SRM
Institute of Science and Technology

21CSC302J-COMPUTER NETWORKS

Unit- II

Internet Protocol

IP Header

Internet Protocol (IP)

- The **transmission mechanism** used by the **TCP/IP protocols.**

- **Transports data in packets** called **datagrams**, each of which is transported separately.

- Datagrams
  - ***Travel along different routes***
  - ***Arrive out of sequence or be duplicated***.

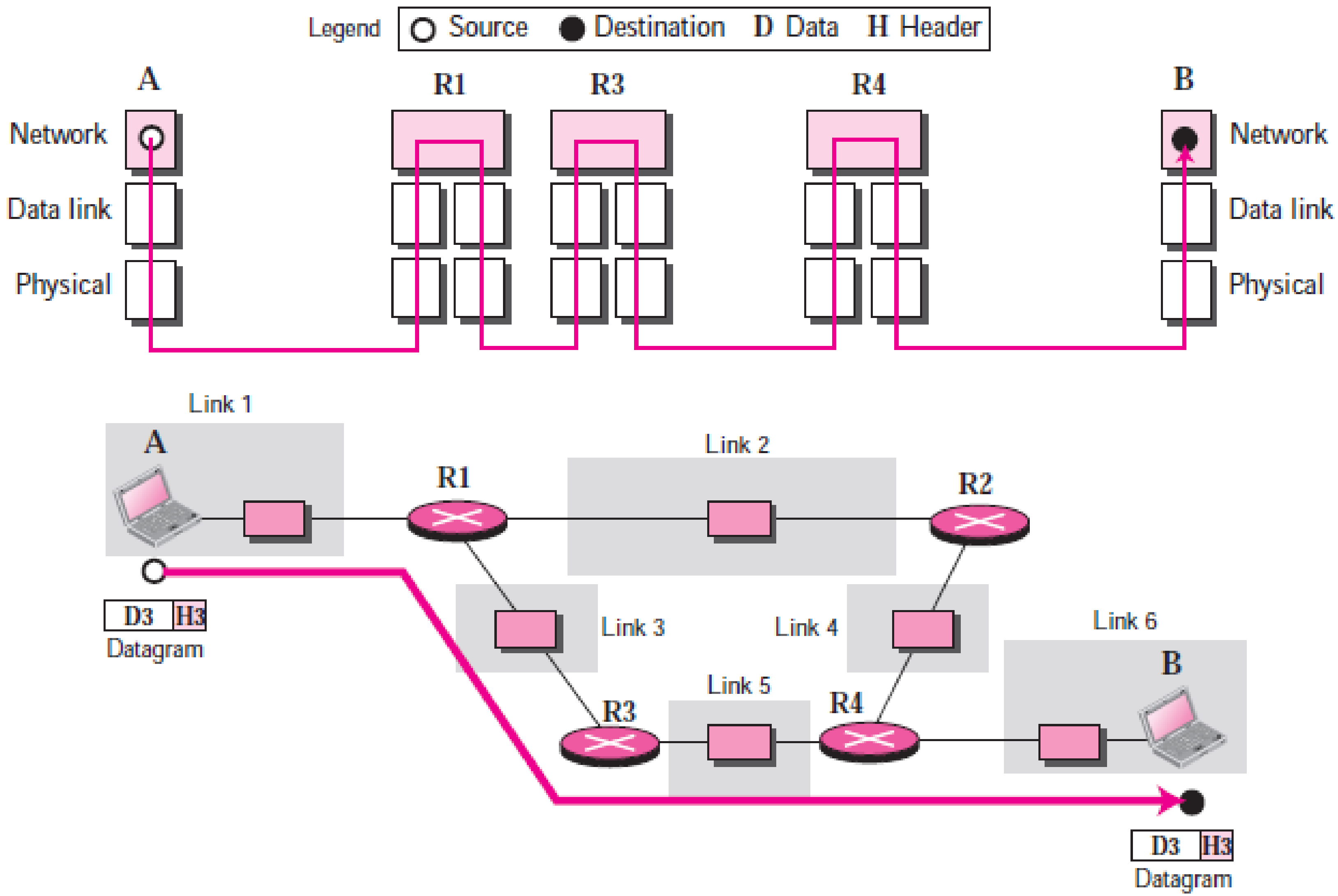
- **Does not keep track of the routes** and has **no facility for reordering datagrams once they arrive at their destination**.

