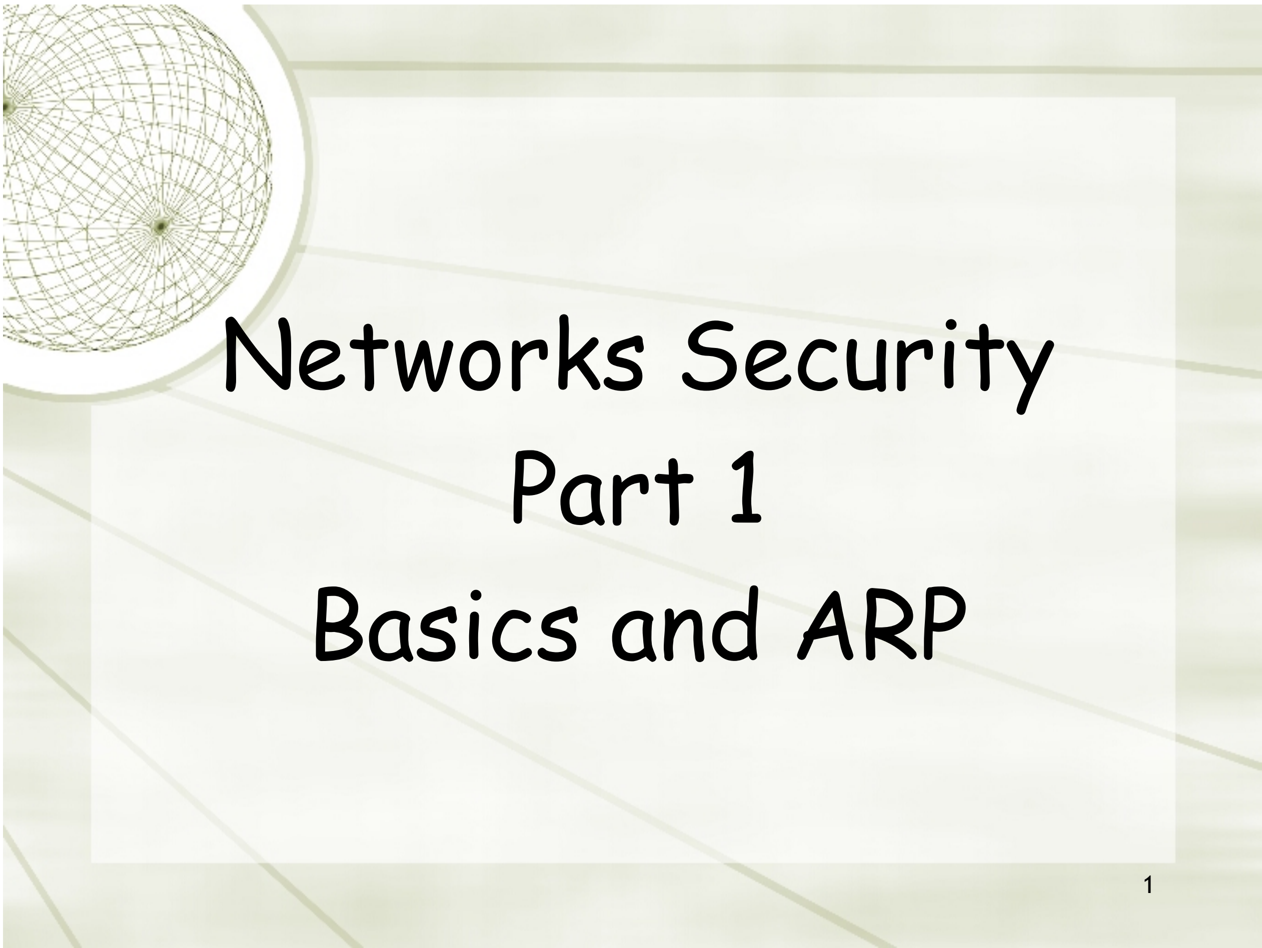
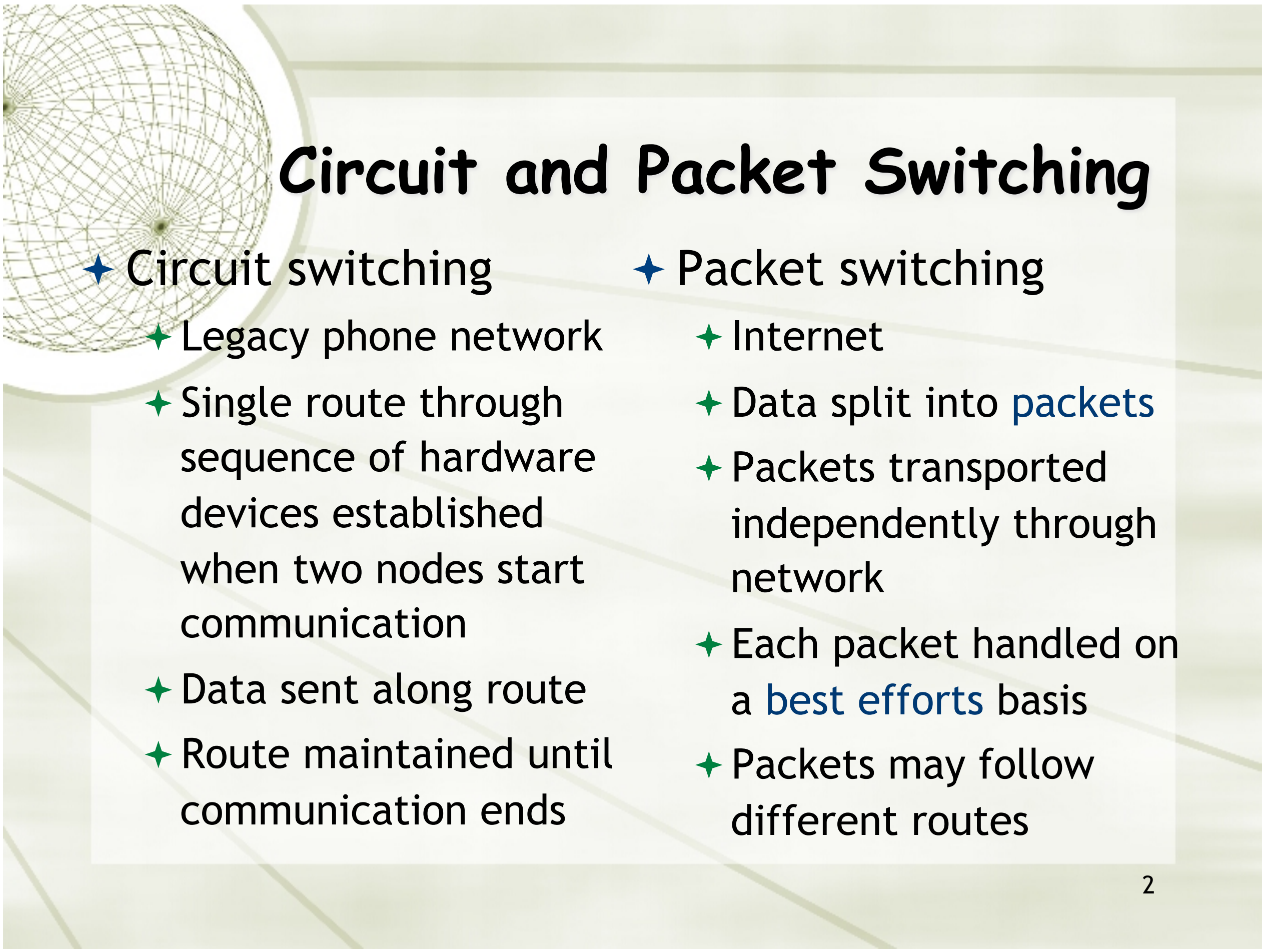


