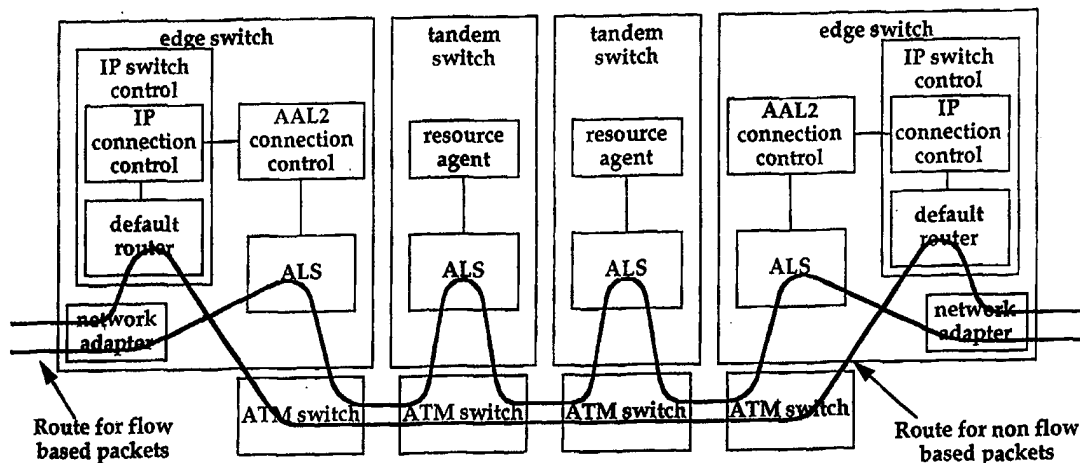




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |                                                                                                                                                                         |
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(54) Title: SCALEABLE DATA NETWORK ROUTER



## (57) Abstract

In a broadband network comprising a plurality of edge switches interconnected by a plurality of tandem switches, IP packet data is routed by determining from each packet whether that packet forms part of a flow of packets. Where a packet is determined to be part of a flow, it is segmented into minicells for transmission over a permanent virtual channel established across the network for that flow. Where a packet is not determined to be part of a flow, a destination edge switch is identified for that packet which is then transported to that edge switch via a default permanent virtual channel. Permanent virtual channels for new flows are established at the network periphery by defining a succession of nodes and virtual channels (VCs) to be used to reach the destination of that flow.

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## **SCALEABLE DATA NETWORK ROUTER**

This invention relates to communications networks and in particular to an arrangement and method for the routing of connectionless packet data in such networks.

### **5 BACKGROUND TO THE INVENTION**

Data networks based on packet protocols, such as Internet Protocol (IP), use addressing information in the packet header to determine the destination of individual packets. Since each packet is treated independently of any other packet, the networks are connectionless. Packets pass  
10 individually through the network between router nodes which determine to which router the packet should be sent next. The processing power required to interpret packet header information and determine the route to the next network node limits the capacity of the router.

15 In many instances, a communication between two terminal nodes in a communications network involves transmitting many IP packets in sequence. This is commonly referred to as a 'flow'. When a flow is identified by a router, a temporary link 'connection' can be set up through the network to carry this flow. All packets with the same header information can then  
20 pass over this connection, avoiding the need to process the headers on an individual basis. This technique is known as IP switching.

With the introduction of broad band asynchronous transfer mode (ATM) networks, there is now a need for the transport of connectionless packet  
25 traffic over such networks, particularly with the introduction of IP voice services to provide Internet based telephony. However, Internet traffic is not readily adapted to real time communication over a broad band network owing to its connectionless format, its multiple routing hops and its typical packet length which does not match the standard ATM cell.

30

### **SUMMARY OF THE INVENTION**

An object of the invention is to minimise or to overcome this disadvantage.

A further object of the invention is to provide an improved method of  
35 carrying IP packet traffic over a broad band network.

The present invention relates to the use of IP switching techniques to implement a scalable distributed router using ATM Adaptation Layer 2 (AAL2) as the bearer for IP packets identified as part of a flow.

- 5 According to one aspect of the invention there is provided a distributed router consisting of a plurality of edge switches interconnected by a plurality of tandem switches where flow based traffic is identified in the edge switch and a temporary connection is established to the destination edge switch where the packet is reconstituted into its original form for onward  
10 transmission.

According to another aspect of the invention there is provided an implementation of Internet Protocol (IP) real time services in which the end to end delay is fixed and low enough to achieve ITU delay standards for voice services.

