to a "broadcast" address (e.g. 130.207.255.255).
Prevent your network from being tracerouted	Drop all outgoing ICMP TTL expired traffic

Access Control Lists

- *ACL:* table of rules, applied top to bottom to incoming packets: (action, condition) pairs

action	source address	dest address	protocol	source port	dest port	flag bit
allow	222.22/16	outside of 222.22/16	TCP	> 1023	80	any
allow	outside of 222.22/16	222.22/16	TCP	80	> 1023	ACK
allow	222.22/16	outside of 222.22/16	UDP	> 1023	53	---
allow	outside of 222.22/16	222.22/16	UDP	53	> 1023	----
deny	all	all	all	all	all	all

Stateful packet filtering

- *stateless packet filter:* heavy handed tool
  - admits packets that "make no sense," e.g., dest port = 80, ACK bit set, even though no TCP connection established:

action	source address	dest address	protocol	source port	dest port	flag bit
allow	outside of 222.22/16	222.22/16	TCP	80	> 1023	ACK

- *stateful packet filter:* track status of every TCP connection
  - track connection setup (SYN), teardown (FIN): determine whether incoming, outgoing packets "makes sense"
  - timeout inactive connections at firewall: no longer admit packets

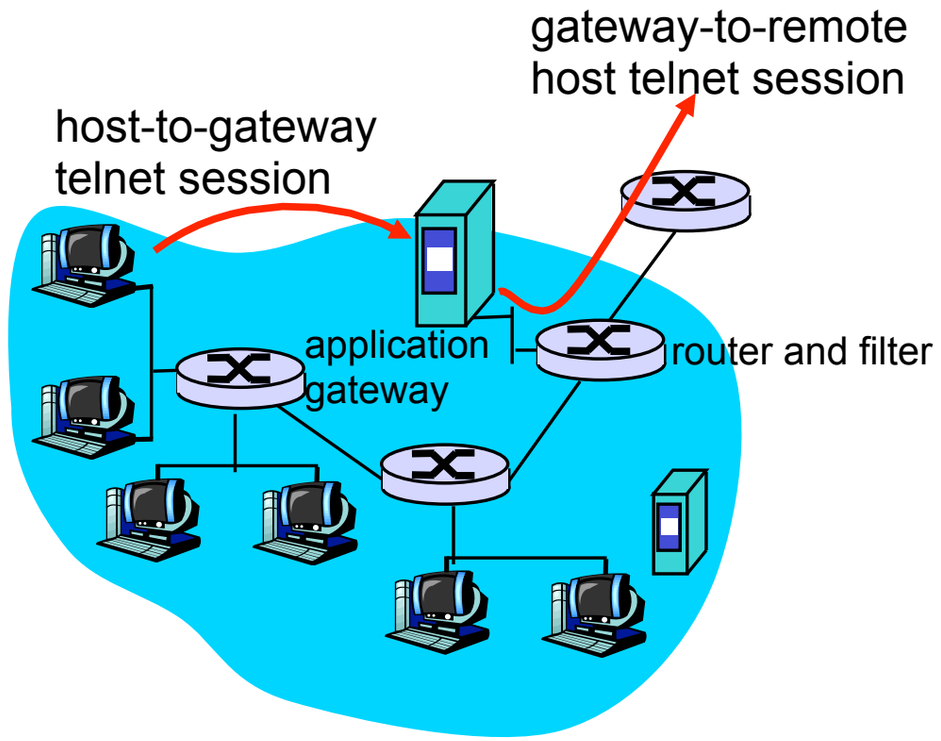
Stateful packet filtering

- ACL augmented to indicate need to check connection state table before admitting packet

action	source address	dest address	proto	source port	dest port	flag bit	check conxion
allow	222.22/16	outside of 222.22/16	TCP	> 1023	80	any	
allow	outside of 222.22/16	222.22/16	TCP	80	> 1023	ACK	X
allow	222.22/16	outside of 222.22/16	UDP	> 1023	53	---	
allow	outside of 222.22/16	222.22/16	UDP	53	> 1023	----	X
deny	all	all	all	all	all	all	

Application gateways

- filters packets on application data as well as on IP/TCP/ UDP fields.
- *example:* allow select internal users to telnet outside.



1. require all telnet users to telnet through gateway.
2. for authorized users, gateway sets up telnet connection to dest host. Gateway relays data between 2 connections
3. router filter blocks all telnet connections not originating from gateway.

