

Training and placement



New networks can be introduced below Old network technologies can be retired Internet Protocol Approach ? ? ? IP packets transfer information across Internet Host A IP > router> router...> router> Host B IP IP layer in each router determines next hop (router) Network interfaces transfer IP packets across networks Router Internet Layer Network Interface Host A Transport Layer Internet Layer Network Interface Router Internet Layer Host B Transport Layer Internet Layer Network Interface Net Net 51 Router Internet Layer Network Interface Net Net 54 Net Net 52 Network Interface Net Net 53 TCP/IP Protocol Suite HTTP Reliable stream service.

SMTP DNS Distributed applications TCP UDP RTP User datagram service Best-effort connectionless packet transfer Network IP (ICMP, ARP) Network Network Interface 3 Interface 1 Interface 2 Diverse network technologies Internet Names & Addresses Internet Names ? Each host has a unique name ? Independent of physical location ? Facilitate memorization by humans ? Domain Name ? Organization under single administrative unit ? Host Name ? Name given to host computer ? User Name ? Name assigned to user Internet Addresses ? Each host has globally unique logical 32 bit IP address ? Separate address for each physical connection to a network.

Routing decision is done based on destination IP address ? IP address has two parts: ? netid and hostid ? netid unique ? netid facilitates routing ? Dotted Decimal Notation: int1. int2. int3. int4 (intj = jth octet) utoronto. ca 128. 100. 10. 13 DNS resolves IP name to IP address Physical Addresses ? ? ? ? LANs (and other networks) assign physical addresses to the physical attachment to the network The network uses its own address to transfer packets or frames to the appropriate destination IP

address needs to be resolved to physical address at each IP network interface Example: Ethernet uses 48-bit addresses ? ?

Each Ethernet network interface card (NIC) has globally unique Medium Access Control (MAC) or physical address First 24 bits identify NIC manufacturer; second 24 bits are serial number 00: 90: 27: 96: 68: 07 12 hex numbers Intel Encapsulation TCP Header contains source & destination port numbers IP Header contains source and destination IP addresses; transport protocol type Ethernet Header contains source & destination MAC addresses; network protocol type Ethernet header IP header HTTP Request TCP header HTTP Request TCP header HTTP Request IP header TCP header HTTP Request FCS Chapter 8 Communication Networks and Services

The Internet Protocol Internet Protocol ? Provides best effort, connectionless packet delivery ? ? ? motivated by need to keep routers simple and by adaptability to failure of network elements packets may be lost, out of order, or even duplicated higher layer protocols must deal with these, if necessary ? ? RFCs 791, 950, 919, 922, and 2474. IP is part of Internet STD number 5, which also includes: ? ? Internet Control Message Protocol (ICMP), RFC 792 Internet Group Management Protocol (IGMP), RFC 1112 IP Packet Header 0 Version 4 IHL 8 Type of Service Flags 16 19 24 Total Length Fragment Offset Header Checksum 31

Identification Time to Live Protocol Source IP Address Destination IP Address Options Padding ? ? Minimum 20 bytes Up to 40 bytes in options fields IP Packet Header 0 Version 4 IHL 8 Type of Service Flags 16 19 24 Total Length Fragment Offset Header Checksum 31 Identification Time to Live Protocol Source IP Address Destination IP Address Options Padding Version: current IP

version is 4. Internet header length (IHL): length of the header in 32-bit words. Type of service (TOS): traditionally priority of packet at each router. Recent Differentiated Services redefines TOS field to include other services besides best effort.

IP Packet Header 0 Version 4 IHL 8 Type of Service Flags 16 19 24 Total Length Fragment Offset Header Checksum 31 Identification Time to Live Protocol Source IP Address Destination IP Address Options Padding Total length: number of bytes of the IP packet including header and data, maximum length is 65535 bytes. Identification, Flags, and Fragment Offset: used for fragmentation and reassembly (More on this shortly). IP Packet Header 0 Version 4 IHL 8 Type of Service Flags 16 19 24 Total Length Fragment Offset Header Checksum 31 Identification Time to Live Protocol Source IP Address Destination IP Address Options Padding

Time to live (TTL): number of hops packet is allowed to traverse in the network. • Each router along the path to the destination decrements this value by one. • If the value reaches zero before the packet reaches the destination, the router discards the packet and sends an error message back to the source. IP Packet Header 0 Version 4 IHL 8 Type of Service Flags 16 19 24 Total Length Fragment Offset Header Checksum 31 Identification Time to Live Protocol Source IP Address Destination IP Address Options Padding Protocol: specifies upper-layer protocol that is to receive IP data at the destination.

Examples include TCP (protocol = 6), UDP (protocol = 17), and ICMP (protocol = 1). Header checksum: verifies the integrity of the IP header. Source IP address and destination IP address: contain the addresses of the

source and destination hosts. IP Packet Header 0 Version 4 IHL 8 Type of Service Flags 16 19 24 Total Length Fragment Offset Header Checksum 31 Identification Time to Live Protocol Source IP Address Destination IP Address Options Padding Options: Variable length field, allows packet to request special features such as security level, route to be taken by the packet, and timestamp at each router.