IP looking down

IP and down

Lecture 1:

- Internetworking
- IP to datalink mapping
  - ARP / connection setup
    - e.g. Ethernet, ADSL, Mobile, Wireless
    - MPLS (e.g. 21CN)
  - Fragmentation

IP is about internetworking

- IP interconnects heterogeneous networks
- Everyday examples include:
  - Ethernet
  - WiFi
  - GPRS/3G
  - ADSL
  - Cable
  - Fibre optic
- There are 100s of types…

Why 100s? The non-technical

- Fundamentalist principles:
  - Telephone companies (bellheads)
    v. computer networking (netheads)
    (http://www.wired.com/wired/archive/4.10/atm.html)
- Proprietary techologies
  - IBM Token Ring / DECNET LAT / CISCO ISL
- Protectionism
- Monitoring
- Lock in customers

Why? The technical

- Different media have different characteristcs
  - Radio (free space and wave guides)
  - Optical (free space and fibre)
  - Electrical
  - Broadcast & point-to-point
- How far?
  - Bluetooth v. NASA deep space network
- The real world, e.g.:
  - Vacuum cleaners -> radio noise
  - Installation -> photons fall out if you bend fibre too much
  - Cost -> cheap connectors mean poor electrical signal

Mapping IP

- Think of common scenarios
  - Laptop – Ethernet & Wifi
  - Smartphone/iPad – WiFi & 3G & Bluetooth
  - ADSL router – Ethernet & ADSL
- Two common problems:
  - Need to map IP address to “subnetwork” address
  - Need to deal with different packet sizes:
    - MTU - “Maximum Transmision Unit”

Ethernet (reminder)

- 48 bit static addresses
  - Often in firmware in NIC
- “all ones” is broadcast address
  - ff:ff:ff:ff:ff:ff
- type identifies next layer protocol

- Ethernet (IEEE 802.3) is one of a family of 802 networks including:
  - 802.11 WiFi
  - 802.16 WiMax…

Ethernet Frame

62 bits	Preamble used for bit synchronization
2 bits	Start of Frame Delimiter
48 bits	Destination Ethernet Address
48 bits	Source Ethernet Address
16 bits	Length or Type
46 -1500 bytes	Data
32 bits	Frame Check Sequence

- Just for completeness...

name	description	note
IEEE 802.1	Bridging (networking) and Network Management	
IEEE 802.2	Logical link control	inactive
IEEE 802.3	Ethernet	
IEEE 802.4	Token bus	disbanded
IEEE 802.5	Defines the MAC layer for a Token Ring	inactive
IEEE 802.6	Metropolitan Area Networks	disbanded
IEEE 802.7	Broadband LAN using Coaxial Cable	disbanded
IEEE 802.8	Fiber Optic TAG	disbanded
IEEE 802.9	Integrated Services LAN	disbanded
IEEE 802.10	Interoperable LAN Security	disbanded
IEEE 802.11 a/b/g/n	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)	
IEEE 802.12	demand priority	disbanded
IEEE 802.13	Used for 100BASE-X Ethernet	
IEEE 802.14	Cable modems	disbanded
IEEE 802.15	Wireless PAN	
IEEE 802.15.1	Bluetooth certification	
IEEE 802.15.2	IEEE 802.15 and IEEE 802.11 coexistence	
IEEE 802.15.3	High-Rate WPAN certification	
IEEE 802.15.4	Low-rate WPAN certification	
IEEE 802.15.5	Mesh networking for WPAN	
IEEE 802.16	Broadband Wireless Access (WiMAX certification)	
IEEE 802.16.1	Local Multipoint Distribution Service	
IEEE 802.17	Resilient packet ring	
IEEE 802.18	Radio Regulatory TAG	
IEEE 802.19	Coexistence TAG	
IEEE 802.20	Mobile Broadband Wireless Access	
IEEE 802.21	Media Independent Handoff	
IEEE 802.22	Wireless Regional Area Network	
IEEE 802.23	Emergency Services Working Group	New (March, 2010)

Address Resolution Protocol (ARP)

- Ethernet header:
  - Sent to broadcast address
  - From source Ethernet address
  - Type = 0x0806
- ARP header:
  - Htype = 1
  - Ptype = 0x800 / Ethernet type for IP
  - Hlen = 6, Plen = 4
- Operation –
  - Request (1) – to broadcast:
    - Sender Ethernet address
    - Sender IP address
    - Target IP address
  - Reply (2) – from target:
    - Insert target Ethernet address

