PART IV: Internetworking of ATM, LANs, and the Internet

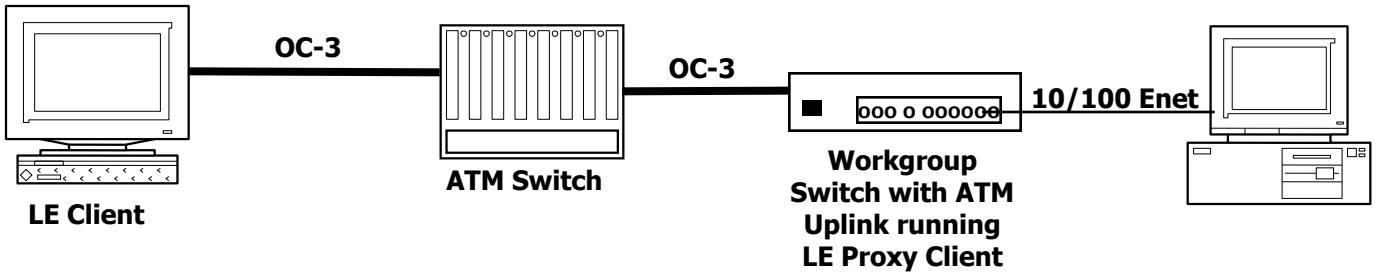
LAN Emulation Over ATM Version 1.0

LAN Emulation Objectives

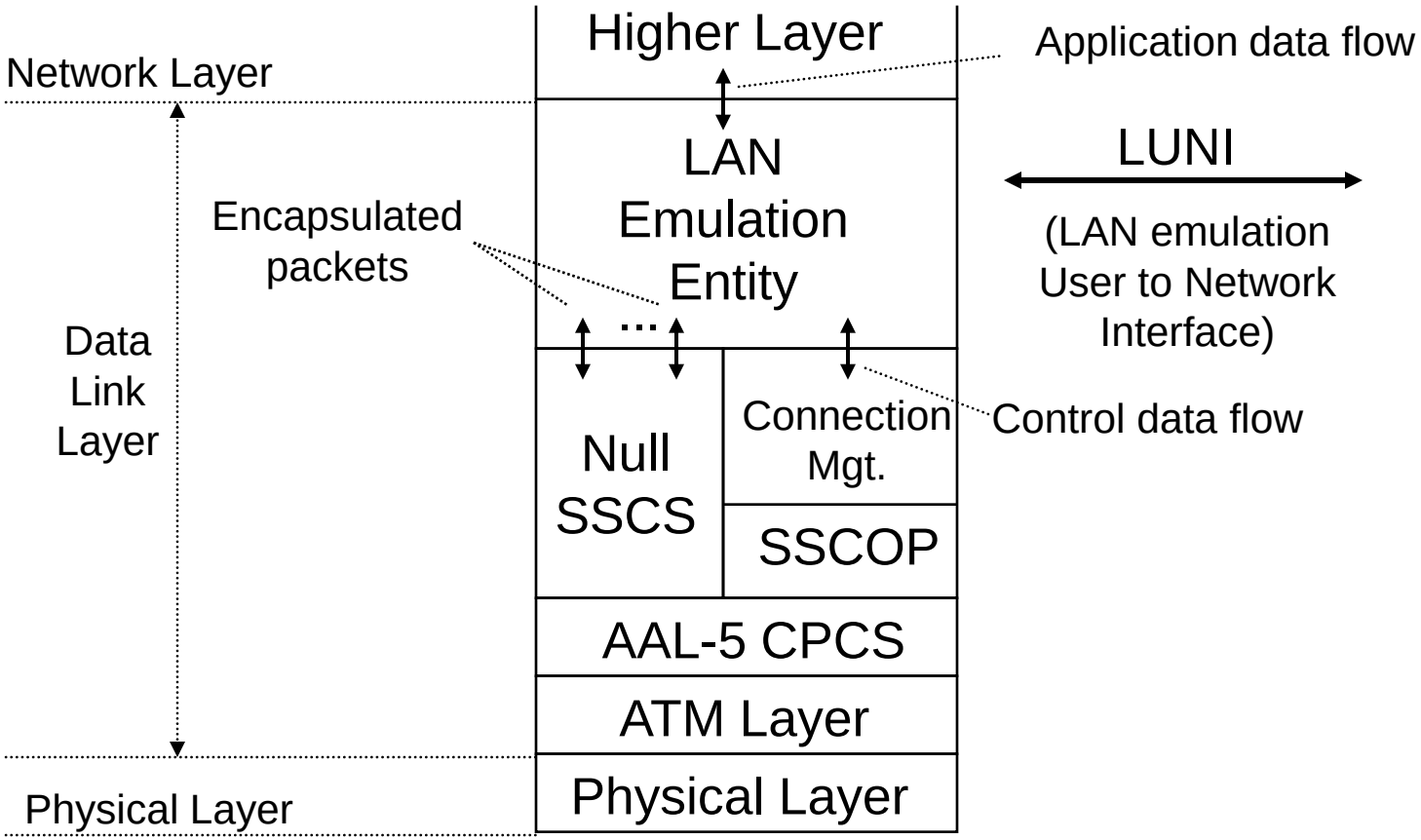
- "Simulate" the LAN MAC service, providing the following services:
  - Connectionless data transfer;
  - Multicast and broadcast;
  - Same MAC driver interface to software applications;
  - Address resolution: map the "topology-independent" LAN MAC address into the "topology-dependent" ATM address.
- Since the MAC driver interface is the same as in LANs, traditional software applications run unmodified over LANE.
- Emulates Ethernet and Token Ring.

