Agenda

- Networking
- OSI Seven Layer Model
- IP Addresses
- ARP Table
- Network Addressing / Netmasks
- Routing
- Direct / Indirect Routes
- Diagnostics
- References

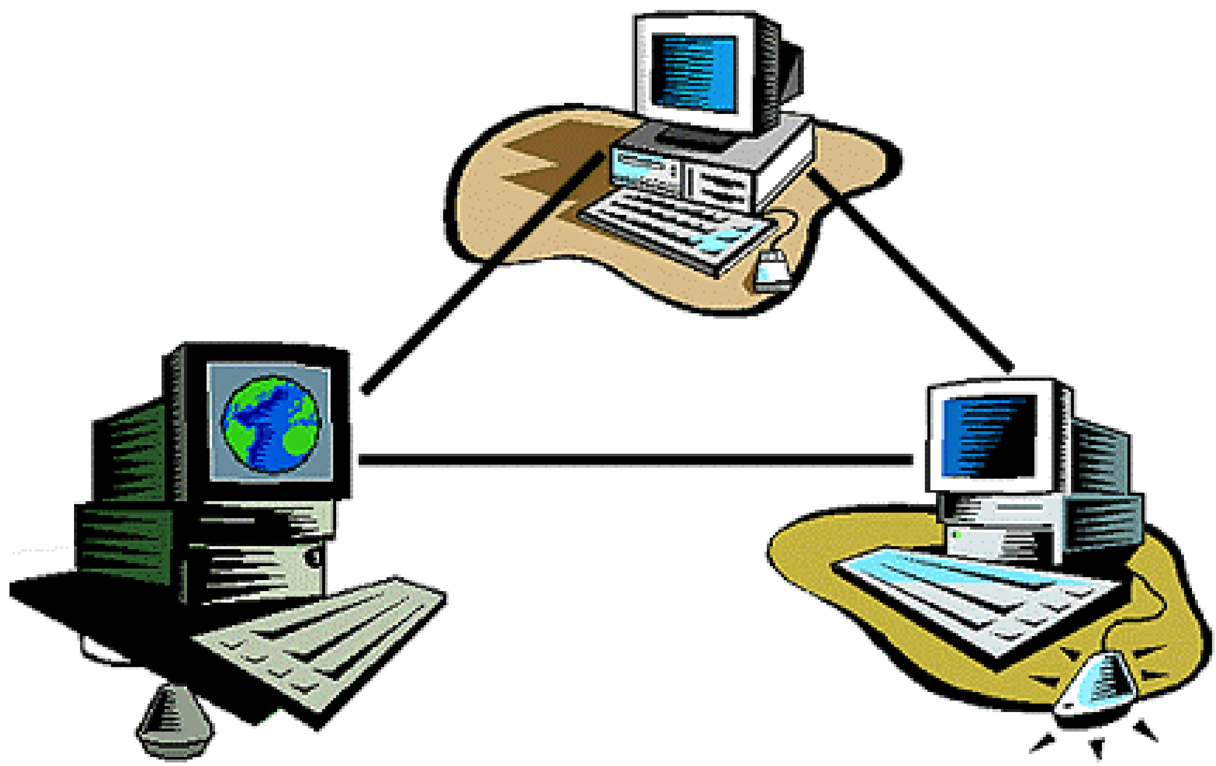
Networks

- Networks have become a fundamental, if not the most important, part of today's information systems..
- Networks form the backbone for information sharing.
  - Email
  - Data
  - Applications

Why Network?