- 15 According to a further aspect of the invention there is provided a method of routing traffic in a distributed router consisting of a plurality of edge switches interconnected by a plurality of tandem switches, the method including identifying flow based traffic in the edge switch and establishing a temporary connection into the destination edge switch whereby the packet is  
20 reconstituted into its original form for onward transmission.

- According to another aspect of the invention, there is provided a method of routing packet data traffic in a broad band network comprising a plurality of edge switches interconnected by a plurality of tandem switches, the method including determining from each said packet whether that packet forms part  
25 of a flow of packets, where a said packet is determined to be part of a flow, segmenting that packet into minicells for transmission over a permanent virtual channel established across the network for that flow, and where a said packet is not determined to be part of a flow, identifying a destination edge switch for that packet and transporting the packet to that edge switch  
30 via a default permanent virtual channel.

- According to a further aspect of the invention there is provided a broad band network comprising a plurality of edge switches interconnected by a plurality of tandem switches and having means for routing packet data traffic, the  
35 network including means for determining from each said packet whether that packet forms part of a flow of packets, means for segmenting a said packet determined to be part of a flow into minicells for transmission over a

permanent virtual circuit established across the network for that flow, and means for identifying a destination edge switch for a said packet and transporting that packet to that edge switch via a default permanent virtual channel where that packet is not determined to be part of a flow.

5

A flow is defined as an established sequence of IP packets from a source to a destination comprising e.g. a file transfer or an Internet voice call.

In our arrangement, the ATM network functions as a distributed router whereby the IP packets are routed to the correct destination. Where a packet is identified as forming part of a flow, the destination will have already been established so that the packet payload can be carried in minicells over the permanent virtual channel that has been provisioned for that flow.

10

## 15 BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described with respect to the following drawings in which:

Figure 1 is an overview of a data network arrangement according to an embodiment of the invention;

20

Figure 2 is a block diagram of edge and tandem switches on an example route through the data network of figure 1;

25

Figure 3 illustrates the general construction of an IP packet;

Figure 4 is an example realisation of an adaptation layer switch in the network of figure 1;

30

Figure 5 is a block schematic diagram of the network adapter shown in figure 2; and

Figure 6 shows example routes through the network of figure 1 for flow based and non flow based packets.

35

## DESCRIPTION OF PREFERRED EMBODIMENT

Referring to figure 1, the broad band network comprises a plurality of interconnected nodes which nodes are of two types, edge switches 11 and

tandem switches 12. Edge switches interconnect and interface with other elements of a data network and are themselves interconnected via tandem switches.

5 In the network of figure 1, nodes are interconnected by permanent virtual channels (PVCs) of a data network based on asynchronous transfer mode (ATM) technology. The ability of an ATM network to support PVCs between pairs of nodes on a network is well known. The PVCs are set up between each edge switch 11 and one or more tandem switches 12. Further PVCs  
10 are established between tandem switches 12 such that a highly or fully meshed core network is generated. Where each edge switch is connected to at least two tandem switches, then at least two possible routes will exist from any source edge switch to any other destination edge switch across the network.

15 In figure 1, for the purpose of illustration, traffic between any source edge switch passes to any destination edge switch through at most two tandem switches. It will be appreciated however that in a large practical network, traffic might pass through many tandem switches before reaching its  
20 destination edge switch.

Figure 2 shows the general construction and interconnection of the edge switches and tandem switches. Each edge switch incorporates an IP network adaptor 21 providing an interface with an IP network employing e.g.  
25 an Ethernet protocol. The adaptor 21 is coupled to an IP switch control 22 and, via an adaptation layer switch (ALS) 23 to a connection control 24 and to an ATM switch 25. Each tandem switch comprises a resource agent 26 coupled via an adaptation layer switch 23a to an ATM switch 25a.

30 Figure 3 shows in schematic form the construction of a typical IP data packet comprising a payload 30 and a header 31 containing supervisory information. The header comprises a number of information fields including a packet length indicator (LI), a protocol indicator (PI), a source identity (SI) and a destination identity (DI). Other header fields (not shown) may be  
35 provided to indicate e.g. the nature of the payload content and a sequence number.

Figure 4 illustrates the network adapter function block of the edge switch of figures 1 and 2. In this example, traffic in the form of data packets arrives at an Ethernet interface 51 from the externally connected data network on an Ethernet connection 58. After removal of the Ethernet link layer information, the data packet passes to the cut-through routing function 52. The routing function 52 compares the packet header information with the entries in a content addressable memory 53 to ascertain whether or not the incoming packet belongs to an already identified flow. If this is the case, the packet is segmented and encapsulated via an encapsulation function 53 in ATM adaptation layer 2 (AAL2) minicells for transmission over the connection which has been set up for that flow. The existence of a flow may be determined for example by the identification of a number of IP packets having the same source and destination identifiers. These identifiers from the first packet or packets of a suspected flow can be stored in the content addressable memory for comparison with corresponding information from subsequent packets.

