IP over ATM

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Agenda

- ATM in nutshell
- Classical IP over ATM
- NHRP
- Creating connections
- Multicast and broadcast
- ATM based IP backbones
- IPv6 over ATM

ATM in nutshell

Basic characteristics of ATM are:

- connection oriented — connection creation is required before any traffic is transfered
- out-of-band signalling
- asynchronous multiplexing based on short packets (cells)
- guaranteed QoS
- provides ”virtual links” for upper layers over ATM network
- differentiated ”virtual links” provided by ATM adaptation layers (AAL)
- efficient traffic management, policing and, accounting

IP over ATM

Transport of IP traffic directly over ATM networks is based on a group of IETF RFCs:

- RFC 2684 ”Multiprotocol encapsulation over ATM adaptation layer 5” (1999) (replaces RFC 1483)
- RFC 2225 ”Classical IP and ARP over ATM” (1997) (obsoletes RFC 1577, RFC 1626)
- RFC 1755 ”ATM signalling support for IP over ATM” (1995)
- RFC 1932 ”IP over ATM: A Framework Document” (1996)
- RFC 2020 ”Support for multicast over UNI 3.0/3.1 based ATM networks” (1996)
- RFC 2149 ”Multicast Server Architectures for MARS-based ATM multicasting” (1997)
- RFC 2226 ”IP broadcast over ATM” (1997)

- RFC 2331 ATM Signalling Support for IP over ATM - UNI Signalling 4.0 (1998)
- RFC 2332 ”NBMA next hop resolution protocol (NHRP)” (1998) (NBMA — non-broadcast multiple access)

+ about 30 additional RFCs

The basic mechanism is defined by ”Classical IP and ARP over ATM” which defines how to encapsulate and send IP packets over ATM. Furthermore, it defines ARP mechanism for to be used with ATM. In classical IP over ATM (ClIP) ATM is used just to provide a link between hosts.

”Classical” in this case means that IP subnetworks form logical subnetworks (logical IP subnetwork, LIS):

- Direct traffic between two LIS is impossible; routers are required
- Inside of a LIS all traffic is transfered using VCCs between hosts
- LIS is not restricted by the structure of underlying ATM network

With ClIP routers become obvious performance bottlenecks. To overcome this problem the Next hop resolution protocol (NHRP) was developed.

Recommendation for MTU size is 9180 octets — as AAL5 supports packet sizes up to 64 kB, maximum MTU is 64 kB.

Encapsulation

In traditional LANs link layer encapsulation provides mechanisms for logical link control (LLC), multiplexing and addressing. LLC can be considered as in-band signalling — however, ATM is based on out-band signalling.

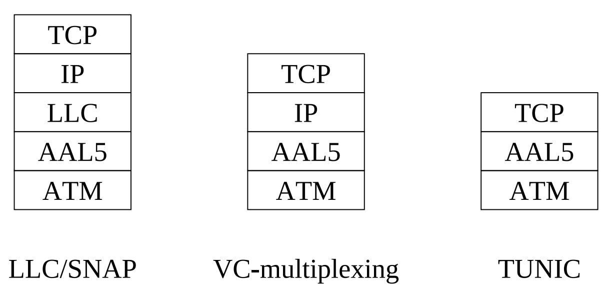
Depending on how IP over ATM transportation is implemented different kinds of encapsulation mechanisms are required.

There are three encapsulation mechanisms:

LLC/SNAP (SNAP: subnetwork attachment point) LAN like encapsulation, requires demultiplexing of received packets at the end points

VC multiplexing no LLC mechanisms (null encapsulation); requires own VCC for each protocol family

TULIP/TUNIC (TCP and UDP over lightweight IP / TCP and UDP over a non-existent IP connection) eliminates IP; no demultiplexing but requires separate VCC for each port pair



IP-over-ATM encapsulation

LLC/SNAP was quite easy and direct way to adapt existing protocols created for multiple access networks. However, it has many weak points for one obvious reasons — services are connection oriented as well as ATM: why to use connectionless IP and especially LLC/SNAP?

With some TUNIC/TULIP like scheme it is possible to offer true QoS for each connection.

IP encapsulation work load

Method	demultiplexing	signalling
LLC/SNAP	source and destination addr. protocol family protocol port	nothing
VC multiplexing	source and destination addr. protocol port	protocol family
TUNIC	nothing	source and destination addr. protocol family protocol port

Addressing and routing

The prevailing method used in addressing is based on both IP and ATM addresses. The mapping between those two is found out using ATM-ARP.

