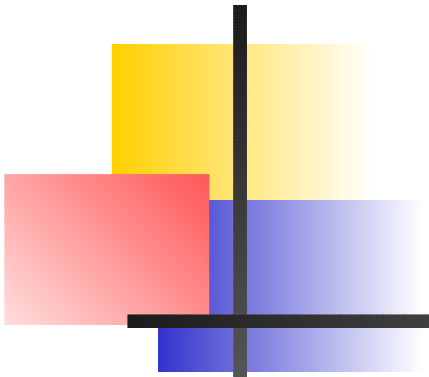

Networking and Routing with IP

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Introduction

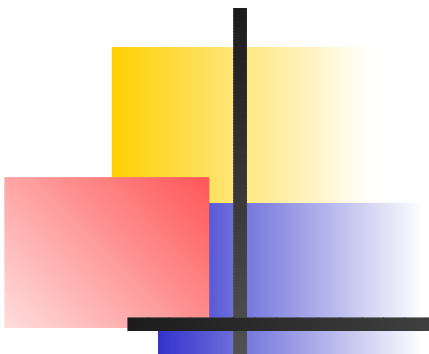
- The "Transmission Control Protocol / Internet Protocol" (TCP/IP) suite was created by the DoD for use as a resilient network that could survive a nuclear war
- At the foundation of this suite is IP, the Internet Protocol
- It is important to understand the IP, as it is the foundation of most modern computer networks
- We will be focusing on IP version 4 (IPv4)

OSI Model

- 7 - Application
- 6 - Presentation
- 5 - Session
- 4 - Transport (TCP)
- 3 - Network (IP, IPX)
- 2 - Data Link (Ethernet, Token Ring, FDDI)
- 1 - Physical (twisted pair, coax, fiber)

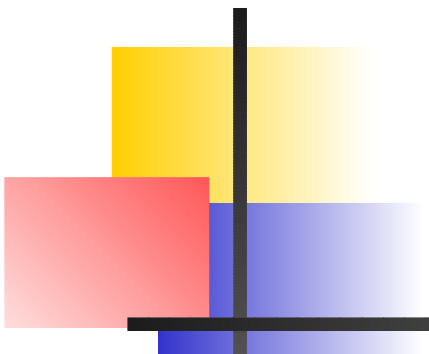
Focus on IP

- Today we will be focusing in on IP, which exists at layer 3 of the OSI model
- IP is the protocol that takes our network packets from our applications and actually gets them across the network.
- IP is based on the concept of unordered best-effort delivery



IP Packets

- IP packets contain a header which includes several important bits of information, such as:
  - Version number
  - Protocol number
  - Time to Live (TTL)
  - Flags
  - Fragmentation offset
  - Source and destination addresses



IP Packets (cont)

Insert diagram of IP packet header

IP Addressing

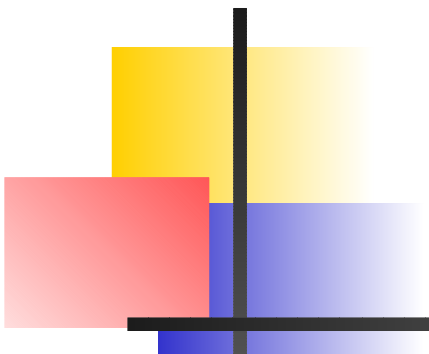
- IP uses 32-bit addresses to identify hosts on the network
- The addresses are composed of two portions, the network address and the host address
- IP addresses are written in something called “dotted quad” notation
- For example, “128.113.42.37”
- How do we tell what part of the address refers to the host, and what part refers to the network?

Classful Addressing

- The bits at the beginning of the address determine the class, and different classes place the network/host separation in a different place
- To see this, look at the first “octet” of the address in binary:
  - 0XXXXXXX - Class A (0.0.0.0 - 127.255.255.255)
  - 10XXXXXX - Class B (128.0.0.0 - 191.255.255.255)
  - 110XXXXX - Class C (192.0.0.0 - 223.255.255.255)
  - 1110XXXX - Class D (224.0.0.0 - 239.255.255.255)

Classful Addressing (cont)

- What do these classes mean in terms of addressing?
  - Class A - 8-bits network, 24-bits host
  - Class B - 16-bits network, 16-bits host
  - Class C - 24-bits network, 8-bits host
  - Class D - Reserved for multicast