Internet Protocol (IPv4) over Ethernet ARP packet		
bit offset	**0 – 7**	**8 – 15**
0	Hardware type (HTYPE)	
16	Protocol type (PTYPE)	
32	Hardware address length (HLEN)	Protocol address length (PLEN)
48	Operation (OPER)	
64	Sender hardware address (SHA) (first 16 bits)	
80	(next 16 bits)	
96	(last 16 bits)	
112	Sender protocol address (SPA) (first 16 bits)	
128	(last 16 bits)	
144	Target hardware address (THA) (first 16 bits)	
160	(next 16 bits)	
176	(last 16 bits)	
192	Target protocol address (TPA) (first 16 bits)	
208	(last 16 bits)	

ARP cache

- IP hosts use ARP to find other IP hosts
- Cache entries; e.g:

```
ppshorizon305:G54ACC drm$ arp –an
? (128.243.35.1) at 0:18:74:1e:bd:40 on en0 ifscope [ethernet]
? (128.243.35.255) at ff:ff:ff:ff:ff:ff on en0 ifscope [ethernet]
```

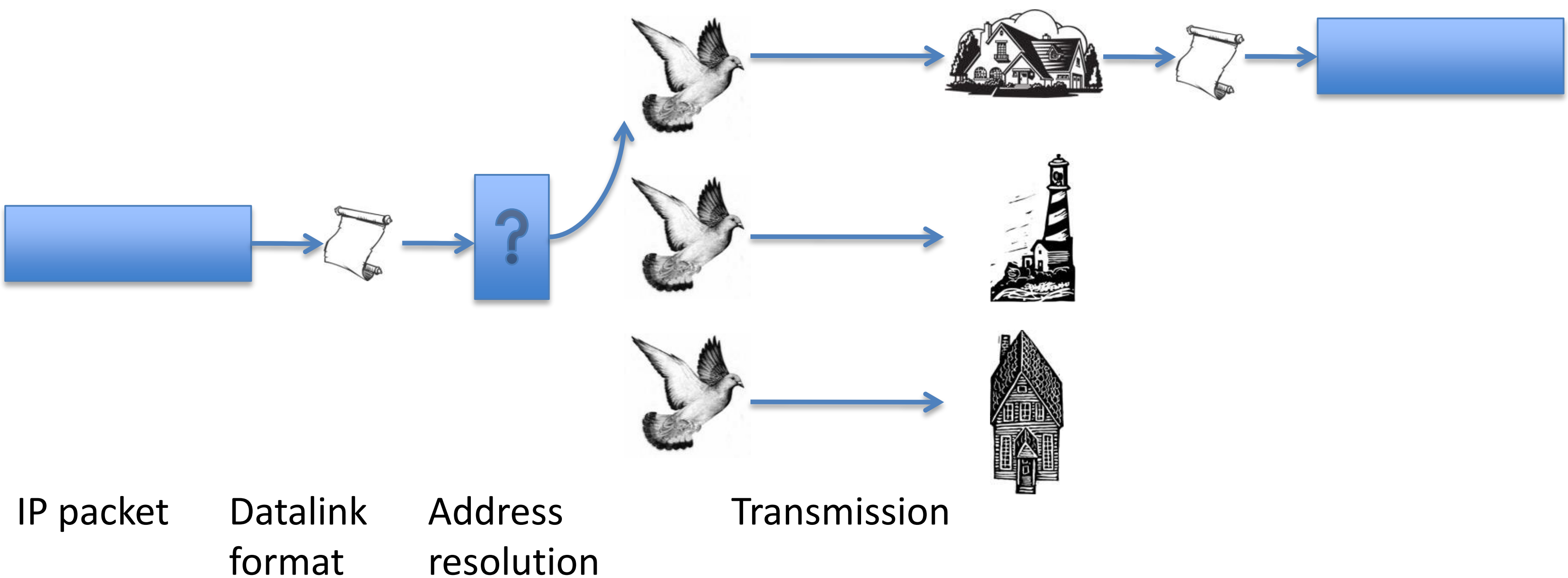
- But be warned, datastructure may not be small!

```
marian$ /usr/sbin/arp -a | wc
     563    2810   40483
```

- Perhaps cache with TCP / UDP information
  - see other lectures…
- What’s the cache eviction policy?
  - “Soft” – unused entries evicted after some time…