If the packet is not recognised as belonging to a flow, the packet is passed to the default router 55 which processes the packet header to determine the distributed router output port (i.e. the edge switch) to which the packet should be sent. The packet is then segmented and sent over an ATM PVC to the destination port, using the underlying ATM network in the normal way as shown in figure 6. ATM adaptation layer 5 (AAL5) is to be preferred for this purpose. During processing of the packet header, the default router may determine that this packet is (or is likely to be) the first part of a flow. If so, packet addressing information is passed to the IP connection control 41 (figure 4) via the default router. The IP connection control then processes the packet addressing information to determine its destination and requests the AAL2 connection control to establish a route for the flow through the AAL2 adaptation layer switch (ALS) network. The function of the ALS is described in B-ISDN ATM Adaptation Layer Type 2 Specification I363.2. The route may be established using a technique called 'Wormhole Routing'. A detailed description of this routing technique is given in our co-pending United Kingdom patent application No 9614138.7.

Although not shown in the drawings, it will be appreciated that sequence buffering may be provided at the network periphery to ensure the correct

ordering of the first few packets of a flow. Once the flow is established, the use of the permanent virtual channel allocated to that flow ensures that subsequent packets are maintained in sequence over the ATM network between the transmitting and receiving edge switches.

- 5 Wormhole Routing is a technique whereby the connection admission control (CAC) function is performed on the periphery of the network leading to a connection specification or 'worm' (figure 2) which defines the succession of the nodes and the AAL2 VC's to be used to reach the endpoint. The CAC function is supported by resource agents built into the ALS components  
10 which monitor the usage of resources and report any impending exhaustion to the CAC functions at the periphery. This technique furnishes a guaranteed route through the ALS network, choosing between multiple path options to take account of congestion and path availability. Once this path is established, an entry is made in the content addressable memory 53 so  
15 that future packets belonging to the new flow will then be recognised and in consequence be correctly directed via the ALS network..

One possible implementation of an ALS node is illustrated in figure 3, the AAL2 function is implemented as a VLSI component serving typically 8000  
20 channels. Multiple instances of this component are able to work over an ATM switch to achieve an ALS of  $n \times 8000$  channels. In one particular embodiment 'n' can range from 1 to 60 so that an ALS node of about 500,000 channels is possible. The resource agent function is implemented in a processor associated with each VLSI component to implement the  
25 'wormhole routing' within as well as between nodes.

At the far end of the link, flow based traffic is extracted from the AAL2 minicell stream and reassembled into IP packets in the terminating network adapter. The link layer information is added and the packet exits the  
30 distributed router via the terminating Ethernet interface.

In our arrangement and method, routing intelligence is distributed around the edge switches; intelligence is added as edge switches are added. The distributed router described therefore scales to very large sizes, and could  
35 be implemented to global dimensions. For example a network of 2000 edge switches and 200 tandem switches has the potential to provide 500 million

customers with 0.1 Erlangs of communication sessions with up to 5 flows in each session.

5 The value of AAL2 in this context is that its minicell structure eliminates the cell assembly delay normally associated with ATM. This is a well known problem at lower bit rates where the time required to fill an ATM cell before it can be launched may be unacceptably long. As an example, consider an IP flow comprising a voice service using G729 coding then G729 is an 8kb/s compression scheme which has a 10 byte frame and an encoding function  
10 which requires about 10 msec of processing. If this IP flow were to be packed into an AAL1 cell at four frames to a cell, then the cell assembly function would take 50 msec and a one cell receive buffer at the far end would add an additional 20 msec. This 70 msec delay inherent in the cell assembly process is a large part of the ITU objective of a maximum 150  
15 msec delay for terrestrially routed voice calls. By contrast, the use of AAL2 in the arrangement and method described above allows for example a 10 byte voice frame to be launched at the end of compression processing, typically taking 20 msec, and the minicell itself can form the receive buffer delay of 5 msec. The delay of the ALS switches is fixed and substantially  
20 less than 1 msec, giving a total delay of about 25msec rather than the 70 msec that was previously required. Thus, the use of AAL2 in our arrangement and method allows ATM to support compressed voice services with much lower latency and so allows IP voice services to achieve PSTN voice quality.

