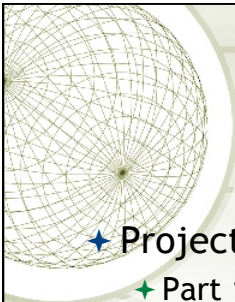




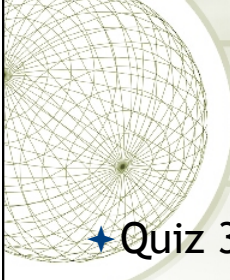
Routes & Routing

Info 341 Networking and Distributed Applications



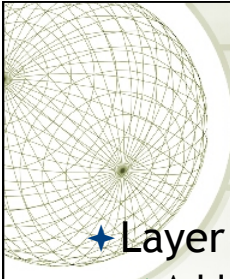
Project

- ✦ Project Parts - values
 - ✦ Part 1 8%
 - ✦ Part 2 12%
 - ✦ Part 3 15%
- ✦ Can build off your own solution, or instructor solution (with small cost)
- ✦ Project Resources link on syllabus



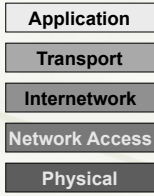
Memo

- ★ Quiz 3
 - ★ Thursday November 10, 2011
 - ★ This coming Thursday



Context

- ★ Layer 3
 - ★ Addresses, fragmentation, reassembly
- ★ Layer 4
 - ★ end-to-end communication
 - ★ UDP, TCP
- ★ Routing
 - ★ At layer 3
 - ★ Often relies on layer 4



Internet Reference Model

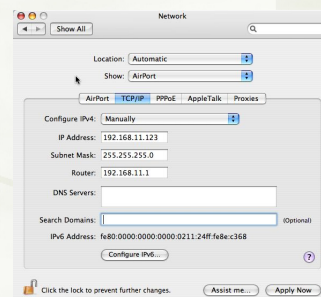
Two Types of Routes

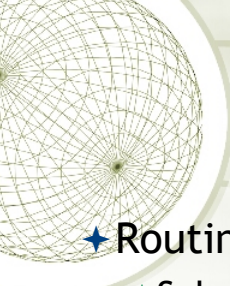
- ★ Static Routes
 - ✦ Set at boot, don't change

- ★ Dynamic Routes
 - ✦ Set at boot
 - ✦ Re-calculated as the network changes

Static Routing

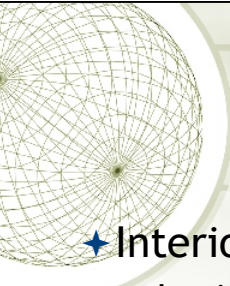
- ★ Most hosts (machines) use a static route
 - ✦ What does the netmask do?
 - ✦ What happens when the destination machine is not on the same network?





