Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

TOWARDS SHARED ATM FIBRES, A PSEUDO METASIGNALLING PROTOCOL, AND ATM LANS.

Grenville Armitage (gja@mullian.ee.mu.OZ.AU)
Keith Adams (kma@mullian.ee.mu.OZ.AU)
Ph. (03) 344-7976
Fax. (03) 344-6678
Department of Electrical and Electronic Engineering
University of Melbourne
Parkville, 3052
AUSTRALIA

ABSTRACT

A signalling protocol for uncoordinated AALs sharing a broadcast fibre is proposed. A single cell carries signalling information. The allocation of VCIs and VPIs to virtual connections, and management of cell switches interconnecting individual ATM fibres, is discussed. It is suggested that each fibre should have a node dedicated to managing VCI/VPIs. Cell switches communicate with AALs through a common metasignalling channel. The bootstrap services to each AAL provide some of the CCITT's metasignalling service. The protocol can establish virtual circuits between AALs on separate fibres, and may be used to support ATM based Local Area Networks.

1. INTRODUCTION.

The ATM Adaptation Layer (AAL) [1] provides an interface between the Virtual Channel and Virtual Path based ATM cell network and higher layer datagram or data stream services [2,3]. AAL's provide the ultimate sources and destinations of ATM cells within a network. The CCITT has developed requirements for the data transfer protocols that AAL's should support [4]. However, requirements for true ATM level signalling protocols are being developed more slowly.

Being connection-orientated, ATM cells contain no explicit source or destination addressing. The virtual circuit any given Virtual Channel Indicator (VCI) and Virtual Path Indicator (VPI) represents depend on previous agreements reached by AALs attached to the network (fibre). To provide initial communication ability between AALs that have just been connected to a fibre, CCITT established the need for a "meta-signalling" channel. This uses a statically defined, and globally applied, VCI/VPI [5,6]. This paper looks at a simple signalling protocol which enables AALs to establish themselves in the network and then go about creating virtual connections with each other. Comparisons are also made with CCITT's own evolving metasignalling protocol, Q.142x [27], which addresses a different network scenario to ours.

2. AALS - WHAT TOPOLOGY ARE WE THINKING OF ?

BISDN is hoped to provide a range of services to customer sites. One example is LAN-LAN interconnect services [7] . In this case there may only be one AAL associated with each customer, performing the segmentation and reassembly of LAN packets transported as cells across the BISDN. Each AAL needs some way of creating initial contact with "the BISDN network", in order to connect to remote LANs. There are also plans to interconnect Metropolitan Area Networks (MANs, based on, for example, IEEE802.6 technology) using national BISDN connections [8,9]. Alternatively the customer obtains multiple BISDN connection points into their building. The customer then connects workstations or terminals with internal AALs. These situations are likely to be provided using separate physical fibres between each customer AAL and the nearest ATM "switch" or "exchange".

A more visionary approach sees customers implementing their own ATM based LANS or MANS, directly connected to the wider ATM network through an ATM cell switch (Figure 1). The adoption of a signalling protocol that can be applied to a multi-node fibre environment would aid the adoption of ATM techniques by private businesses, who often need the wiring simplicity of shared media. The concept of a multi-node shared fibre is the very basis of systems such as IEEE 802.6 and FDDI [10]. The signalling protocol described here assumes, and deals with, a shared fibre with multiple AALs connected, all co-ordinating their use of VCI/VPI's so as not to conflict with each other. This appears to be the first point of departure from Q.142x, the metasignalling protocol being developed by Study Group 11 [27].