Classless Inter Domain Routing

- Classful addressing lacks flexibility, so a new system was created.
- This new system basically allows us to put the network/host boundary anywhere in the address we so choose
- Essentially, we can arbitrarily designate X-bits for network, and Y-bits for host

The network/host boundary

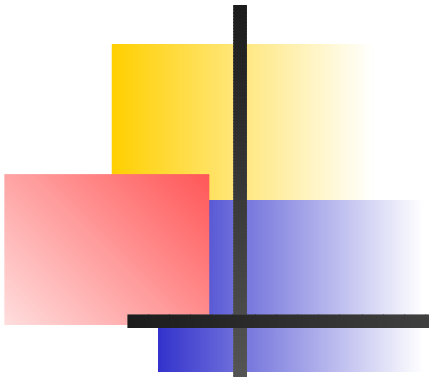
- When configuring an IP device, we need to tell it which part of the address is network, and which part is host.
- This piece of additional information is known as the netmask, and can be written in two common forms
- For example, take a class C network:
  - IP: 204.183.72.6, netmask: 255.255.255.0
  - 204.183.72.6/24

Special IP addresses

- Loopback - 127.0.0.1
- Network address - all host bits zero (204.183.72.0)
- Broadcast address - all host bits one (204.183.72.255)

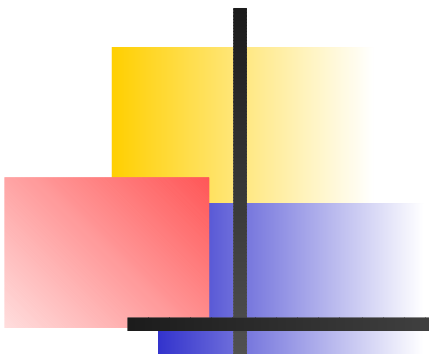
Special IP addresses (cont)

- Some ranges of IP addresses have been specially set aside for experimental or private usage, and are not routed on the Internet
- Some of these may seem familiar to you:
  - 10.0.0.0/8
  - 172.16.0.0/12
  - 192.168.0.0/16



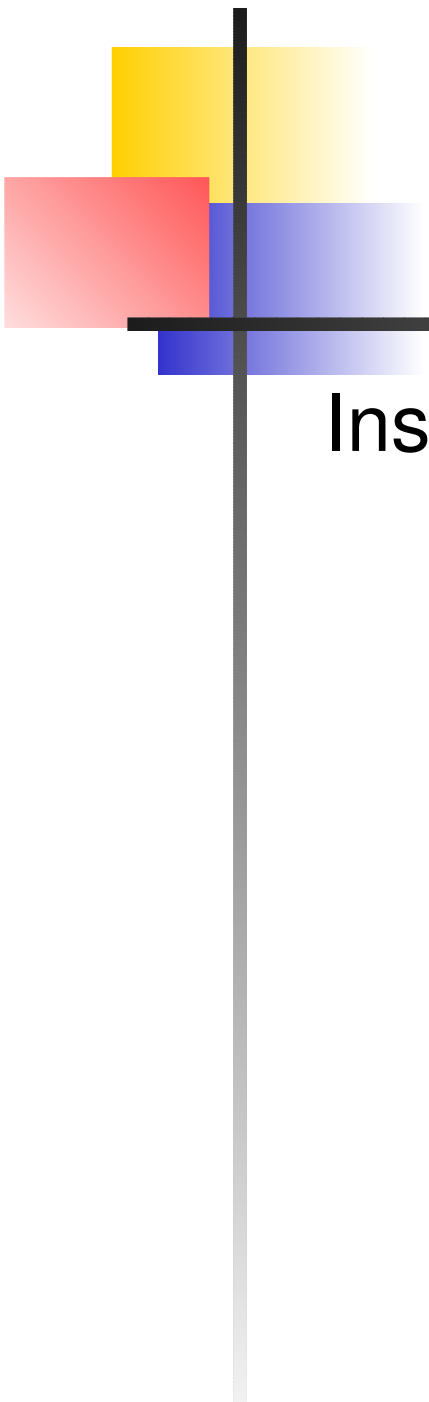
IP Routing

- Routing is the process by which a packet is sent from a host on one network to a host on another network
- To effectively route packets, a router must know the following:
  - Destination address
  - Neighbor routers from which it can learn about remote networks
  - Possible routes to all remote networks
  - The best route to each remote network
  - How to maintain and verify routing information



