LAN Emulation,
IP Over ATM
and MPOA

ACN 2007
Overview

- LAN Emulation (LANE)
- Classical IP over ATM
- Next Hop Resolution Protocol (NHRP)
- Multiprotocol over ATM (MPOA)
LAN Emulation: Features

- One ATM LAN can be $n$ virtual LANs
- Logical subnets interconnected via routers
- Need drivers in hosts to support each LAN
- Only IEEE 802.3 and IEEE 802.5 frame formats supported. (FDDI can be easily done.)
  - A router or switch can bridge FDDI traffic onto an ATM LANE service after converting the packets to either the Ethernet or Token Ring
- Doesn't allow passive monitoring (promiscuous)
- No token management (SMT), collisions, beacon frames.
- Allows larger frames.

| LE header (2B) | IEEE 802.3 or 802.5 Frame |
The LAN emulation data frames preserve all the information contained in the original 802.3 (or 802.5) frames.

- **Byte: 0** - LE header (LEC ID) | Dest. MAC address
- **Byte: 4** - Destination MAC address
- **Byte: 8** - Source MAC address
- **Byte: 12** - Src. MAC address | Type/length
- **Byte: 16 and up** - Information

DIX vs. 802.3
LAN Emulation: Control Frame

**Marker = FF00**  **Protocol = 01**  **Vers.=1**

**Op-code**  **Status**

**Transaction ID**

**Requester-LEC ID**  **Flags**

**Source-LAN-destination**

**Source-LAN-destination**

**Target-LAN-destination**

**Source-ATM-address**

**LAN Type**  **max Frame**  **Number TLVS**  **ELANname size**

**Target-ATM-address**

**ELAN-name**

**TLVS begin**

- **same ID for one req.-resp.**
- **Source MAC address that triggered a LE-ARP sequence. May be encoded "not present"**
- **Op-Code:**
  - LE_CONFIGURE_REQUEST
  - LE_CONFIGURE_RESP
  - LE_REGISTER_REQUEST
  - LE_REGISTER_RESPONSE
  - LE_UNREGISTER_REQUEST
  - LE_UNREGISTER_RESP
  - LE_ARP_REQUEST
  - LE_ARP_RESP
  - ...
LAN Emulation:

- LAN Emulation driver replaces Ethernet driver and passes the networking layer packets to ATM driver.
- Each ATM host is assigned an Ethernet address.
- **LAN Emulation Server (LES)** translates Ethernet addresses to ATM addresses.
- Hosts set up a VC and exchange packets.
- **All software that runs of Ethernet can run on LANE**.
LAN Emulation:

1. Client gets recipient’s ATM-address from LES and sets up a VC

2. Client sends message on this VC

3. Messages for ATM clients are directly delivered

4. Messages for non-ATM clients are forwarded through bridges

LAN Emulation Client A

LAN Emulation Client B

ATM Switch

ATM Switch

Broadcast Unknown Server (BUS)

Bridge

Non ATM Client

LAN Emulation Server (LES)
Protocol Layers:

- ATM Switch
- Bridge

Higher Layers:
- IP
- IPX
- NDIS
- ODI

LAN host:
- ATM
- Physical

ATM Switch:
- ATM
- AAL5
- ATM

ATM-LAN Bridge:
- ATM
- AAL5
- MAC
- Lane
- Phy

LAN Host:
- MAC
- Physical

open data link interface (Novell/Apple)
LAN Emulation:

- NDIS = Network Driver Interface Specification
- ODI = Open Datalink Interface
- IPX = NetWare Internetworking Protocol

**LAN Emulation Software:**

- **LAN Emulation Clients** in each host
- **LAN Emulation Servers**
  - LAN Emulation Configuration server (**LECS**)
  - LAN Emulation Server (**LES**)
  - Broadcast and unknown server (**BUS**)
Operation:

- **Initialization:**
  
  - LEC must identify the *type of emulated LAN* that it is joining and determine the addresses of the **LECS** and **LES**.
  
  - To determine the ATM address of the **LECS**, the LEC performs the following:
    
    - Attempts to extract this address *from the switch* with the use of **ILMI**. If successful, the LEC attempts to connect to that address.
    
    - If unsuccessful, uses a *well-known ATM address* to try and establish the SVC.
    
    - If unsuccessful, uses a PVC at \(VPI=0, VCI=17\) to establish the connection.
    
    - If still unsuccessful, tries to contact the **LES**.
    
    - **Client gets Server's address from LECS (Configuration …)**
Operation:

● Configuration:

- The LEC sends its ATM address, its MAC address and the requested LAN types and frame sizes to the LECS.
- The LECS returns the LES address and the LAN type and frame size to use.

● Joining:

- LEC attempts to join the emulated LAN. To do this it:
  - Creates a control direct bi-directional VCC with the LES.
  - Transmits a Join Request (ATM address, LAN information, Proxy indication (if client is a concentrator), optional MAC address).
  - LES possibly accepts the request via the already existing bi-directional VCC or an uni-directional Control-VCC by sending the Join Response.
Operation:

Registration and BUS initialization:

- **BUS** takes care of processing broadcast requests from a **LEC** to other **LECs**.
- The BUS must be aware of all ATM stations on the line.
- … when each LEC comes up, it registers at the BUS. The LEC must:
  - Register **any** MAC addresses
  - **Resolve the 0xFFFFFFFFFFFF** MAC address (*broadcast address*) to get the ATM address of the BUS
  - **Create a unidirectional multicast send** VCC **to BUS**. This VCC will be used when the LEC desires to perform a broadcast.
  - Accept a **unidirectional multicast forward** VCC **from** the BUS. This is the VCC that the BUS will use when performing broadcasts over to the LEC.
Operation:

- **Data Movement:**

  - Top-level application sends the driver the information with the desired MAC address.
  - LAN emulation driver can then proceed with the following steps:
    - Verify that the internal cache contains the association between the MAC address and the ATM address.
    - If not, inquire of the LES
    - While waiting for a response, the LEC may transmit frames using the BUS
    - Once a response has been received, a direct connection is established using the signalling protocol. The association of the ATM address and the MAC address are added to the cache.
    - Connections are deleted based on inactivity
IP over ATM Issues:

1. Q: How many VC’s do we need for n protocols?
   A: Packet encapsulation [RFC1483] [RFC2684]
   Multiprotocol Encapsulation over ATM Adaptation Layer 5

2. Q: How to find ATM addresses from IP addresses?
   A: Address resolution [RFC1577] [RFC2225]
   Classical IP and ARP over ATM

3. Q: How to handle multicast?
   A: MARS, [RFC 2022]
   Support for Multicast over UNI 3.0/3.1 based ATM Networks.

4. Q: How do we go through n subnets on a large ATM network?
   A: [NHRP]
Packet Encapsulation [RFC1483]*):

- **Question**: Given an ATM link between two routers, how many VC’s should we setup?

- **Answer 1**: One VC per Layer 3 protocol.

Null Encapsulation: No sharing. VC based multiplexing.
Ethernet
DIX vs. 802.3

Each user is identified by a service access point SAP (1 byte destination/source service access point – just 256 standard values!!)
Ethernet
802.3 LLC, SNAP, SAP
Packet Encapsulation [RFC1483]*):

*) obsolete – replaced by [RFC2684]

- IP
- IPX
- Apple Talk
- LLC
- Layer 3 Packet
- AAL 5 Trailer

**Answer 2**: Share a VC using Logical Link Control (LLC) / Subnetwork Access Protocol (SNAP).

LLC Encapsulation Protocol Types: 0x0800 = IP, 0x0806 = ARP, 0x809B = AppleTalk, 0x8137 = IPX
Address Resolution [RFC1577]*):

* obsolete – replaced by [RFC2225]

- IP address: 123.145.134.65
  ATM address: 47.0000 1614 999 2345.00.00.AA....

- Issue: IP Address $\leftrightarrow$ ATM Address translation
  - Address Resolution Protocol (ARP)
  - Inverse ATM ARP: VC $\rightarrow$ IP Address

- Solution: ATMARP servers
Classical IP over ATM

- ATM stations are divided into Logical IP Subnets (LIS).
- ATMARP server translates IP addresses to ATM addresses.
- Each LIS has an ATMARP server for resolution.
- IP stations set up a direct VC with the destination or the router and exchange packets.
2 options exist:

1.) Run a standard TCP/IP implementation with multicast support over an emulated LAN

2.) Extend the Classical IP and ARP over ATM model with multicast capabilities.

- In ATM, multicasting is done using a point to multipoint connection, which must be explicitly set up before it can be used

- Therefore, the IP approach to multicasting is very different from ATM multicasting!!!
IP Multicast over ATM [RFC2022]:

- The goal stated in the introduction of RFC 2022 is as follows:
  - Define a group address registration and membership distribution mechanism that allows UNI 3.x/4.x based networks to support the multicast service of protocols such as IP.
  - Define specific endpoint behaviours for managing point to multipoint VCCs to achieve multicasting of layer 3 packets.
IP Multicast over ATM [RFC2022]:

- The resolution of IP multicast Class D addresses is done by the Multicast Address Resolution Server (MARS).
  - extended analog of the ATM ARP Server
  - registry, associating layer 3 multicast group identifiers
- In general, the MARS Cluster will overlap completely with a Logical IP Subnet (LIS),
- Multicast routers in a traditional TCP/IP implementation use the Internet Group Management Protocol (IGMP) to find out which (or rather if) hosts on the LAN want to receive packets addressed to a host group.
  - On an Ethernet, the transmission to a multicast address is relatively cheap (but not in ATM)
  - With ATM, a multicast is not so cheap and the IGMP reports (that will result from the query) must all be received and re-assembled by AAL5
IP Multicast over ATM [RFC2022]:

- Multicast Address Resolution Servers (MARS)
- Internet Group Multicast Protocol (IGMP)
- Multicast group members send IGMP join/leave messages to MARS
- Hosts wishing to send a multicast send a resolution request to MARS
- MARS returns the list of addresses
- MARS distributes membership update information to all cluster members
Next Hop Resolution Protocol

- Routers assemble packets → Slow
- NHRP servers can provide ATM address for the edge device to any IP host
- Can avoid routers if both source and destination are on the same ATM network.
Multiprotocol Over ATM

- Problem: IPX, IP, DECnet, CLNP, AppleTalk, DDP, IPv6, Vines, etc. over ATM
  - Data transfer
  - Address resolution
  - Route determination
  - Multicasting
  - Multiple server synchronization
- Solution: LAN Emulation, or IP over ATM (operates at level 2 or 3)
- MPOA := LANE + IP\_over\_ATM + NHRP + MARS (operates at level 2 + 3)
  - MPOA is capable of using both routing and bridging information to locate the optimal exit from the ATM cloud
  - It allows the physical separation of internetwork layer route calculation and forwarding, a technique known as virtual routing
Multiprotocol Over ATM

- Uses NHRP to find the shortcut to the next hop
- No routing (reassembly) in the ATM network
Summary

- **LANE** allows current applications to run on ATM
- **Classical IP** allows ARP using ATMARP servers
- **NHRP** removes the need for routing in an ATM net
- **MPOA** combines LANE and NHRP