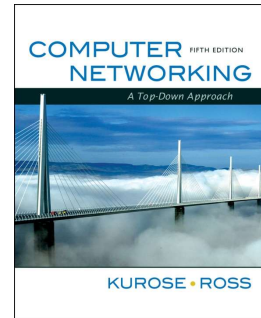


# RSC

## Part II: Network Layer

### 2. Introduction to IP



**Redes y Servicios de Comunicaciones**  
**Universidad Carlos III de Madrid**

These slides are, mainly, part of the companion slides to the book "Computer Networking: A Top Down Approach" generously made available by their authors (see copyright below). The slides have been adapted, where required, to the teaching needs of the subject above.

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*Computer Networking:  
A Top Down Approach  
5<sup>th</sup> edition.*  
Jim Kurose, Keith Ross  
Addison-Wesley, April  
2009.

## RSC Part II: Network Layer

- II. 1 Basic Network layer concepts
- II.2 Introduction to IPv4
  - Datagram format
  - ICMP
- II.3 IPv4 addressing
- II.4 IPv4 in operation
  - ARP
- II.5 IPv6
- II.6 Network routing
  - Link state
  - Distance Vector
- II.7 Routing in the Internet
  - Hierarchical routing
  - RIP

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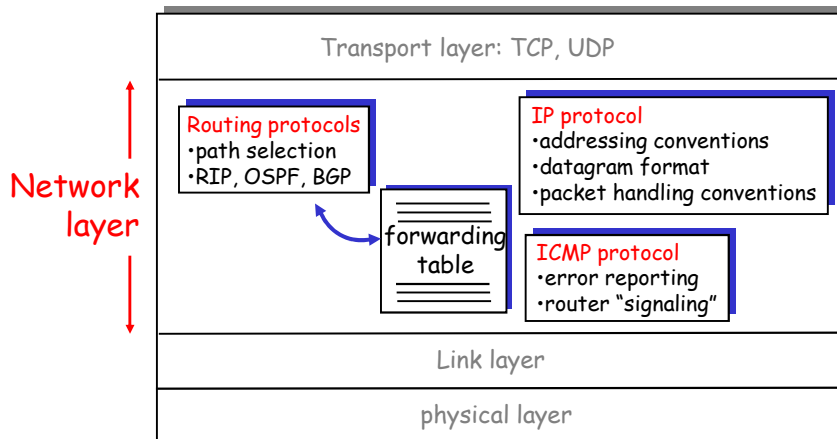
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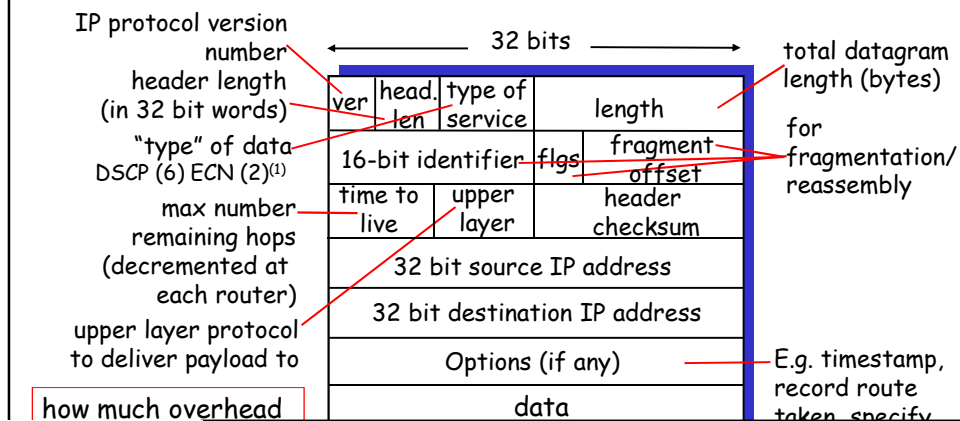
## The Internet Network layer

Host, router network layer functions:



Network Layer 4-3

## IP datagram format



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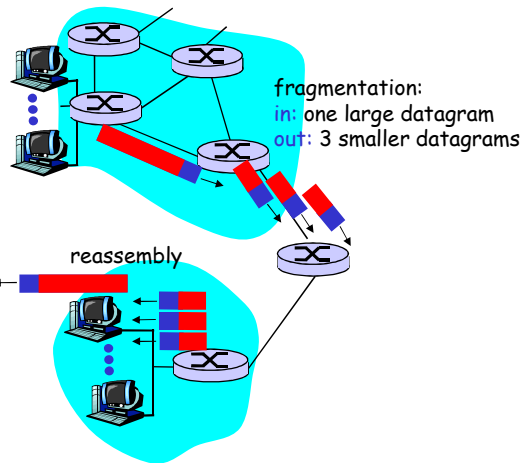
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## IP Fragmentation & Reassembly

- network links have MTU (max.transfer size) - largest possible link-level frame.
  - different link types, different MTUs
- large IP datagram divided ("fragmented") within net
  - one datagram becomes several datagrams
  - "reassembled" only at final destination
  - IP header bits used to identify, order related fragments



Network Layer 4-5

## IP Fragmentation and Reassembly

### Example

- 4000 byte datagram
- MTU = 1500 bytes

length	ID	fragflag	offset
=4000	=x	=0	=0

One large datagram becomes several smaller datagrams

1480 bytes in data field

length	ID	fragflag	offset
=1500	=x	=1	=0

length	ID	fragflag	offset
=1500	=x	=1	=185

offset =

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## ICMP: Internet Control Message Protocol

- used by hosts & routers to communicate network-level information
    - error reporting: unreachable host, network, port, protocol
    - echo request/reply (used by ping)
  - network-layer "above" IP:
    - ICMP msgs carried in IP datagrams
  - ICMP message: type, code plus first 8 bytes of IP datagram causing error
- | Type | Code | description                                   |
|------|------|---|
| 0    | 0    | echo reply (ping)                             |
| 3    | 0    | dest. network unreachable                     |
| 3    | 1    | dest host unreachable                         |
| 3    | 2    | dest protocol unreachable                     |
| 3    | 3    | dest port unreachable                         |
| 3    | 6    | dest network unknown                          |
| 3    | 7    | dest host unknown                             |
| 4    | 0    | source quench (congestion control - not used) |
| 8    | 0    | echo request (ping)                           |
| 9    | 0    | route advertisement                           |
| 10   | 0    | router discovery                              |
| 11   | 0    | TTL expired                                   |
| 12   | 0    | bad IP header                                 |

Network Layer 4-7

## Traceroute and ICMP

- Source sends series of UDP segments to dest
  - First has TTL =1
  - Second has TTL=2, etc.
  - Unlikely port number
- When nth datagram arrives to nth router:
  - Router discards datagram
  - And sends to source an ICMP message (type 11)
- When ICMP message arrives, source calculates RTT
- Traceroute does this 3 times
- Stopping criterion**
- UDP segment eventually arrives at destination host
- Destination returns ICMP "port unreachable" message

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