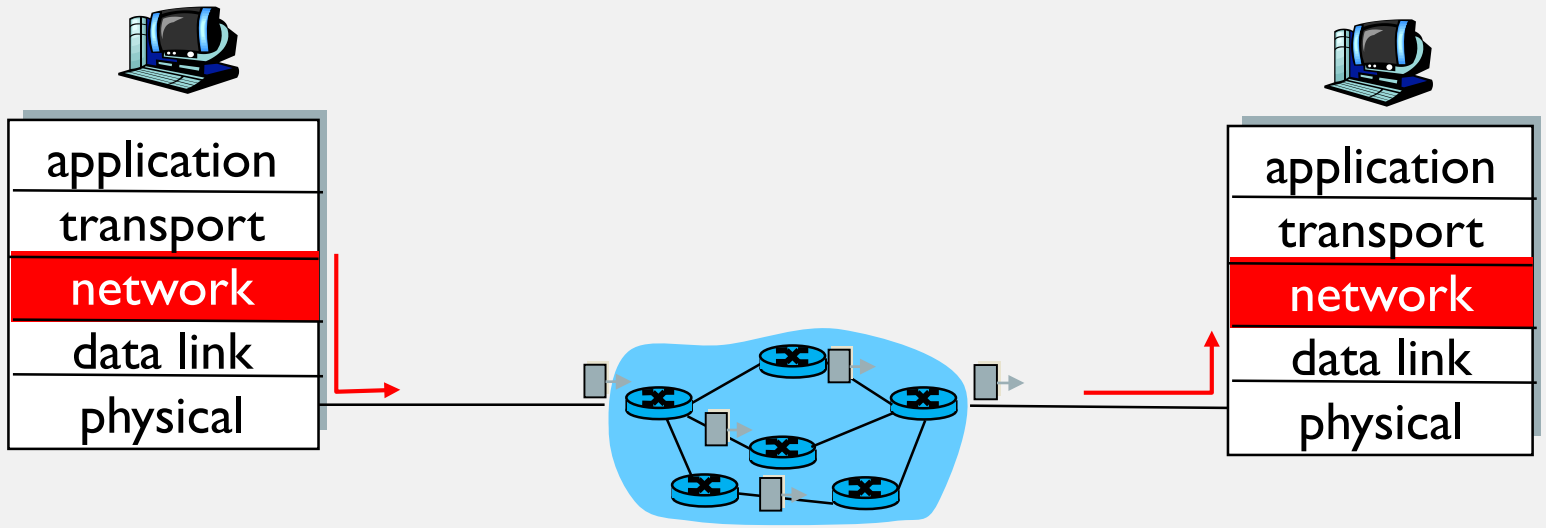
IP PROTOCOL SPECIFICATION

CPSC 441 - Tutorial 10

Winter 2018

WHAT IS **IP**?

- **I**nternet **P**rotocol is a Network Layer Protocol



FEATURES

- IP is the highest layer protocol which is implemented at both routers and hosts
- Unreliable, connectionless, best effort service
- The first publicly used version of the Internet Protocol was version 4 (IPv4) with 32 bits address space
- IPv6 is the next generation IP that tries to address the shortcomings of IPv4
  - Address space: 128 bits
  - Designed to live alongside IPv4

IPv4 **HEADER**

- 13 requiring fields totaling 160 bits in size.
- Options (Pink field) is optional!

Offsets	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Version				IHL				DSCP						ECN		Total Length															
4	32	Identification																Flags			Fragment Offset											
8	64	Time To Live								Protocol								Header Checksum															
12	96	Source IP Address																															
16	128	Destination IP Address																															
20	160	Options (if IHL > 5)																															

- **Version (4 bits)**
  - For IPv4, this has a value of 4 (hence the name IPv4)
- **Internet Header Length (4 bits)**
  - IP header can have a variable number of options
  - The minimum value for this field is 5 (RFC 791) or 20 bytes; the maximum length is 15 words = 60 bytes
- **Differentiated Services Code Point (6 bits)**
  - Recently redefined by RFC 2474 for Differentiated services (DiffServ). Used for real-time data streaming like VoIP
- **Explicit Congestion Notification (2 bits)**
  - An optional feature that is defined by RFC 3168 for notification of network congestion without dropping packets
  - Both endpoints must support it and be willing to use it
- **Total Length (16 bits)**
  - The entire IP datagram size, including the header and payload

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0	0	Version				IHL				DSCP						ECN		Total Length															
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- **Identification (16 bits)**
  - Used primarily for uniquely identifying the group of fragments of a single IP datagram
- **Flags (3 bits)**
  - Bit field used to control or identify fragments
  - Bit 0: Reserved, Bit 1: Don't fragment (DF), Bit 2: More fragments (MF - Zero for non-fragmented packets; for fragmented packets, all but the last packet has this flag set; the last packet will have a non-zero "Fragment Offset" field)
- **Fragment Offset (13 bits)**
  - Measured in units of 64-bit words (8 byte)
- **Time To Live (8 bits)**
  - Limits a datagram's lifetime to break routing circles
  - Specified in seconds but in practice is used as a hop count (decrement by 1 at each router) and set to 64 at the start
  - When TTL is zero, the router should discard the packet; typically an ICMP Time Exceeded message is sent to the sender
- **Protocol (8 bits)**
  - Defines the protocol used in the payload. There are over 140 protocols defined (TCP is 0x06; UDP is 0x11)

IPv4 **HEADER**

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Offsets	Octet	0								1								2								3							
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0	0	Version				IHL				DSCP						ECN		Total Length															
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- **Header Checksum**
  - the 16-bit one's complement of the one's complement sum of all 16-bit words in the **header**
- **Options: not often used**
  - Used to control fragmenting, routing, debugging, security, etc.
  - Must be padded so that the header is divisible by 32 bits (4 bytes)

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IPv6 **HEADER**

- 8 requiring fields totaling 320 bits in size.