25 It will be understood that the above description of a preferred embodiment is given by way of example only and that various modifications may be made by those skilled in the art without departing from the spirit and scope of the invention.

**CLAIMS**

1. A method of routing traffic in a distributed router arrangement  
5 consisting of a plurality of edge switches interconnected by a plurality of tandem switches, the method including identifying flow based traffic in the edge switch and establishing a temporary connection into the destination edge switch whereby the packet is reconstituted into its original form for onward transmission.
- 10
2. A method of routing packet data traffic in a broad band network comprising a plurality of edge switches interconnected by a plurality of tandem switches, the method including determining from each said packet whether that packet forms part of a flow of packets, where a said packet is  
15 determined to be part of a flow, segmenting that packet into minicells for transmission over a permanent virtual channel established across the network for that flow, and where a said packet is not determined to be part of a flow, identifying a destination edge switch for that packet and transporting the packet to that edge switch via a default permanent virtual  
20 channel.
3. A method as claimed in claim 2, wherein the determination of whether a said packet is part of a flow is performed by comparison of information stored in the header of that packet with corresponding information stored in  
25 a memory.
4. A method as claimed in claim 3, wherein a route for a new flow is established by defining on the periphery of the network a succession of nodes and virtual channels (VCs) to be used to reach the destination of that  
30 flow.
5. A method as claimed in claim 2, 3 or 4, wherein the segmented packets constituting a flow are transported in ATM Adaptation Layer Two (AAL2) minicells.

6. A method as claimed in any one of claims 2 to 5, wherein said packets contain Internet voice traffic.

5 7. A distributed router arrangement consisting of a plurality of edge switches interconnected by a plurality of tandem switches, wherein flow based traffic is identified in each said edge switch and a temporary connection is established to the corresponding destination edge switch where the packet is reconstituted into its original form for onward  
10 transmission.

8. A broad band network comprising a plurality of edge switches interconnected by a plurality of tandem switches and having means for routing packet data traffic, the network including means for determining from  
15 each said packet whether that packet forms part of a flow of packets, means for segmenting a said packet determined to be part of a flow into minicells for transmission over a permanent virtual circuit established across the network for that flow, and means for identifying a destination edge switch for a said packet and transporting that packet to that edge switch via a default  
20 permanent virtual channel .where that packet is not determined to be part of a flow.