Difference – Network and Other Lower Layers

- **Main difference** between **the communication at the network layer and the communication at data link or physical layers**.
  - ***Communication at the network layer is end to end***
  - ***Communication at the other two layers are node to node.***

- The datagram started at computer A is the one that reaches computer B.

- The network layers of the **routers can inspect the source and destination of the packet** ***for finding the best route***



Communication at the network layer

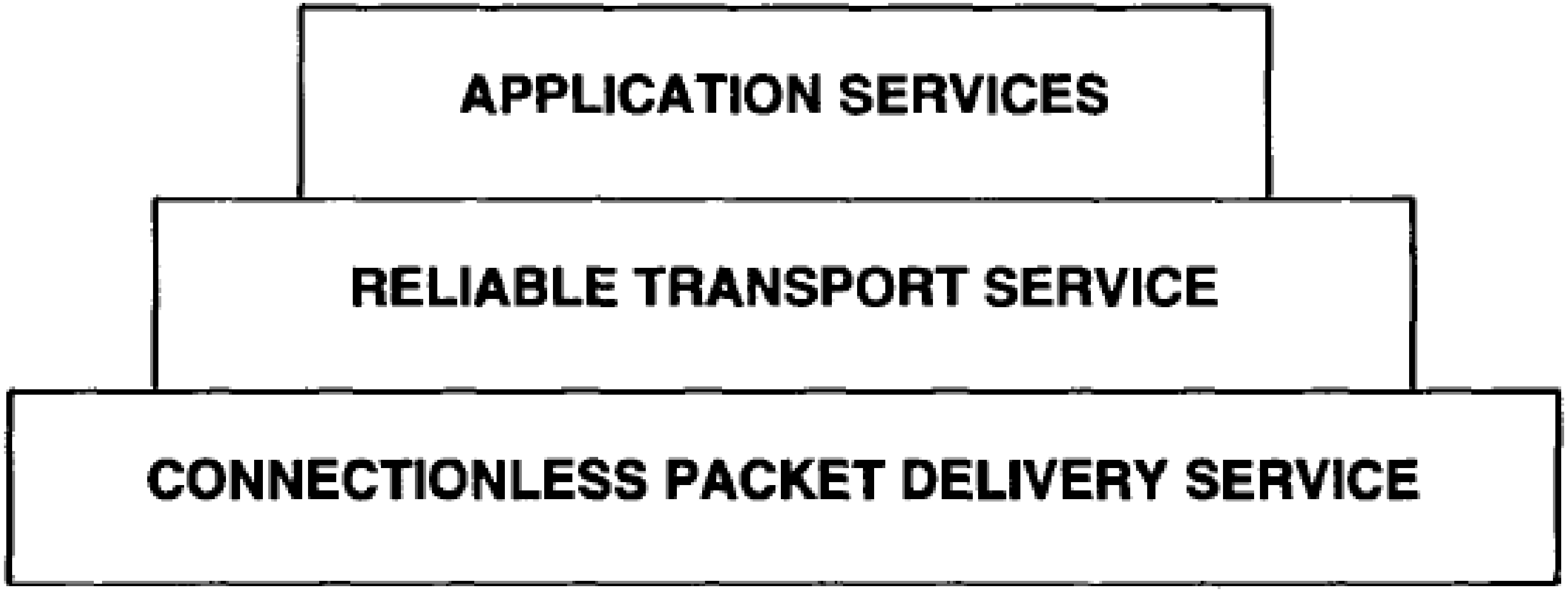
Difference – Network and Other Lower Layers

- They are **not allowed to change the contents** of the packet.

- The **communication is logical**, ***not physical.***

- **Network layer of computer A and B** *think* that ***they are sending and receiving datagrams,*** **the actual communication again is done at the physical level.**

- **TCP/IP** internet provides **three sets of services** and its dependencies are as shown in Figure



The three conceptual layers of internet services

- At the lowest level, **a connectionless delivery service provides a foundation** on which everything rests.

- At the next level, **a reliable transport service** ***provides a higher level platform on which applications depend***.