Enables computers to communicate with one another

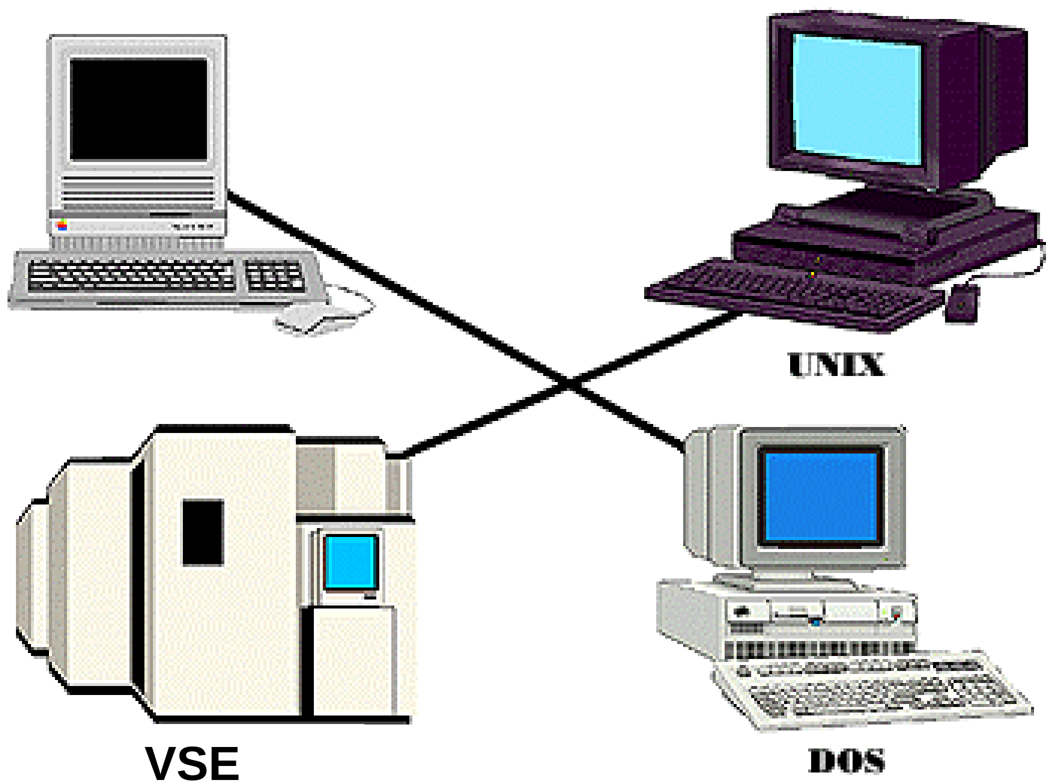
to share files,
programs,
commands and
any other data
nearly instantly



Interoperability

Allows different types of computers, using different operating systems, to communicate with each other –

as long as they follow the same network protocols.



OSI Seven Layer Model

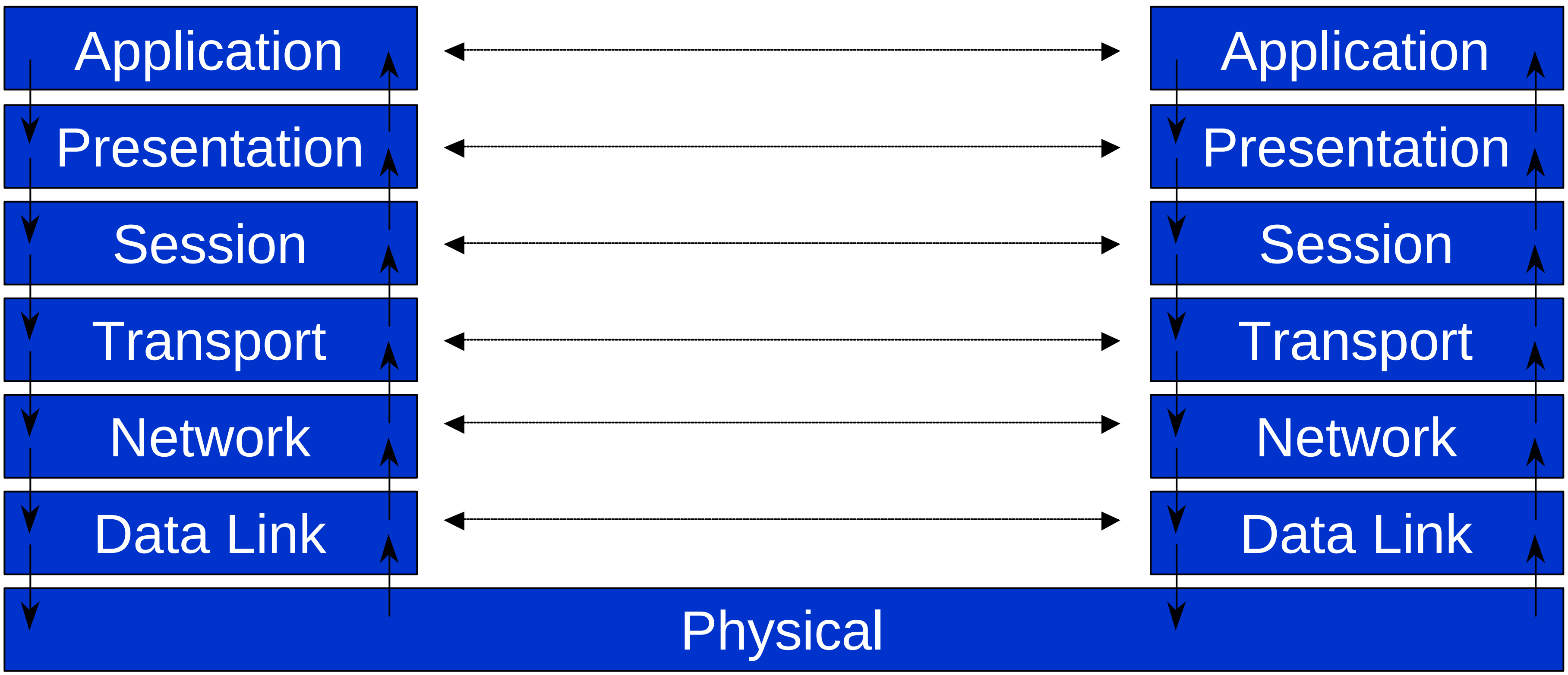
- The OSI Seven Layer Model was created to facilitate the development of computer protocols.
  (Open Systems Interconnect)
- Familiarity with the OSI “Seven Layer Model” is required for high-level network administration and troubleshooting.

