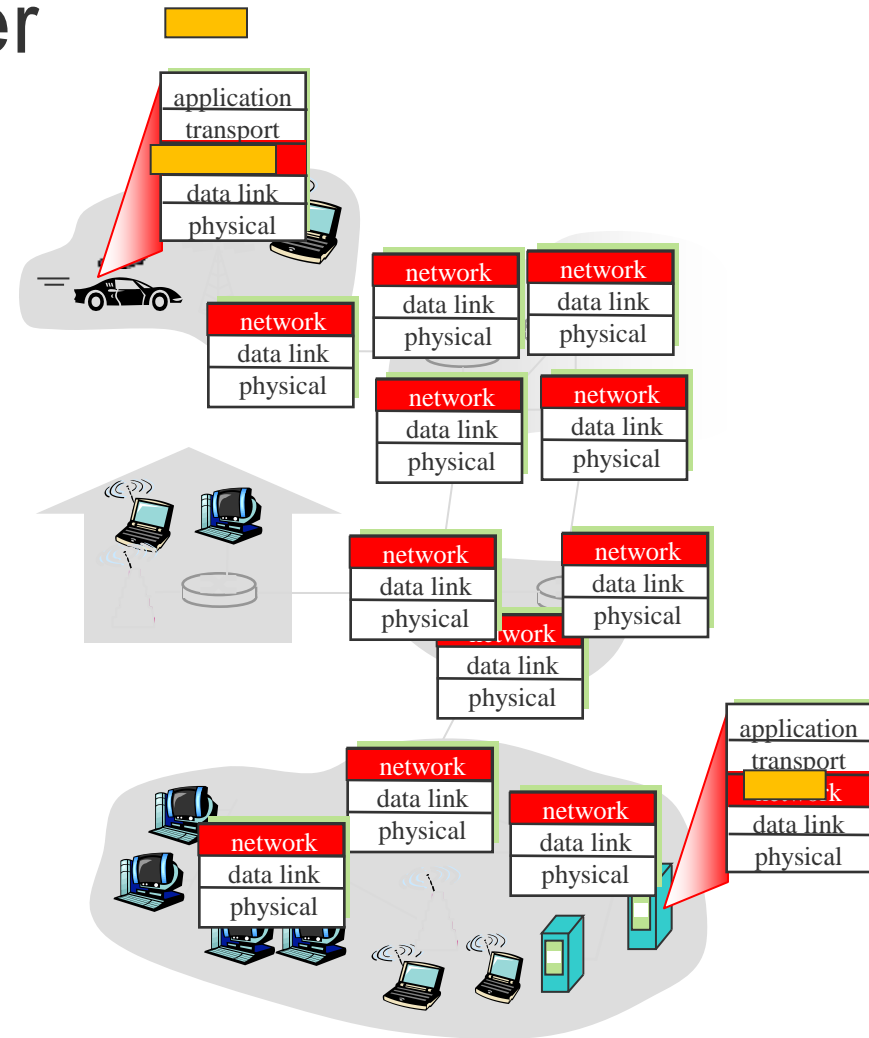# Network Layer and Internetworking

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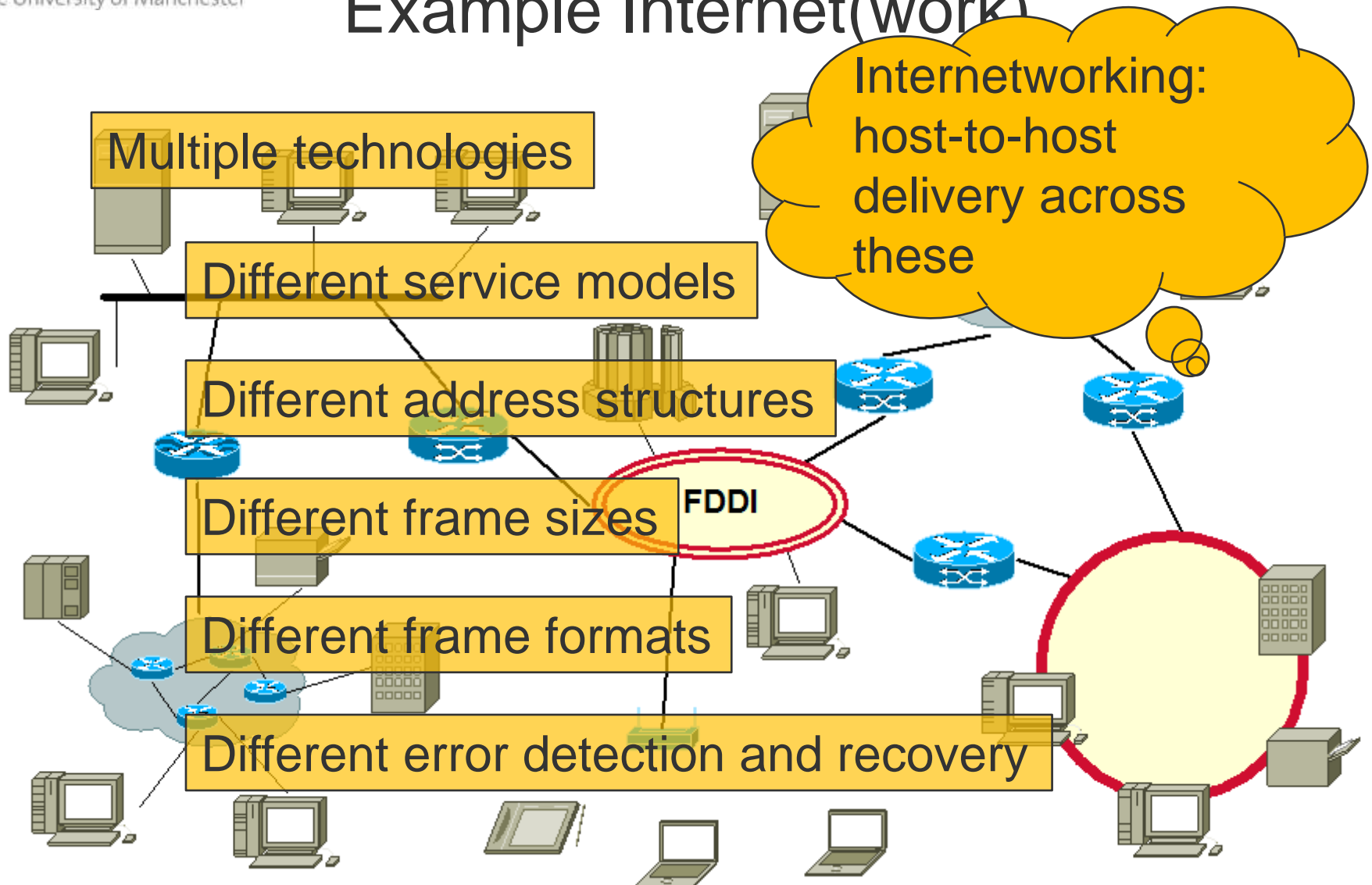