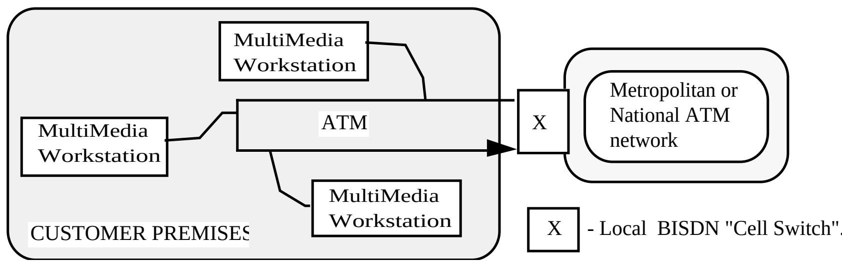

Figure 1

3. A SHARED FIBRE FROM THE AALS PERSPECTIVE.

From an ATM interface perspective the fibre is merely a source of cells generated by remote AALs. On a shared fibre all ATM interfaces can "see" cells being generated by each other. Each AAL is only passed cells whose VCI/VPIs (in their headers) correspond to current virtual connections to themselves. Therefore we need a mechanism to coordinate each AAL’s use of VCI/VPIs, and their association with particular virtual circuits (or Virtual Channel Connections [11]). Another requirement is that individual AALs are able to “link into” this mechanism when they are first switched on, a “bootstrap” process. CCITT have advocated the use of preassigned "metasignalling" channels [6], over which an AAL can initially query the network around it. Initially this was VPI = 0, VCI = 1 (although Q.142x has expanded on this restriction).

On a shared fibre, signalling (meta or otherwise) between AALs (the nearest Cell Switch also appears as an AAL for signalling traffic) needs some scheme to identify which AALs are intended to receive any given signalling unit. One method would be to preallocate a VPI for each AAL. Another scheme is to use a common, broadcast virtual channel and path. The signalling units carry information within them to identify the source and destination AALs. This is the method we have chosen to implement.

We have loosely named our signalling datagrams Metasignalling Units (MSUs), despite the similarity to CCITT’s term ‘metasignalling’. They are designed to fit within a single ATM cell. Type 3 Segmentation and Reassembly mode [12,14], and a null Convergence Sublayer, is used to transport our MSUs, giving a maximum MSU size of 44 bytes. The common fields of the MSU are shown in Figure 2. A single cell MSU was chosen to avoid problems reassembling multi-cell datagrams from a broadcast channel carrying cells from uncoordinated AALs.

The source and destination indicators are carried in the first two fields of the MSU. At the risk of inventing another useless Four Letter Symbolic Identifier (FLSI) we identify each ATM interface in the B-ISDN network with an ATM Terminal Interface Address (ATIA) (Figure 4). ATIAs are similar in concept to SNI Addresses used in the Switched Multimegabit Data Service (SMDS, [15]), based on E.164 addressing [16].

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

MetaSignalling Unit

Destination ATIA	Source ATIA	MSU Type	Request ID	MSU Payload	Padded with zeroes
8 bytes	8 bytes	2 bytes	2 bytes	?? bytes	

Figure 2

We expect to base our 64 bit ATIAs on E.164. The MSU Type and Request ID fields allow the signalling channel to carry a variety of service requests simultaneously. Every AAL connected to the shared fibre through its ATM interface will receive and inspect each cell sent on the metasignalling channel, discarding cells which do not contain their ATIA in the MSU's destination field.

4. THE SWITCHING NODE, AND COORDINATING VCI/VPI ALLOCATION.

Our model assumes that any given fibre will have at least one AAL on it which actually controls a "fast packet" Cell Switch giving access to the rest of the BISDN world (e.g. [18, 19, 20]). This AAL and Switch are combined into an Intelligent Cell Switch (ICS) node. When an AAL starts up it sends 'query' MSUs on the metasignalling channel to locate the ATIA of the ICS. A "broadcast" MSU locates the ICS in a manner analogous to the Internet Protocols ARP, RARP, and Proxy ARP [21, 22, 23] (and AppleTalk's dynamic node ID assignment, AARP, and routing table maintenance schemes [24]). After this the AAL may establish metasignalling communication with the ICS using directed MSUs.

Every virtual connection established between two AALs will be unidirectional, and use one VCI/VPI on each particular segment of fibre [17]. The establishment of a virtual connection needs a means of contacting remote AALs and allocating VCI/VPIs that are not otherwise being used on a given segment of shared fibre. This now starts to go beyond CCITT metasignalling, however the broadcast metasignalling channel allows both of these needs to be met when teamed with some additional AAL level services.

We introduce the idea of a Permanent VCI/VPI Server (PVS) which exists as part of an AAL connected to a particular shared fibre (possibly contained withing the ICS node). When an AAL needs to create a new incoming virtual connection it requests a VCI/VPI from its local PVS. When all AALs on a given fibre use one PVS, the PVS itself ensures that no VCI/VPI clashes occur. The PVS node is located in the same way as the ICS node, using a broadcast 'query' MSU. Figure 3 shows a generic two-fibre system.