OSI Seven Layer Model

- Each layer of the OSI model supports the layer above and utilizes the layer below.
- Each layer is supposed to be completely independent of the layers above and below
- Accepted as a basis for the understanding of how a network protocol stack should operate

OSI Seven Layer Model

- "Equal" layers converse with each other.



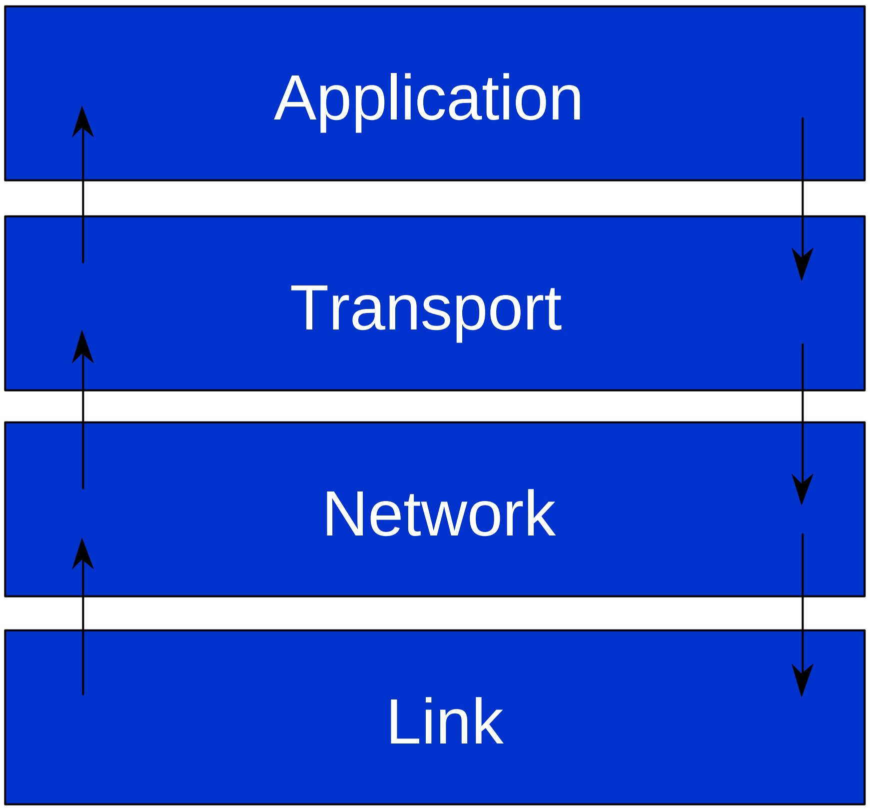
OSI Seven Layer Model

- Application
  - Network applications such as terminal emulation and file transfer
- Presentation
  - Formatting of data and encryption
- Session
  - Establishment and maintenance of sessions
- Transport
  - Provision of reliable and unreliable end-to-end delivery

OSI Seven Layer Model

- Network
  - Packet delivery, including routing
- Data Link
  - Framing of units of information and error checking
- Physical
  - Transmission of bits on the physical hardware