Avian Carriers

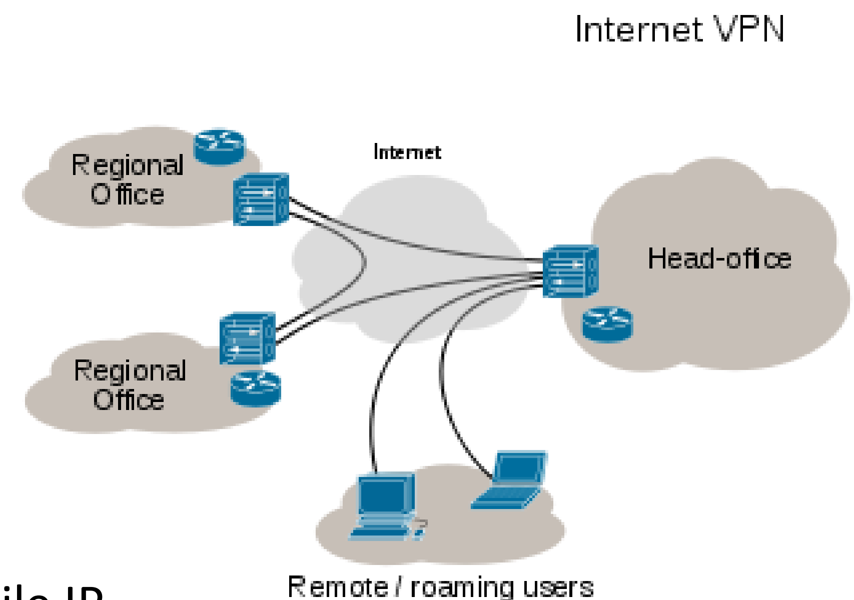
- RFC 1149 (Request For Comments)
  - all Internet standards start this way



VCs

- Various networks use “virtual circuit” identifiers rather than static addresses
  - May be created by connection setup (X.25, GPRS)
  - Or static configuration (FrameRelay)
  - Or a bit of both (ATM)
- Hence equivalent mapping IP to virtual circuit may require:
  1. connection setup
     - “on demand” dialing
  2. table lookup: IP -> VC identifier

IP as a subnetwork!



- Sometimes we want to treat the Internet as a subnetwork; why?
  - Virtual Private network

- Examples:
  – IP over IP: RFC 2005 e.g. for Mobile IP
  – PPTP: RFC 2637 – PPP over GRE
  – L2TP: RFC 2661 – PPP inside UDP packets
  – IPSEC: RFC 2401 – Encryption per IP packet
  – SSTP: MSFT – PPP or L2TP over SSL
- If we want it private – need encryption…

Fragmentation

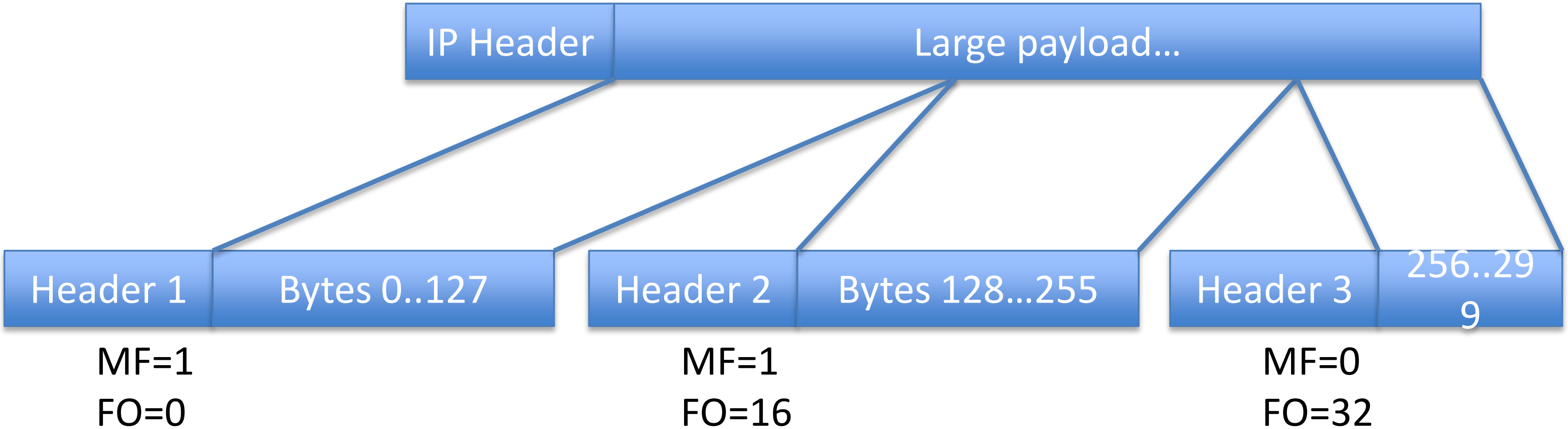
- IP allows datagram sizes up to 64Kbytes
- Physical networks often only support smaller frame types (Maximum Transmission Unit, MTU):
  - e.g. Ethernet 1500bytes, dialup PPP ~256bytes