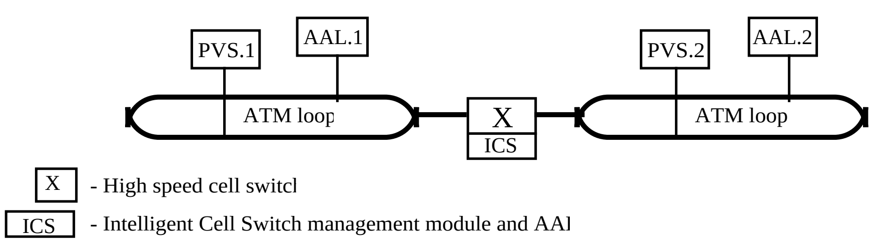

Figure 3

5. BEYOND Q.142X - ESTABLISHING VIRTUAL CONNECTIONS

Higher layers using the services of any given AAL to transport AAL_SDUs will be identified using another FLSI - an AAL Endpoint Protocol Identifier (AEPI) (Figure 4). With this in mind we assume that virtual connections are going to be requested between a local AEPI and a remote

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

(ATIA, AEPI) pair. This model is broadly similar to the connectionless environment of Ethernet where a datagram is sent to a destination identified by Ethernet Address and Ethernet Protocol Type [25, 26]. We felt it would aid the implementation of ATM LANs if we incorporated basic virtual connection establishment facilities in our protocol. By contrast the CCITT's concept of a metasignalling protocol only aims to set up a link between an AAL and its closest "exchange", over which "higher level" signalling protocols will operate.

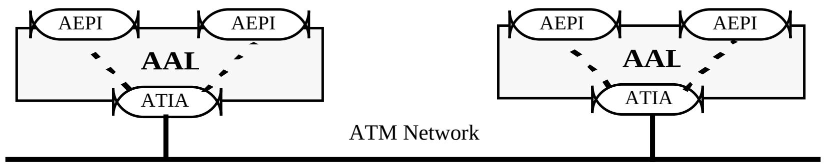

Figure 4

The ICS is an integral and transparent part of our connection scheme. It combines both routing and switching services. For cells whose VCI/VPIs are in its hardware routing table the ICS operates in cell-switching mode. Cells arriving on the metasignalling channel are treated as MSUs and passed up to the ICS management module. We have defined MSUs which carry connection request, acknowledgment, connection shutdown, and quality of service information. At this point the ICS may potentially provide a routing function, as our signalling protocol enables two AALs to establish a virtual connection between each other, even if on separate fibres. When connection establishment MSUs pass through the ICS it takes special note of them in preparation for adding new entries to its hardware routing table. Entries are removed when disconnection MSUs pass through. The ICS itself contains an AAL and may also support AAL service users which other AALs can establish normal virtual connections to.

Our protocol coordinates the use of PVS nodes on each fibre, and intervening ICS nodes, so that a sequence of VCI/VPI's correctly carries ATM cells from one endpoint AAL to the other, and the subsequent datagrams are delivered between the correct AEPIs.

There is insufficient room to detail all the elements of our signalling protocol. However various MSUs can be collected into a few subgroups, with mnemonic names for each MSU. The first group relates to bootstrap functions - locating the PVS and ICS nodes. The second group relates to using the PVS node. The third group creates connections between (ATIA, AEPI) pairs. The final group establishes Quality of Service parameters with the local ICS for virtual connections that one may wish to create or have already created.

WHOISPVS and WHOISICS are broadcast MSUs, designed to elicit IAMPVS and IAMICS MSUs from the respective nodes. Two of these are shown in figure 5. The IAMPVS and IAMICS responses are directed back to the AAL that broadcast the query, enabling it to establish the ATIAs of the PVS and ICS respectively.

All destination bits set to '1'	64 bits
ATIA of Requesting AAL	64 bits
<WHOISPVS>	16 bits
Null ID	16 bits
Empty Payload	

ATIA of Requesting AAL	64 bits
ATIA of PVS	64 bits
<IAMPVS>	16 bits
Null ID	16 bits
Empty Payload	

Figure 5

INEEDVCI ,YOUGETVCI, YOUGETNAK, RECLAIMRQ, RELEASEVCI, RELEASEACK, and RELEASENAK are MSUs which request the PVS for free VCI/VPI's or release VCI/VPI's which are no longer being used. Any AAL on the fibre uses the PVS when it requires the use of a VCI/VPI which is known to be free.