The “Layers” of IP



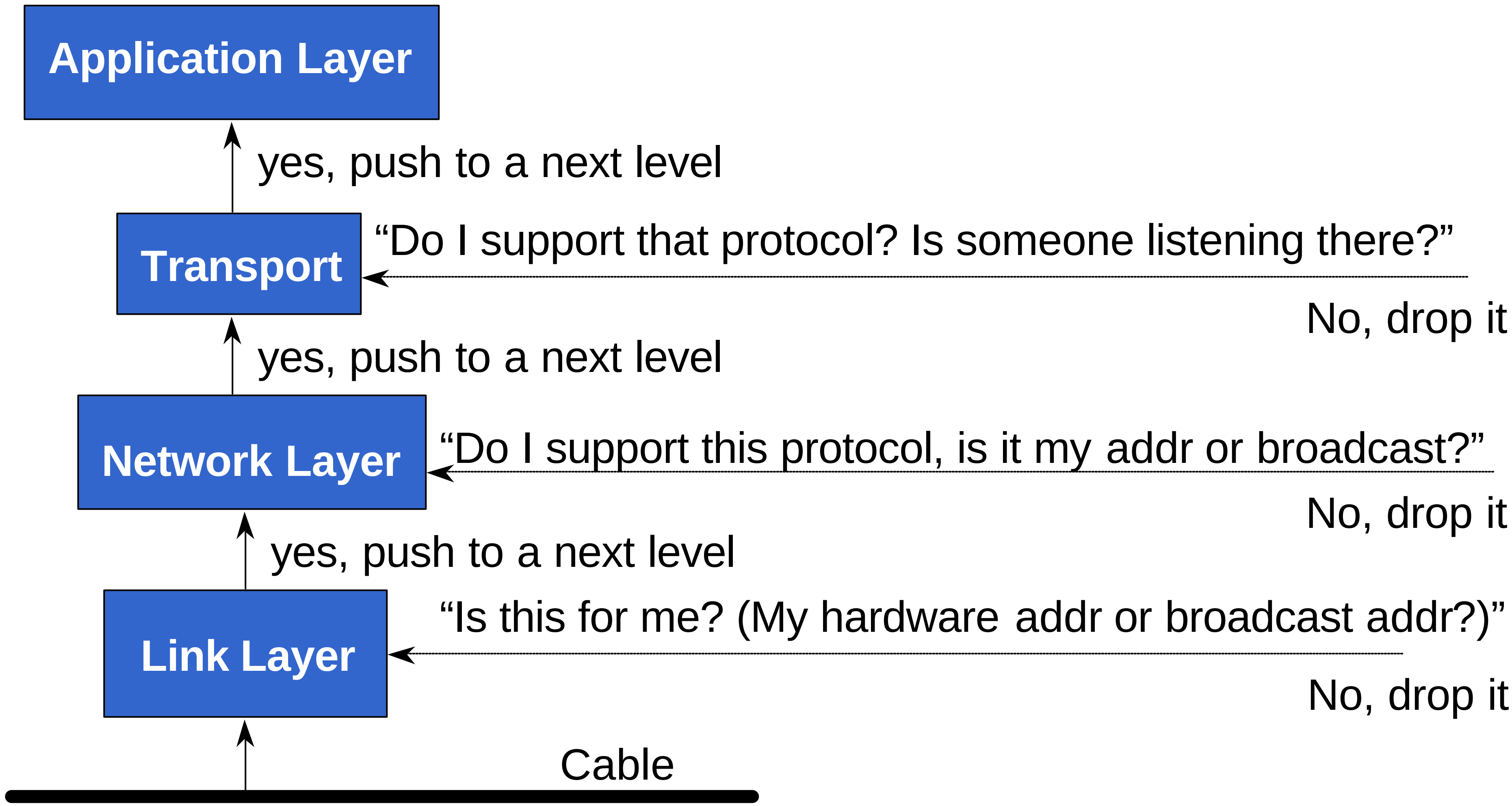
Telnet, FTP, eMail,Socket-Apps

UDP, TCP, RAW

IP, ICMP, IGMP

Ethernet, Token Ring, Serial

Communication Between Layers



IP Addresses

- An IP Address uniquely identifies a node or host connection to an IP network.
- IP addresses are used by the IP protocol to uniquely identify a host on the Internet.
- An IP address is a 32 bit binary number
  - represented as 4 fields
  - each field represents an 8 bit numbers in the range 0 to 255 (called octets) separated by decimal points.