- One of the **most significant advantages** of this conceptual separation
  - ***Becomes possible to replace one service without disturbing others.***

Internet software is designed around three conceptual networking services arranged in a hierarchy; much of its success has resulted because this architecture is surprisingly robust and adaptable.

Connectionless Delivery System

- The **most fundamental internet service** consists of a ***packet delivery system***.

- The service is defined as
  - ***Unreliable,***
  - ***Best-effort,***
  - ***Connectionless packet delivery system,***

- The **service provided by network hardware** that ***operates on a best-effort delivery paradigm***.

Unreliable

- **Delivery is not guaranteed**

- The packet may be
  - ***Lost,***
  - ***Duplicated,***
  - ***Delayed, or***
  - ***Delivered out of order***

- But the **service will not detect such conditions**, ***nor will it inform the sender or receiver.***

Connectionless

- **Each packet is treated independently from all others.**

- **Each datagram is handled independently,**

- **Each datagram can follow a different route** to the destination.

- A sequence of packets sent from one computer to another **may travel over different paths**, or some ***may be lost while others are delivered.***

Best Effort Delivery

- The Internet software makes an earnest attempt to deliver packets.
- The **internet does not discard packets** unpredictably;
- **Unreliability arises** only ***when resources are exhausted or underlying networks fail***.

Best Effort Delivery

An example of a more commonly understood best-effort delivery service is the post office. The post office does its best to deliver the mail but does not always succeed. If an unregistered letter is lost, it is up to the sender or would-be recipient to discover the loss and rectify the problem. The post office itself does not keep track of every letter and cannot notify a sender of loss or damage.

Purpose of the Internet Protocol

- The protocol that **defines the unreliable, connectionless delivery mechanism** is called the ***Internet Protocol***
- Usually referred to by its initials, ***IP.***
- IP provides three important definitions.

The IP protocol *defines the basic unit of data transfer* used throughout a TCP/IP internet. It *specifies the exact format of all data* as it passes across the internet.

IP software *performs the routing function, choosing a path over which data will be sent*.

In addition to the precise, formal specification of data formats and routing, IP *includes a set of rules that embody the idea of unreliable packet delivery*. The rules characterize how hosts and routers should process packets, how and when error messages should be generated, and the conditions under which packets can be discarded.

- **IP is a fundamental part of the design** that ***a TCP/IP internet is sometimes called an IP-based technology*****.**

The unit of communication at the network layer is a datagram.

The Internet Datagram

- **A datagram is divided into *header and data.***

DATAGRAM HEADER	DATAGRAM DATA AREA

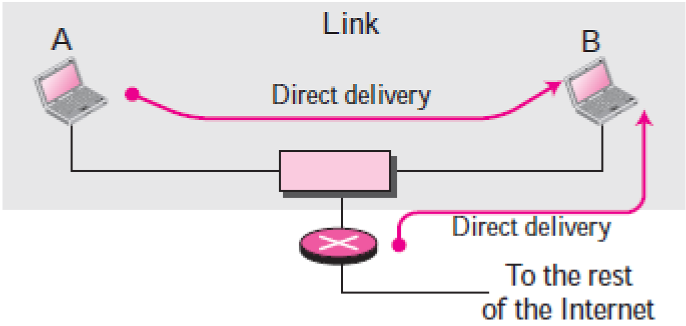
- The datagram header contains
  - ***the source and destination addresses and***
  - ***a type field that identifies the contents of the datagram.***

- The difference,
  - ***The datagram header contains IP addresses***
  - ***The frame header contains physical addresses.***

- **The delivery of a packet to its final destination** is accomplished using ***two different methods of delivery***
  - ***Direct and indirect.***

Direct

- In a **direct delivery,** the final destination of the packet is a host connected to the same physical network as the deliverer.



- Direct delivery occurs
  - ***When the source and destination of the packet are located on the same physical network or***
  - ***If the delivery is between the last router and the destination host***

- The sender can easily determine if the delivery is direct.

Direct

- Extract the network address of the destination
- Compare this address with the addresses of the networks to which it is connected.
- If a match is found, the delivery is direct.
- In direct delivery, the sender uses the destination IP address to find the destination physical address.
- The IP software then gives the destination IP address with the destination physical address to the data link layer for actual delivery.
- This process is called *mapping the IP address to the physical address*.