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

Our virtual connection establishment MSUs consist of CONNECT_RQ, CONNECT_ACK, CONNECT_NAK, I_DISCONNECT, U_DISCONNECT, and DISCONNECT_ACK. These allow any AAL to establish a unidirectional virtual connection to a remote AAL service user, and for either end to shut down the virtual connection. A network model is shown in Figure 6, with each step in a virtual connection between AAL.1 and AAL.2 having an "Initiating AAL" and "Connection AAL". Across the whole network the connection is considered to run from the Sender AAL to the Receiver AAL. The protocol is generalised so that the Sender and Receiver AAL may also be the Initiating AAL or Connection AAL on any given fibre. All 4 pieces of information are carried in the CONNECT_RQ message, with ICS nodes performing routing to get the MSU to the Receiver AAL. On any given segment of fibre the Connection AAL tentatively allocates a VCI/VPI which it will allocate to this virtual connection (using the PVS for that segment of fibre). When a CONNECT_ACK reply is routed back to the Sender AAL, each ICS is passes through uses its contents to create a VCI/VPI mapping in its hardware routing table. CONNECT_NAKs result in the releasing of the VCI/VPI, and no routing table entry. Disconnect requests are routed just like connection requests, and hardware routing table entries are removed as DISCONNECT_ACK replies pass back through the ICSs.

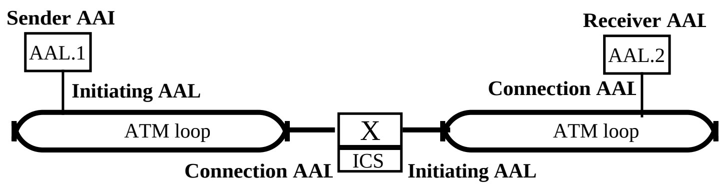

Figure 6

Figure 7 shows the CONNECT_RQ and CONNECT_ACK MSUs format.

ATIA of Connection AAL	64 bits
ATIA of Initiating AAL	64 bits
<CONNECT_RQ>	16 bits
16 bit Request ID	16 bits
ATIA of Receiver AAL	64 bits
ATIA of Sender AAL	64 bits
Receiver AEPI	16 bits
Sender AEPI	16 bits
Quality of Service Parameters	32 bits

ATIA of Initiating AAL	64 bits
ATIA of Connection AAL	64 bits
<CONNECT_ACK>	16 bits
16 bit Request ID	16 bits
ATIA of Receiver AAL	64 bits
ATIA of Sender AAL	64 bits
VCI/VPI that connection AAL will receive cells on	32 bits

Figure 7

ICS nodes become simultaneous Connection and Initiating AALs when they regenerate connection and disconnection MSUs from one fibre to another. The Receiver AAL is able to reject or accept connections based on the Sender AAL field, and intermediate ICS nodes may do the same based on the limited Quality of Service indicator field of the CONNECT_RQ. The QoS field provides a limited facility to associate a desired Quality of Service with the virtual connection being requested. The scope of the QoS field is still under development. However it will at least carry an indication of the desired SAR and CS service type for the requested virtual connection. It will also convey some indication of peak or average cell rates desired for the requested connection. This connection protocol is seen as providing support for higher layer signalling protocols and relatively unfussy transport protocols such as TCP/IP. More complex QoS specification may need different signalling protocols running over virtual connections established using our system.

Our virtual connections are all unidirectional and unicast. Multicast virtual connections are not yet supported, although this is being looked into.

Finally a small collection of MSUs is being developed to exchange rate and congestion information between ICS nodes and the Sender AAL. Our protocol will enable ICS nodes to exercise rate control of the Sender AAL while a virtual connection is active.

6. SOME COMPARISONS WITH Q.142X

It is inevitable that our divergence from Q.142X will be contested. The first, and obvious, point to be made is that our protocol was developed without initial reference to Q.142X, making it possible only to discuss differences rather than explain how our design evolved from CCITTs own plans.

In common we have the need to enable AALs to be connected to a fibre and establish some form of working link to “the rest of the network”. Both protocols provide a solution to this problem. Q.142X appears to assume that the only other entity communicating on the metasignalling channel is “the network”. We assume a broadcast metasignalling channel that many AALs may be sending and receiving cells on. As a result our protocol requires source and destination information to be carried with each MSU. The Q.142X message format appears unable to cope with multiple AALs sharing a virtual channel. A work-around using Q.142X would be to have each user AAL use a metasignalling channel on a private virtual path to “the network” node. This would be an inelegant way of supporting shared fibre environments because it requires fixed relationships between AAL identity and VPI to be established in addition to ATIA identifiers for higher level connections.