IP Addresses

- An IP address is shown as four decimal (base 10) numbers between 0 and 255 separated by periods.
- For example:

  192.168.42.222

- This is called “dotted decimal” format.
- The four numbers between the dots are called “octets”.
  - Each decimal number represents 8 bits.
- An 8-bit binary number ranges from

  0 (0000 0000) to 255 (1111 1111).

IP Addresses

- IP datagrams (the data packets exchanged between hosts) are transmitted by a physical network attached to the Host
- Each IP datagram contains a source IP address and a destination IP address.
- To send a datagram to a certain IP destination, the target IP address must be translated or mapped to a physical address.
  - Address Resolution Protocol (ARP) is used to translate IP addresses to physical MAC addresses.

ARP Table

- On a single physical network, individual hosts are known on the network by their physical hardware address.
- Higher level protocols address destination hosts in the form of a symbolic address (IP address in this case).
- When such a protocol wants to send a datagram to destination IP address w.x.y.z, the device driver does not understand this address.

ARP Table

- ARP will translate the IP address to the physical (mac) address of the destination host.
  - a lookup table is used to perform this translation
  - ARP Cache
- If the address is not found in the ARP cache, a broadcast is sent out on the network.
  - ARP Request
- If a machine on the network recognizes its own IP address in the request, it will send an ARP reply back to the requesting host.

ARP Table

- The reply contains the physical hardware address of the host and source route information (if the packet has crossed bridges on its path).
- Both this address and the source route information are stored in the ARP cache of the requesting host.
- All subsequent datagrams to this destination IP address can now be translated to a physical address.

Network and Host Addresses

- Since an IP address is a very large number, it was decided that the “zip code” would be a part of the address itself.
- The “zip code” portion of an IP address is called the “network”.
- The “street address” portion of an IP address is called the “host”.

Network and Host Addresses

- Each IP address is actually a “network” address which tells routers the group and a “host” address which defines the particular node in that group.
- In other words, a router can figure out the equivalent of street address, city, state and zip of any node on the Internet from just 32 ones & zeros.

Netmasks

- Netmasks are the IP specific masks which define the boundary between network and host information.
- A common Netmask is: 255.255.255.000
- Which, in binary representation is:

  11111111 . 11111111 . 11111111 . 00000000

Network and Host Addresses

- Each IP address provides a router with the Network address and the Host address within that network.
    - Ex. 192.168.42.222
- By use of a “mask” the IP address can be divided into a Network address and a Host address.
    - Ex. 255.255.255.000
- An IP address can be partitioned into a host and network address at any point.

Netmasks

192.	168.	42.	222
11000000	10101000	00101010	11011110
255.	255.	255.	0
11111111	11111111	11111111	00000000

Routing

- Routing is the function of forwarding packets between networks, both logical and physical.
- Routing is performed by special devices called “Routers”.
- IP provides the basic mechanism for routers to interconnect different physical networks.

What is a Router?

- Bridges, Hubs , Switches
  - With routing function
- Host- Based Router
  - Computer with multiple network interfaces running IP routing code
- Other hardware / software systems dedicated to IP routing

Routing

- Each router or host makes its own routing decisions
  - Based on its “routing table”.
- Sending computer
  - does not determine entire path to destination

Routing

- Each Router has a routing table
  - matches destination addresses with next hops.
- Each Router is initially configured to know its neighbors
  - static routes
- Routing Protocols determine the contents of these tables.
  - OSPF, RIP, BGP
  - sends its table to its neighbors periodically
  - receives tables from neighbors, updates its own and sends out again periodically

Direct Routing

- The destination host is attached to the same physical network to which the source host is attached.
- An IP datagram can be sent directly, simply by encapsulating the IP datagram in the physical network frame.
- This is called direct delivery and is referred to as direct routing.

