Finish Network Layer Start Transport Layer

CS158a

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Apr 25, 2007.

Outline

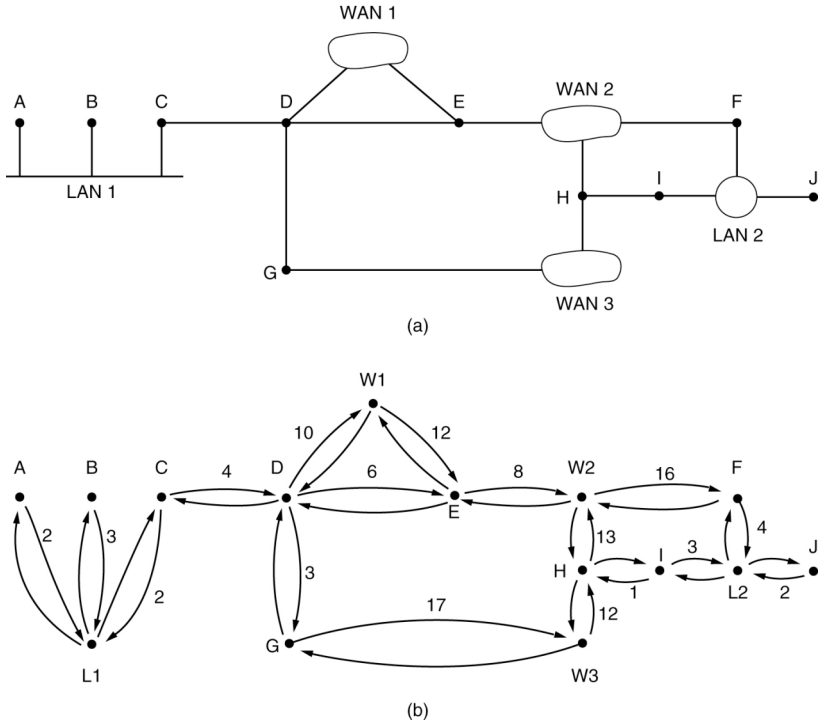
- OSPF
- BGP
- IPv6
- Transport Layer Services
- Sockets
- Example Socket Program

OSPF

- We now look at routing in the internet.
- Recall the internet is split into a larger number of Autonomous Systems (AS).
- A routing algorithm within an AS is called an **interior gateway protocol**.
- A routing algorithm between AS's is called an **exterior gateway protocol**.
- The original interior gateway protocol (RIP) was replaced by **OSPF** (**open shortest path first**) sometime in the early 1990s.
- IETF wanted this standard to be open (non-proprietary), support a variety of distance metrics, to be dynamic, to support load balancing, to support hierarchal systems, and to be moderately secure.

More on OSPF

- OSPF supports three kinds of connections and networks:
  1. Point-to-point lines between routers
  2. Multiaccess networks with broadcasting (like LANs)
  3. Multiaccess networks without broadcasting (most packet-switched WANs)
- Here **multiaccess** means that the network might have multiple routers on it.
- Here is an example graph of such a network (notice the second diagram is an abstraction of the first, where we have nodes for the network itself as well as nodes for each router on it, and where we have weighted the connections):



Still More on OSPF

- A router using OSPF essentially represents the network by such a graph and then computes the shortest path to each other router (done like link state).
- OSPF supports splitting AS's into numbered **areas**, which are contiguous and do not overlap.
- Outside an area its internal topology is not visible.
- Every AS has a backbone area, called area 0, and all other areas are connected to this backbone (possible by tunnels).
- A tunnel is represented by an arc and has a cost.
- Each router connected to two or more areas is part of the backbone.
- Within an area each router has the same link state database and runs the same shortest path.
- OSPF has three kinds of routes: intra-area, inter-area, and inter-AS.
  - Intrarea routes are essentially computed using only link state.
  - Interarea routes are all computed in three steps: compute source to backbone, backbone to destination area, destination area to final destination.

Even More on OSPF

- OSPF distinguishes four classes (allowed ot overlap) of routers:
  1. Intra-area routers
  2. Area Border Routers connect two or more areas
  3. Backbone Routers are on the backbone
  4. AS boundary routers that talk to routers in other AS's.
- When a router boots it sends HELLO on each of its point-to-point lines and multicasts them on LANs to the group of other routers on the LAN.
- OSPF works by exchanging information between adjacent routers.
- On each LAN one router is voted to be a **designated router**.
- Two routers are **adjacent** if they are on the same LAN and one is the designated router. Only adjacent routers exchange information.
- Periodically each router floods LINK STATE UPDATE messages to each of its adjacent routers.
- This has a sequence number to prevent it from propagating forever.
- These messages are also sent when a line goes up or down or changes cost.
- Other messages that are used are DATABASE DESCRIPTION, which gives the sequence number of all link state entries currently held by the sender. (Used when a line is brought up), LINK STATE REQUEST, and LINK STATE ACKNOWLEDGEMENT.