Elements these slides come from Kurose and Ross, authors of "Computer Networking: A Top-down Approach", and are copyright Kurose and Ross
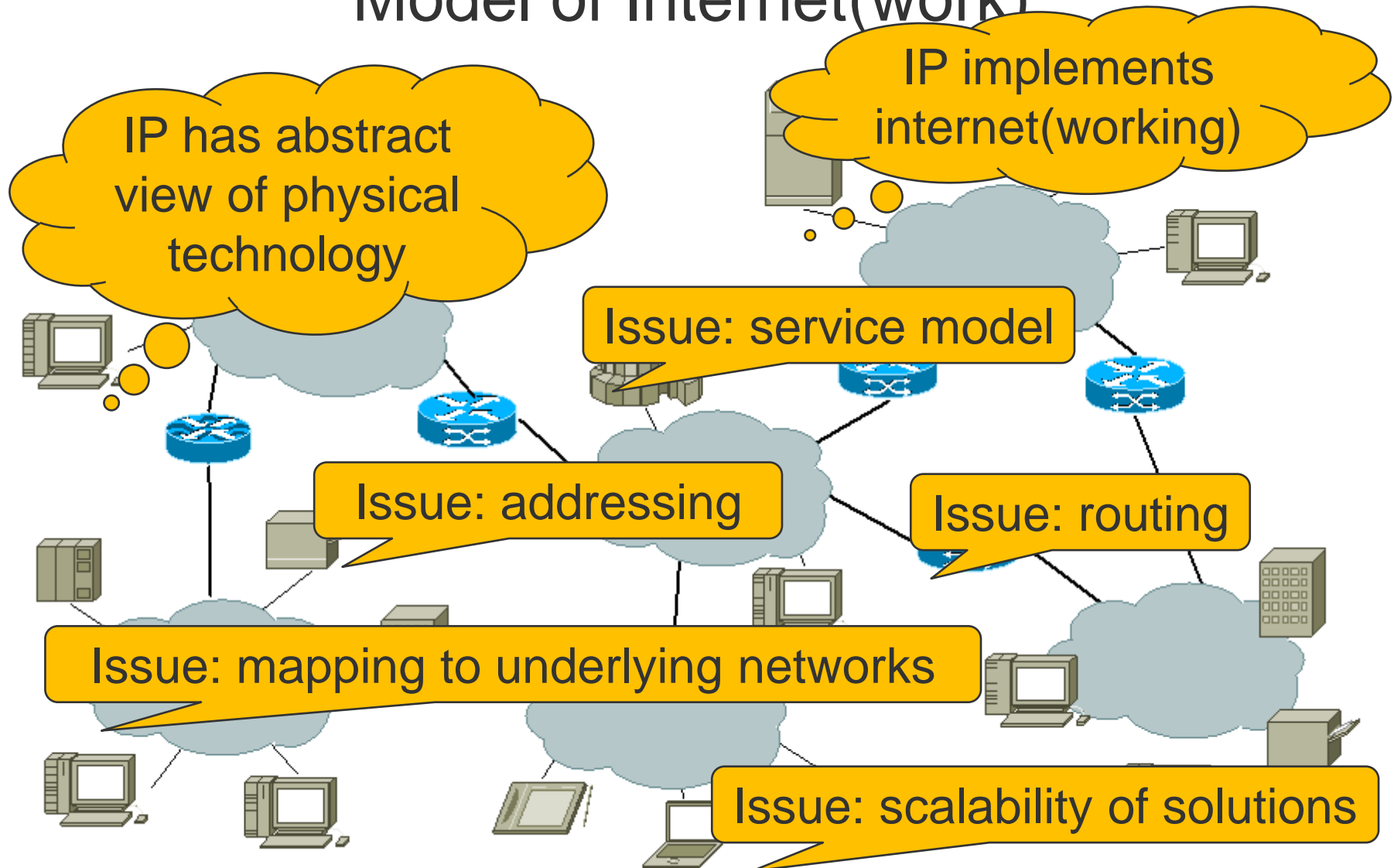
Network Layer