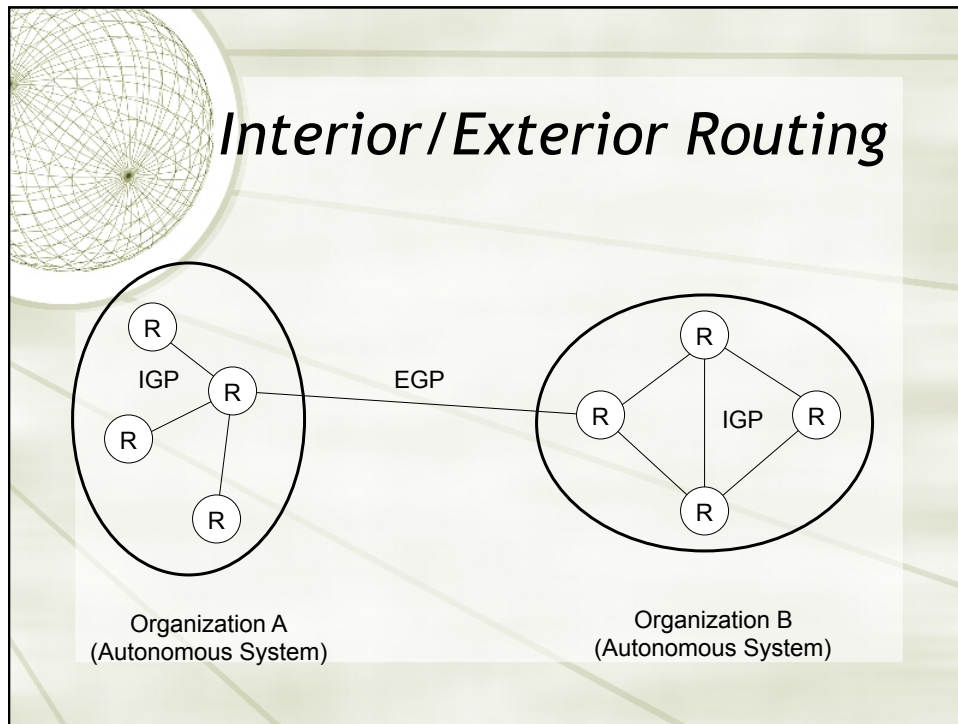
Dynamic Routes

- ★ Routing Protocols
 - ◆ Solve the routing problem by allowing routers to communicate with each other
 - ◆ They facilitate the discovery of additional routing connections



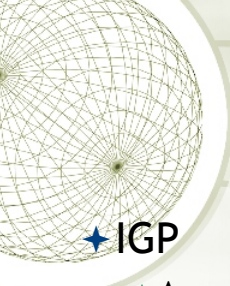
Two Routing Domains

- ★ Interior & Exterior Routing
 - ◆ Logically separate
 - ◆ Interior routing is for routes among routers that you control
 - ◆ IGP - Interior Gateway Protocols
 - ◆ Exterior routing is for the larger global networks
 - ◆ EGP - Exterior Gateway Protocols



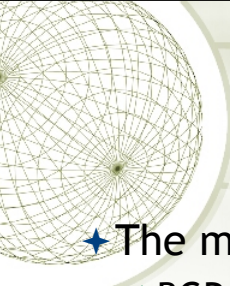
Routing Metrics

- ★ How can we get an “optimal” route?
 - ★ Routing Metric is the measure (weight) of a path used when choosing a route
 - ★ Hop count
 - ★ The number of hops to a destination
 - ★ Number of intermediate routers (hops) to get to the destination
 - ★ Administrative cost
 - ★ Manually set “weight” on the link
 - ★ Used to specifically control quantity of traffic over a link



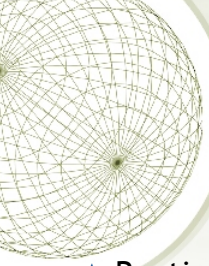
IGP/EGP Metrics

- ★ IGP
 - ★ An organization managing a set of machines (Autonomous System) is free to set their own metrics for route calculation
- ★ EGP
 - ★ EGPs rarely bother to use metrics, rather just looking for the existence of a path



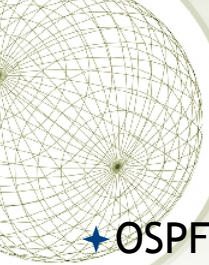
IGP/EGP

- ★ The most common EGP
 - ★ BGP (Border Gateway Protocol)
 - ★ Specifically between large systems
- ★ Common IGPs
 - ★ OSPF - Open Shortest Path First
 - ★ RIP - Routing Information Protocol



Border Gateway Protocol (BGP) Characteristics

- ✦ Routing among Autonomous Systems
- ✦ *Policy Enforcement* - either sender or receiver can enforce policy. A manager could set BGP to restrict route advertisements to limited other networks
- ✦ *Transit Routing* - BGP allows networks to specify if they will (or won't) pass traffic to other networks
- ✦ *Reliable Transport* - BGP uses TCP for communication of route information



OSPF

- ✦ OSPF is a standard
 - ✦ Open Shortest Path First
 - ✦ IETF (Internet Engineering Task Force)
 - ✦ RFCs (Request For Comment) 1131, 1247, 1583, 2328



OSPF Characteristics

- ★ *Full CIDR and Subnet Support* - OSPF supports 32 bit addresses and masks
- ★ *Authenticated Exchanges* - Routers can be set to authenticate to each other before exchanging route information
- ★ *Imported Routes* - OSPF can allow routes learned from other protocols
- ★ *Link-State algorithm*
- ★ *Admin assigned metrics*



