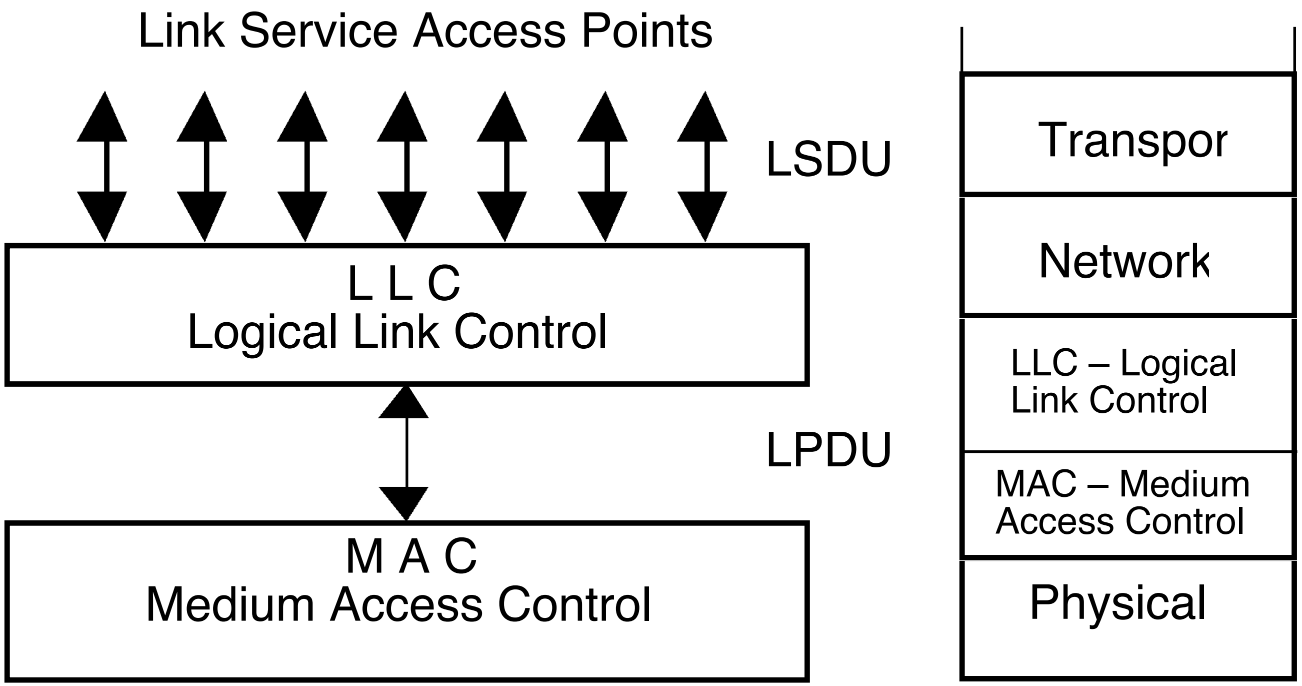
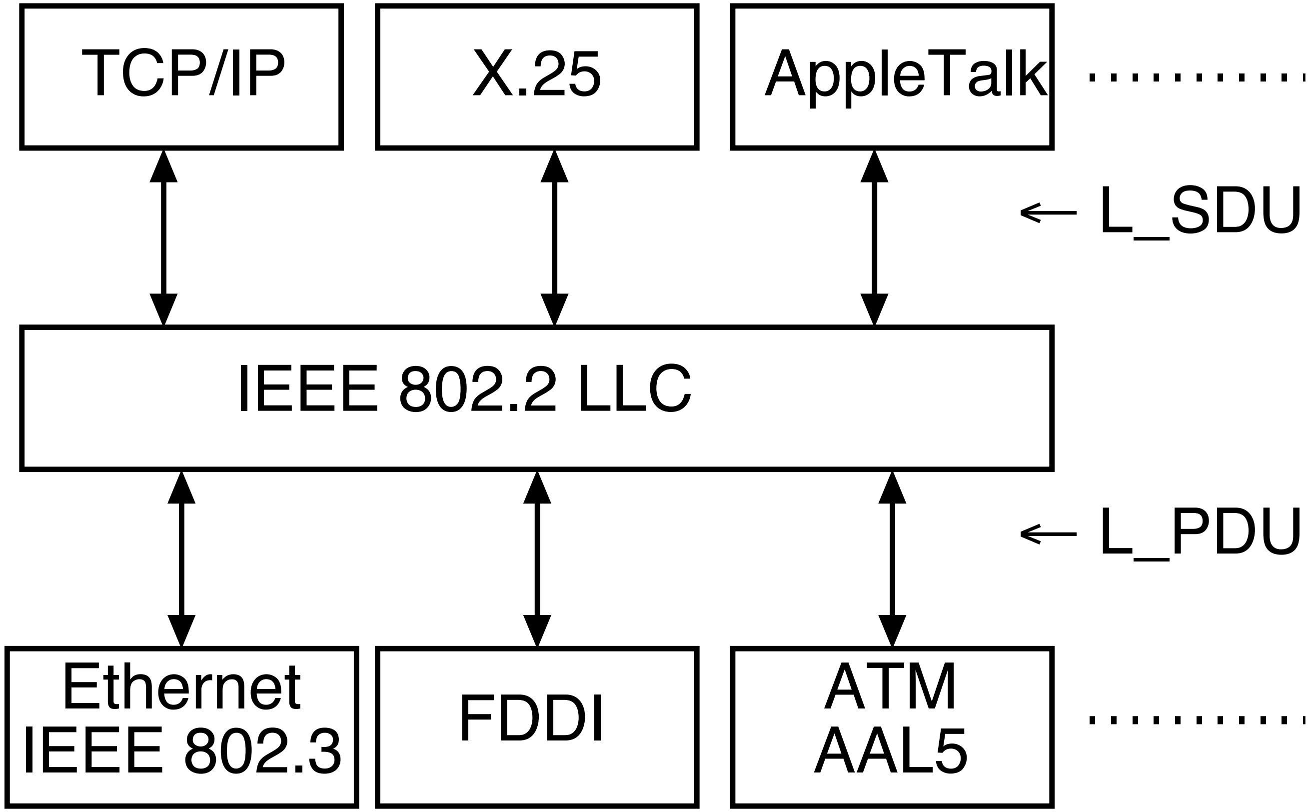
IEEE 802.2 – Logical Link Control