- Transports segments between hosts

- In every host and router

- Segments in frames

- Issues:
  - spanning the globe
  - service model
  - coordination
  - minimise data
  - minimal manual setup
  - forwarding & routing

Example Internet(work)

Internetworking: host-to-host delivery across these

Multiple technologies

Different service models

Different address structures

Different frame sizes

FDDI

Different frame formats

Different error detection and recovery

Model of Internet(work)

IP has abstract view of physical technology

IP implements internet(working)

Issue: service model

Issue: addressing

Issue: routing

Issue: mapping to underlying networks

Issue: scalability of solutions

Internet Network Layers

Application
Presentation
Session
Transport
Network
Link
Physical

SSL/TLS?

TCP

UDP

IP?

Physical Network?
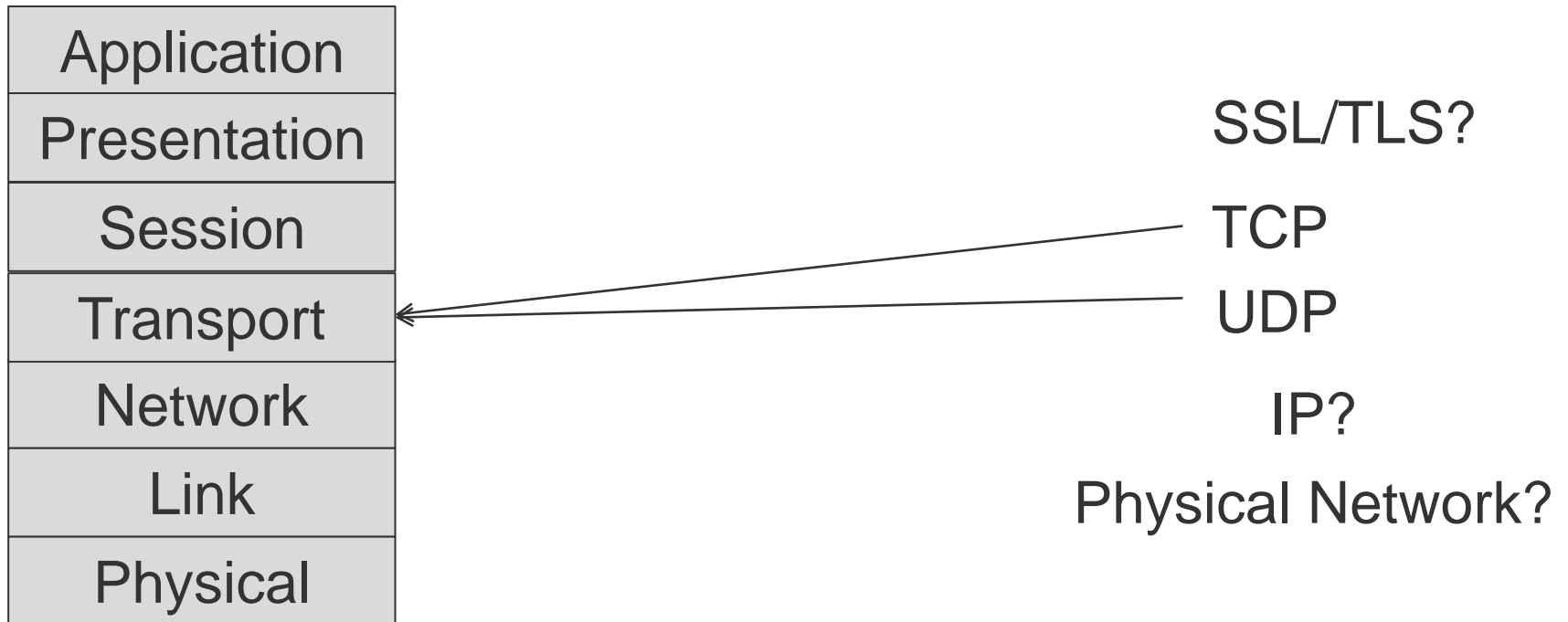
IP: Service Model

- Created via service models of underlying networks
  - can only promise achievable
- Connectionless:
  - places minimal demands on underlying networks
  - datagrams may be delivered out of order
- Unreliable:
  - no error recovery implemented in network by IP
  - although delivery not guaranteed, is best effort
  - reasons for datagrams not being delivered:
    - datagram corruption, physical link failure
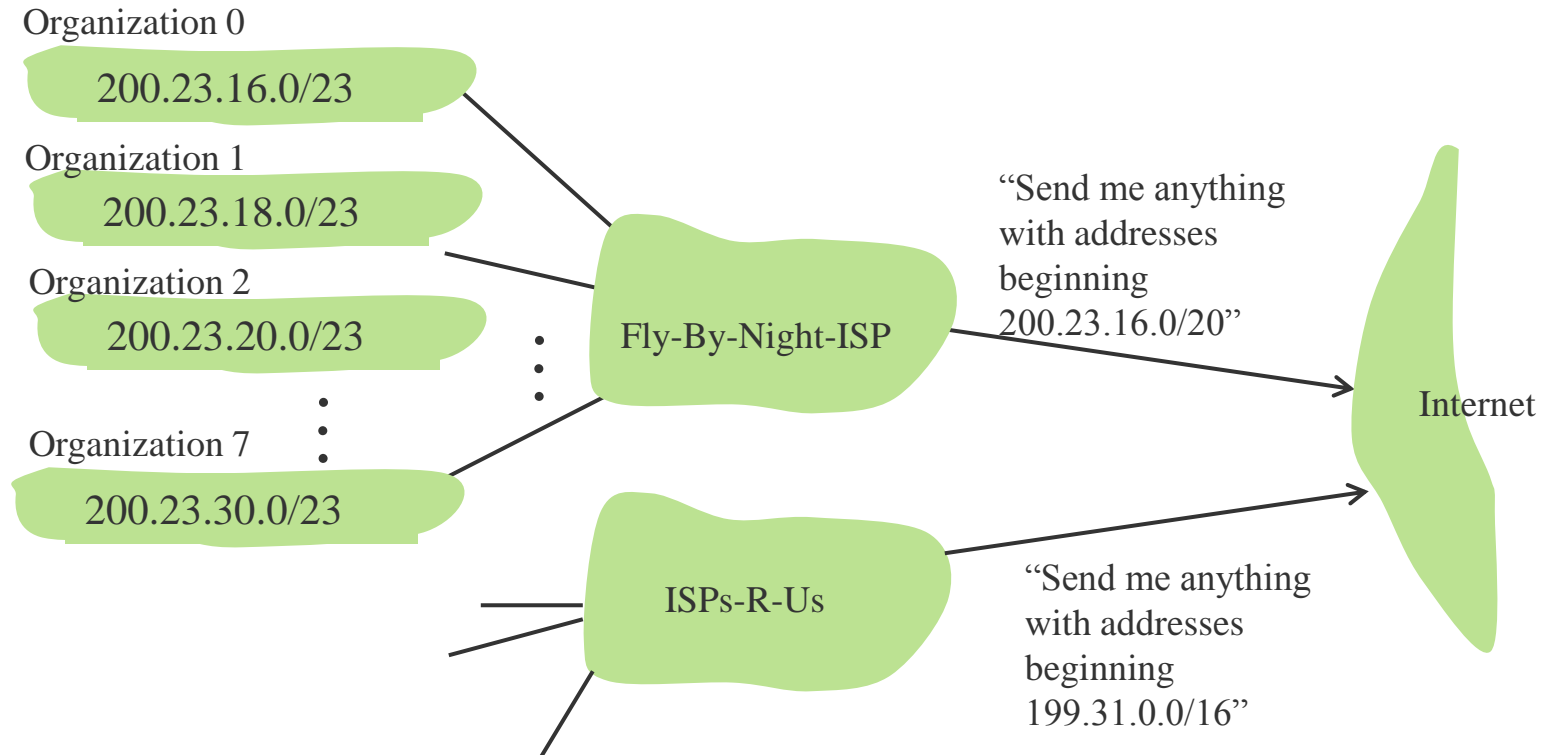   - congestion causing datagrams to be discarded