Figure 1

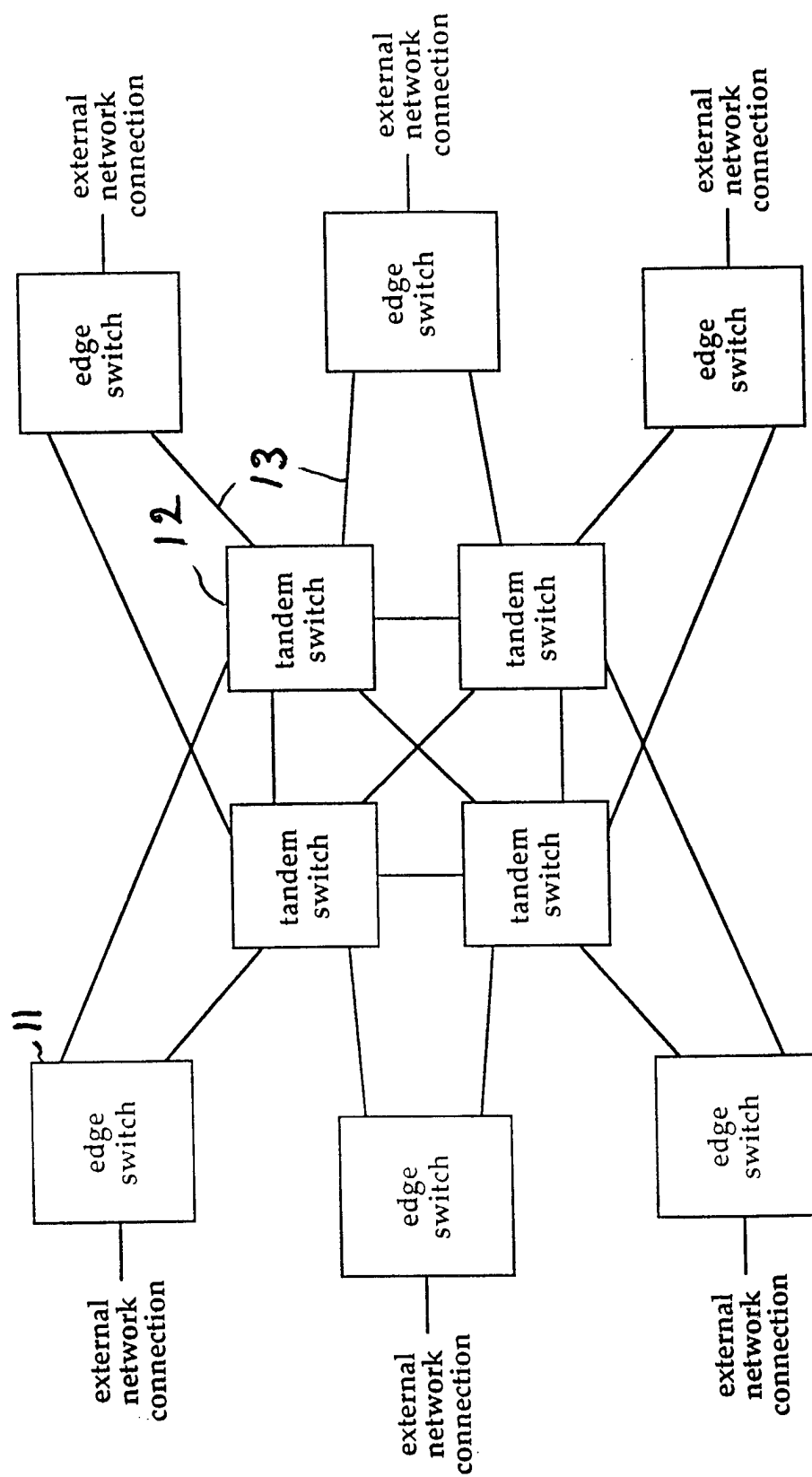
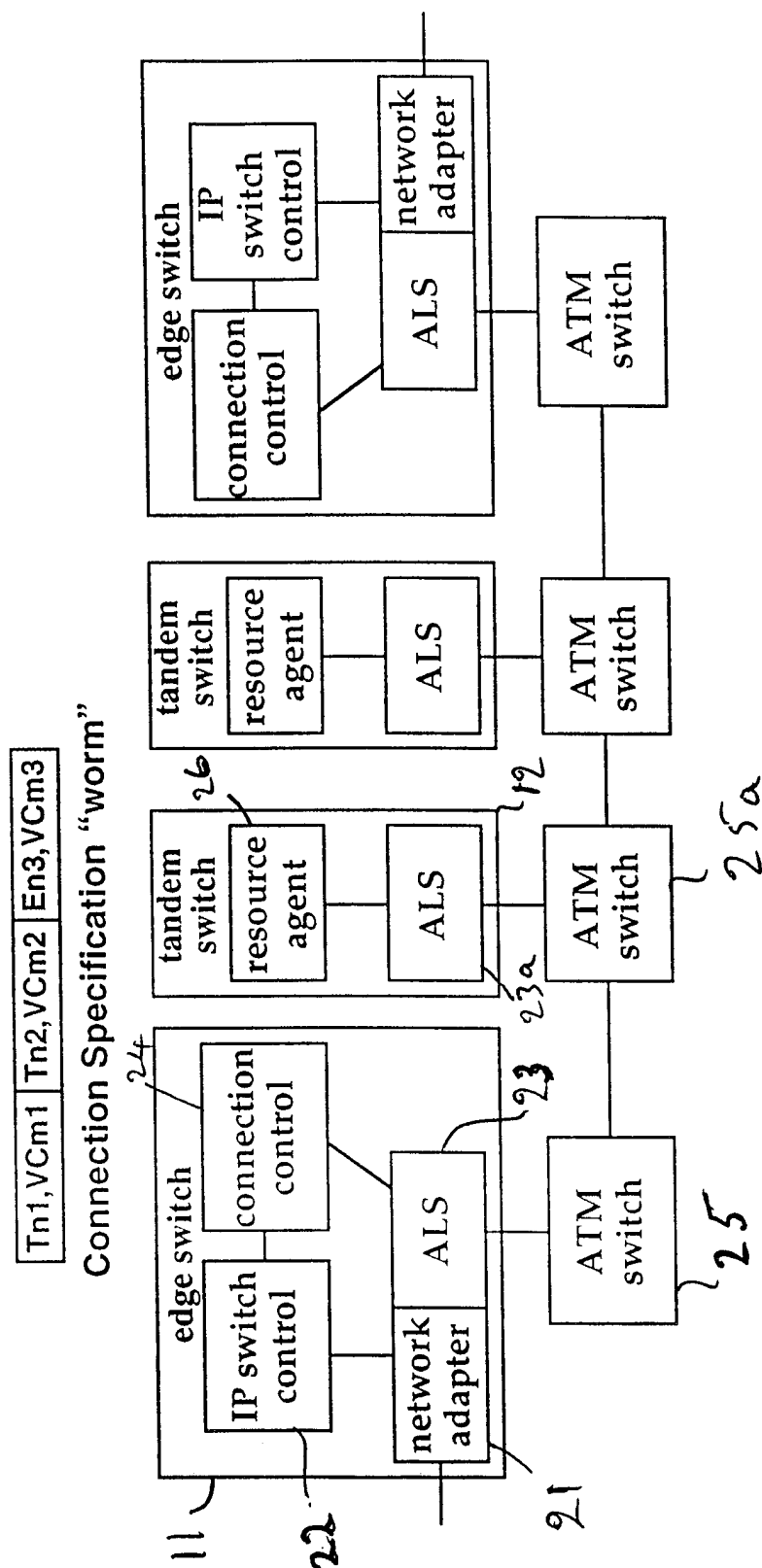


