L3 packets are forwarded by routers based on their L3 destination address.

At L2, hosts send packets where the destination is in the same L3 (sub)network directly to that host. L3 Packets to destinations outside the (sub)net are encapsulated in L2 frames addressed to the default gateway. Within that encapsulation, the L3 packet remains addressed to the final destination.

IP header—20-bytes. For now, we care about the source & destination addresses.

Name	Bytes	Description
Version	<1	
Length	<1	
DS Field	1	
Packet Length	2	
Identification	2	
Flags	<1	
Fragment Offset	>1	
Time To Live	1	
Protocol	1	
Header Checksum	2	
Source IP Address	4	
Destination IP Address	4	

Routing Protocols—Allow routers to share information about how to reach networks

ADDRESSING

Dotted Decimal Notation, e.g. 192.168.1.1—Four octets separated by periods. Each octet is a number from 0-255, representing 8 bits. The whole address represents a 32-bit binary number.

Address Classes—Network size (number of possible addresses)

1st Octet Range	Class	Addresses Per Net	Purpose
0			Reserved
1-126	A	2 ^ 24	Unicast
127			Reserved for loopback
128 - 191	B	2 ^ 16 = 65,536	Unicast
192 - 223	C	2 ^ 8 = 256	Unicast
224 - 239	D		Multicast
240 - 255	E		Reserved (formerly experimental)

Addresses in the same network must not be separated by a router; addresses in different networks must be separated by a router.

ROUTING

Router Forwarding

- Use the L2 frame's FCS to check for errors; if error found, discard the frame mercilessly
- Remove the L2 encapsulation; we're done with it forever
- Choose one of the router's exit interfaces based on the longest match between the L3 destination address and the options in the routing table
- Encapsulate the L3 packet within a fresh L2 frame (Ethernet, HDLC, or PPP) for its next hop

ROUTING PROTOCOLS

Perhaps better called route-sharing protocols, routing protocols add to the router's automatic routes to directly-connected networks. Specifically, they:

- Learn routes from other routers and tell them about yours
- For each destination, place the best learned route in the routing table
- When a route is no longer valid, remove it and, if possible, replace it
- Avoid routing loops

Convergence—the time taken for all routers in an internetwork to learn all their routes

DNS, ARP, AND ICMP

All three of these protocols are defined at OSI layer 3.

DNS (Domain Name System)—Servers map names, like cisco.com, to IP addresses

ARP (Address Resolution Protocol)—Asks for the L2 address of a host, given the L3 address by broadcasting an *ARP Request* message within the LAN. The host interface holding that address will give its L2 address in an *ARP Reply*.

ICMP (Internet Control Message Protocol)—provides messages regarding reachability

PING (Packet INternet Groper)—sends an *ICMP Echo Request* packet to the destination and receives an *ICMP Echo Reply* back, verifying connectivity. [Technically, when RFC 792 defines ICMP, it mentions "echo" and "echo reply" messages, never using the term ping. Further, "ping" appears historically to have been a reference to sonar, not an acronym for a lowbrow phrase.]