Coordination: Addresses

Regional Internet Registries

End users

ICANN

delegate

delegate

delegate

address
block

address
block

address
block

ISPs

Global
Coordination

Manageable
process

Minimise Data: Routing

- ISP's block: 200.23.16.0/20
  - <u>11001000 00010111 0001</u>0000 00000000
- Organization 0: 200.23.16.0/23
  - <u>11001000 00010111 0001000</u>0 00000000
- Organization 1: 200.23.18.0/23
  - <u>11001000 00010111 0001001</u>0 00000000
- Organization 2: 200.23.20.0/23
  - <u>11001000 00010111 0001010</u>0 00000000
- …
- Organization 7: 200.23.30.0/23
  - <u>11001000 00010111 0001111</u>0 00000000

Minimise Data: Routing

Organization 0
200.23.16.0/23

Organization 1
200.23.18.0/23

Organization 2
200.23.20.0/23

Organization 7
200.23.30.0/23

Fly-By-Night-ISP

"Send me anything with addresses beginning 200.23.16.0/20"

Internet

ISPs-R-Us

"Send me anything with addresses beginning 199.31.0.0/16"

- Hierarchical addressing allows efficient advertisement of routing information:
- Address Block Aggregation

Network Address Translation (NAT)

- Another way to conserve address; also some security

- Addresses unique only within local/corporate network

- Interact with rest of Internet via "NAT Box"
  - translates local addresses to globally unique ones
  - uses pool of globally unique addresses

- Relies on fact that at any point in time:
  - only subset of computers interact with the Internet

- Requires that applications:
  - not to put IP address in application data

Minimise Manual: Host

Need Local information?