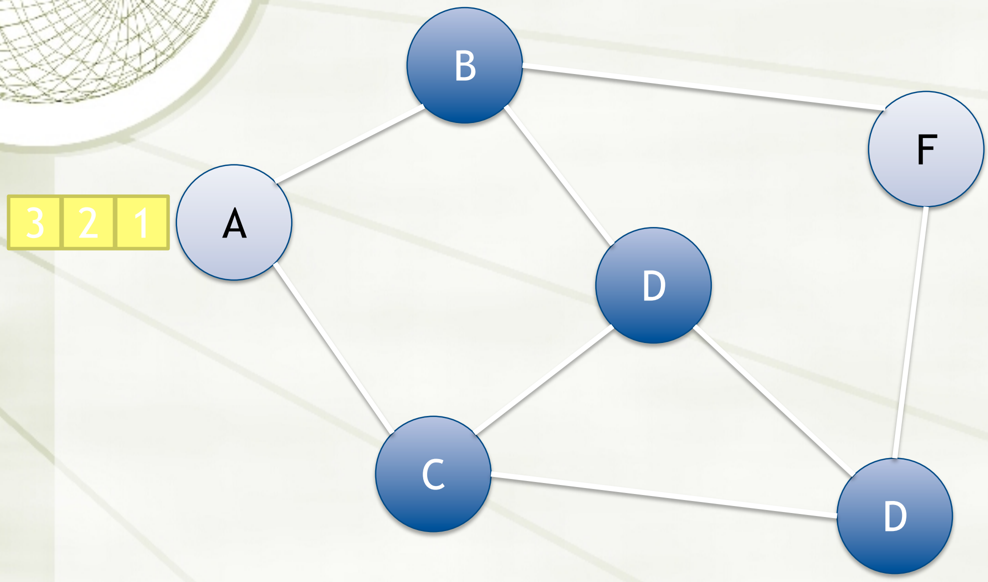
Networks Security Part 1 Basics and ARP



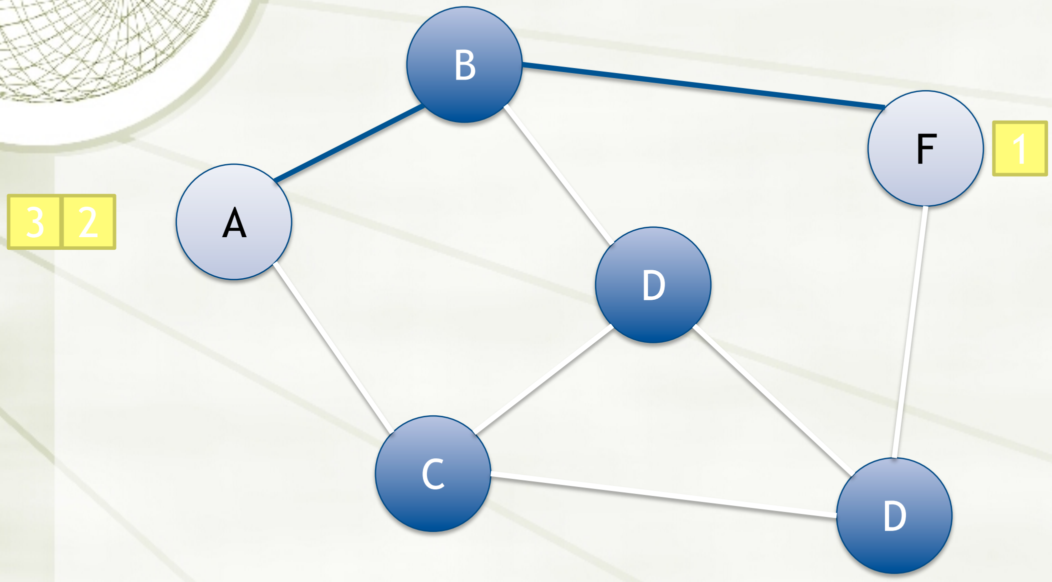
Circuit and Packet Switching

- Circuit switching
  - Legacy phone network
  - Single route through sequence of hardware devices established when two nodes start communication
  - Data sent along route
  - Route maintained until communication ends
- Packet switching
  - Internet
  - Data split into packets
  - Packets transported independently through network
  - Each packet handled on a best efforts basis
  - Packets may follow different routes