Study Group XVIII had expected that signalling be supported by Type 3 SAR services, and we saw little reason to change that for metasignalling. Hence our (meta)signalling layer makes conventional use of its local AAL to send and receive MSUs on the single metasignalling channel. A null CS layer, and Type 3 SAR layer provides use with 44 byte MSUs and CRC checking on each MSU is provided by the SAR encapsulation. Q.142X opts to create a new ATM cell type which corresponds to no conventional SAR type, in order to take the full 48 bytes of an ATM cell payload. This appears to be an unnecessary complication to the data paths within a standard AAL.

Our protocol expands beyond Q.142X in its provision of virtual connection establishment facilities. Although Q.142X expects an AAL to establish signalling connections with “the network”, we have generalised this to establishing virtual connections to arbitrary (ATIA, AEPI) pairs. We place no restrictions on what data is carried over the virtual connection, and make no implicit assumptions about what constitutes an AAL Service User. At its most basic level our protocol can emulate the services provided by Q.142X if “the network” exists as a signalling process at a known AEPI on the ICS node. The chink in the armour of both systems is that ultimately an inter-Cell Switch routing protocol must be implemented. We have not tackled that yet, however our connection establishment protocol will work between ICS nodes just as well as between user AALs and ICS nodes. Thus it can provide the initial support for an ICS which wishes to locate any other ICS nodes on its connected fibres.

7. ATM LANS?

An ATM LAN is currently the “in thing” to be working towards in some circles. But what is it? A definitive answer would probably be contentious. However we see one basic characteristic is that it provides an “in house” ability to transport datagrams from some arbitrary higher layer protocol between AALs. The AALs will probably exist within conventional devices such as workstations, mass-storage devices, and multi-media conferencing tools. All of this using ATM

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

because of its promise of high speeds using technology which should become reasonably priced once the wider B-ISDN market expands.

Our model of shared fibres hanging off one or more Cell Switches combines both broadcast and star technologies, both of which can find applications in LAN environments. We believe that our protocol provides a reasonable means for supporting, for example, TCP/IP between machines on an ATM LAN. We have set up TCP/IP links over an emulated ATM network where the IP layer associates itself with a known AEPI identifier, and IP datagrams are transferred over virtual connections established between the known AEPIs on different machines.

An ATM LAN need not be based on shared fibres, each AAL could be connected directly to the local Cell Switch. Our protocol works properly in this case because it merely involves a shared fibre with only one AAL and an ICS. Our protocol will also cope with an ATM LAN based purely around a shared fibre without any ICS node. Although this would be unusual each AAL can decide that no response to their WHOISICS queries means there is no ICS on the fibre. Any requests for a virtual connection to a given ATIA will be sent directly to that AAL over the metasignalling channel.

8. CONCLUSION

A single-cell signalling protocol has been described using a broadcast technique on a single metasignalling channel. Multiple AALs may be physically connected and managed on one shared fibre. The protocol provides the ability to interconnect AALs on physically separate fibres, using an Intelligent Cell Switch node. A Permanent VCI/VPI Server entity is proposed, for the shared fibre environment, as a means to coordinate VCI/VPI usage on each fibre. Virtual connections established by this protocol can support a range of higher layer services, including more mature or powerful signalling systems. This research group has successfully implemented this protocol using three Sun workstations as AALs, an ICS, and a PVS. As a real world example we created a Point-to-Point TCP/IP link between two machines using our AALs to provide datagram transport, and our signalling protocol to create the virtual connections “on demand” [28].

A comparison with Q.142X has been made, and explanations given as to our divergent path. It may be contended that we are re-inventing squarer wheels, however we believe that this protocol is light-weight enough to have some merit on its own, without precluding the use of more properly conforming (meta)signalling protocols.

ACKNOWLEDGMENT

This research was carried out as part of Telecom Research Laboratories contract 7064.