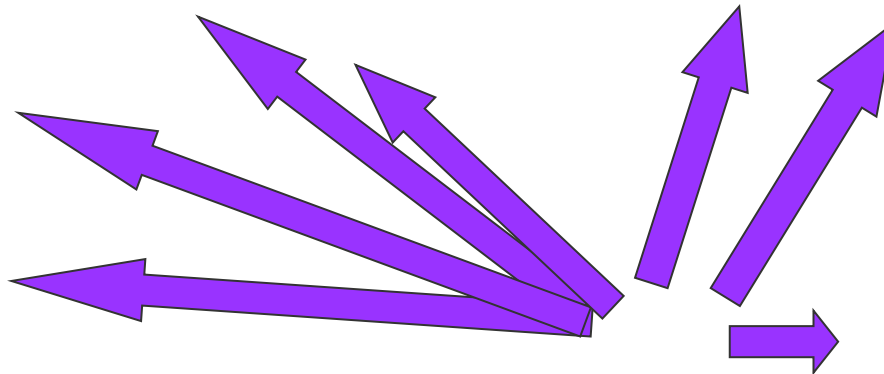xx.xx.xx.xx
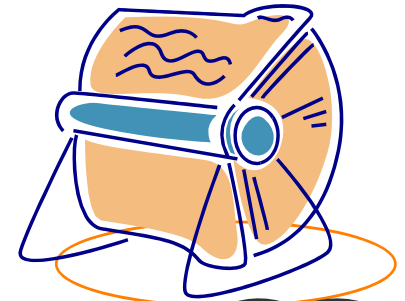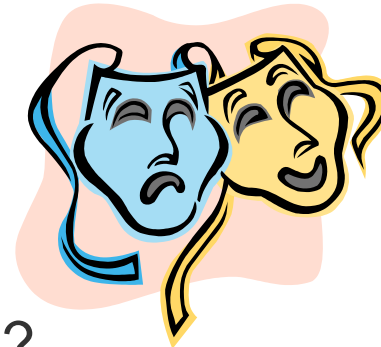