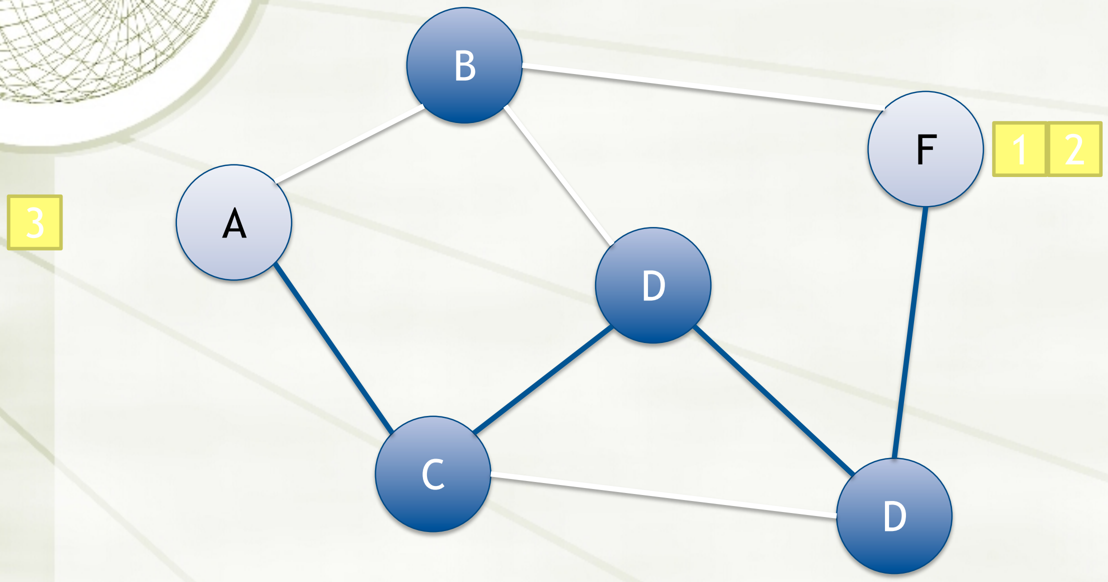
Packet Switching



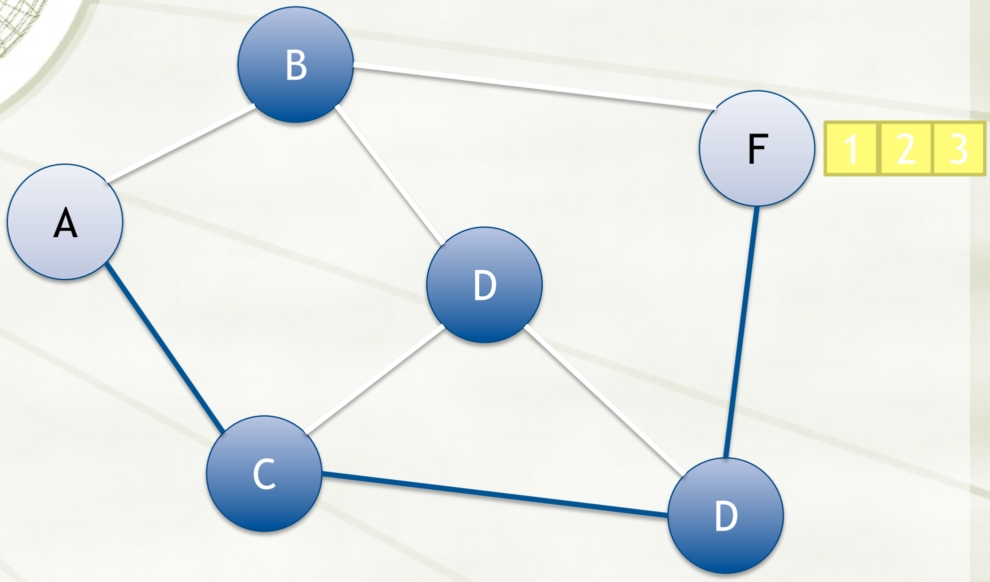
Packet Switching



Packet Switching



Packet Switching

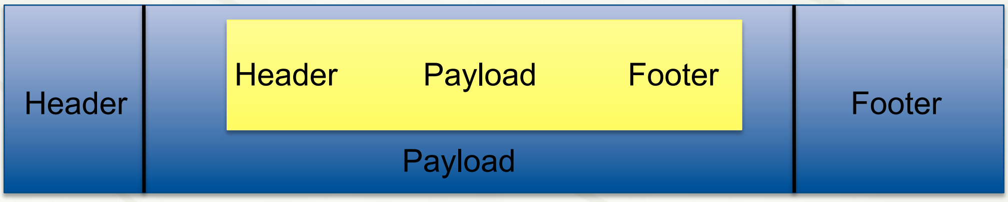


Protocols

- A protocol defines the rules for communication between computers
- Protocols are broadly classified as connectionless and connection oriented
- Connectionless protocol
  - Sends data out as soon as there is enough data to be transmitted
  - E.g., user datagram protocol (UDP)
- Connection-oriented protocol
  - Provides a reliable connection stream between two nodes
  - Consists of set up, transmission, and tear down phases
  - Creates virtual circuit-switched network
  - E.g., transmission control protocol (TCP)

Encapsulation

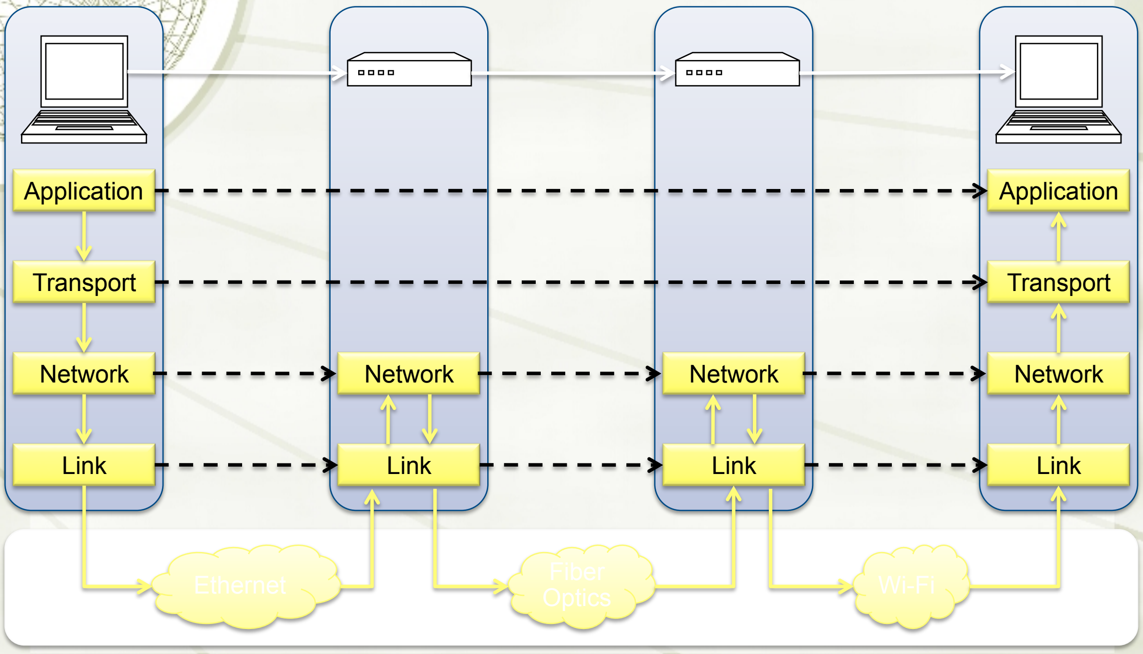
- A packet typically consists of
  - Control information for addressing the packet: header and footer
  - Data: payload
- A network protocol N1 can use the services of another network protocol N2
  - A packet p1 of N1 is encapsulated into a packet p2 of N2
  - The payload of p2 is p1
  - The control information of p2 is derived from that of p1



Network Layers

- Network models typically use a stack of layers
  - Higher layers use the services of lower layers via encapsulation
  - A layer can be implemented in hardware or software
  - The bottommost layer must be in hardware
- A network device may implement several layers
- A communication channel between two nodes is established for each layer
  - Actual channel at the bottom layer
  - Virtual channel at higher layers