LANE Characteristics

- The ATM "cloud" emulates a network at layer 2.
- Multiple emulated networks may coexist in the same ATM network.
- A client node may belong to multiple emulated networks.
- Support for bridging between ATM and traditional networks:



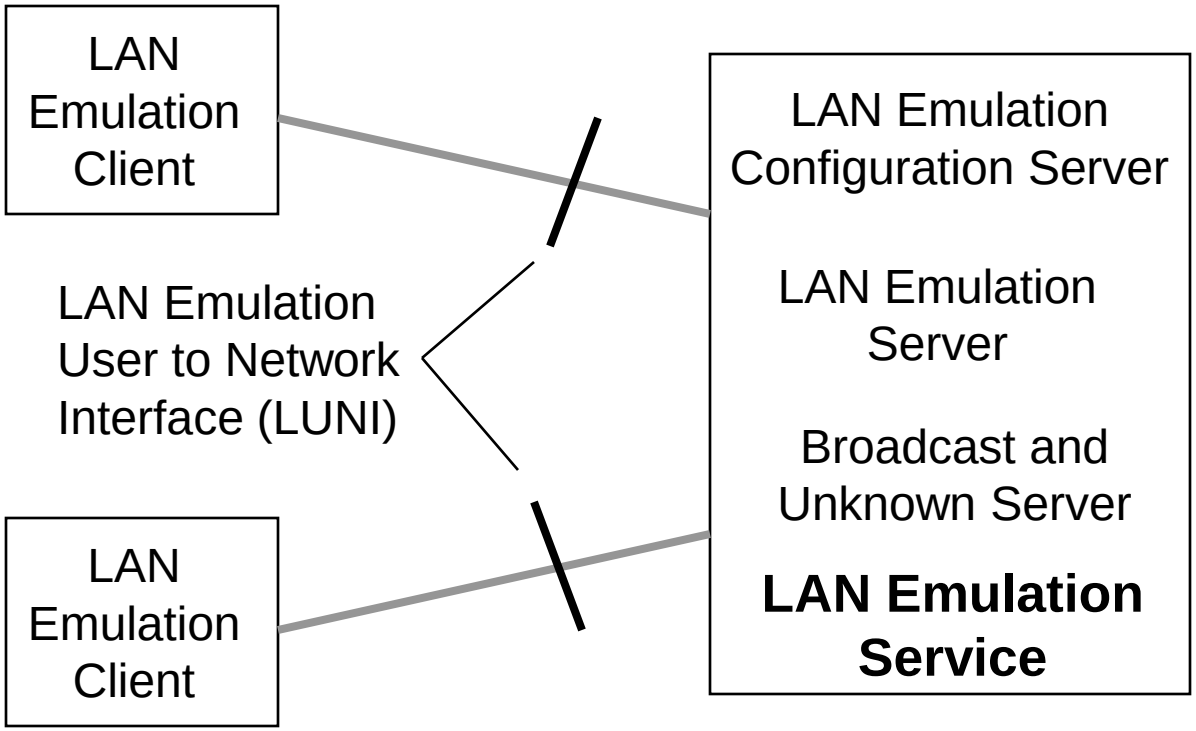
Architecture



LAN Emulation Servers

- LAN Emulation uses servers to implement the initial configuration, address resolution, broadcast and multicast functions:
  - **LAN Emulation Server (LES)**
    - Control of the emulated LAN.
    - Responsible for address resolution.
  - **LAN Emulation Configuration Server (LECS)**
    - Assigns clients to individual emulated LAN services.
    - Gives LES address to the client.
  - **Broadcast and Unknown Server (BUS)**
    - Responsible for relaying broadcast and multicast frames.
    - Responsible for relaying frames addressed to unknown destinations.