→Single IP datagram may need to be divided into "fragments" for transmission…

- See IP header details:
  - MF (More Fragment bit)
  - ID (Identity)
  - FO (Fragment Offset)

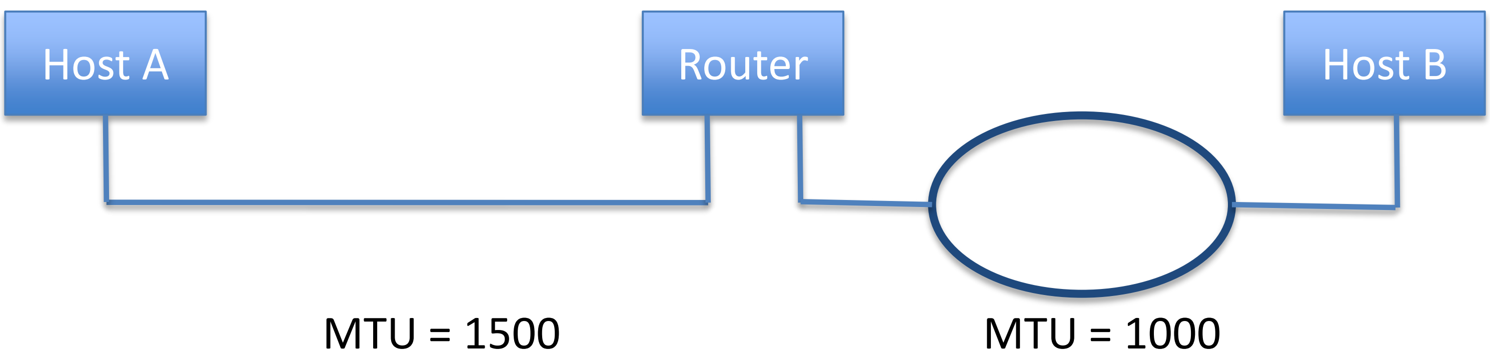
IP fragmentation

- Each fragment is a (new) IP packet
  - Has IP header, original source & destination
  - Identification field same for each fragment
  - Fragment offset identifies where in original packet
    - N.B. fragment offset * 8
  - “More Fragments” flag set in all but last fragment
- e.g. 300 btyes on MTU = 128



Fragmenting packets

- May be:
  - done by sending host
  - done by intermediate router:
  - prevented with IP “Do not fragment” flag
  - avoided by Path MTU discovery (see ICMP…)



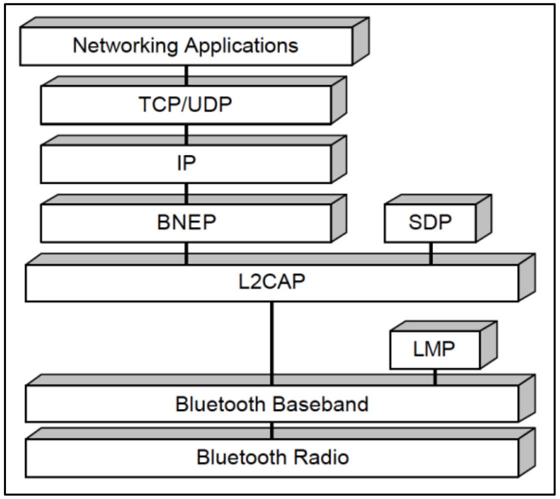
Reassembling fragments

- Done ONLY by the ultimate destination of the packet
  - After checking header checksum, destination, and ID but before any more processing
- Maintains a pool of fragments
  - Discarded after a time-out
  - If all fragments of a datagram received the datagram is reassembled and handled as before

- Lose one segment and you lose the whole message
  - Bad if segment loss is likely or number of segments is large
- e.g. NFS v.2 used UDP, v.3 uses TCP
  - because block size 8K -> 32K
  - many more segments!
  - => higher effective packet loss rate with UDP
    and more wasted bandwidth

..mind if I call you Bruce(*)

- Bluetooth
  - v1.0 was IP/PPP/RFCOM/L2CAP
  - v1.1 changed to BNEP
    - Make Bluetooth look like Ethernet
- ATM
  - Invented LANE - "LAN Emulation"
    - Make ATM look like Ethernet



- Why?
  - Many companies built their protocols directly on Ethernet
  - And it "keeps things simple"

(*) http://orangecow.org/pythonet/sketches/bruces.htm & YouTube

Summary

- IP about interconnecting networks
  - Key to success as it can adopt new technologies
- The subnetworks can be heterogeneous
  - Adapted for different circumstances
- Two primary issues arise at the interface
  - Mapping IP address to subnetwork addresses
  - Dealing with MTUs