- The upper part of the DataLink layer for the 802.*x* networks provides a common interface to the Network Layer from the different media.
- It accepts *Link Service Data Units* from the Network Layer and delivers *Link Protocol Data Units* to the MAC layer
- Several *Link Service Access Points* are multiplexed on to the basic service and effectively define sub-addresses for the node.



An actual LLC layer might have several systems above it and several physical protocols below it

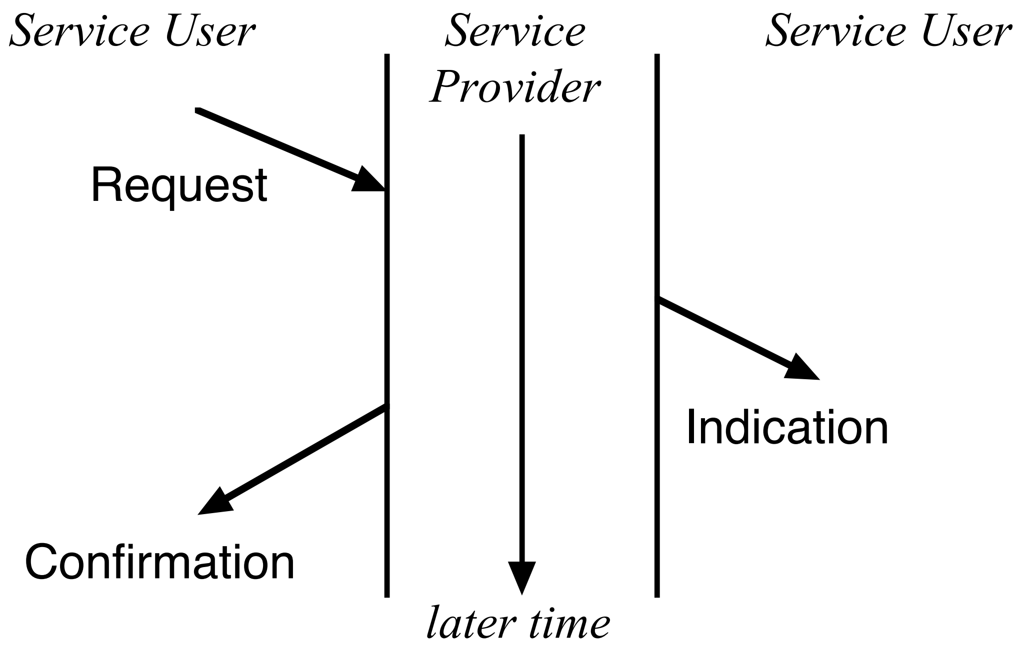


Protocol diagrams

The 802.2 LLC protocols use three message types —

- A **Request** is passed down to request a service
- The Request appears at the "peer" service user as an **Indication**
- A **confirmation** is returned to the requester.