Internet Layers

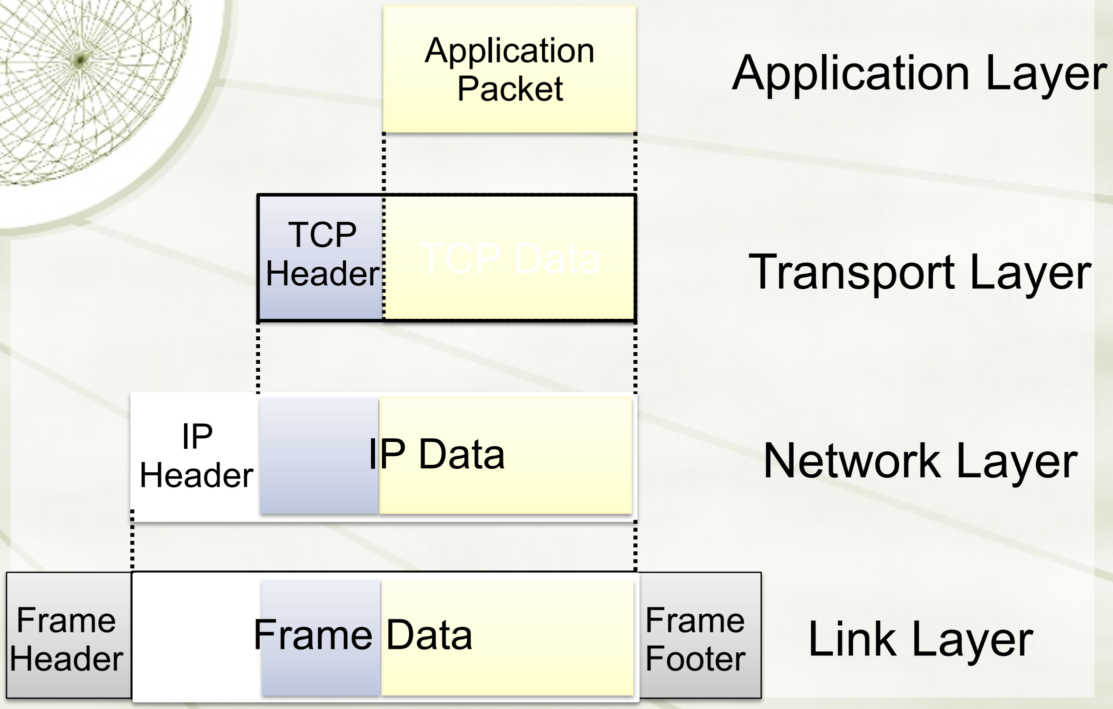


Physical Layer

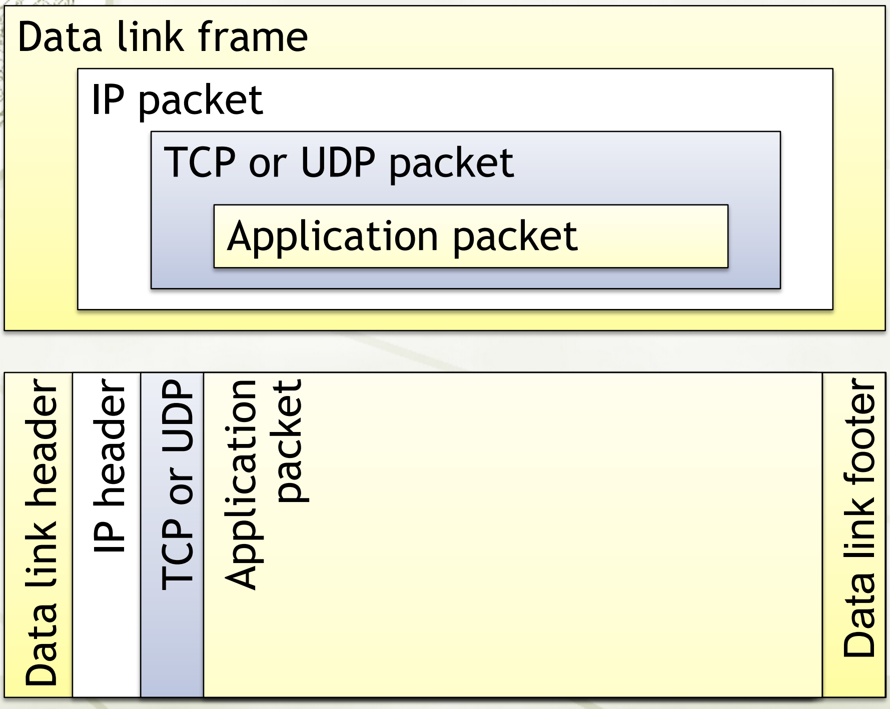
Intermediate Layers

- Link layer
  - Local area network: Ethernet, WiFi, optical fiber
  - 48-bit media access control (MAC) addresses
  - Packets called frames
- Network layer
  - Internet-wide communication
  - Best efforts
  - 32-bit internet protocol (IP) addresses in IPv4
  - 128-bit IP addresses in IPv6
- Transport layer
  - 16-bit addresses (ports) for classes of applications
  - Connection-oriented transmission layer protocol (TCP)
  - Connectionless user datagram protocol (UDP)

Internet Packet Encapsulation



Internet Packet Encapsulation



Data link frame

IP packet

TCP or UDP packet

Application packet

Data link header

IP header

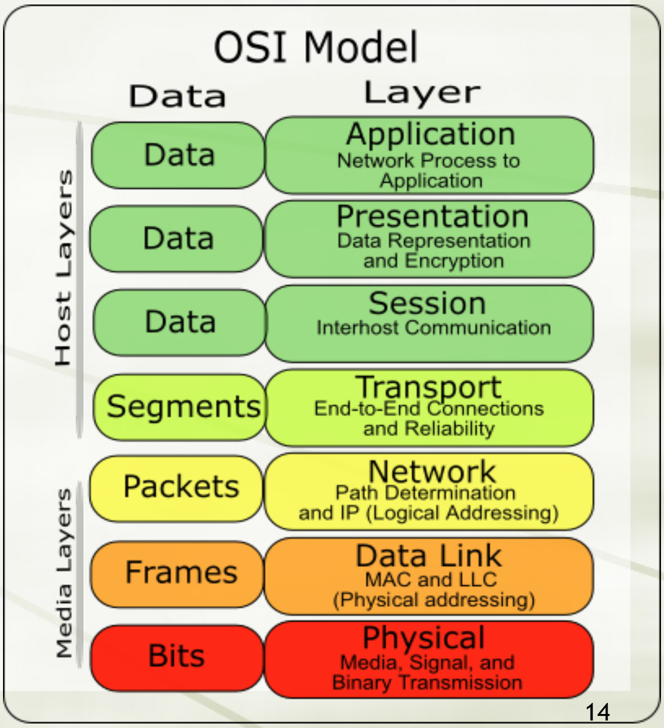
TCP or UDP

Application packet

Data link footer

The OSI Model

- The OSI (Open System Interconnect) Reference Model is a network model consisting of seven layers
- Created in 1983, OSI is promoted by the International Standard Organization (ISO)



OSI Model

Data	Layer
Data	Application Network Process to Application
Data	Presentation Data Representation and Encryption
Data	Session Interhost Communication
Segments	Transport End-to-End Connections and Reliability
Packets	Network Path Determination and IP (Logical Addressing)
Frames	Data Link MAC and LLC (Physical addressing)
Bits	Physical Media, Signal, and Binary Transmission

Network Interfaces

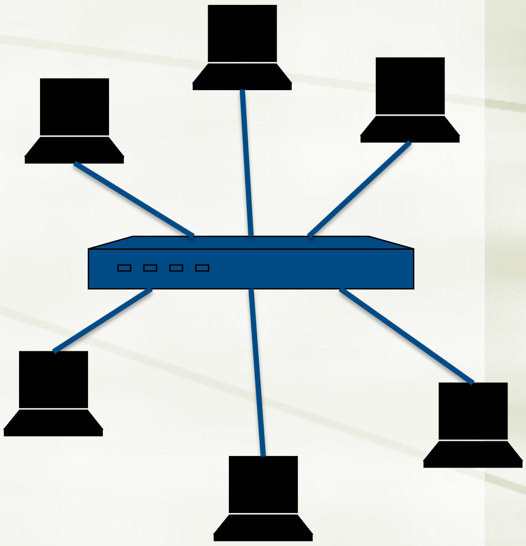
- Network interface: device connecting a computer to a network
  - Ethernet card
  - WiFi adapter
- A computer may have multiple network interfaces
- Packets transmitted between network interfaces
- Most local area networks, (including Ethernet and WiFi) broadcast frames
- In regular mode, each network interface gets the frames intended for it
- Traffic sniffing can be accomplished by configuring the network interface to read all frames (promiscuous mode)

MAC Addresses

- Most network interfaces come with a predefined MAC address
- A MAC address is a 48-bit number usually represented in hex
  - E.g., 00-1A-92-D4-BF-86
- The first three octets of any MAC address are IEEE-assigned Organizationally Unique Identifiers
  - E.g., Cisco 00-1A-A1, D-Link 00-1B-11, ASUSTek 00-1A-92
- The next three can be assigned by organizations as they please, with uniqueness being the only constraint
- Organizations can utilize MAC addresses to identify computers on their network
- MAC address can be reconfigured by network interface driver software

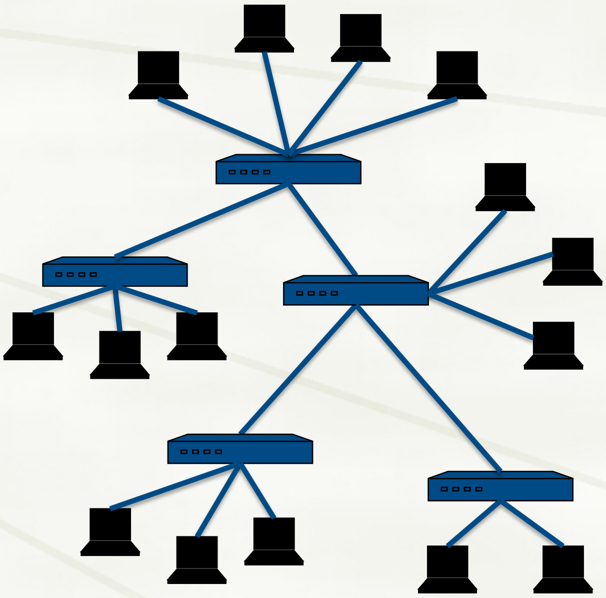
Switch

- A switch is a common network device
  - Operates at the link layer
  - Has multiple ports, each connected to a computer
- Operation of a switch
  - Learn the MAC address of each computer connected to it
  - Forward frames only to the destination computer



Combining Switches

- Switches can be arranged into a tree
- Each port learns the MAC addresses of the machines in the segment (subtree) connected to it
- Fragments to unknown MAC addresses are broadcast
- Frames to MAC addresses in the same segment as the sender are ignored



MAC Address Filtering

- A switch can be configured to provide service only to machines with specific MAC addresses
- Allowed MAC addresses need to be registered with a network administrator
- A MAC spoofing attack impersonates another machine
  - Find out MAC address of target machine
  - Reconfigure MAC address of rogue machine
  - Turn off or unplug target machine
- Countermeasures
  - Block port of switch when machine is turned off or unplugged
  - Disable duplicate MAC addresses