Indirect Delivery

- **If the destination host is not on the same network,**

- **The packet goes from router to router *until it reaches the one connected to the same physical network as its final destination.***

- Figure 6.2 shows the concept of indirect delivery.

- **The sender uses *the destination IP address and a routing table to find the IP address of the next router to which the packet should be delivered.***

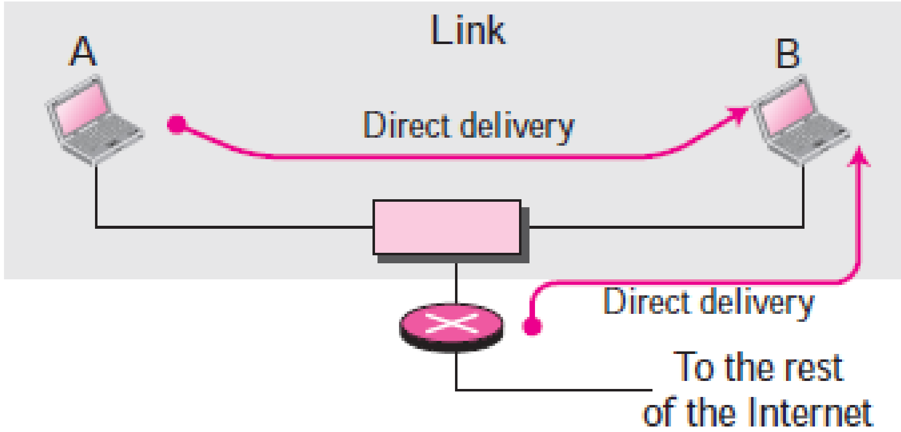
Indirect Delivery

- **The sender uses ARP** ***to find the physical address of the next router.***

- **The address mapping is**
  - ***between the IP address of the final destination and the physical address of the final destination.***
  - ***between the IP address of the next router and the physical address of the next router.***

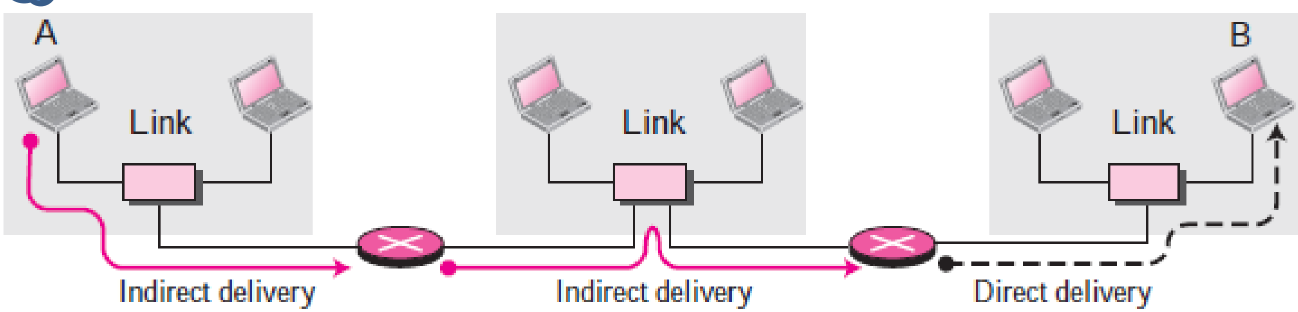
- Delivery always involves one direct delivery but zero or more indirect deliveries.

- The last delivery is always a direct delivery.