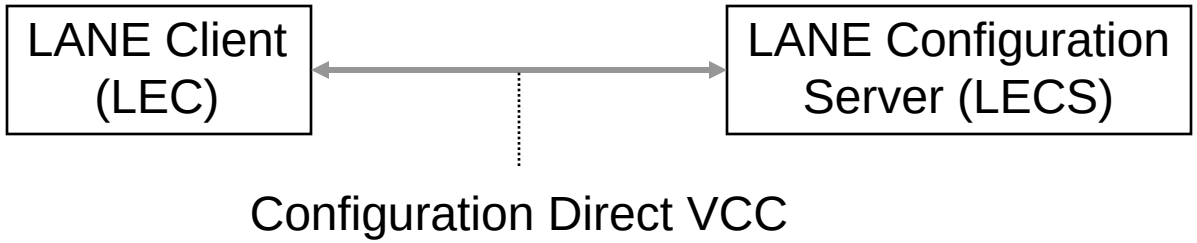
LAN Emulation Servers (cont.)



Data and Control Connections

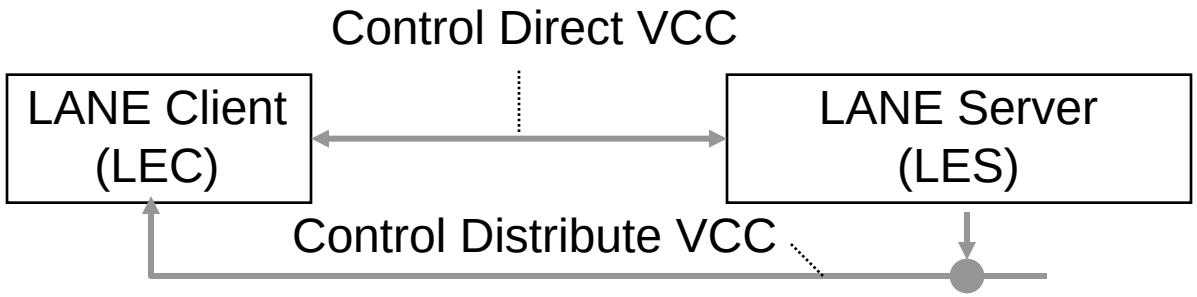
- Each LAN Emulation Client (LEC) maintains multiple virtual circuits for data and control transfer.
- These virtual circuits can be either dynamically created by signaling (SVCs) or statically configured (PVCs).
  - Commercial equipment nowadays do not support LANE on PVCs.
- Connections to the servers are typically long-lived (stay on as long as the client is in the LAN).
- Client-to-client data connections may be terminated if they stay idle for too long.

LEC - LECS Control Connection



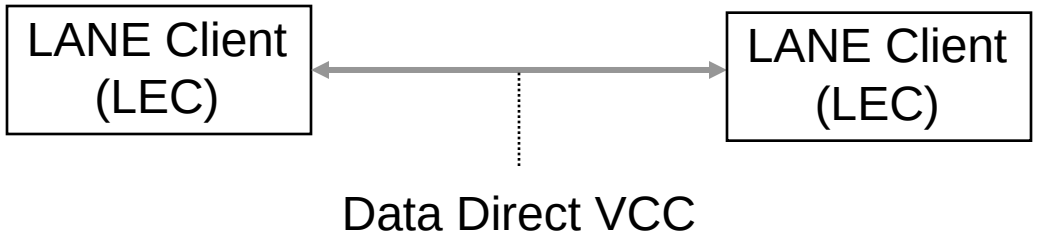
- The **Configuration Direct VCC** is created by the LEC when it first joins the ELAN.
- It is used to communicate configuration information from the LECS to the LEC.
- It can be left open after the configuration phase, or dropped.