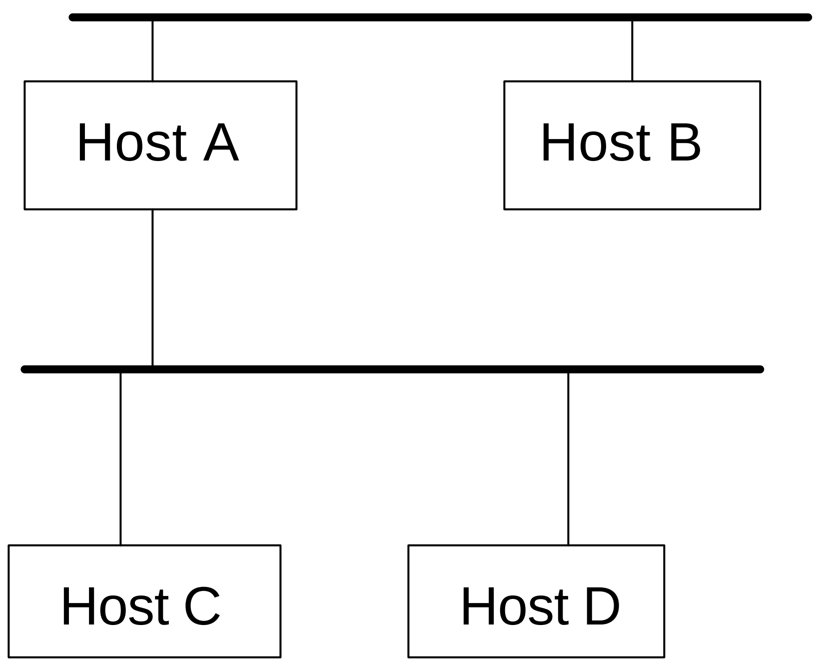
Indirect Routing

- Indirect routing occurs when the destination host is not on a network directly attached to the source host.
- The destination is reached via one or more IP gateways.
  - (Note that in TCP/IP terminology, the terms gateway and router are used interchangeably for a system that actually performs the duties of a router.)
- The address of the first of these gateways (the first hop) is called an indirect route.

Routes

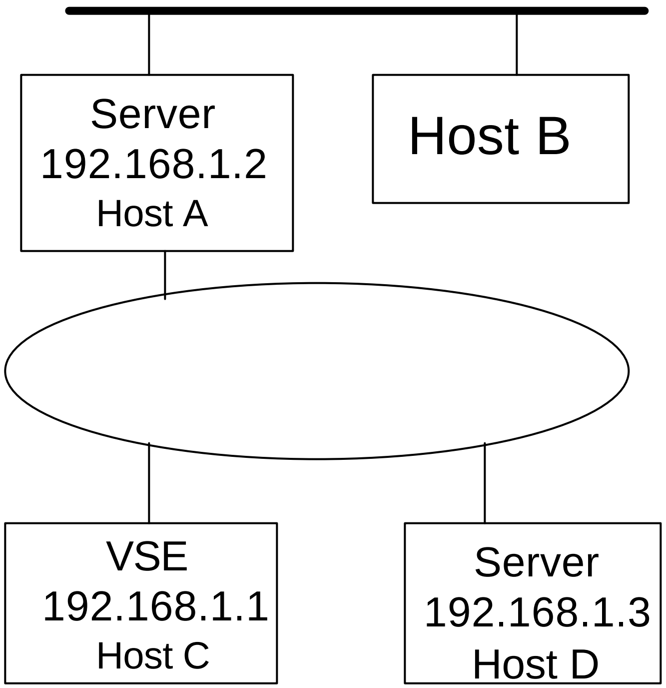
- In some cases there are multiple subnets defined on the same network.
- If the destination host is on the same network as the source host, on different subnets, then indirect routing is used.
- Thus, there is a need for a router that forwards the traffic between subnets.

Direct and Indirect Routes.



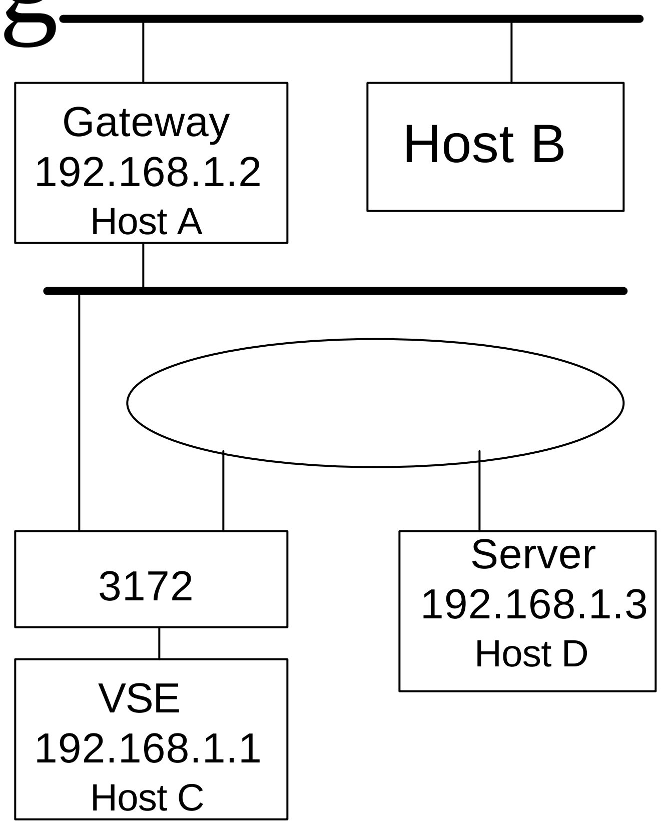
Host C has a direct route to hosts A and D
and an indirect route to host B via gateway A