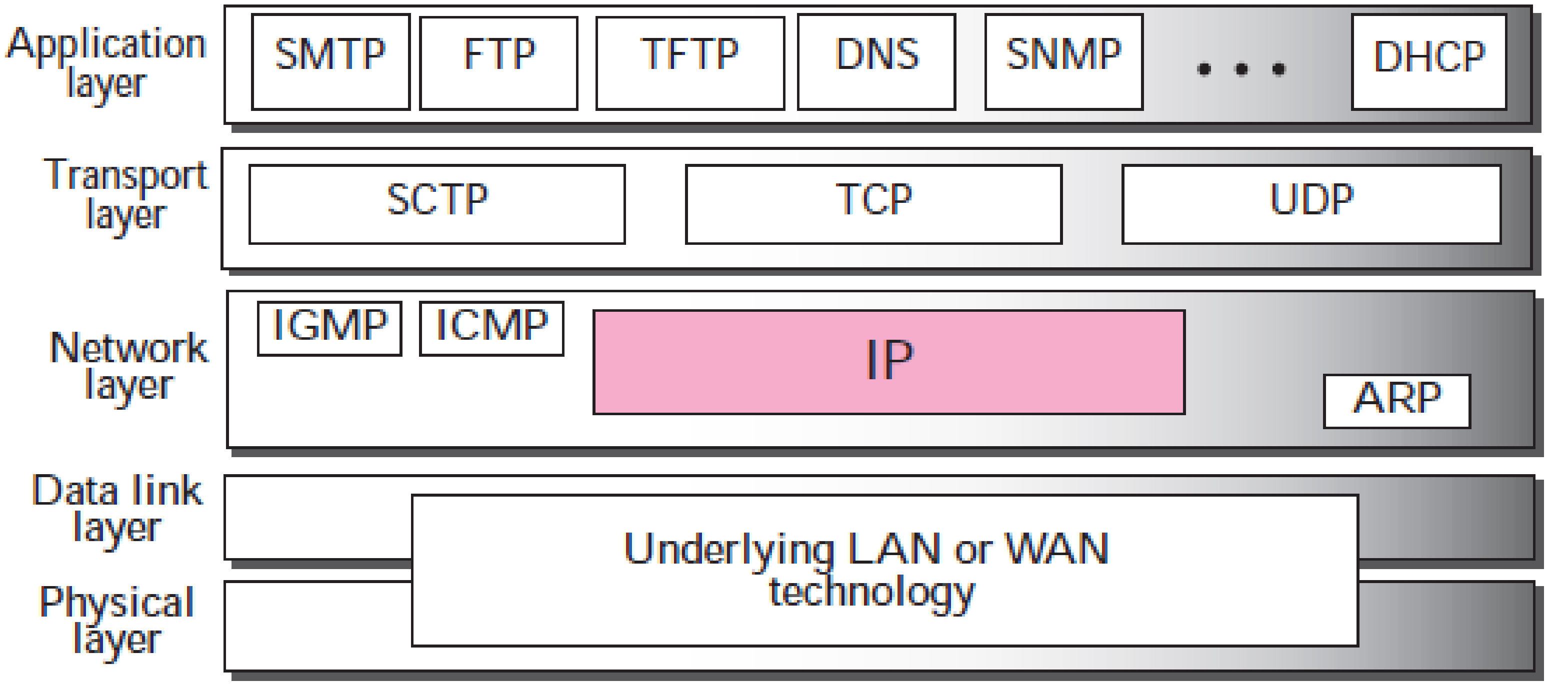


Direct Delivery

Address Mapping



Indirect Delivery



Position of IP in TCP/IP Protocol Suite

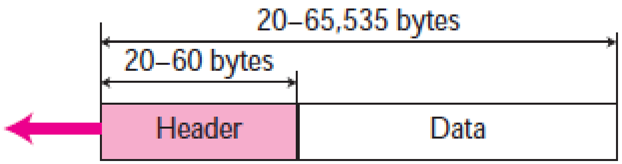
IP Datagram Format

- Packets in the network (internet) layer are called **datagrams.**

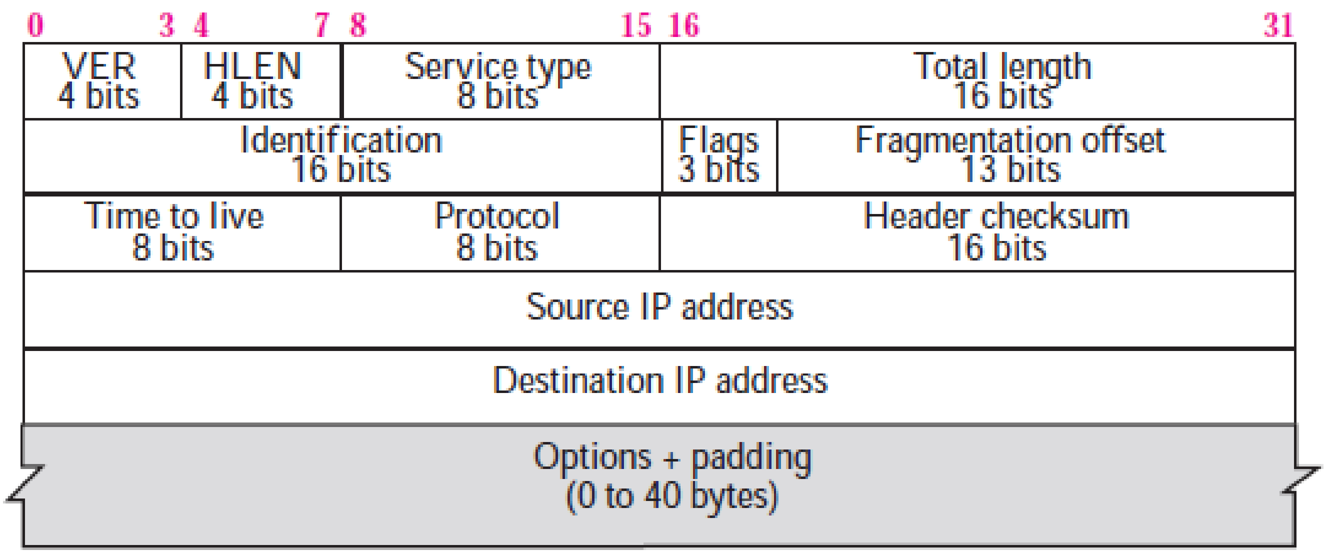
- Figure shows the IP datagram format.

- **A datagram is a variable-length packet** consisting of two parts
  - ***Header and Data.***

- The header is **20 to 60 bytes in length** and contains information essential to routing and delivery.



a. IP datagram



b. Header format

IP Datagram

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VER

- **The version of the IP protocol** ***was used to create the datagram.***

- It is **used to verify that the sender, receiver, and any routers in between them** ***agree on the format of the datagram.***

- **All IP software is required to check the version field before processing a datagram** ***to ensure it matches the format the software expects.***

- If standards change, machines will reject datagrams with protocol versions that differ from theirs

- The current IP protocol version is 4.

HLEN

- This 4-bit field defines the ***total length of the datagram header in 4-byte words.***

- This field is needed ***because the length of the header is variable (between 20 and 60 bytes).***

- **When there are no options,** ***the header length is 20 bytes, and the value of this field is 5 (5 × 4 = 20).***