Other protocols may use more message types



Logical Link Control Services

The most important is the unacknowledged connectionless service, with the two primitives —

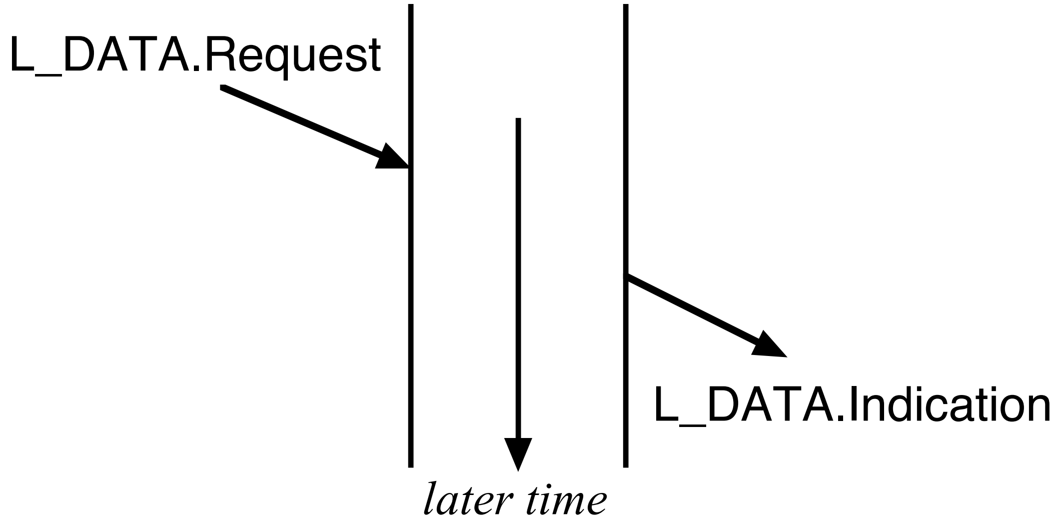
$$\left.\begin{array}{r}\text{L\_DATA.request}\\ \text{L\_DATA.indication}\end{array}\right\}$$

with basic functions

```
L_DATA.request(local_address,
                remote_address,
                l_sdu,
                service_class)
L_DATA.indication(local_address,
                remote_address,
                l_sdu,
                service_class)
```

The LLC layer is called with a request to pass "`l_sdu`" (user data) from "`local_address`" to "`remote_address`", or to receive `l_sdu` from a remote address.
There is no acknowledgement; the `l_sdu` is just sent and appears.

The protocol diagram is trivial —



- The address parameters at least combine the MAC address field and the LLC address field (SSAP or DSAP – Source Service Access Point and Destination Service Access Point).
- The remote_address for the `L_DATA.request` may be a broadcast address.
- The `L_DATA.indication` returns the identical LSDU as was provided to the matching `L_DATA.request`.

MAC Service Data Units

The Logical Link Control Layer supplies `m_sdu` (MAC service data units) for transmission by the MAC layer. The format of the `m_sdu` is given later, but uses the primitives –

```
MA_DATA.request(destination_address,
                m_sdu,
                requested_service_class)
```

and the corresponding –

```
MA_DATA.indication(
                destination_address,
                source_address,
                m_sdu,
                reception_status,
                requested_service_class)
```

Link Protocol Data Units.

- The LLC layer receives information (the LLC SDU) through one of its “Service Access Points” (SAPs), and delivers it to its MAC layer, or vice versa.
- The information transferred through the network must specify the “Source Service Access Point” (SSAP) and “Destination Service Point” (DSAP); held in the LLC header prefixed to the SDU.

For simple traffic the LLC header has the form

DSAP address	SSAP address	Control	Information
8 bits	8 bits	8 bits	8*M bits

- The Service Access Points are given “well known” addresses for the usual cases, and the Control byte is value 0x03 for connectionless data. For data transfer the “Information” field is the LLC SDU data.
- For routed ISO protocols the LLC Header value (in hexadecimal) is 0xFE-FE-03.