Direct Routing



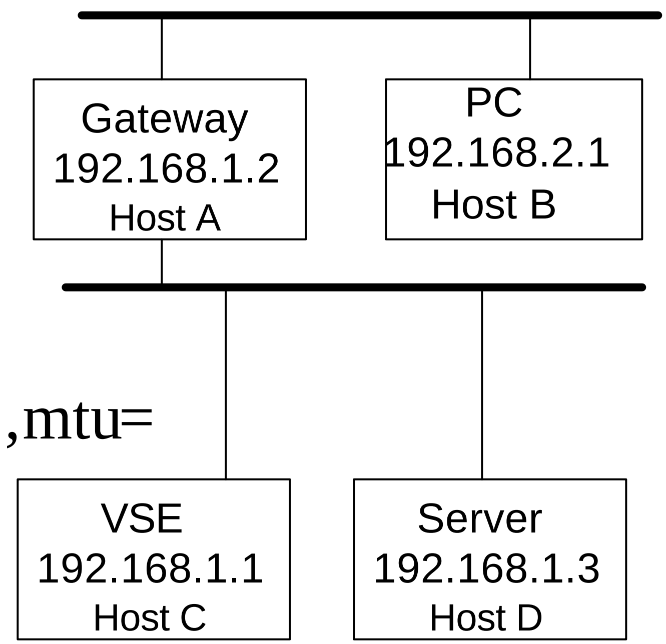
- Server connected via Ethernet
  or Token Ring
- One Link definition
  – Define Link,id=L1,type=…,dev=…,mtu=
- One Route definition
  – Define Route,id=R1,linkid=L1,ipaddr=192.168.1.0

Direct Routing



- Multiple Adapters (3172)
- One Link definition
  - Define Link,id=L1,type=…,dev=…,mtu=
- Two Adapter Definitions
  - Define Adapter,linkid=L1,type=Ethernet,
    number=0
  - Define Adapter,linkid=L1,type=Tokenring,
    number=1
- Two Route definitions
  - Define Route,id=R1,linkid=L1,ipaddr=192.168.1.2
  - Define Route,id=R2,linkid=L1,ipaddr=192.168.1.3

Indirect Routing



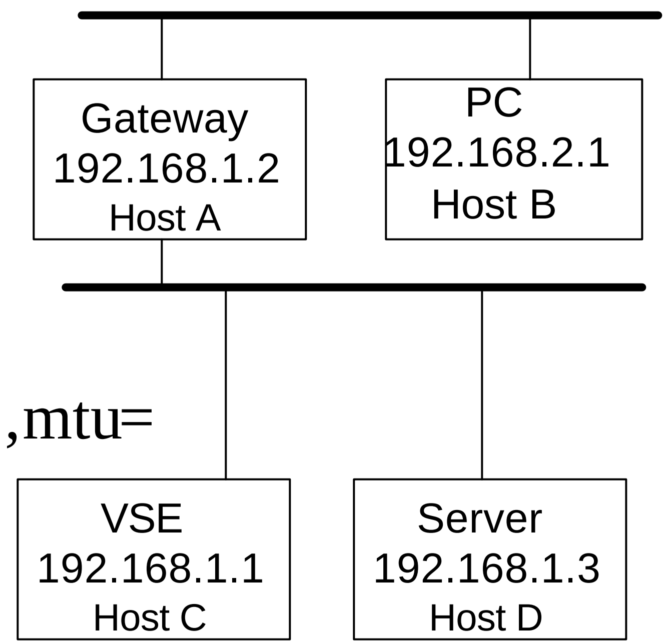
- PC connected via Gateway
- One Link definition
  - Define Link,id=L1,type=…,dev=…,mtu=
- Two Route definitions
  - Define Route,id=R1,linkid=L1,ipaddr=192.168.1.0
  - Define Route,id=R2,linkid=L1,ipaddr=192.168.2.0,