The host's perspective

- On your desktop, routing is fairly simple
- All you have to configure is the IP, netmask, and default gateway
- Using these, your operating system can determine if the host you are trying to talk to is on your network
  - If it is on your network, then you talk directly to it
  - If it isn't on your network, then you send the packet to the default gateway router, which knows how to get the packet to the remote host

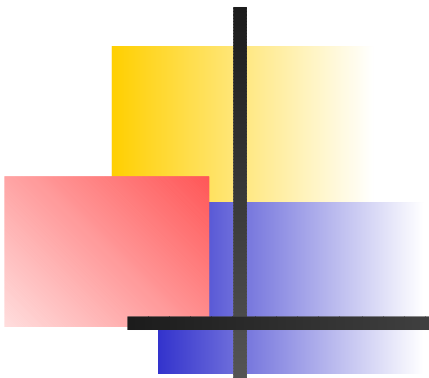


Simple example

Insert diagram of two hosts/networks and a router

Larger networks

- Most real internetworks are not this simple
- Usually there are many networks, and many routers between them
- Suddenly, the task of figuring out how to route IP packets isn't so simple anymore

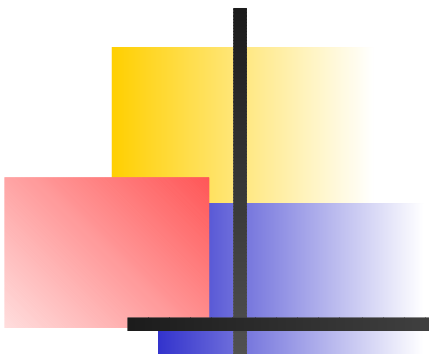


Realistic example

Insert diagram of lots of networks and routers to scare people

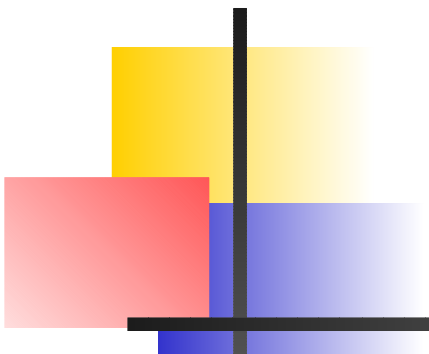
Types of IP Routing

- There are three basic types of routing:
  - Static routing
  - Default routing
  - Dynamic routing



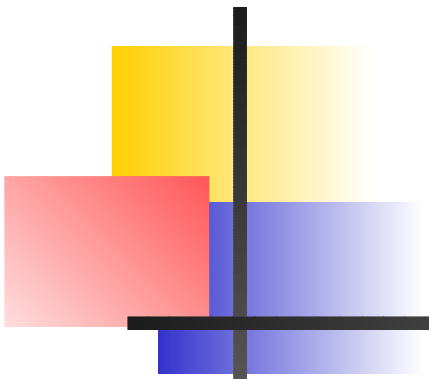
Static routing

- With static routing, you manually tell each router how to reach all of your networks
- It is simple and has little overhead.
- However, it does not scale to large networks very easily
- Just imagine how many routes you would have to configure each time you added a router to the internetwork



Default routing

- This is the simplest form of routing, and is what your desktop usually does
- Cisco calls the default route the “gateway of last resort”
- Essentially, it is a manually configured network route, that is used if the router doesn’t have any other routes that will get the packet to its destination



Dynamic routing

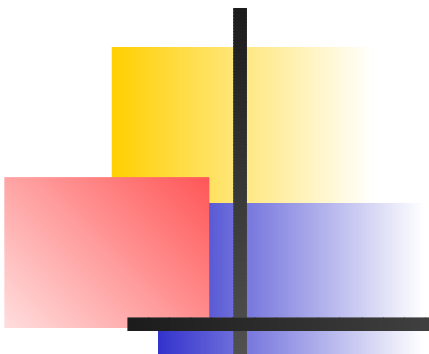
- This is the most complicated form of routing, and is what most real routers in large networks use
- With dynamic routing, the routers learn about the network through their neighbor routers, build an internal picture of this network, and compute all the necessary routes
- These routes are then placed in the router's routing table, which is used to route IP traffic
- There are several different protocols in use for dynamic routing.