- **When the option field is at its maximum size,** ***the value of this field is 15 (15 × 4 = 60).***

Type of Service (TOS)

- Defined **how the datagram should be handled.**
- Part of the field was
  - ***used to define the precedence of the datagram;***
  - ***the rest defined the type of service (low delay, high throughput, and so on).***
- IETF has changed the interpretation of this 8-bit field.
- This field now defines a set of **differentiated services.**
- The new interpretation is shown in Figure 7.3.

TOS

0	1	2	3	4	5	6	7
PRECEDENCE			D	T	R	UNUSED	

- Three PRECEDENCE bits **specify datagram precedence**, ***with values ranging from 0 (normal precedence) through 7 (network control),***
- **Allowing senders** ***to indicate the importance of each datagram.***
- Although some routers ignore **type** of service,
- It is an important concept because it ***provides a mechanism that can allow control information to have precedence over data.***

TOS

For example,

Many routers use a precedence value of 6 or 7 for routing traffic to make it possible for the routers to exchange routing information even when networks are congested.

TOS

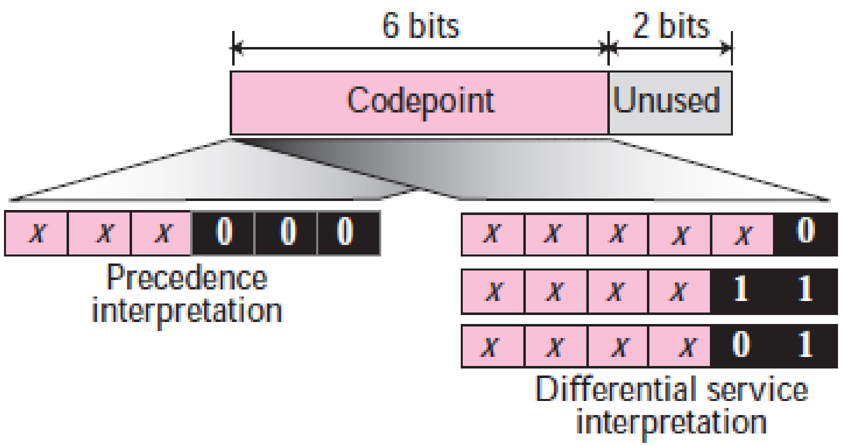
- **Bits D, T, and R specify** - **type of transport desired for the datagram**.
  - ***D – Low Delay***
  - ***T – High Throughput***
  - ***R – High Reliability***

