COMP2011 -- **Networks**, Databases and Graphics

4. Sharing resources -- Packet Networks: Virtual Circuits & Datagrams

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Two ways of implementing pack-switched networks

- Virtual-circuits
    - Wide Area Networks (WANs)
- Datagrams
    - Local Area Networks
    - Internet

Virtual-circuits or Datagrams?

Two Questions:

1. Are bits always delivered in the same order in which they are sent?
2. Can we distinguish three phases in the life of a circuit, i.e. setting it up, using it and tearing it down?

- Answer “yes”
  - Virtual-circuits – a fixed route (or circuit) is established
    - Set up route and reserve resources
    - Use it
    - Tear it down
- Answer “no”
  - Datagrams -- each packet is an independent event

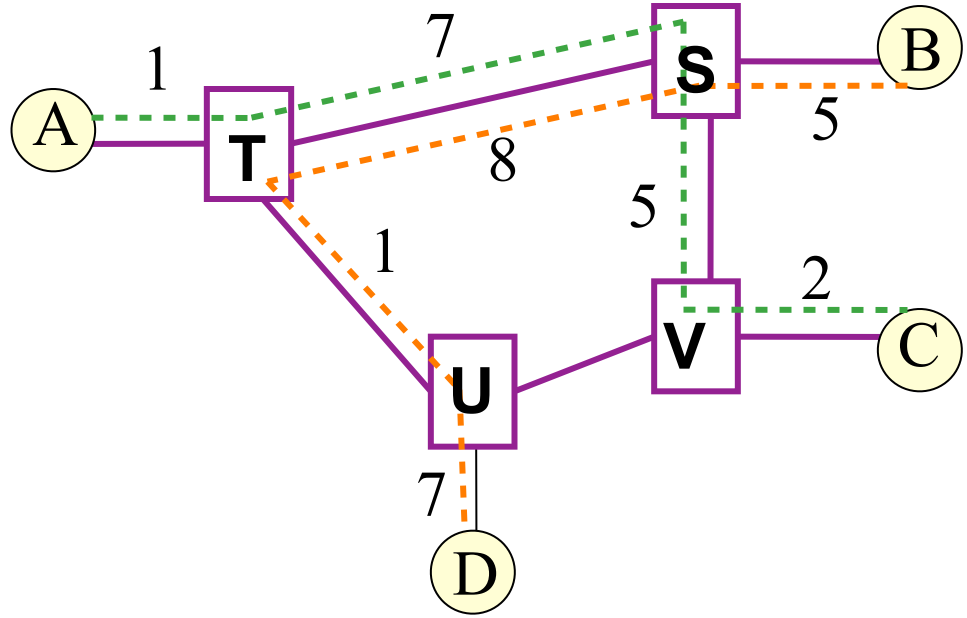
Virtual Circuits (VCs)

- Two things happen when a virtual circuit is set up in a packet-switched network (very similar to a circuit-switched network)
  - A route is chosen (through a selection of switches)
    - Route will not change during the life of the VC
    - Route selection is common to many technologies
  - Resources are reserved
    - Link capacity
    - Sufficient buffer space for queuing packets

VCs -- Addresses and Identifiers

- Each hosts must have a unique addresses
  - Like phone number
  - Needed when a connection is set up
    - Where a VC is set up to
  - Millions of hosts, millions of addresses
    - Long addresses (128 bits => ~10^{38} addresses)
- We can not use addresses to distinguish between VCs
  - There may be many VCs to a host.
  - Need to identify each VC!
- Solution: All VCs on any particular link have distinct VC Identifiers (VCIs)
  - Thousands of VCs per link, thousands of VCIs per link
    - Short VCIs (24 bits => ~10^7 VCs)
  - VCIs are also called Logical Channel Numbers (X.25), Data-Link Channel Identifiers (Frame Relay), Virtual Channel Numbers, Virtual Path Numbers (ATM) …

Virtual Circuits



- Example: the VC between B and D (orange line) has VCI 5 between B and S, VCI 8 between S and T and so on.
- Switches must keep a record of
  – the links being used by each VC
  – the VCIs being used on each link.

Source			Destination	
Link from	VCI		Link to	VCI
T	7	®	V	5
T	8	®	B	5
V	5	®	T	7
B	5	®	T	8

Forwarding table for switch S

Virtual Circuits – Advantages

- Small headers
  - Minimises packet overhead
- Efficient forwarding
  - Simple table look-up
- Easy to ensure sequenced delivery
  - All packets follow the same route
- Admission control
  - Host specifies requirements when asking for a connection
  - Network only accepts if it has resources
  - In contrast to the Internet: all traffic is accepted and everyone suffers when the network is overloaded.
- Traffic Policing
  - "Contract" for each VC
  - Can police on a per-VC basis

Virtual Circuits - Disadvantages

- VCI field in packet header must change at each switch
  - May need to re-calculate checksum
    - Extra bits for bit-error discovery
  - Processing overhead?
- VC set-up overhead
  - At least two PDUs to set up a VC (PDU: protocol data unit)
  - At least two PDUs to disconnect VC
  - Suppose you only want to send one Data PDU?

- Impossible to repair a VC if a link or a switch breaks.
  - Adjacent switches cannot repair (they do not retain end-point addresses
  - Hosts must request new VCs

Datagram

- A self-contained unit of transmission
- Global addresses
- Each datagram is routed independently
– Treated as a separate event
– Without reference to any other datagrams which many have preceded it.
– Rather as letters flow through the postal service

Datagram Networks

- LANs
  - Datagrams are usually be delivered to their final destination in one “hop”.
- Mesh-type networks, e.g. the Internet
  - Datagrams travel along several “hops”
  - Packet-switches are called routers or bridges
  - Switch processing: choose “next hop” on basis of destination address
  - At a switch the next hop for a particular destination may change with time and events in the network.
  - No circuit is set up. No concept of “setting up a route” or “reserving resources for a connection”.
  - Datagrams are not necessarily delivered in the same order in which they are sent.

Datagram forwarding

- Internet router (has a routing table)
  - Must know which link to use for each and every destination address
  - Looking up a routing table is complex
    - Routing table maybe huge
    - Search for every incoming datagram
    - Several entries may match

Example of a routing table

Address	Mask	Link
128.16.0.0	255.255.0.0	4
128.16.5.2	255.255.255.255	1
128.16.5.0	255.255.255.0	2
…	…	…

Datagrams – disadvantages

- Heavy processing in switches
  - Fortunately clever look-up algorithms exist
- Global addresses are big – large per-packet overhead
- Admission control and policing must be per-host, not per-connection
  - Fortunately, addressed by Internet Quality-of-Service (QoS) techniques
- Independent routing cannot guarantee sequenced delivery
  - Mark datagrams with sequence numbers and re-order them when received.

Datagrams - advantages

- Datagram networks often use "dynamic routing"
  - Routing table continually updated by information from other switches
  - New routes are learnt when switches break or become congested
  - No need for end-points to act to recover the situation.
  - Robust!
- No connection set-up overhead
  - Good for short transactions
- Datagram service is very simple
  - Cheap to implement
  - No unwanted "features"

Summary

- Sharing links
  - Circuit-switching
    - Fixed allocations
    - FDM, TDM
  - Statistical multiplexing
    - packet-switching
- Sharing networks
  - Circuit-switching network
  - Packet-switching network
    - Global address
    1. Virtual Circuits
    2. Datagrams