- Protocols such as IP have a further level of encapsulation.
- The LLC Header, with address 0xAA, is followed by a "SubNetwork Attachment Point (SNAP) Header".
- The 5-byte SNAP Header has a 3 byte (24 bit) code giving an "administering authority" and 16 bits for protocol (00-80 for IP).
- The full prefix is then

```
0x AA-AA-03             LLC Header
0x 00-00-00 08-00       SNAP Header
```

- When transferring AppleTalk the SNAP header value is
  `0x 08-00-07 80-9B`.
- In total, an 8-byte header is added to the user message (LLC_SDU) in forming the LLC_PDU submitted to the MAC layer.
- *Often use Ethernet conventions, rather than IEEE 802.3. The 802.3* length *field becomes a* protocol type *field, set to denote the traffic type.*
- The LSB (leftmost) address bit is 0 for unique addresses and 1 for group addresses. 00000000 is a null address and 11111111 is a broadcast address, usually intended for all destination SAPs.

Interconnection of LANs

- Repeaters work at the Physical Level and recognise the coding of bits on to the Physical medium.
  All traffic on each side is repeated to the other side.
  Ethernet or IEEE 802.3 will recognise collisions and force jams.
  Limit, say 5, to number of repeaters in any path node-to-node.
- Bridges work at the DataLink level and recognise frame formats.
  Some bridges selectively forward frames (eg spanning tree)
  Some may work between formats (eg Ethernet and Token Ring)
- Routers work at network level and recognise protocols and traffic types eg TCP/IP, Appletalk
  Selectively forward (or block) transmission depending on protocol
- Gateways at Transport level can convert between protocols.
- The more general term "switch" is often used now for devices that combine functions from several levels.

Problems of Bridging or Connecting LANs

The problems include —

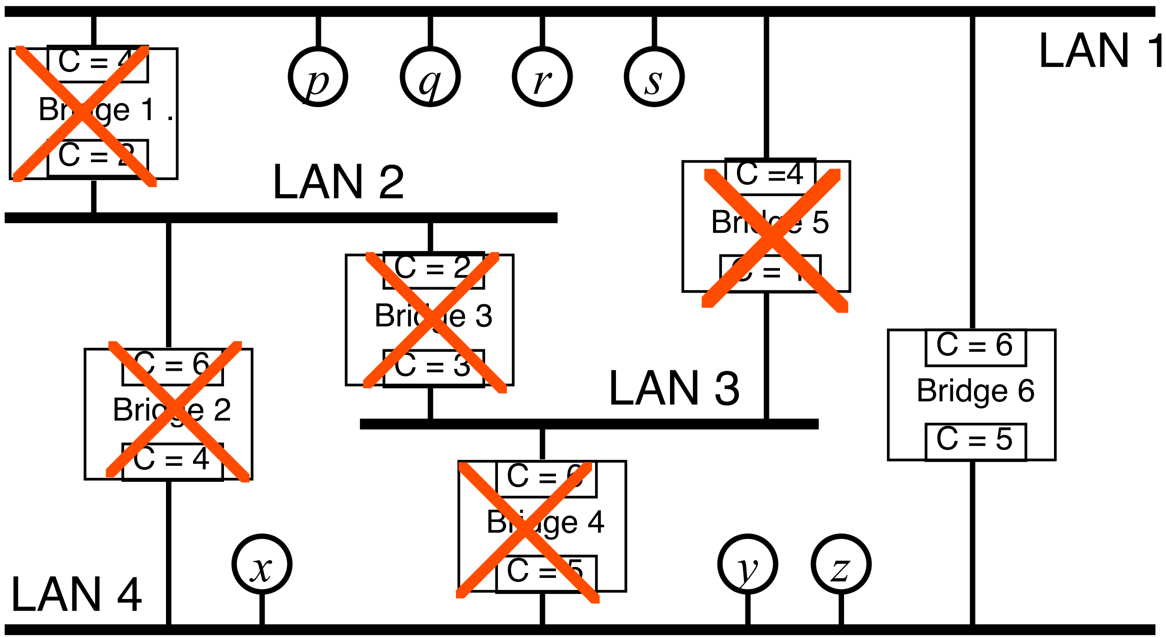
- Different data rates –
  Ethernet 10, 100 or 1000 Mb/s, Token Ring 4 or 16 Mb/s, FDDI 100 Mb/s
- Different Frame sizes
  Ethernet 1500 octets, Token Ring (< 10 ms, say 5000 octet), Token Bus 8000 octet
  Bridges cannot reliably fragment and reassemble frames
- Ethernet cannot handle "address recognised", priorities or ring maintenance

Bridges — forwarding and address learning

- A bridge builds a routing table of addresses which are visible from each port
- A message is not forwarded to a port which cannot see the destination (ie forward only broadcast messages, messages to that station or messages to a station which has not transmitted.