- It may not be possible for an internet to guarantee the **type** of transport requested (i.e., it could be that no path to the destination has the requested property).

TOS

- In the late 1990s, the IETF redefined the meaning of the 8-bit ***SERVICE TYPE*** field to accommodate a set of ***differentiated services*** (DS).

- Figure 7.5 illustrates the resulting definition.



- The first 6 bits make up the codepoint subfield and the last 2 bits are not used.

TOS

- The codepoint subfield can be used in two different ways.

- When the 3 right-most bits are 0s, the 3 left-most bits are interpreted the same as the precedence bits in the service type interpretation.

- In other words, it is compatible with the old interpretation.

- The precedence defines the eight-level priority of the datagram (0 to 7) in issues such as congestion.

TOS

- If a router is congested and needs to discard some datagrams, those datagrams with lowest precedence are discarded first.

- Some datagrams in the Internet are more important than the others.

- For example, a datagram used for network management is much more urgent and important than a datagram containing optional information for a group.

TOS

- When the 3 right-most bits are not all 0s, the 6 bits define 56 (64 - 8) services based on the priority assignment by the Internet or local authorities according to Table 7.1.

- The first category contains 24 service types;

- the second and the third each contain 16.

Category	*Codepoint*	*Assigning Authority*
1	XXXXX0	Internet
2	XXXX11	Local
3	XXXX01	Temporary or experimental

Value for Code Point

TOS

- The first category is assigned by the Internet authorities (IETF).
- The second category can be used by local authorities (organizations).
- The third category is temporary and can be used for experimental purposes.
- Note that these assignments have not yet been finalized.

Protocol	*TOS Bits*	*Description*
ICMP	0000	Normal
BOOTP	0000	Normal
NNTP	0001	Minimize cost
IGP	0010	Maximize reliability
SNMP	0010	Maximize reliability
TELNET	1000	Minimize delay
FTP (data)	0100	Maximize throughput
FTP (control)	1000	Minimize delay
TFTP	1000	Minimize delay
SMTP (command)	1000	Minimize delay
SMTP (data)	0100	Maximize throughput
DNS (UDP query)	1000	Minimize delay
DNS (TCP query)	0000	Normal
DNS (zone)	0100	Maximize throughput

Default Types of Service

Total Length (HLEN)

- The TOTAL LENGTH field gives ***the length of the IP datagram measured in octets,*** including octets in the header and data.

- **The size of the data area can be computed *by subtracting the length of the header (HLEN) from the TOTAL LENGTH.***

- TOTAL LENGTH field is 16 bits long, the maximum possible size of an **IP** datagram is 216 or 65,535 octets.

- In most applications this is not a severe limitation.

Total Length (HLEN)

- It may become more important in the future if higher speed networks can carry data packets larger than 65,535 octets.

Length of data = total length – header length

The *total length* field defines the total length of the datagram including the header.

- The field length is 16 bits, the total length of the IP datagram is limited to 65,535 (2^{16} - 1) bytes, of which 20 to 60 bytes are the header and the rest is data from the upper layer.