OSPF Mechanics

- ★ **Hierarchical Assignment**
 - ★ Each router is assigned a level in a hierarchy
 - ★ The number of levels in an organization define the administrative area (responsibility) for each router
 - ★ There must be at least 2 levels in the hierarchy
 - ★ Logically this corresponds to the Internet (outside the organization) and LAN (inside the organization)
 - ★ Only routers at the same level in the hierarchy exchange data



OSPF Mechanics

★ Route Determination

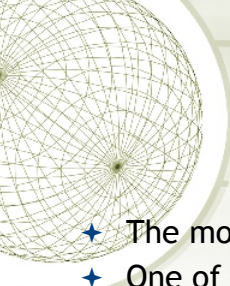
- ★ Routers at the same level in the hierarchy exchange Link-State Advertisements (LSAs)
 - ★ Sometimes you can see these in Wireshark!
- ★ The LSA indicates a link is 'live' - after some time without an LSA the link is assumed to be 'dead'
- ★ Routers use the LSAs to build a graph representation of the known 'networks'
- ★ The Shortest-Paths algorithm is used to determine the best route to a known location



Why use OSPF?

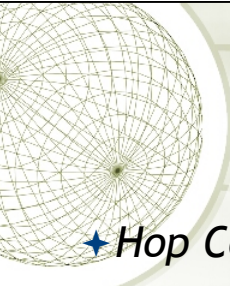
★ Hierarchical strategy

- ★ Good for scalability, can handle many routers in an organization
 - ★ Limits scope of LSAs
 - ★ High administrative overhead and complex to implement, only high end devices typically support OSPF
- ★ Because of the overhead, smaller organizations often pick RIP



RIP

- ★ The most simple Interior Gateway Protocol (IGP)
- ★ One of the first TCP/IP routing protocols
- ★ Originated in BSD Unix
 - ★ routed
- ★ Has become a standard over time
 - ★ two different versions, RIP1 and RIP2



RIP Characteristics

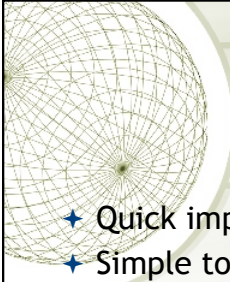
- ★ *Hop Count Metric* - distance in hops
- ★ *Unreliable delivery* through UDP
- ★ *Broadcast or Multicast* delivery
- ★ *Support for default route propagation*
- ★ *Passive route detection* - by listening to route information

RIP Mechanics

- ✦ Each RIP router periodically broadcasts its whole route table
 - ✦ Sometimes you can see these in Wireshark!
- ✦ When a RIP message is received, the router compares its internal table with the route table it received
- ✦ If the router that sent the RIP message knows a shorter path to a network, accounting for the cost of sending to that router, then the new route replaces the old route
- ✦ Any route longer than 16 hops on the network is considered unreachable

RIP Packet Format

0	8	16	24	31
COMMAND (1-5)		VERSION (2)		MUST BE ZERO
FAMILY OF NET 1		ROUTE TAG FOR NET 1		
IP ADDRESS OF NET 1				
SUBNET MASK FOR NET 1				
NEXT HOP FOR NET 1				
DISTANCE TO NET 1				
FAMILY OF NET 2		ROUTE TAG FOR NET 2		
IP ADDRESS OF NET 2				
SUBNET MASK FOR NET 2				
NEXT HOP FOR NET 2				
DISTANCE TO NET 2				
...				



Why use RIP?

- ✦ Quick implementation (just turn it on)
- ✦ Simple to run, but...
 - ✦ No security, broadcasts go to everyone
 - ✦ When you have a large number of routers running RIP, the RIP messages get to be large and it can use a lot of broadcast
 - ✦ RIP doesn't scale well due to limit of 16 hops
 - ✦ RIP doesn't support variable length subnet masks!
 - ✦ RIP can't calculate routes based on throughput, reliability, or delay - just number of hops