LEC - LES Control Connections



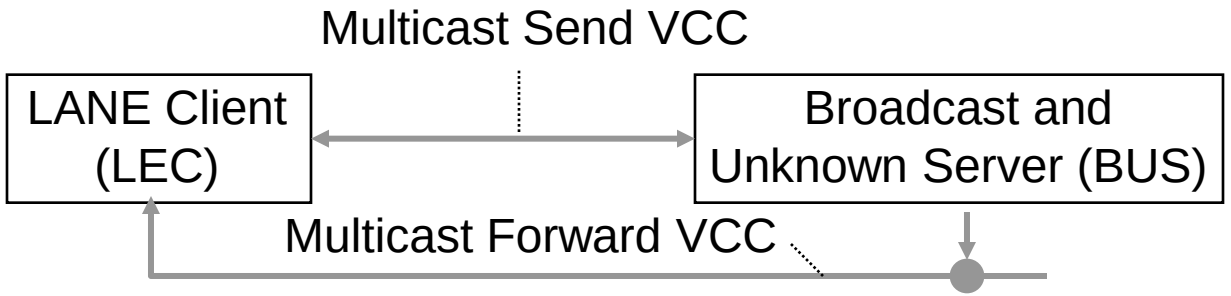
- The LEC creates the **Control Direct VCC** to send control traffic to the LES.
- The LES may use the Control Direct VCC to send back control data to the LEC, or it may setup a **Control Distribute VCC** for that.
- The Control Distribute VCC may be point-to-point or point-to-multipoint.
- Both VCCs must remain open as long as the LEC is participating in the ELAN.

LEC - LEC Data Connection



- A LEC who has data to send to another LEC does so by establishing a **Data Direct VCC** to that LEC (after it finds out that LEC's address).
- The Data Direct VCC is bidirectional (e.g., it can be used to transfer data on either direction).
- Data Direct VCCs may be dropped after a certain period of inactivity (typically 20 minutes).
- Data Direct VCCs may be dropped if the LEC runs out of resources.

LEC - BUS Data Connection



- The **Multicast Send VCC** is created by the LEC and is used by the LEC to send multicast/broadcast packets to the BUS to be forwarded.
- The BUS may use the Multicast Send VCC to send data back to the LEC.
- The BUS will establish a **Multicast Forward VCC** to send data back to the LEC. This may be a point-to-point or point-to-multipoint VCC.
- Both VCCs must be maintained as long as the LEC is in the ELAN.

Client Initialization Sequence

- **Initial State:**
  - The client knows a number of parameters "a priory": ELAN name, type, frame size.
- **LECS Connect Phase:**
  - The client establishes the Configuration Direct VCC to the LECS.
  - The LECS is "discovered" through one of the following:
    - Ask the UNI (using ILMI).
    - Use a well-known LECS address (47.00.79.00.00.00.00.00.00.00.00.00-00.A0.3E.00.00.01-00)
    - Use the LECS well-known PVC (VPI=0, VCI=17).

Client Initialization Sequence (cont.)

- **Configuration Phase:**
  - The LECS tells the client the address of the LES it should use.
- **Join Phase:**
  - The client establishes the Control Direct VCC with the LES.
  - The LES gives the client a 16-bit LE Client Identifier (LECID).
  - The client registers a single MAC address with the LES.
- **Initial Registration:**
  - The client is allowed to register any number of additional MAC addresses (for proxy, for example).
  - Note that bridges do not register addresses behind them; they ask the BUS to forward all unknown frames.