Identification - This field is used in fragmentation

Flags - This field is used in fragmentation

Fragmentation offset - This field is used in fragmentation

Time To Live (TTL)

- ***Specifies how long, (in seconds), the datagram is allowed to remain in the internet system.***
- The idea is both simple and important:
  - ***whenever a computer injects a datagram into the internet, it sets a maximum time that the datagram should survive.***
- Routers and hosts process datagrams must decrement the TTL as time passes and remove the datagram from the internet when its time expires

Time To Live (TTL)

- ***Estimating exact times is difficult*** **because routers do not usually know the transit time for physical networks.**

- **All the machines must**
  - ***have synchronized clocks and***
  - ***know how long it takes for a datagram to go from one machine to another.***

- Whenever a TTL field reaches zero,
  - ***the router discards the datagram and***
  - ***sends an error message back to the source.***

Time To Live (TTL)

- The idea of keeping a timer for datagrams is
  - *it guarantees that datagram cannot travel around an internet forever, even if routing tables become corrupt and routers route datagrams in a circle.*
- This value is ***approximately two times the maximum number of routes between any two hosts***.

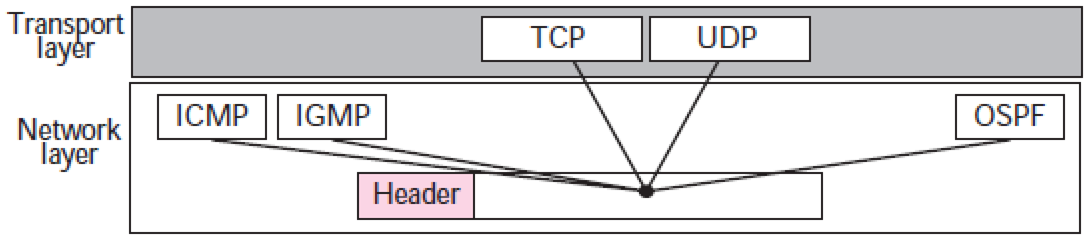
Protocol

- This 8-bit field **defines the higher-level protocol** t***that uses the services of the IP layer.***

- An IP datagram can encapsulate data from several higher level protocols such as TCP, UDP, ICMP, and IGMP.

- This field specifies the final destination protocol to which the IP datagram should be delivered.

- IP protocol multiplexes and demultiplexes data from different higher-level protocols, the value of this field helps in the demultiplexing process when the datagram arrives at its final destination



Value	Protocol	Value	Protocol
1	ICMP	17	UDP
2	IGMP	89	OSPF
6	TCP		

Checksum

- ***Ensures integrity of header values.***

- The IP checksum is formed by treating the header as a sequence of 16-bit integers (in network byte order),
  - ***adding them together using one's complement arithmetic, and***
  - ***taking the one's complement of the result.***

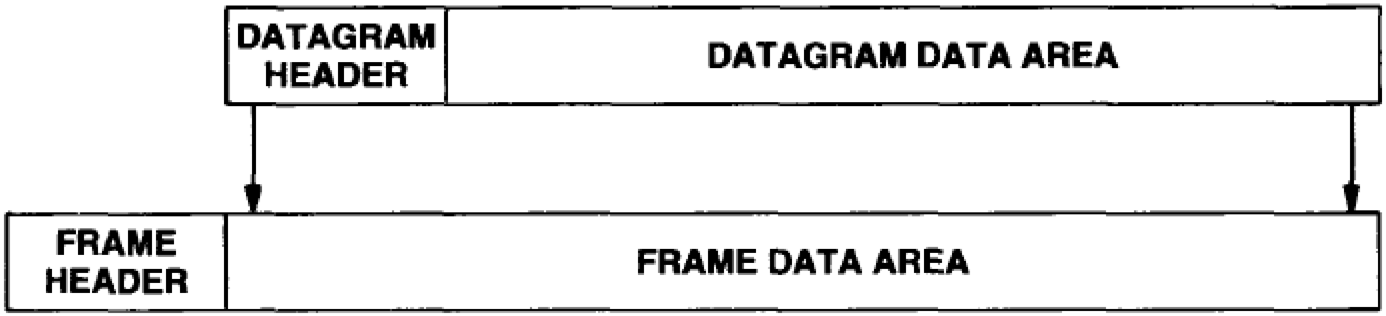
- For purposes of computing the checksum, field HEADER CHECKSUM is assumed to contain zero.

- Only applies to values in the IP header and not to the payload.

Source address – This 32-bit field defines the IP address of the source. This field must remain unchanged during the time the IP datagram travels from the source host to the destination host.

Destination address – This 32-bit field defines the IP address of the destination. This field must remain unchanged during the time the IP datagram travels from the source host to the destination host.

Encapsulation



Thank You