Viewing and Changing MAC Addresses

- Viewing the MAC addresses of the interfaces of a machine
  - Linux: `ifconfig`
  - Windows: `ipconfig /all`
- Changing a MAC address in Linux
  - Stop the networking service: `/etc/init.d/network stop`
  - Change the MAC address: `ifconfig eth0 hw ether <MAC-address>`
  - Start the networking service: `/etc/init.d/network start`
- Changing a MAC address in Windows
  - Open the Network Connections applet
  - Access the properties for the network interface
  - Click “Configure …”
  - In the advanced tab, change the network address to the desired value
- Changing a MAC address requires administrator privileges

ARP

- The address resolution protocol (ARP) connects the network layer to the data layer by converting IP addresses to MAC addresses
- ARP works by broadcasting requests and caching responses for future use
- The protocol begins with a computer broadcasting a message of the form

  who has <IP address1> tell <IP address2>

- When the machine with <IP address1> or an ARP server receives this message, its broadcasts the response

  <IP address1> is <MAC address>

- The requestor's IP address <IP address2> is contained in the link header
- The Linux and Windows command arp - a displays the ARP table

```
Internet Address      Physical Address      Type
128.148.31.1          00-00-0c-07-ac-00     dynamic
128.148.31.15         00-0c-76-b2-d7-1d     dynamic
128.148.31.71         00-0c-76-b2-d0-d2     dynamic
128.148.31.75         00-0c-76-b2-d7-1d     dynamic
128.148.31.102        00-22-0c-a3-e4-00     dynamic
128.148.31.137        00-1d-92-b6-f1-a9     dynamic
```

ARP Spoofing

- The ARP table is updated whenever an ARP response is received
- Requests are not tracked
- ARP announcements are not authenticated
- Machines trust each other
- A rogue machine can spoof other machines

ARP Poisoning (ARP Spoofing)

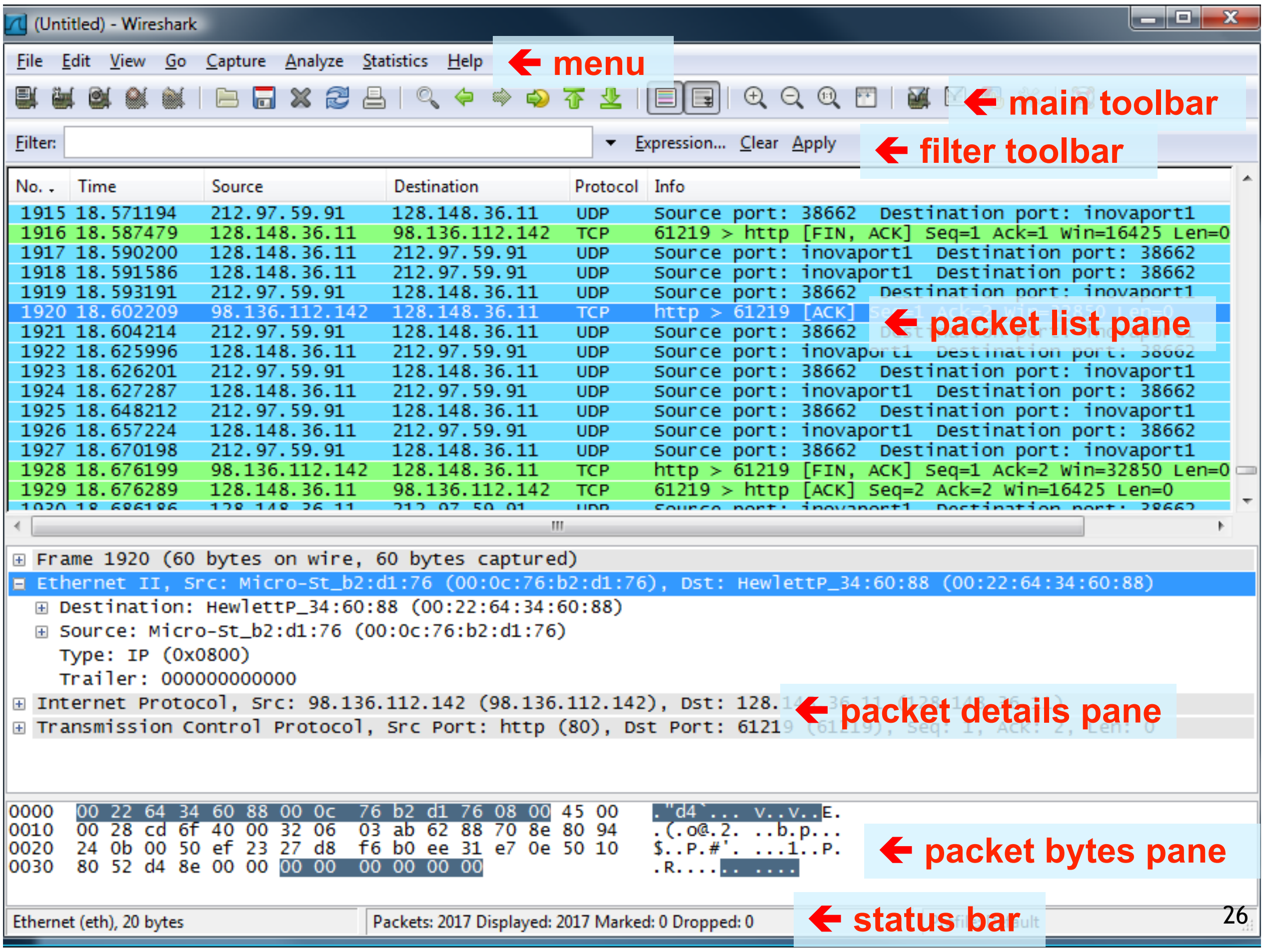
- According to the standard, almost all ARP implementations are stateless
- An arp cache updates every time that it receives an arp reply… even if it did not send any arp request!
- It is possible to “poison” an arp cache by sending gratuitous arp replies
- Using static entries solves the problem but it is almost impossible to manage!

Telnet Protocol (RFC 854)

- Telnet is a protocol that provides a general, bi-directional, not encrypted communication
- `telnet` is a generic TCP client
  - Allows a computer to connect to another one
  - Provides remote login capabilities to computers on the Internet
  - Sends whatever you type
  - Prints whatever comes back
  - Useful for testing TCP servers (ASCII based protocols)

Wireshark

- Wireshark is a packet sniffer and protocol analyzer
  - Captures and analyzes frames
  - Supports plugins
- Usually required to run with administrator privileges
- Setting the network interface in promiscuous mode captures traffic across the entire LAN segment and not just frames addressed to the machine
- Freely available on www.wireshark.org