    Gateway=192.168.1.2

Default Route

- The default route is sometimes called the “Route of Last Resort”.
- The default route is used for any destination which matches none of the networks in the routing table

Default Routes

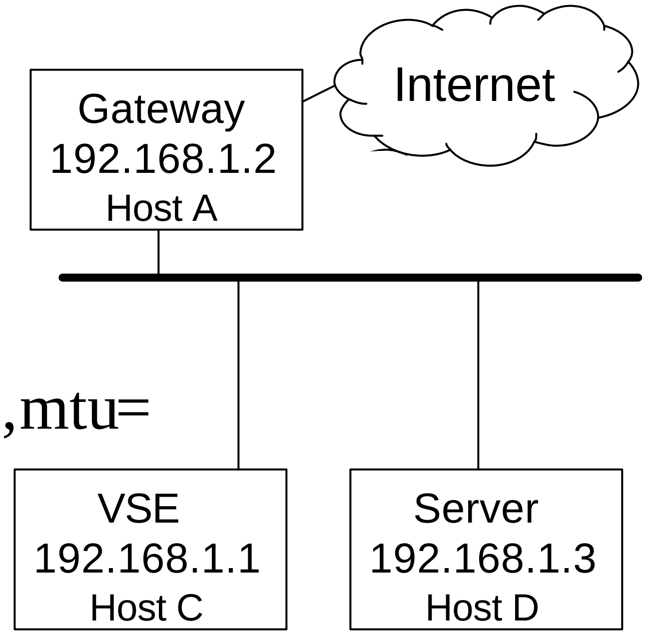


- PC connected via Gateway
- One Link definition
  - Define Link,id=L1,type=…,dev=…,mtu=
- Two Route definitions
  - Define Route,id=R2,linkid=L1,ipaddr=192.168.2.0,
    Gateway=192.168.1.2
  - Define Route,id=R1,linkid=L1,ipaddr=0.0.0.0

Default Gateway

- When a host wishes to communicate with destinations outside its local network, it sends the packets to a router called the “Default Gateway”.
- It is the Default Gateway’s responsibility to forward the packet appropriately so it can get to the destination network.
- Gateways route packets based on their destination network, not the destination machine.

Default Gateway



- Internet connected via Gateway
- One Link definition
  - Define Link,id=L1,type=…,dev=…,mtu=
- Two Route definitions
  - Define Route,id=R2,linkid=L1,ipaddr=192.168.1.0
  - Define Route,id=R1,linkid=L1,ipaddr=0.0.0.0,

    Gateway=192.168.1.2

Routes

- Q ROUTES,IP=192.168.1.3
  - Enables inspection of TCP/IP for VSE Routing table
  - Helps determine routes, debug routing problems

```
86 q routes,ip=192.168.1.3
 F2 0084 IPN447I (( TCP/IP Routes ))
 F2 0084 IPN448I  ID: HOST D          Link ID: L1
 F2 0084 IPN449I     IP Address: 192.168.1.3
 F2 0084 IPN450I     Net: 12625921 Subnet: 0 Host: 3
```

Diagnostics - VSE

- TRACERT <IP addr>
- Traces path to destination.
  - TRACERT e-VSE.COM

    SET HOST= 206.152.227.11

    Hop: 204.210.234.001

    Hop: 024.095.080.186

    Hop: 216.028.255.010

    Hop: 209.115.127.130

    TRACERT was successful, milliseconds: 00058.

Diagnostics - PC

- Obtaining the IP Address on a PC
  - IPCONFIG / WINIPCFG
    - IP ADDRESS
    - SUBNET MASK
    - DEFAULT GATEWAY
    - DNS

Diagnostics - PC

- TRACERT <IP addr>
  - Trace the path taken by datagrams to the destination address
- Route Print
  - Display the entries in the PC routing table
- PING <IP addr> -L 1024 –F
  - Pings an IP address with a length of 1024 and do not fragment
    - Useful in determining MTU

Diagnostics - VSE

- Discover <IP addr>
  - Determines the MTU size between the VSE host and another host on your network.
    - sends packets into the network starting with the smallest possible value (576) and incrementing by 16 with the *do not fragment* bit set on in the TCP header. The last successful transmission determines the MTU size for that connection.
  - To be effective, set the MTU size set at its maximum value prior to using this command

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