Best-Effort Delivery

- IP datagrams may be lost, duplicated, delayed, delivered out of order, or delivered with corrupted data.
- The Internet Protocol does not attempt to correct problem packets.
- Higher layers of protocol software are required to handle each of these errors.

Internet Control Message Protocol

- **ICMP** is an error reporting and network management system.
- ICMP attempts to keep the Internet running as efficiently as possible.
- ICMP works to correct network problems, although it does not try to correct individual packet problems.

ICMP Packets

- ICMP packets are sent in IP datagrams. They have no special priority, although an error in an IP packet never creates an error message.

ICMP Header

- The **Type** field indicates the type of ICMP message.
- The **Code** field provides data specific to the type.
- The **Checksum** detects errors in the ICMP packet.

ICMP Message Types

- Each message is identified by an 8-bit type field.

Some Uses for ICMP

1. Echo (ping)
2. Tells the source a packet exceeded the TTL.
3. Tells the source that a packet had to be fragmented.
4. Redirect the host to a better router.
5. Controls the rate at which a host sends packets. (Source Quench)
6. Tell the source the destination is unreachable. Either the network or the host is down.
7. Request subnet mask.
**Ping**
- The ping utility sends ICMP packets with the echo function to a remote computer.
- When a computer receives an ICMP echo packet, it sends it back to the host that sent it.
- Ping times how long it takes to get a reply to make a simple measure of network performance.

**Traceroute**
- Traceroute measures the number of hops required to reach a destination.
- Traceroute sends an IP packet with the Time To Live (TTL) value set to 1.
- When a router decrements the TTL to zero, it discards the packet and sends an ICMP packet to the source to inform it of the problem.
- Traceroute repeats this with increasing numbers TTL values.

**MTU**
- ICMP can be used to determine maximum the MTU along a path.
- Sending packets with the “do not fragment” flag will cause a node to send an ICMP message back to the source when a packet needs to be fragmented. The ICMP message includes the maximum packet size allowed at that point.
- IP can adjust to sending packets that won’t fragment along the way.

**MTU (Maximum Transmission Unit)**
- When a router receives a datagram that is larger than the MTU of the network over which it is to be sent, the router divides the datagram into smaller pieces called fragments.
- Each fragment uses the IP datagram format, but carries only part of the data.

**Multiple Router Network**

**Router Redirection**
- If A1 wants to send a packet to a computer on network B, it will have to send the packet to a router.
- If A1 sends the packet to router 2, router 2 will send the packet to router 1 and will send an ICMP message to the source to inform it of the correct router to use.