BUT simple selective forwarding can give loops where LANs have multiple paths. Solve this problem by building a spanning tree.

Also usually forget connections which have not seen traffic for say 20 minutes.



source → *dest*	*message is on LAN(s)*	*information learned by "Bridge 6"*
$p \rightarrow r$	1, 4	P is on LAN 1
$x \rightarrow q$	1, 4	X is on LAN 4
$r \rightarrow s$	1, 4	R is on LAN 1
$r \rightarrow p$	1	nothing
$x \rightarrow p$	1, 4	nothing
$z \rightarrow x$	4	Z is on LAN 4

Spanning Tree algorithm

- Each bridge has a unique identifier — MAC address & priority
- All bridges on the LAN share a group address "all stations on this LAN"
- Within each bridge, each port has a unique "port identifier"
- Each port has a cost of transmitting through that port to its LAN
- All bridges exchange Bridge Protocol Data Units (BPDUs) containing costs to reach other bridges and LANs

Spanning Tree algorithm 2

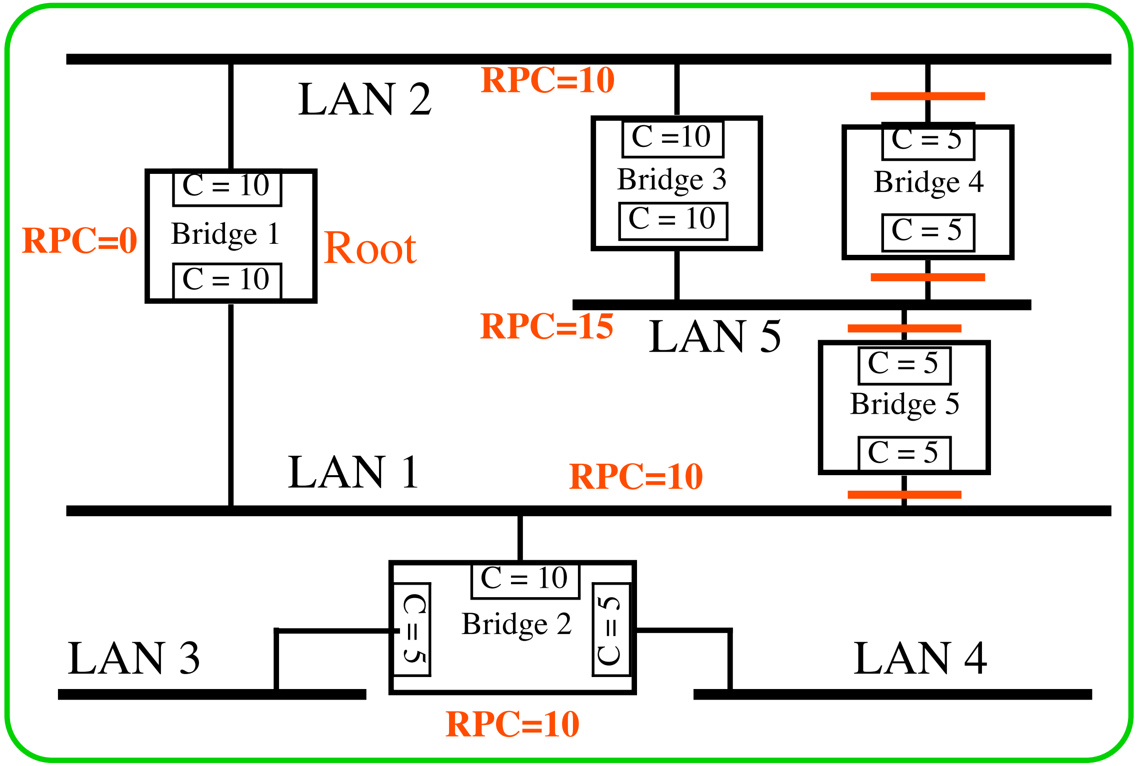
1. Bridges exchange Bridge Protocol Data Units (BPDUs); if any sees one with *lower* bridge ID it drops out of contention for becoming the root bridge.