REFERENCES

[1] CCITT SGXVIII Draft Recommendation I.362, “B-ISDN ATM Adaptation Layer (AAL) Functional Description”, June 1990.
[2] CCITT SGXVIII Draft Recommendation I.150, “B-ISDN ATM Functional Characteristics”, June 1990.
[3] Martin de Prycker, “Asynchronous Transfer Mode - Solution for Broadband ISDN”, Chapter 3, Ellis Horwood, 1991.
[4] CCITT SGXVIII Draft Recommendation I.363, “B-ISDN ATM Adaptation Layer (AAL) Specification”, June 1990.
[5] CCITT SGXVIII Draft Recommendation I.311, “B-ISDN General Network Aspects”, Section 3.3.3, June 1990.

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.

[6] CCITT SGXVIII Draft Recommendation I.361, “B-ISDN ATM Layer Specification”, Section 2.2.3, June 1990.
[7] M.A.Summerfield, "An Interworking Unit for Bridging Ethernet LANS across an ATM Network", Proc. Australian Broadband Switching and Services Symposium, Sydney, July 1991.
[8] J. Burgin, E. Tirtaatmadja, R. Palmer, “Metropolitan Area Network Interconnection: A path to Broadband ISDN”, Proc. IEAust Communications Conference, Melbourne, October 1990.
[9] P.H. Harris, D.M. Dorman, “Evolution of Switched High-Speed Data Networks to B-ISDN”, Proc. Australian Broadband Switching and Services Symposium, Sydney, July 1991.
[10] Martin de Prycker, “Asynchronous Transfer Mode - Solution for Broadband ISDN”, Chapter 6, Ellis Horwood, 1991.
[11] CCITT SGXVIII Draft Recommendation I.113, “Vocabulary of Terms for Broadband aspects of ISDN”, Section 2.2, June 1990.
[12] CCITT SGXVIII Draft Recommendation I.363, “B-ISDN ATM Adaptation Layer (AAL) Specification”, Section 5.3.1, June 1990.
[13] Unused.
[14] CCITT WPXVIII/8 Meeting Report - Annex 3 (Part B), “Text of WP XVIII/8 B-ISDN Recommendations”, Appendix 9 - I.363, Sub-appendix 3, “Functional Model for the AAL Type 3/4”, Melbourne, December 1991.
[15] "Generic System Requirements in support of Switched Multimegabit Data Service", Technical Advisory TA-TSY-000772, Bellcore Technical Advisory, Issue 2, Section 4.2.1, March 1989.
[16] CCITT Recommendation E.164.
[17] CCITT SGXVIII Draft Recommendation I.311, “B-ISDN General Network Aspects”, Section 2.2.2, June 1990.
[18] Rob Palmer, “An Experimental ATM Switch for BISDN Studies”, Int. Journal of Digital and Analog Communication Systems, Vol.3, 1990.
[19] Marek R. Wernik, Ernst A. Munter, “Broadband Public Network and Switch Architecture”, IEEE Communications Magazine, pp.87,88, January 1991.
[20] Martin de Prycker, “Asynchronous Transfer Mode - Solution for Broadband ISDN”, Chapter 4, Ellis Horwood, 1991.
[21] D.C. Plummer, “An Ethernet Address Resolution Protocol”, RFC-826, November 1982.
[22] R. Finlayson, T. Mann, J. Mogul, M. Theimer, “A Reverse Address Resolution Protocol”, RFC-903, June 1984.
[23] D. Comer, “Internetworking with TCP/IP - Principals, Protocols, and Architecture”, p.196, Prentice Hall, 1988.
[24] G.S. Sidhu, R.F. Andrews, A. B. Oppenheimer, "Inside AppleTalk", Addison-Wesley, March 1989.
[25] “The Ethernet - A Local Area Network”, Version 1.0, Digital Equipment Corporation, Intel Corporation, Xerox Corporation, September 1980.
[26] C. Hornig, “A Standard for the Transmission of IP Datagrams over Ethernet Networks”, RFC-894, April 1984.
[27] CCITT SGXI Draft Recommendation Q.142x “B-ISDN Meta-Signalling Protocol”, Geneva, March 1992.
[28] G. J. Armitage, K. M. Adams, “Some Observations on the ATM Adaptation Layer Services needed to support TCP/IP”, Australian Broadband Switching and Services Symposium ‘92, July 1992.

Proc. Australian Broadband Switching and Services Symposium, Melbourne, July 1992, pp.271-278. This pdf reconstructed Dec 2005.