However, some other models are also considered:

Peer model — IP address is mapped directly into ATM address (NSAP), no ARP mechanism is required;this model is more or less abandoned due to problems with interworking of IP and ATM routing

Integrated model — route calculations are based on both IP and ATM topology information resulting optimal routes (used in MPOA)

Integrated routing model — using PNNI for both IP and ATM routing; especially suitable for multi-service networks

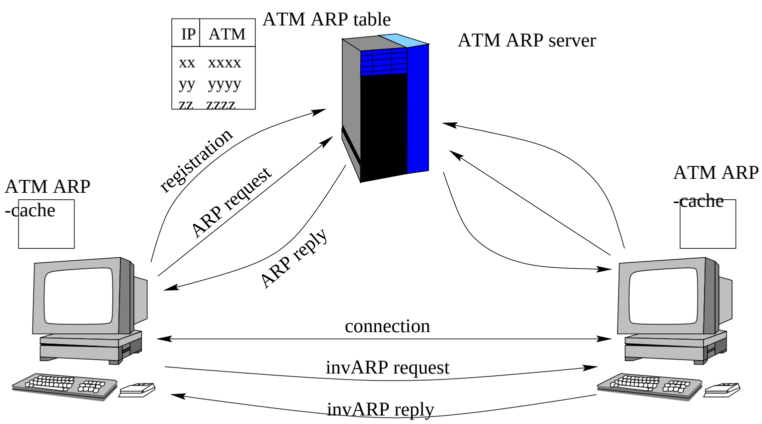
Address resolution

In LANs address resolution is commonly based on broadcast messages. As ATM lacks broadcast capabilities some other mechanism has to be used.

ATM ARP is based on specialised ATM ARP server. The basic mechanism is:

- When a host joins into network it forms a connection to the ATM ARP server using predefined ATM address
- It sends its own ATM and IP addresses to the server which stores them
- When a host desires to resolve some IP address it sends a query to the server
- After a successful query the host can create a direct connection to the destination
- A connection should be invalidated after 15 minutes but it is no teared down; invalidated connection should be revalidated by

  - sending a new query to the server
  - sending a Inv-ARP query to the other end point (only if the server cannot respond)
- IP to ATM address mappings are timed out after 20 minutes, all hosts should resent their own mappings each 15 minutes



ATM ARP

NHRP

In classical IP over ATM networks traffic between users of different LISs must go through one or more IP routers which can become bottlenecks. Furthermore, it makes it impossible to use special characteristics provided by ATM (such as QoS). To overcome these problems NHRP mechanism was developed.

NHRP is not a routing protocol but an ARP mechanism that enables hosts to avoid unnecessary IP hops. A next hop server (NHS) can provide an address resolution for destination host if the destination belongs into the same LIS. Otherwise NHS can provide the ATM address of a router or if possible, the ATM address of the destination. The latter case requires that NHSs of different LISs are interconnected using Server cache synchronisation protocol (SCSP).

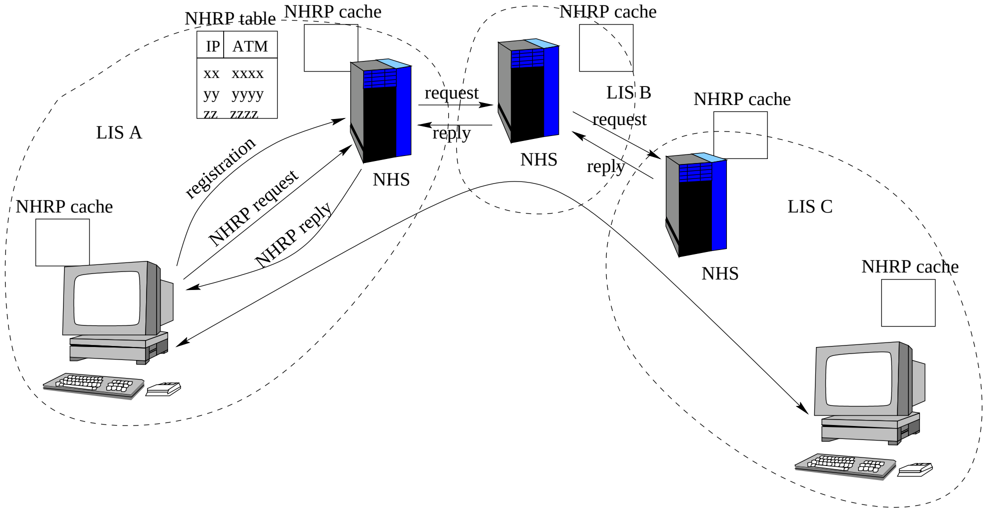
NHRP is not bind to IP but it can be used with other protocols as well (e.g. MPOA). NHRP can be used with plain ClIP and hosts can decide which mechanism to use.

How NHRP works

In principle NHRP operates in the same way as ATM ARP. The difference is in the case where the IP address to be resolved does not belong into the same LIS. In such case NHS relays the query into other NHSs. For that each NHS must be aware of what address mapping can be found behind each neighbour NHS.