Figure 2



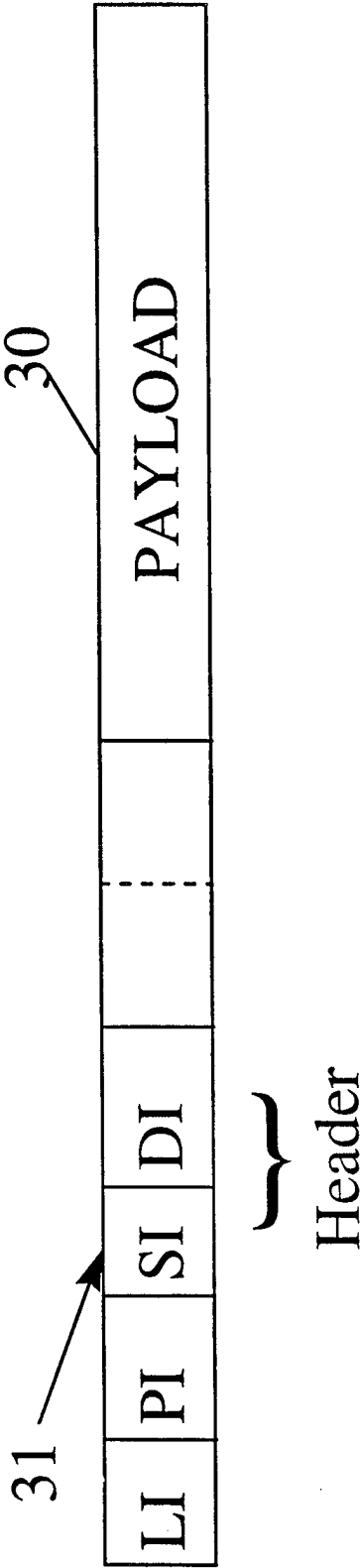


Figure 3

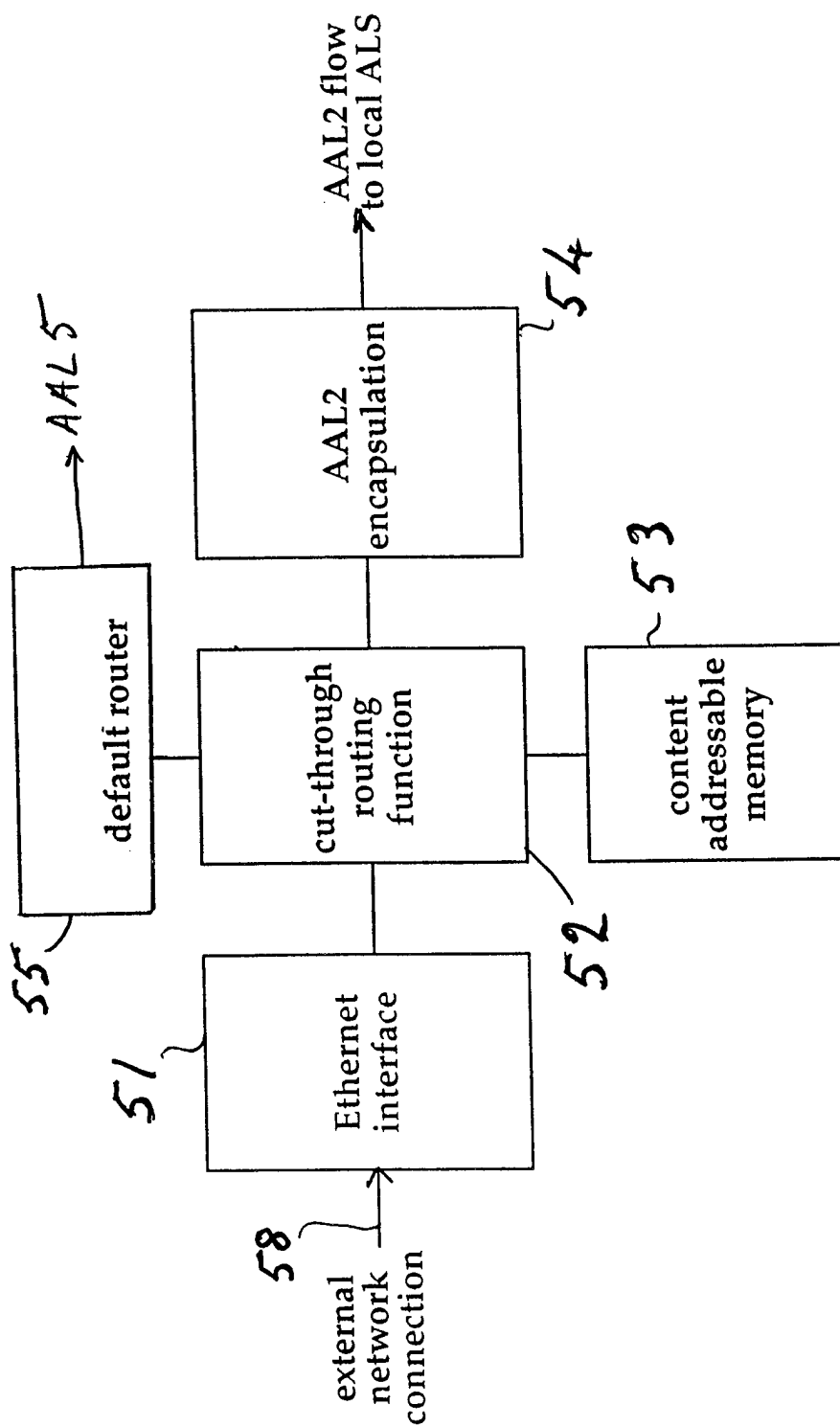
**Figure 4**

Figure 5

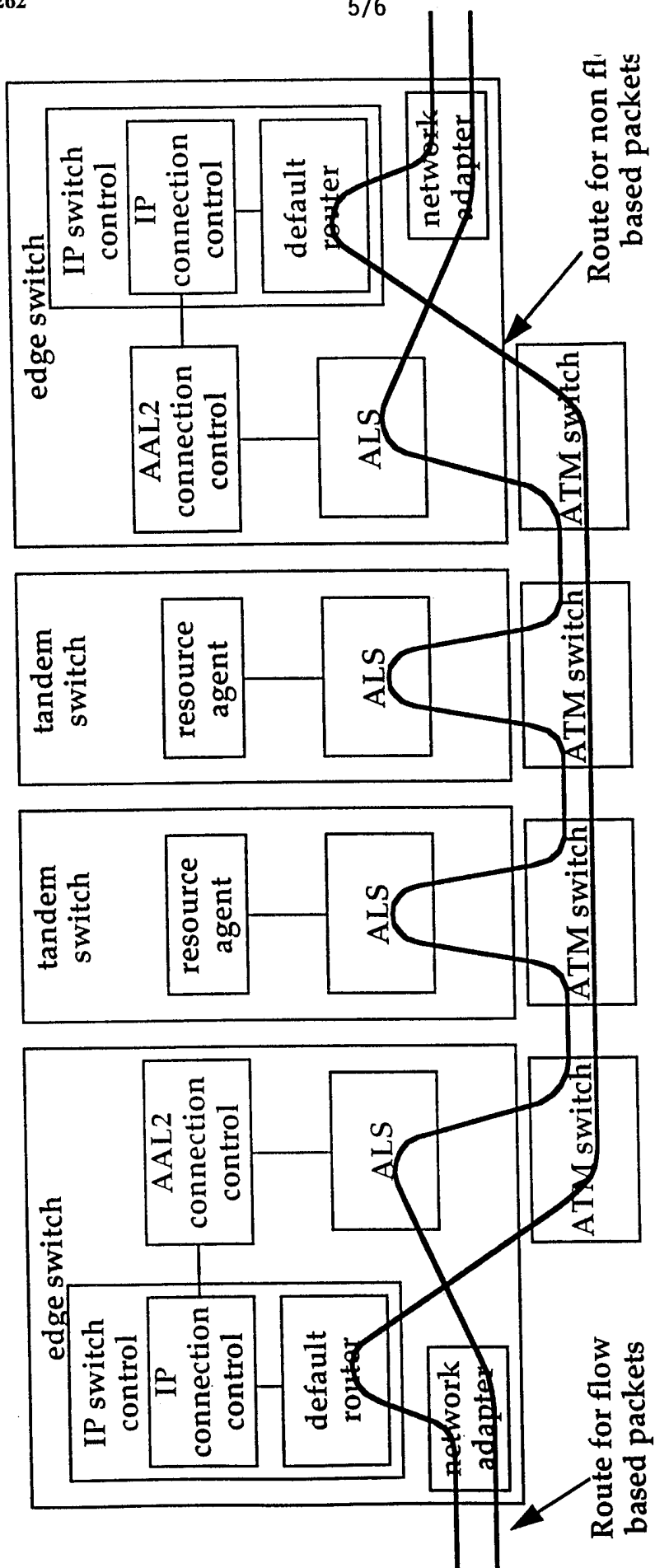
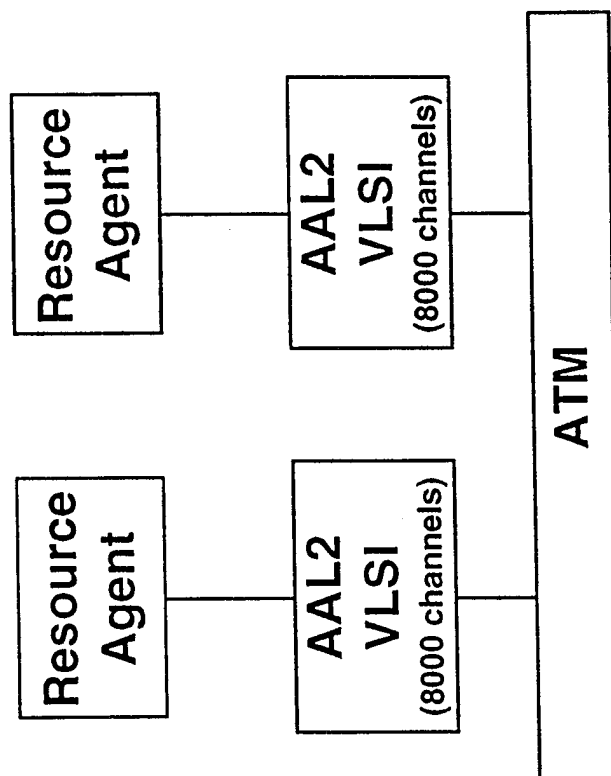


Figure 6



Adaptation Layer Switch Architecture

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 97/03300

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04Q11/04

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04Q

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                             | Relevant to claim No. |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X          | <p>PARULKAR G ET AL: "AITPM: A STRATEGY FOR INTEGRATING IP WITH ATM" COMPUTER COMMUNICATIONS REVIEW, vol. 25, no. 4, 1 October 1995, pages 49-58, XP000541650<br/> see page 50, left-hand column, line 34 - right-hand column, line 15<br/> see page 53, left-hand column, line 3 - page 54, right-hand column, line 30<br/> ---<br/> -/--</p> | 1-3,7,8               |

☒ Further documents are listed in the continuation of box C.

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Date of mailing of the international search report

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|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X                     | <p>BOX D F ET AL: "ARCHITECTURE AND DESIGN OF CONNECTIONLESS DATA SERVICE FOR A PUBLIC ATM NETWORK"</p> <p>NETWORKING: FOUNDATION FOR THE FUTURE, SAN FRANCISCO, MAR. 28 - APR. 1, 1993, vol. 2, 28 March 1993, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 722-731, XP000399339</p> <p>see page 723, right-hand column, line 21 - line 42</p> <p>see page 727, left-hand column, line 6 - right-hand column, line 40</p> <p style="text-align: center;">---</p> | 1-3,7,8               |
| A                     | <p>WO 95 17789 A (AT &amp; T CORP) 29 June 1995</p> <p>see page 2, line 11 - page 3, line 25</p> <p style="text-align: center;">-----</p>                                                                                                                                                                                                                                                                                                                                     | 2,5,8                 |

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Information on patent family members

International Application No

PCT/GB 97/03300

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