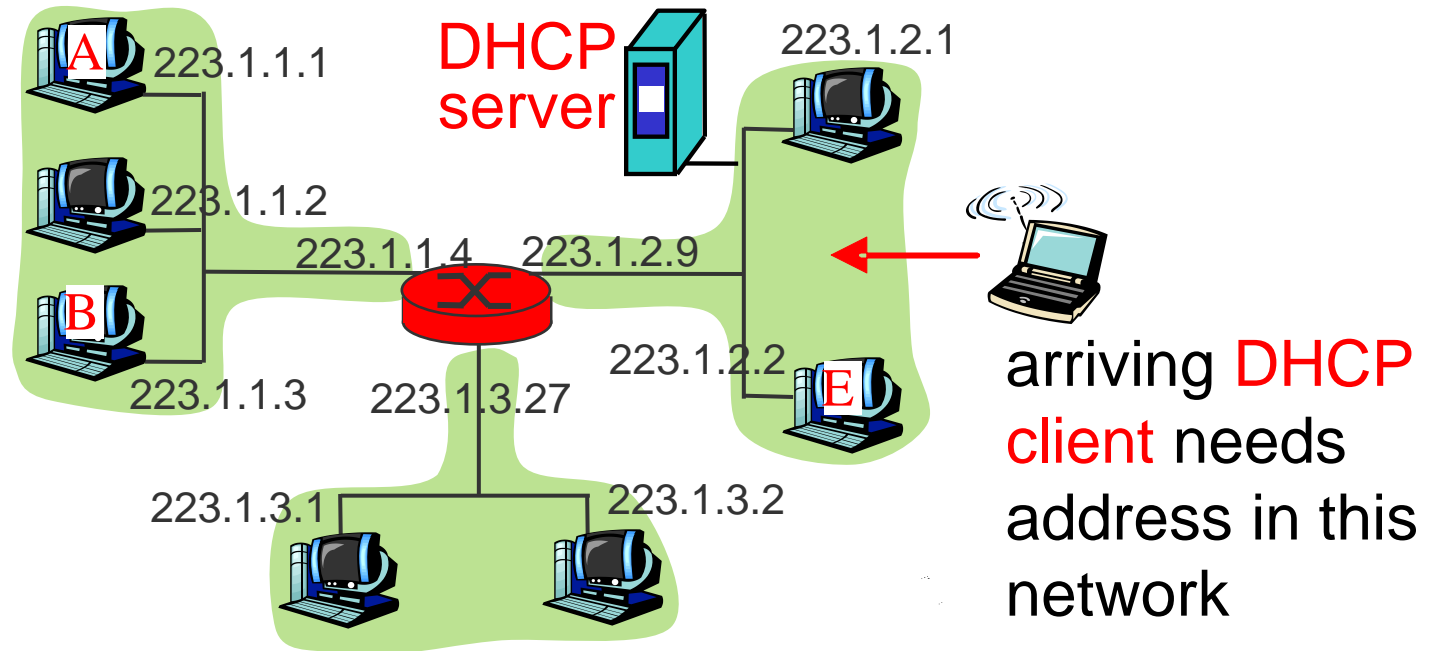
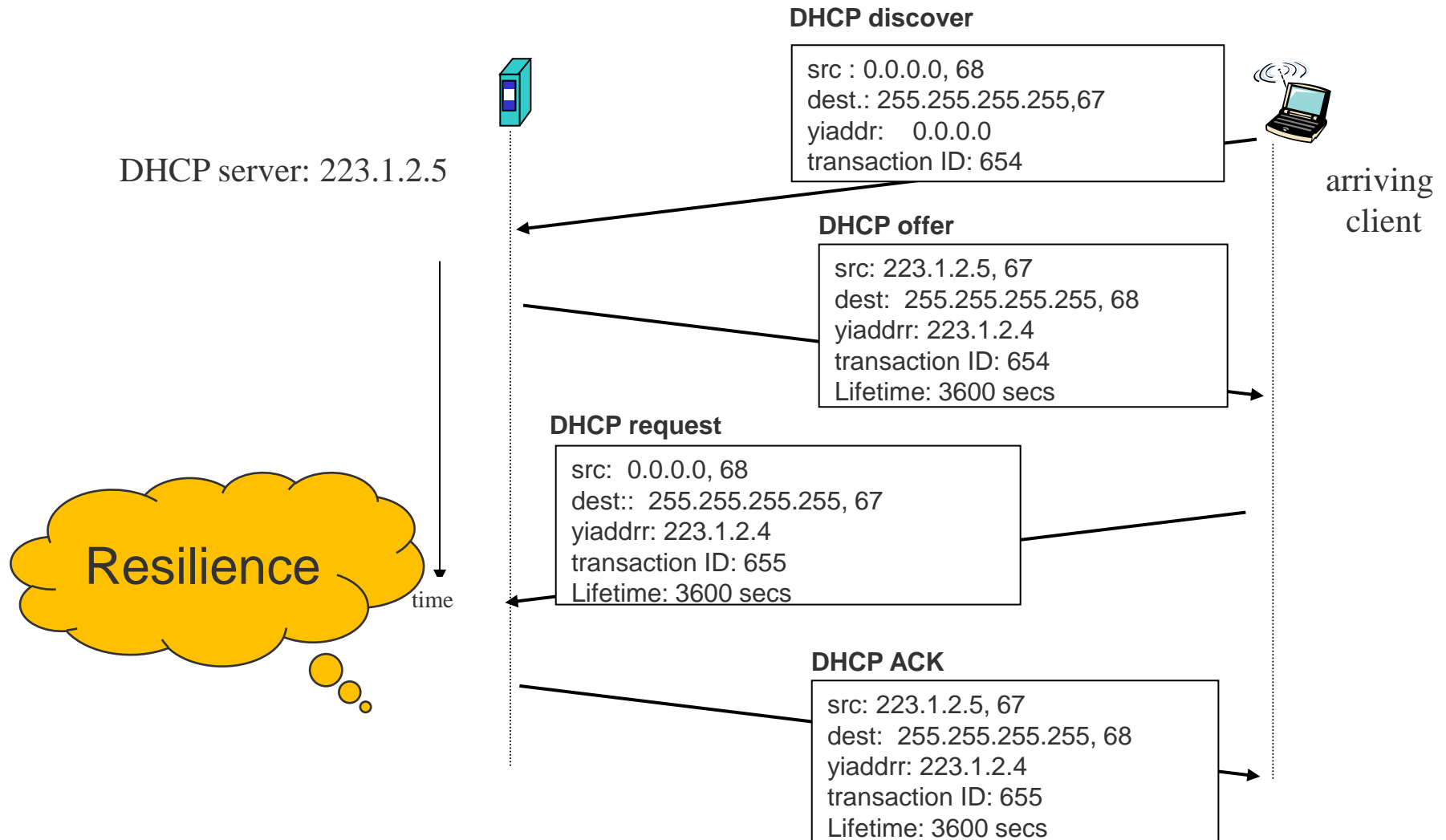Need Information about Network?