The query is relayed from NHS to NHS until a correct address mapping is found. The replay is returned using the same path allowing NHSs to learn that particular mapping (NB: authorative request / direct answer).

To enable usage firewalls NHS can be configures not to provide certain address resolutions.



NHRP in action

Creating SVCs

IP over ATM network can be based on permanent ATM connections (PVC). RFC 1755 defines how to create SVCs using ATM Forum UNI 3.1 while RFC 2331 uses UNI 4.0. There is also possibility to use point-to-multipoint connections.

Integration of IP QoS (IntServ) and ATM QoS is also considered: RFCs 2379-2382 define how to utilise ATM connection parameters with RSVP.

Multicast and broadcast

Some definitions:

unicast traffic: target is a single well defined receiver

multicast traffic: target is a group of receivers

broadcast traffic: target is all members of a network

ATM signalling (UNI 3.1) supports point-to-multipoint connections that are not similar to IP multicast connections. RFC 2022 defines how to use those

ATM connections combined with multicast address resolution server (MARS) to implement true IP multicast.

The hosts are connected to the MARS that delivers them information about other members of the multicast group. The actual data traffic can be transfered using VC-mesh or a ATM multicast server. Any traffic between LISs requires IP router.

How MARS works

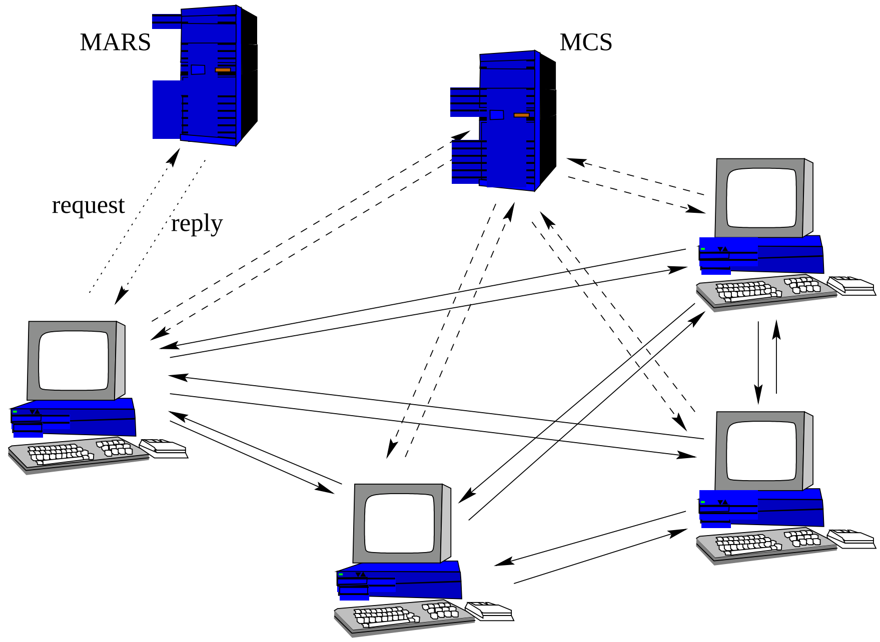
MARS can be considered as a specialised ARP server just like NHS — its purpose is to take care of multicast addresses.

The principle of the operation is:

- A client host registers into MARS and delivers its ATM address into those multicast groups it wishes to belong
- MARS adds the new client into its control VC

- When a client wishes to resolve an IP multicast address, it sends a query to MARS
- MARS replies with all ATM addresses registered into that group
- The client can create a VC to each member or it can utilise the multicast server (MCS)

If MCS is used, each member of the multicast group forms a point-to-point connection into MCS. MCS creates a single point-to-multipoint connection to all members. A sender sends the packets to MCS which relays them to all group members.



Multicast in IP-over-ATM networks

ATM based IP backbones

Previous mechanisms are more or less limited into direct communications between hosts. However, the most popular usage of ATM with IP has been in router interconnections especially in backbone networks.

There are many advantages in using ATM:

- fine grained capacity allocation
- compatibility with telecom networks
- multiple connections through single interface
- efficient resource usage

However, there are also some drawbacks:

- router interconnections are rather static: no need for ATM signalling
- suboptimal IP routing
- backbone links require all the transmission link capacity — no need for

multiplexing

As a result of this ATM based backbones are being replaced by other solutions (such packet over SONET). However, ATM usage is shifting to access networks — in practise all xDSL systems utilise ATM.

IPv6 over ATM

There are two RFCs concerning IPv6 transfer over ATM networks

- RFC 2491 ”IPv6 over NBMA networks”
- RFC 2492 ”IPv6 over ATM Networks”

This far IPv6 has not caused large changes into IP-over-ATM mechanisms compared to IPv4.