Offsets	Octet	0								1								2								3							
Octet	Bit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0	0	Version				Traffic Class				Flow Label																							
4	32	Payload Length																Next Header								Hop Limit							
8	64	Source Address																															
12	96																																
16	128																																
20	160																																
24	192	Destination Address																															
28	224																																
32	256																																
36	288																																

- **Version (4 bits)**
  - For IPv6, this has a value of 6
- **Traffic Class (8 bits)**
  - The same as the redefined IPv4 fields:
    - The first 6 bits are differentiated services for real-time data streaming
    - The last 2 bits are for ECN (Explicit Congestion Notification)
- **Flow Label (20 bits)**
  - Originally created for giving real-time applications special service
  - When set to a non-zero value, it serves as a hint to routers and switches with multiple outbound paths that these packets should stay on the same path so that they will not be reordered
  - It has further been suggested that the flow label be used to help detect spoofed packets

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- **Payload Length (16 bits)**
  - The size of the payload in octets, including any extension headers
  - This is different from IPv4 as it does not include the fixed IPv6 header
- **Next Header (8 bits)**
  - The same as the IPv4 Protocol field
- **Hop Limit (8 bits)**
  - Replaces the time to live field of IPv4
- **Fragmented Packets**
  - Notice there is no fragmentation fields, so routers cannot fragment IPv6 packets as they do for IPv4
  - Hosts may use the fragmentation extension to send packets larger than an MTU (Maximum Transmission Unit)
- **IPv6 also does not have a checksum field**

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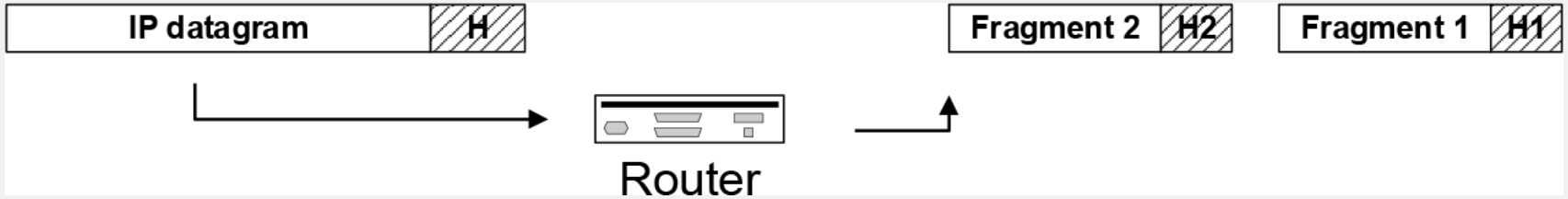
MAXIMUM TRANSMISSION UNIT

- Maximum size of IP datagram is 65535, but the data link layer protocol generally imposes a limit that is much smaller
- Ethernet frames have a maximum payload of 1500 bytes
- The limit on the maximum IP datagram size, imposed by the data link protocol is called maximum transmission unit (**MTU**)
- MTUs for various data link protocols:

Ethernet:	1500	FDDI:	4352
802.3:	1492	ATM AAL5:	9180
802.5:	4464	802.11 (WLAN):	2272

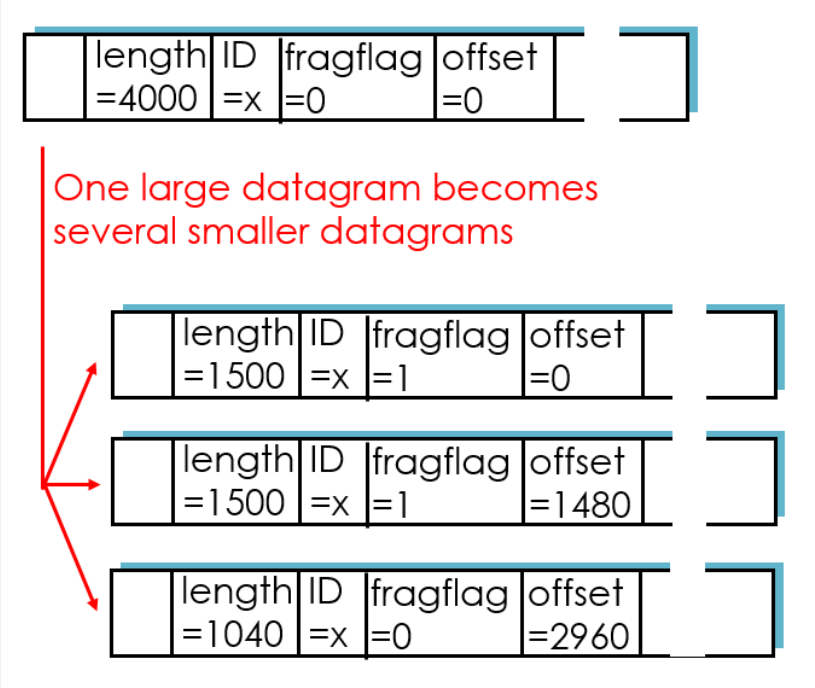
IP FRAGMENTATION

- What if the size of an IP datagram exceeds the MTU?
  - IP datagram is fragmented into smaller units
- Fragmentation can be done at the sender or at intermediate routers
- Reassembly of original datagram is only done at destination hosts



EXAMPLE OF FRAGMENTATION

- A datagram of 4000 bytes from a network with MTU 1500



REFERENCES

- Wikipedia
  - http://en.wikipedia.org/wiki/IPv4
  - http://en.wikipedia.org/wiki/IPv6
  - http://en.wikipedia.org/wiki/IPv6_packet