xx.xx.xx.xx ⟷ yy:yy:yy:yy:yy:yy

DHCP

How find?

ARP

Minimise Manual: DHCP

- Dynamic Host Configuration Protocol

Minimise Manual: DHCP

DHCP discover

```
src : 0.0.0.0, 68
dest.: 255.255.255.255,67
yiaddr:    0.0.0.0
transaction ID: 654
```

DHCP server: 223.1.2.5

arriving client

DHCP offer

```
src: 223.1.2.5, 67
dest:  255.255.255.255, 68
yiaddrr: 223.1.2.4
transaction ID: 654
Lifetime: 3600 secs
```

DHCP request

```
src:  0.0.0.0, 68
dest::  255.255.255.255, 67
yiaddrr: 223.1.2.4
transaction ID: 655
Lifetime: 3600 secs
```

time

Resilience

DHCP ACK

```
src: 223.1.2.5, 67
dest:  255.255.255.255, 68
yiaddrr: 223.1.2.4
transaction ID: 655
Lifetime: 3600 secs
```

Minimise Manual: ARP

A – Net: 1,1; P 256

Network 1

C - Net: 1,5; P: 548

B – Net: 1,2; P: 13

D – Net: 1,6; P: 1936

- Address Resolution Protocol

Minimise Manual: Router

routing algorithm

local forwarding table	
header value	output link
0100	3
0101	2
0111	2
1001	1

value in arriving
packet's header

0111

1

3 2
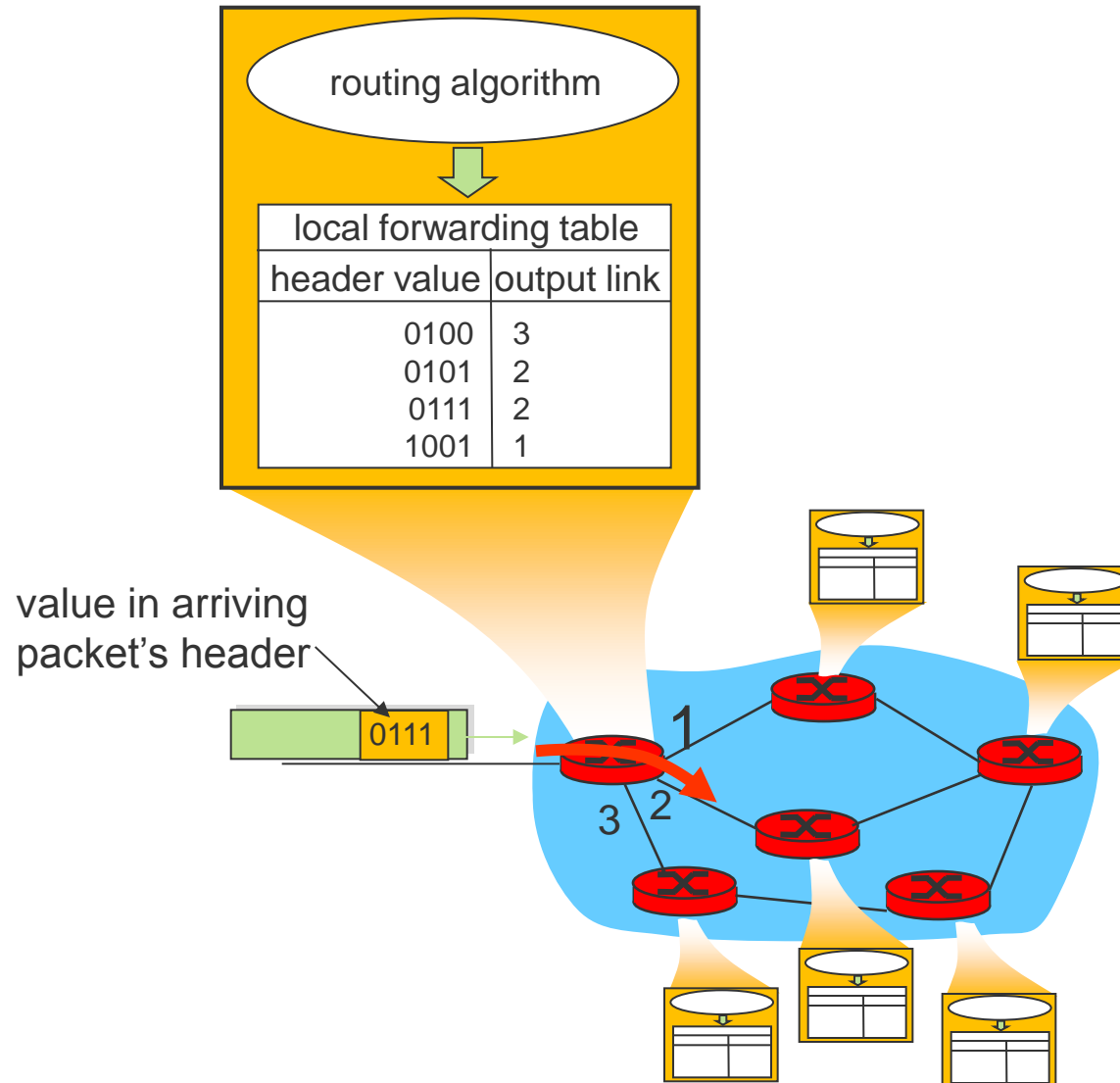
Internet Protocol Version 6 (IPv6)

- Main motivation was to deal with growth of Internet
- Adding more scalable addresses means changing:
  - datagram format and software on all computers
- Opportunity for other fundamental changes; wish list:
  - support for resource allocation, auto-configuration
  - security support, improved option mechanism
  - support for real-time services
  - enhanced routing functionality (mobile host support)
- Many wish list features now added to IPv4
- Transition plan (IPv4 $\rightarrow$ IPv6) also part of design goal

IPv6: Addressing

- 2^{128} or 3.4×10^{38} addresses; every atom on planet!
  - for realistic utilisation: 1500 per square foot of surface
- Address space is partitioned; again decoded by ms bits
- Partitioning is for usage not address structure; e.g.:
  - aggregatable unicast addresses; c.f. CIDR
  - encapsulating other address spaces
    - IPv4, NSAP (ISO), IPX (Novell)
  - locally (link or site) significant/unique addresses
  - multicast addresses
  - lots reserved to solve future problems

IPv6: Multicast/Anycast Addressing

- Multicast partition:
  - sub-fields for flags, scope and group identifier
  - current scopes: link, site, organisation, planet
  - values spread over possible to allow extension
  - 14 is planet, 15 is unassigned (solar system/universe?)
- Anycasting partition:
  - group only only need to deliver to one (nearest?)
  - e.g. accessing service from group of servers
  - routing system chooses actual destination