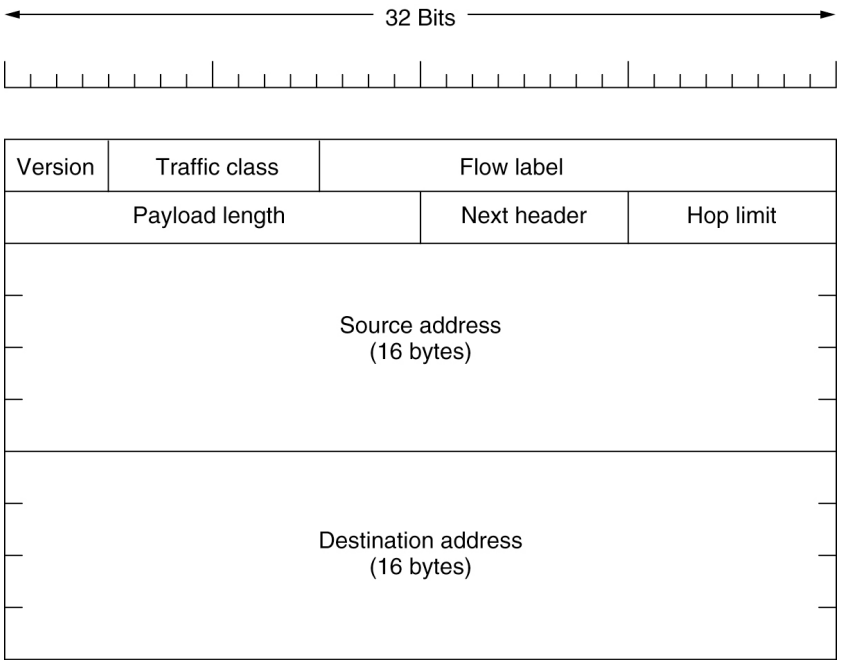
BGP

- Within an AS, the recommended routing protocol is OSPF.
- Between AS's, BGP is used (Border Gateway Protocol).
- Exterior Gateway Protocols have to be different because some countries have different laws concerning what can be sent in packets and through whom.
- To a BGP router the world consists of AS's and the line between them.
- Networks are grouped into three categories: **stub networks**, which only have one connection in the BGP graph; **multiconnected networks**, which have multiple connections; and transit networks which will be willing to handle third party packets, possible with restrictions and at some cost.
- BGP router communicate first by establish a TCP connection. It is uses essentially a distance vector protocol, where it also keeps track of the path used instead of just the outgoing line.
- This avoids the count to infinity problem as well as insuring security.

IPv6

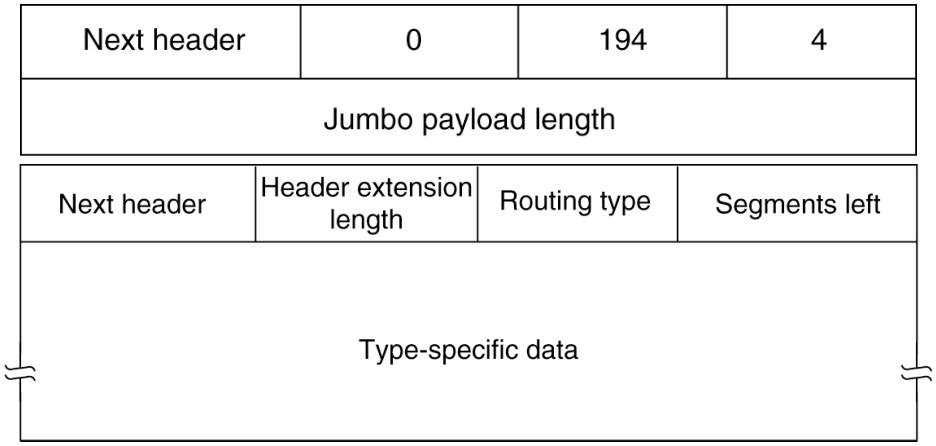
- In the mid-1990s it was realized that we are running out of IP addresses and that a more robust extension to IP then NAT or CIDR was needed.
- IPv6 was the decided upon solution.
- It has 16 byte addresses (a sequence of 8, 4-digit hex groups) and a simplified header (only 7 rather than 13 fields), it has greater support for options, and it had some features for quality of service.
- Unlike IPv4 the header now has a fixed length.
- It also supports 6 different kinds of extension headers.

Components of an IPv6 Header



Require Header Components

Extension header	Description
Hop-by-hop options	Miscellaneous information for routers
Destination options	Additional information for the destination
Routing	Loose list of routers to visit
Fragmentation	Management of datagram fragments
Authentication	Verification of the sender's identity
Encrypted security payload	Information about the encrypted contents



Extension Headers

Transport Layer Services

- The goal of the transport layer to to provide efficient, reliable, and cost effective service to the application layer,
- The hardware/software that does this work is called the **transport entity**.
- The transport, like the network layer, also supports connectionless and connection oriented service.
- At the network layer we make no guarantees that a packets arrives correctly or at all, this is done at the transport layer.
- As many application layer protocols make use of the transport layer, unlike the network layer, the transport layer must be convenient to use.

Service Primitives of the Transport Layer

- LISTEN
- CONNECT
- SEND
- RECEIVE
- DISCONNECT

Sockets

- I want over my solution to HW5 from my 2001, Pic20 class.
- This solutions contains a socket example.