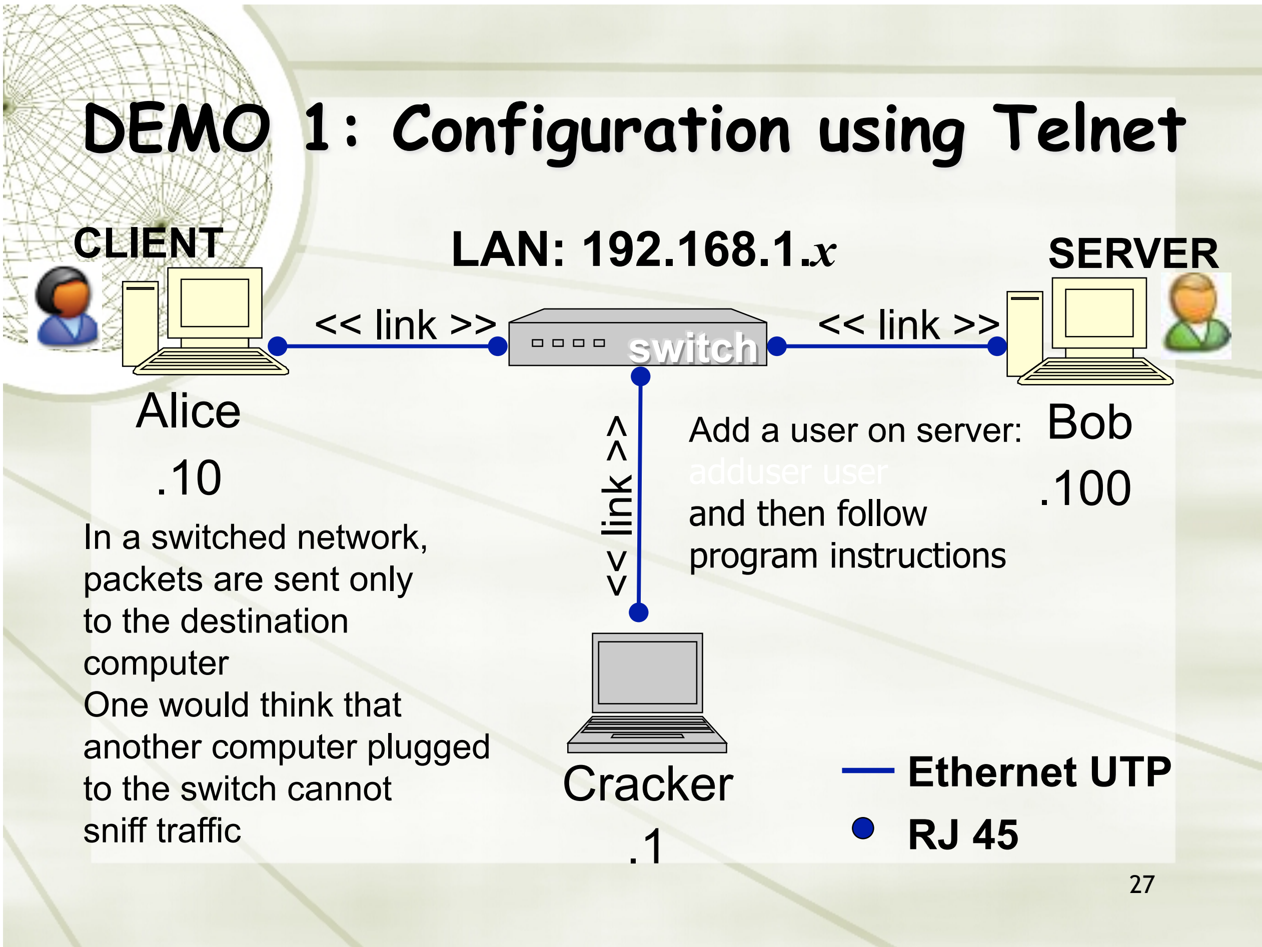


```
No. .  Time       Source          Destination     Protocol Info
1915 18.571194  212.97.59.91    128.148.36.11   UDP   Source port: 38662  Destination port: inovaport1
1916 18.587479  128.148.36.11   98.136.112.142  TCP   61219 > http [FIN, ACK] Seq=1 Ack=1 Win=16425 Len=0
1917 18.590200  128.148.36.11   212.97.59.91    UDP   Source port: inovaport1  Destination port: 38662
1918 18.591586  128.148.36.11   212.97.59.91    UDP   Source port: inovaport1  Destination port: 38662
1919 18.593191  212.97.59.91    128.148.36.11   UDP   Source port: 38662  Destination port: inovaport1
1920 18.602209  98.136.112.142  128.148.36.11   TCP   http > 61219 [ACK] Seq=1 Ack=2 Win=32850 Len=0
1921 18.604214  212.97.59.91    128.148.36.11   UDP   Source port: 38662  Destination port: inovaport1
1922 18.625996  128.148.36.11   212.97.59.91    UDP   Source port: inovaport1  Destination port: 38662
1923 18.626201  212.97.59.91    128.148.36.11   UDP   Source port: 38662  Destination port: inovaport1
1924 18.627287  128.148.36.11   212.97.59.91    UDP   Source port: inovaport1  Destination port: 38662
1925 18.648212  212.97.59.91    128.148.36.11   UDP   Source port: 38662  Destination port: inovaport1
1926 18.657224  128.148.36.11   212.97.59.91    UDP   Source port: inovaport1  Destination port: 38662
1927 18.670198  212.97.59.91    128.148.36.11   UDP   Source port: 38662  Destination port: inovaport1
1928 18.676199  98.136.112.142  128.148.36.11   TCP   http > 61219 [FIN, ACK] Seq=1 Ack=2 Win=32850 Len=0
1929 18.676289  128.148.36.11   98.136.112.142  TCP   61219 > http [ACK] Seq=2 Ack=2 Win=16425 Len=0
1930 18.686186  128.148.36.11   212.97.59.91    UDP   Source port: inovaport1  Destination port: 38662
```

```
⊞ Frame 1920 (60 bytes on wire, 60 bytes captured)
⊟ Ethernet II, Src: Micro-St_b2:d1:76 (00:0c:76:b2:d1:76), Dst: HewlettP_34:60:88 (00:22:64:34:60:88)
   ⊞ Destination: HewlettP_34:60:88 (00:22:64:34:60:88)
   ⊞ Source: Micro-St_b2:d1:76 (00:0c:76:b2:d1:76)
     Type: IP (0x0800)
     Trailer: 000000000000
⊞ Internet Protocol, Src: 98.136.112.142 (98.136.112.142), Dst: 128.148.36.11 (128.148.36.11)
⊞ Transmission Control Protocol, Src Port: http (80), Dst Port: 61219 (61219), Seq: 1, Ack: 2, Len: 0
```

```
0000  00 22 64 34 60 88 00 0c  76 b2 d1 76 08 00 45 00   ."d4`... v..v..E.
0010  00 28 cd 6f 40 00 32 06  03 ab 62 88 70 8e 80 94   .(.o@.2. ..b.p...
0020  24 0b 00 50 ef 23 27 d8  f6 b0 ee 31 e7 0e 50 10   $..P.#'. ...1..P.
0030  80 52 d4 8e 00 00 00 00  00 00 00 00               .R...... ....
```

Ethernet (eth), 20 bytes | Packets: 2017 Displayed: 2017 Marked: 0 Dropped: 0



DEMO 1: Configuration using Telnet

CLIENT

LAN: 192.168.1.x

SERVER

<< link >>

switch

<< link >>

Alice

.10

<< link >>

Add a user on server:

adduser user

and then follow program instructions

Bob

.100

In a switched network, packets are sent only to the destination computer

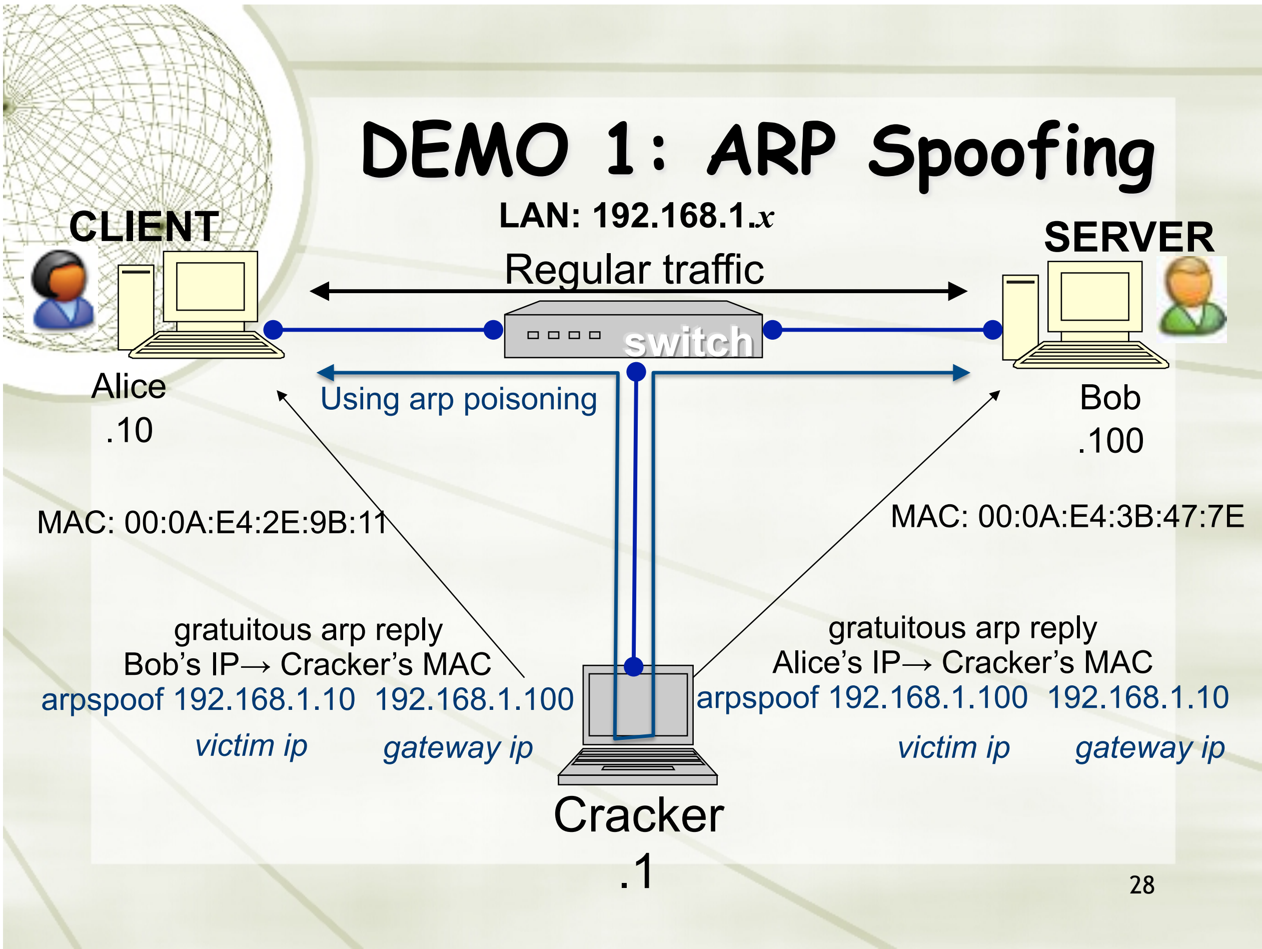
One would think that another computer plugged to the switch cannot sniff traffic

Cracker

.1

Ethernet UTP

● **RJ 45**



DEMO 1: ARP Spoofing

LAN: 192.168.1.x

CLIENT

SERVER

Regular traffic

switch

Alice

.10

Using arp poisoning

Bob

.100

MAC: 00:0A:E4:2E:9B:11

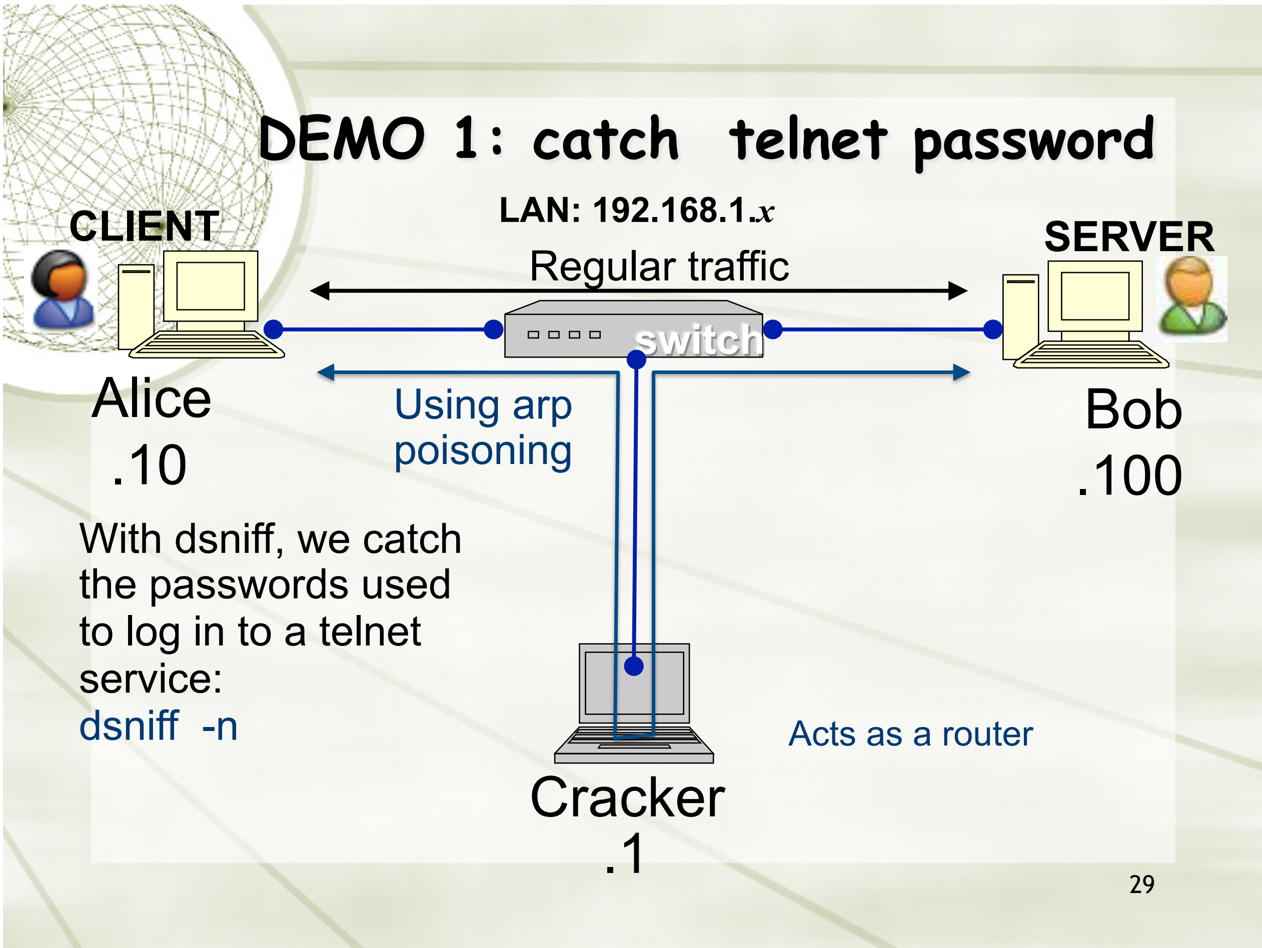
MAC: 00:0A:E4:3B:47:7E

gratuitous arp reply
Bob's IP→ Cracker's MAC
arpspoof 192.168.1.10 192.168.1.100
victim ip *gateway ip*

gratuitous arp reply
Alice's IP→ Cracker's MAC
arpspoof 192.168.1.100 192.168.1.10
victim ip *gateway ip*