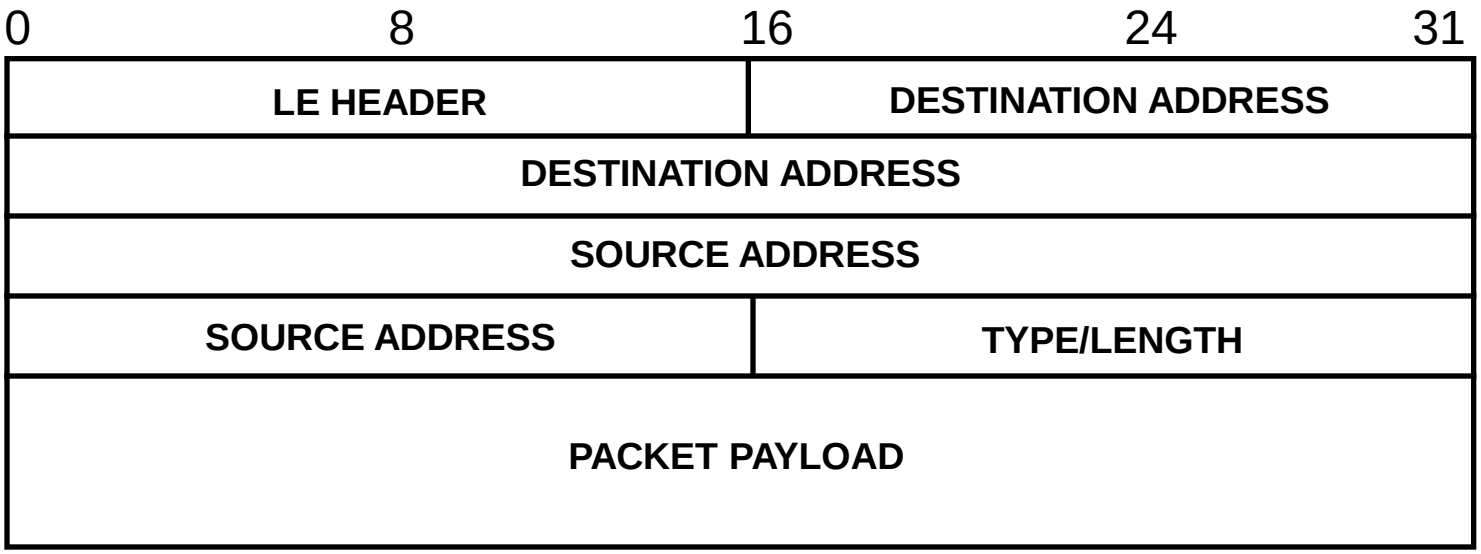
Completing the Client Registration

- **Connecting to the BUS:**
  - The client uses the standard address resolution service of the LES to resolve the broadcast address (FF-FF-FF-FF-FF-FF).
  - The LES provides the client with the ATM address of the BUS.
  - The client establishes the Multicast Send VCC.
  - The BUS establishes the Multicast Forward VCC.
- **Operational:**
  - The client is ready to take part in the ELAN.

ATM Address Resolution

- Issue: translating between MAC addresses and ATM addresses (required to establish connections).
- Service is provided by the LES.
- When a client wants to send a frame to a MAC address, it:
  - Sends a LE_ARP request for that MAC address to the LES on the Control Direct VCC.
  - The LES may consult its internal database and respond with a LE_ARP reply over the Control Direct VCC or the Control Distribute VCC; ***or***
  - The LES may forward the LE_ARP request to the appropriate client, receive the reply, and forward it to the original requestor.
- Clients can also look at the source MAC address of frames received on data VCCs, and add that to their caches.

LANE Data Frame Format (Ethernet)



- The LE Header is either 0000 or the LECID of the sending client.
- The packet payload must not include the FCS field.

Issue: the Type/Length Field

- In standard Ethernet, if Type/Len ≤ 1536, then it is Len; if it is more, then it is Type
  - The maximum size of an Ethernet packet is 1514 bytes.
- In ATM, the maximum size depends on the ELAN, but the following values are legal: 1516, 4544, 9234 and 18190.
  - Possibility of confusion!
- Solution for LLC frames that use Len:
  - If the packet length is less than 1536, use it normally.
  - If the packet length is more than 1536, use zero for Type/Len, and derive the packet size from the AAL-5 header.