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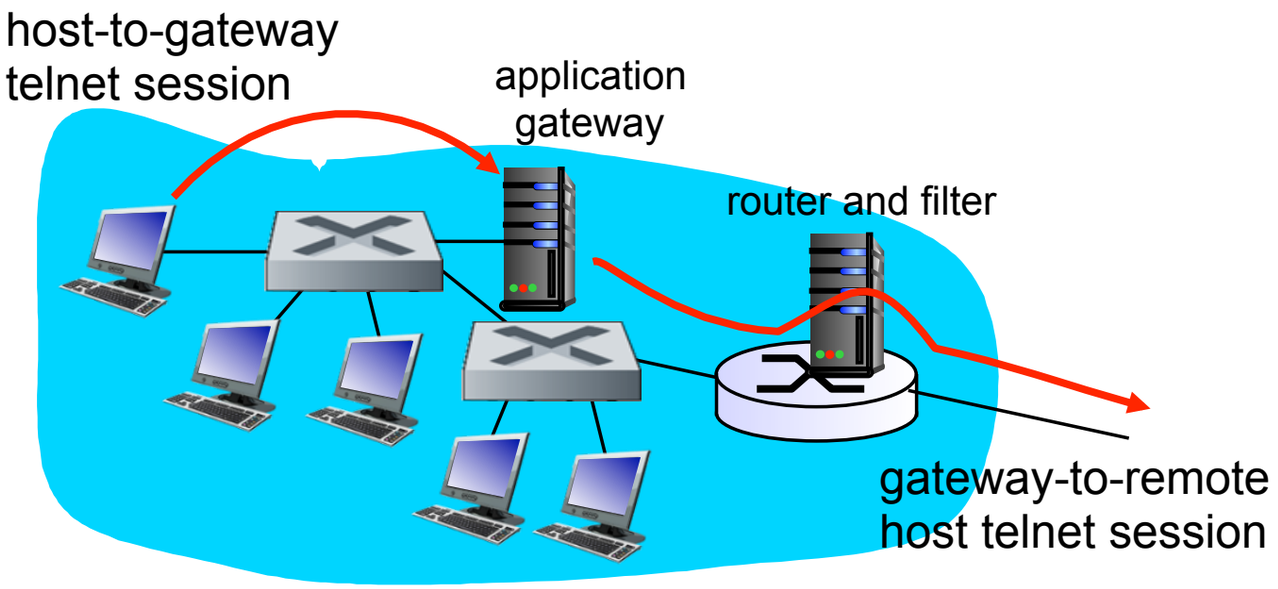

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Limitations of firewalls and gateways

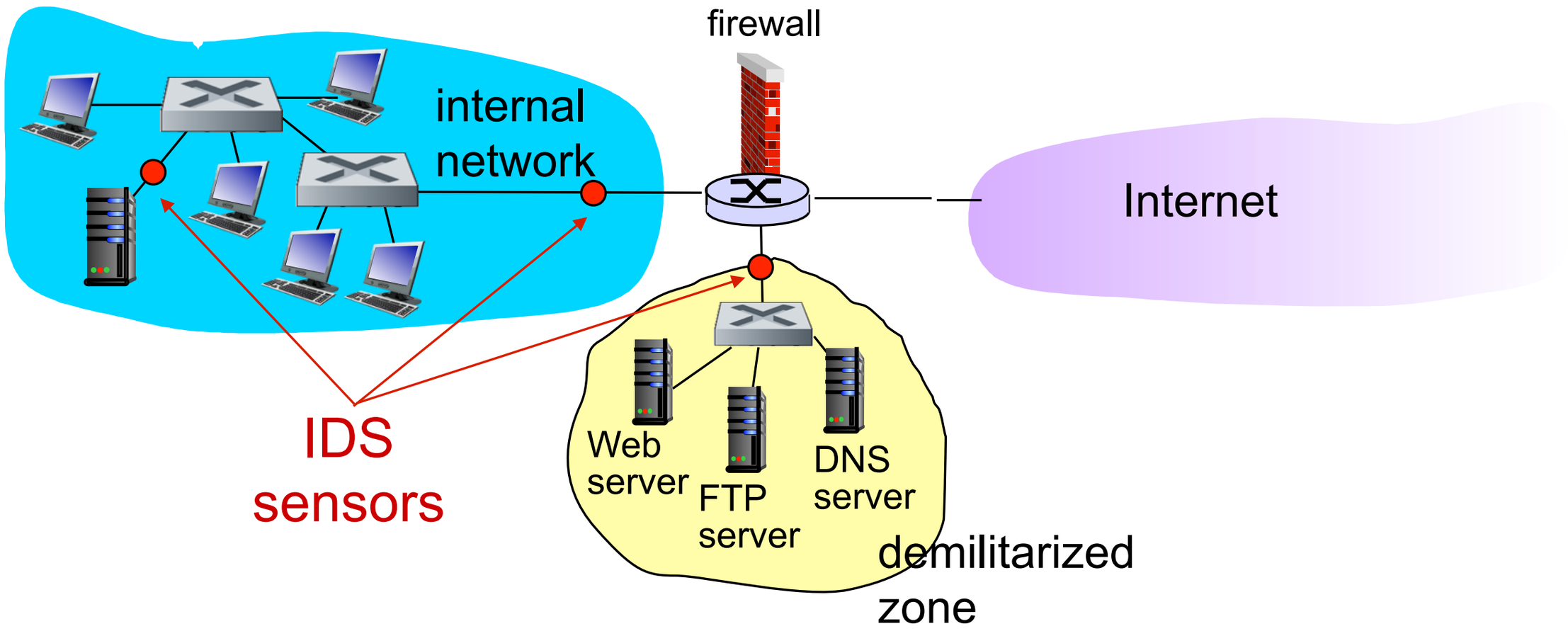
- *IP spoofing:* router can't know if data "really" comes from claimed source
- if multiple app's. need special treatment, each has own app. gateway
- client software must know how to contact gateway.
  - e.g., must set IP address of proxy in Web browser
- filters often use all or nothing policy for UDP
- *tradeoff:* degree of communication with outside world, level of security
- many highly protected sites still suffer from attacks

Intrusion detection systems

- packet filtering:
  - operates on TCP/IP headers only
  - no correlation check among sessions
- *IDS: intrusion detection system*
  - *deep packet inspection:* look at packet contents (e.g., check character strings in packet against database of known virus, attack strings)
  - examine correlation among multiple packets
    - port scanning
    - network mapping
    - DoS attack

Intrusion detection systems

- multiple IDSs: different types of checking at different locations



Network Security (summary)

Basic techniques…...

- cryptography (symmetric and public)
- message integrity
- end-point authentication

…. used in many different security scenarios

- secure email
- secure transport (SSL)
- IP sec
- 802.11

Operational Security: firewalls and IDS