Major types of protocols

- Interior Gateway Protocol
  - Exchanges information within an autonomous system
- Exterior Gateway Protocol
  - Exchanges information between autonomous systems
- An Autonomous System (AS) is a collection of networks under a common administrative domain

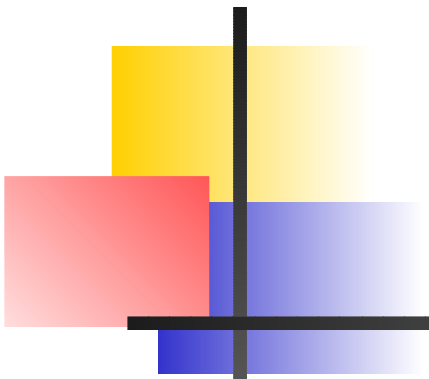
Classes of routing protocols

- Distance vector
  - Uses the distance to the remote network to find the best path
  - Each router a packet passes through is considered a “hop”
  - The best route is the one with the lowest “hop count”
- Link state
  - Typically called shortest path first
  - Routers keep track of directly attached neighbors, the topology of the entire network, and the routing table
  - Link-state routers know more about the internetwork than with any distance-vector protocol
- Hybrid
  - Uses aspects of both distance-vector and link-state



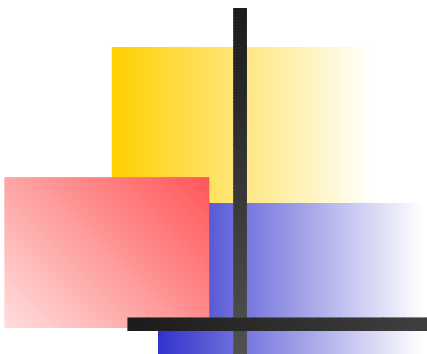
OSPF

- Open Shortest Path First, or OSPF, is a very popular and scalable interior gateway protocol
- It is also an example of a link-state protocol
- Routers use multicast packets to exchange information with each other
- The concept of a “designated router” (DR) and a “backup designated router” (BDR) is used to reduce update traffic and manage synchronization
- When initializing, an OSPF router goes through 7 states of operation



OSPF states

- Down - No information yet exchanged
- Init - Router sends “hello packets” to establish neighbor relationships. These packets tell about the router sending them, and also any other routers that it knows about
- Two-way - A router sees itself in a hello packet from another router
- ExStart - Routers negotiate master/slave relationships with the DR and BDR
- Exchange - Routers send each other link-state information
- Loading - Routers request more complete information to complete their knowledge of the network
- Full - Routers are fully operational



OSPF summary

- OSPF also handles link-state updates, so the routers can correct their picture of the network if a change should occur
- OSPF has a number of additional features that are important for large-scale networks, but are beyond the scope of this presentation

BGP

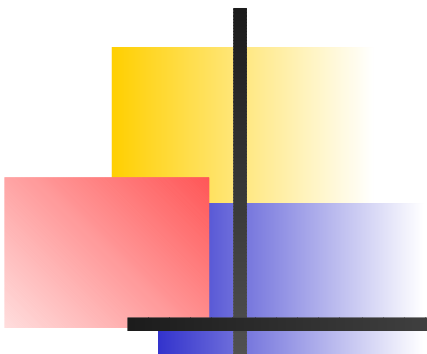
- The Border Gateway Protocol (BGP) is the primary Exterior Gateway Protocol in use on the Internet today
- The purpose of BGP is to route between autonomous systems
- For example, BGP is what Internet Service Providers (ISPs) use to exchange information with each other
- BGP is considered to be an advanced distance-vector routing protocol
- BGP uses TCP to exchange information between routers

BGP Features

- BGP has a number of interesting and important features
- It allows one to have connections with multiple ISPs (multihoming)
- It allows policy-based control over routing
- Basically, it is the routing protocol that the Internet is built upon
- A more detailed discussion of BGP is well beyond the scope of this presentation

Conclusion

- We have seen an overview of how IP works and is routed across networks
- Having a basic understanding of these concepts is very important, because many other concepts build upon them.



Questions?

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