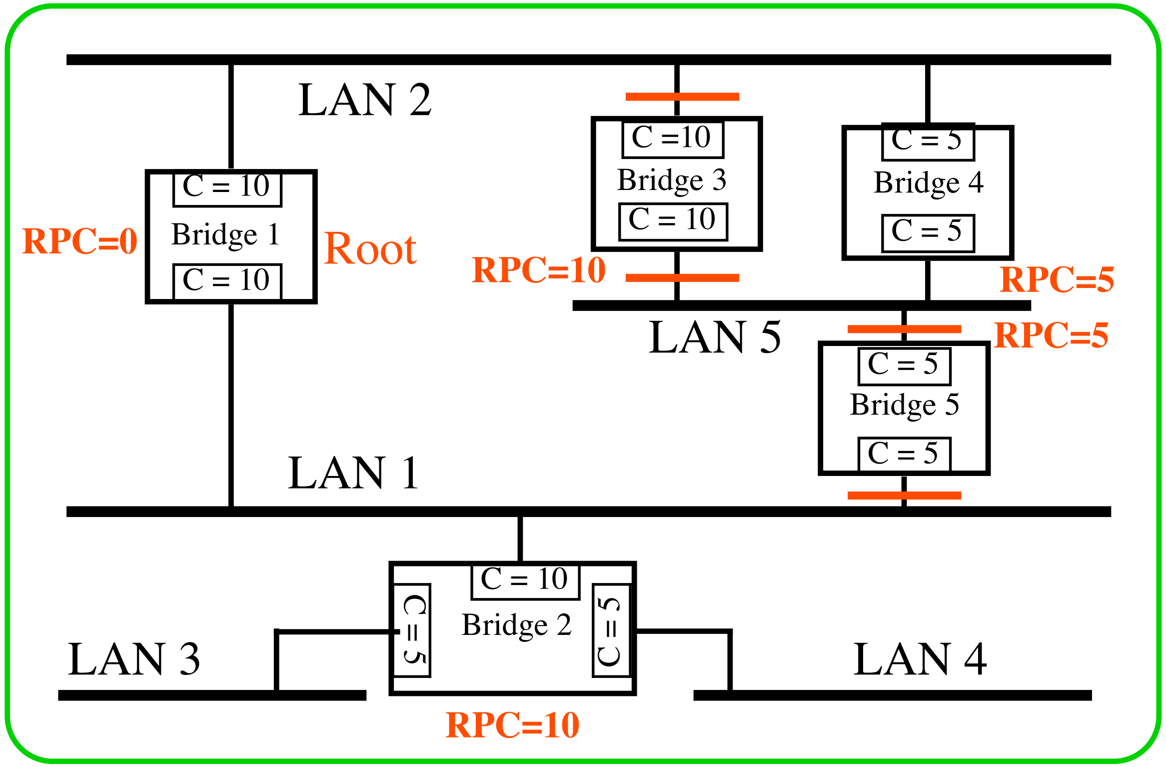
2. The bridge which finds it has the lowest BridgeID becomes the *root bridge*

3. The root bridge sends BPDUs to all other stations (LAN broadcast) which accumulate *root path costs* (to the root) as they traverse the LAN.
   Only the *receiving* port contributes to the Root Path Cost.
   Although BPDUs travel outwards from the Root, they accumulate costs from the bridge to the root, *not* from root to bridge.

4. For each LAN, the bridge port with minimum root path cost becomes the *designated port* for this LAN; its bridge becomes the *designated bridge* for the LAN.

5. The designated bridge and port are the only ones to provide communication between the LAN and the root bridge.
All other ports which directly see the root bridge are disabled.
With multiple paths, prefer (i) the highest priority bridge and then (ii) the lowest port identifier.





1. Bridge 1 has lowest Bridge ID and becomes the root bridge
2. LANs 1 & 2 are connected directly to the root bridge
3. From LAN5, Bridge 3 gives RPC = 10, while Bridges 4 & 5 give RPC = 5. Bridge 3 drops out because of cost, and Bridge 5 drops ouit because of higher bridge ID.

Virtual LANs (VLANs)

This material has been moved to the end of the next handout, after the discussion of the main LAN types.