Cracker

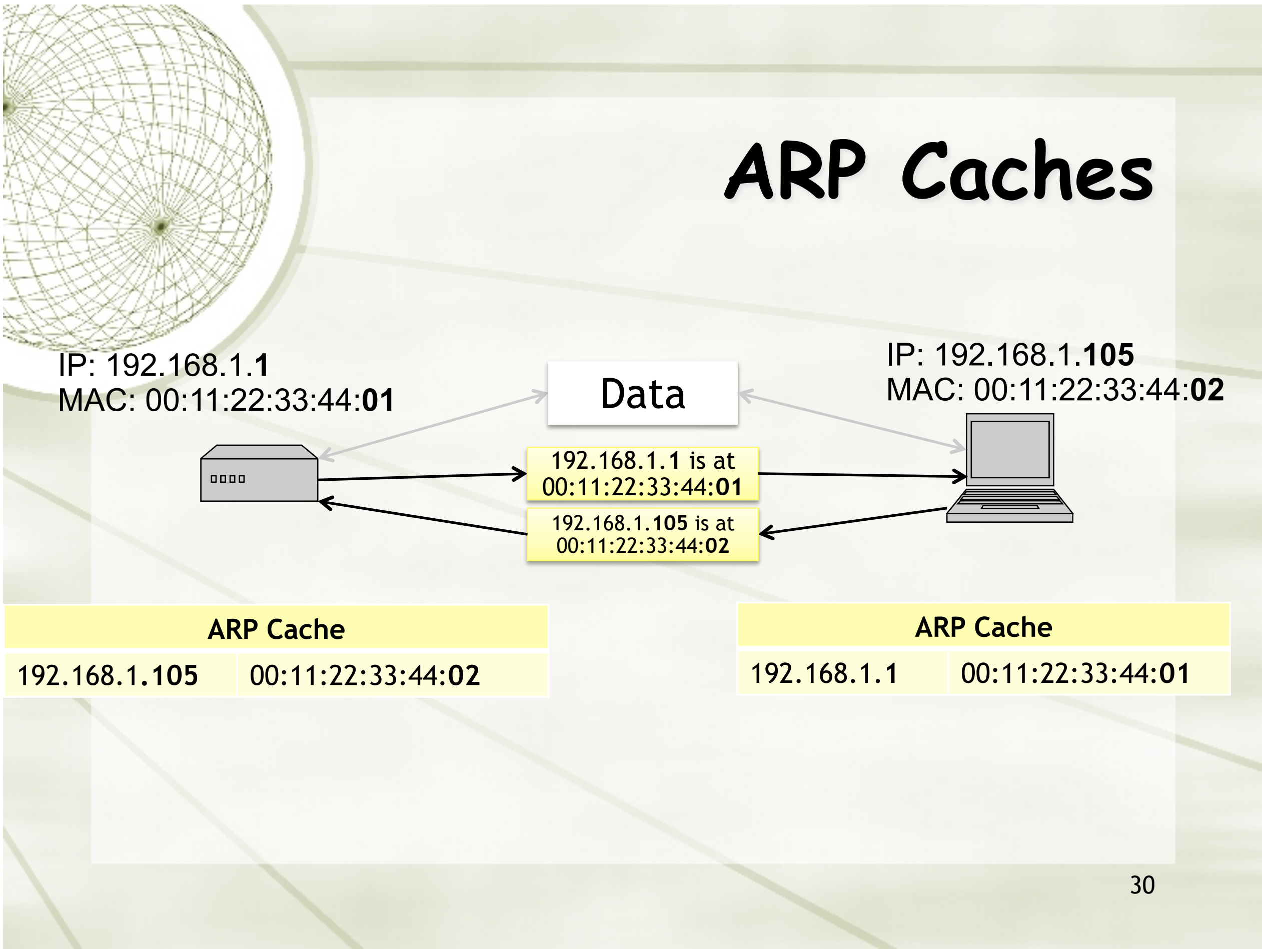
.1



DEMO 1: catch telnet password

With dsniff, we catch the passwords used to log in to a telnet service:

```
dsniff  -n
```



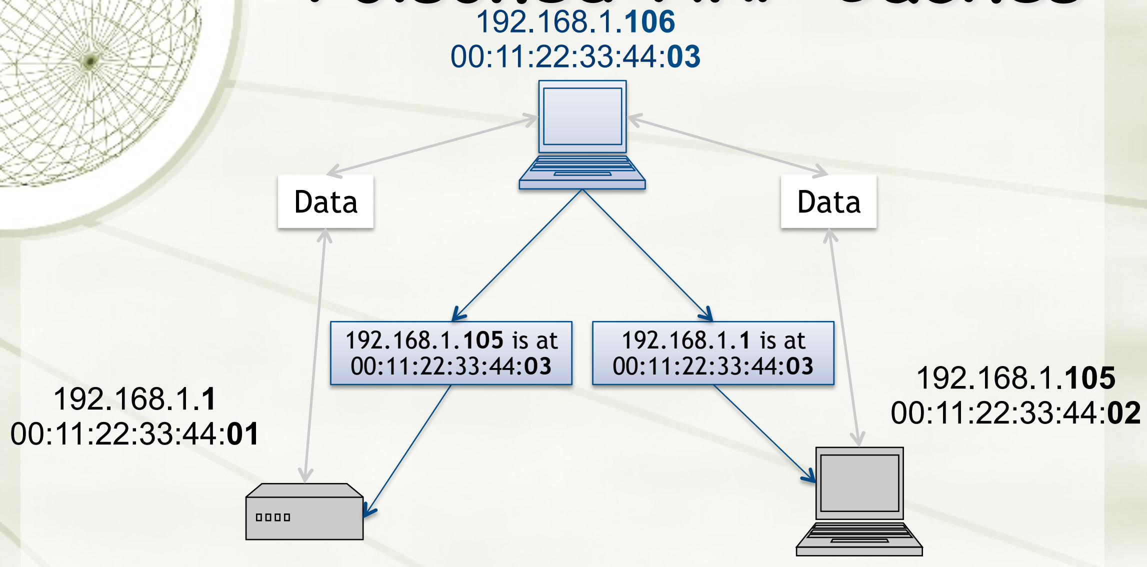
ARP Caches

IP: 192.168.1.**1**
MAC: 00:11:22:33:44:**01**
IP: 192.168.1.**105**
MAC: 00:11:22:33:44:**02**
Data
192.168.1.**1** is at 00:11:22:33:44:**01**
192.168.1.**105** is at 00:11:22:33:44:**02**

ARP Cache	
192.168.1.**105**	00:11:22:33:44:**02**

ARP Cache	
192.168.1.**1**	00:11:22:33:44:**01**

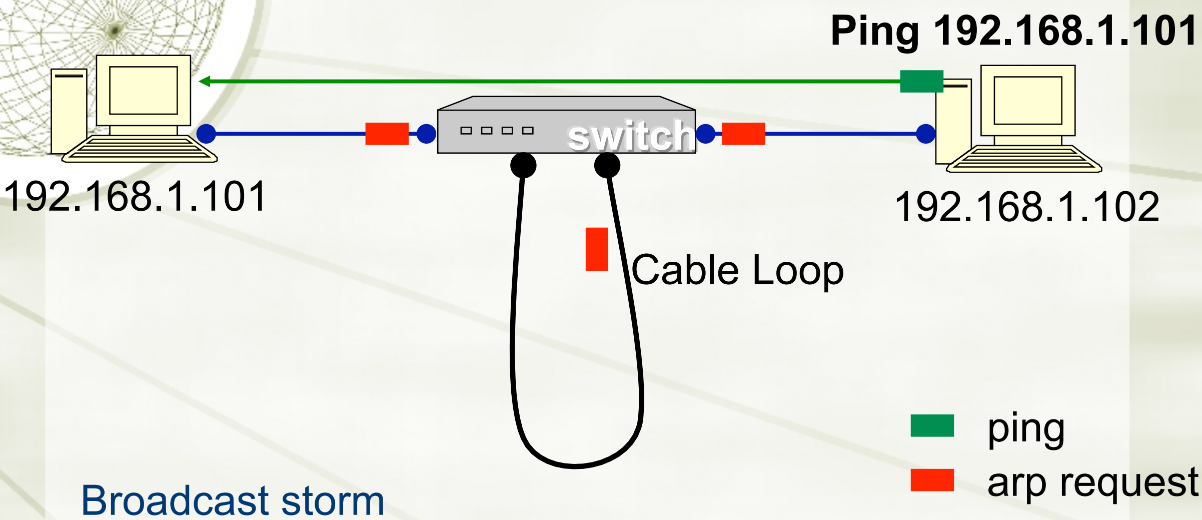
Poisoned ARP Caches



Poisoned ARP Cache	
192.168.1.105	00:11:22:33:44:03

Poisoned ARP Cache	
192.168.1.1	00:11:22:33:44:03

DEMO 2: network DOS using ARP



Broadcast storm

How can it be avoided?