Lecture 12:
Operating Systems and Networks
Behzad Bordbar
recap

- Processes communicating same machine: shared object and pipe
- Need network to communicate across machines
- Different type of network
- Modes of transmission (circuit switching and packet switching)
- Protocols: (well-known set of rules and formats to be used for communication between processes to perform a given task)
- OSI view [most layers interacting with layer below or above]
Content

- IP
- Datagram
- Routing protocol RIP1
- other IP protocols
- ping traceroute....
IP

- TP: transmission mechanism used by TCP and UDP
- uses other protocols ARP, RARP, ICMP ...
- Best effort delivery (post office in Romeo): Unreliable and connectionless protocol
- No error checking or tracking
- Datagrams can be lost for various reasons
- noise converting a 0 to 1
- Congested router might drop packages
- loop because of bad networking and datagram times out
- broken link
- IP must be paired with another protocol to become reliable
Datagram

- Packets in IP: two parts Header and data
  - Header (20-60 bytes)
    - Version (4 bits) IPv4
    - HLEN: Header Length (4 bits) (0…15 multiple of 4)
    - Service type (8 bits) (priority, throughput, delay)
    - Total length (16 bits) 65535 bytes
    - Time to live (8 bits) how many hops can go
    - Protocol (8 bits)
Datagram

- Header checksum (16 bits)
- Source IP address
- Destination IP address

Body

How can I see the packets?
At home... not here!!!!
tcpdump or wireshark (windump on windows)
observe mac addresses ...
Routing

- Necessary in non-broadcast networks (cf Internet)
- Next we look at a simple routing algorithm which IP is base on called Distance-vector algorithm
- each node stores table of state
- cost info of links,
- cost infinity for faulty links
- determines route taken by packet (the next hop)
- periodically updates the table and sends to neighbours
- Theoretical foundation [Bellman-Ford]

- Internet similar except
  - use default routes, plus multicast and authentication
  - better convergence
Routing example

**Routings from A**

<table>
<thead>
<tr>
<th>To</th>
<th>Link</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>local</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Routings from B**

<table>
<thead>
<tr>
<th>To</th>
<th>Link</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>local</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
# Routing tables

<table>
<thead>
<tr>
<th>Routings from A</th>
<th>Routings from B</th>
<th>Routings from C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To</strong></td>
<td><strong>Link</strong></td>
<td><strong>Cost</strong></td>
</tr>
<tr>
<td>A</td>
<td>local</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Routings from D</th>
<th>Routings from E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To</strong></td>
<td><strong>Link</strong></td>
</tr>
<tr>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
</tr>
<tr>
<td>D</td>
<td>local</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
</tr>
</tbody>
</table>
**RIP routing algorithm**

**Update**: Each 30 seconds or when local table changes, send update on each non-faulty outgoing link.

**Propagation**: When router X finds that router Y has a shorter and faster path to router Z, then it will update its local table to indicate this fact. Any faster path is quickly propagated to neighbouring routers through the *Update* process.

Shown to converge by mathematicians (Bertsekas). See next slide for details.


**RIP routing algorithm**

**Variables:** TL local table, TR table received.

**Send:** Each t seconds or when TL changes, send TL on each non-faulty outgoing link.

**Receive:** Whenever a routing table TR is received on link n:

- for all rows RR in TR {
  - if (RR.link != n) {
    - RR.cost = RR.cost + 1;
    - RR.link = n;
    - if (RR.destination is not in TL) add RR to TL;
    // add new destination to TL
  }
  else for all rows RL in TL {
    - if (RR.destination = RL.destination and
      (RR.cost < RL.cost or RL.link = n)) RL = RR;
    // RR.cost < RL.cost : remote node has better route
    // RL.link = n : remote node is more authoritative
    
  }
}
Sample routes

• Send from C to A:
  — to link 2, arrive at B
  — to link 1, arrive at A

• Send from C to A if B table modified to:
  — to link 5, arrive at E
  — to link 4, arrive at B
  — to link 1, arrive at A

• NB extra hop.

<table>
<thead>
<tr>
<th>Routings from C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To</strong></td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>default</td>
</tr>
</tbody>
</table>
other protocols that IP uses

- Address Resolution Protocol (ARP) associates an IP address with the physical address.
- What is the IP address of www.cs.bham.ac.uk?
- Host makes an arp packet broadcast to everybody... all ignore except the host that ip belongs to.
- `$arp www...`
- You can use tcpdump to see the arp packets.
- Reverse Address Resolution protocol (RARP) the other way.
other protocols that IP uses

- Internet Control Message Protocol (ICMP) mechanism to send (by host and routers) a notification about the datagram back to sender. ... similar to postcard by Julliet.

**Exercise:**

- Learn about IP addresses and Mask
- Ping
- Traceroute