Issue: Packet Ordering

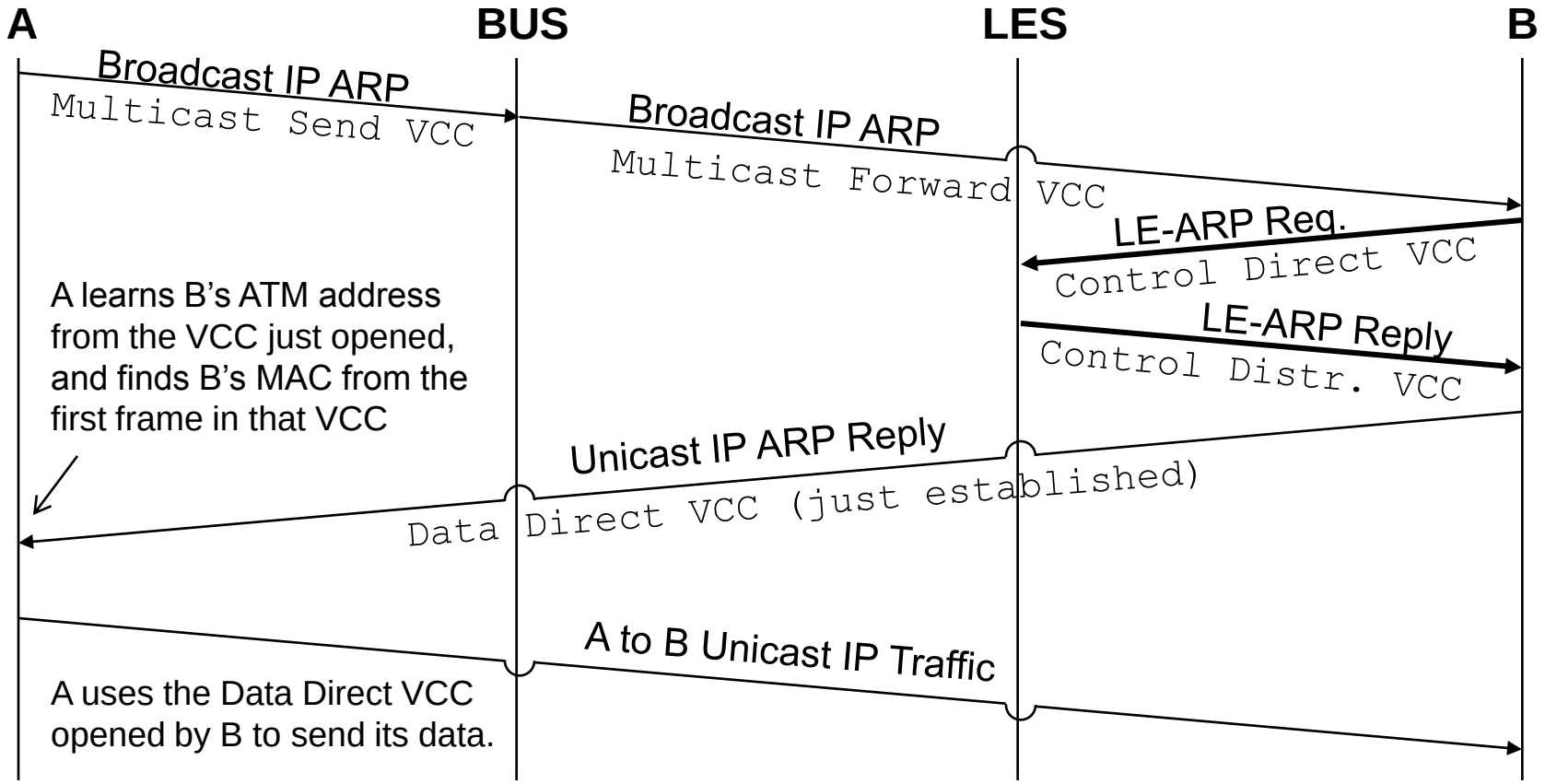
- Upon receiving a frame for transmission destined to an unknown (unicast) MAC address, the LEC starts the address resolution procedure.
- However, while that procedure is in progress, the client is allowed to send the frame to the BUS and have it forwarded everywhere.
- Once the address resolution procedure completes, the LEC can open a Data Direct VCC to the destination.
- Issue: a packet sent through the Data Direct VCC may get to the destination ahead of packets still in transit through the BUS
  - This out-of-order event **does not** happen on a LAN!
- Solution: the FLUSH Message Protocol.
  - Only kind of control message allowed in Data VCCs.

The Flush Message Protocol

- Procedure:
  - Stop sending data. Discard or hold any packets from the upper layer until the procedure completes.
  - Send an LE_FLUSH_REQUEST down the old path.
  - The BUS forwards the LE_FLUSH_REQUEST to the other client.
  - The client responds with an LE_FLUSH_RESPONSE through its Control Direct VCC.
  - The LES forwards the LE_FLUSH_RESPONSE back to the original sender.
  - Once the LE_FLUSH_RESPONSE is received, the original sender can resume transmission.
- FLUSH messages have the LANE header set to the reserved value FF00 so that they can be distinguished from data frames.

Example

Node A wishes to send an IP Packet to node B. All ARP caches are empty.



THE END