PNNI-based Routing Algorithm in ATM Network

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Abstract : In this paper, we propose an implementation scheme of source routing function, one of the characteristics, in applying PNNI protocol to ATM switching system. The proposed substance is a PNNI routing software structure design and source routing algorithm. The software structure guarantee maximal independence among blocks by keeping a function manager, composing a handling block separately, working together between those. As the path selection scheme has characteristics to choose real-time path and establish a path satisfying QoS, the source routing algorithm is desirable that pre-calculated scheme together with ondemand scheme is used.

Key-Words : ATM, PNNI, Source Routing, Path Selection

1. Introduction

Asynchronous The Transfer Mode(ATM) technology to make possible flexible assistance of high band and service quality settle down as key technology in Broadband Integrated Service Digital Network(B-ISDN) establishment, and play an important in supporting the high speed, large capacity, multimedia service, etc.

In ATM network, Switched Virtual Connection(SVC) service capability has to be supported in order to provide various call, connection establishment at on-demand, and for these, UNI signaling standard between usersnetworks and NNI standard to connect between nodes or networks are needed.^[1, 2]

In ATM network, the interface between networks or nodes uses the static routing method to be established statically, or the dynamic routing method to reflect a network form changing dynamically as sharing information in common as defining protocol for routing between nodes. ATM Forum already announce the Private Network to Network Interface(PNNI) protocol assistant dynamic routing, and it being widely applied from private network to public network^[3].

Under the PNNI, nodes involved in ATM network automatically construct a network topology, and dynamically re-structure a network configuration as changing of network. Also, as PNNI manages the network hierarchically, it provides the

network scalability and the routing path establishment function by using source routing technique to assure Quality of Service(QoS).

In this paper, we propose an application scheme of source routing function, one of the characteristics, in applying PNNI protocol to ATM switching system.

The remainder of this paper is organized as follows. In Section 2, we introduce the protocol of PNNI. In Section 3, we explain the source routing. In Section 4, we present the routing algorithm. Finally, we conclude the paper in Section 5.

2. PNNI Protocol PNNI Signaling Protocol **PNNI** Routing Protocol SAAL SSCF (0.2130) SSCOP (0.2110) AAL 5 (I.363) AAL 5 (I.363) ATM (I.150) Layer Physical Laver

Fig. 1. PNNI Protocol Stack

PNNI protocol is composed of routing protocol and signaling protocol as Fig. 1^{[3,4].}

As the PNNI routing protocol is the protocol to be required for selecting path between source node and destination node, it consists of topology data exchange procedure for exchanging network configuration information, database construction for network configuration, and path selection algorithm^[3]. The main function of PNNI routing protocol is the catching state of neighbor node and link, the routing database consistency between nodes, the flooding function of topology. PNNI uses hierarchical structure concept to apply for large network. The one of main characteristics of PNNI hierarchy structure is that the hierarchical network is formed automatically with means of address system containing topology. PNNI signaling protocol defines the flow of control message for point-to-point(PtP) point-to-multipoint(PtMP) connection set-up or through ATM network. PNNI signaling protocol is based on ATM Forum UNI3.1 and UNI4.0 signaling protocol. It supports alternate path routing by cranback procedure on the occasion of failing source routing and call set-up^{[4][5]}.

3. Source Routing

General networks use the static routing method to allocate a path to be planned in advance about selection of communication path, but the PNNI act as a dynamic source based routing protocol.



Fig. 2. Source Routing Architecture

The source routing scheme is that the source node

decide the hierarchical path connecting from a source to an object node on End-to-End, as shown in Fig. 2. In the middle via node of that path, it follows a path establishment command that source node select. In these cases, for choosing the reliable path in source node, the reachable information to each addresses and the topology information about available resource that each nodes have, are advertised periodically within network. As the case of periodical exchanging a routing information among network nodes(the topology information and reachable information) is larger increase in burden, the scope of network to apply the source based dynamic routing algorithm is restricted in actuality. To make up for this point, through the PNNI supports the hierarchical structure using address information and summarization characteristic about information, we support a scalability to be applied a large network by decreasing the routing information to exchange within network.

The PNNI describes an routing path information by using Designated Transit List(DTL) about the path to be decided by the source routing method. DTL is composed of node identifier(ID) array and transit pointer of current node, as shown in Fig. 3. DTL information elements show the path passing by PNNI routing domain from ingress node to egress node, and be loaded within SETUP message. The DTL shows an exact path from Peer Group(PG) to be belong to the current source node, passing by Hop-by-Hop a Logical Group Node(LGN) of a higher hierarchical PG of PNNI hierarchical structure, to arrive a destination node.

DTL length
СТР
Port_ID
Node_ID(1.1)
Node ID(1.3)
DTL length
СТР
Port ID
Node_ID(1)
Node_ID(2)

Fig. 3. PNNI DTL Stack

4. Routing Algorithm

4.1 Routing Software Architecture

We propose a software structure for PNNI routing protocol in Fig. 4. The function of each software manager is as follows.

<u>Hierarchy Manager</u> is the base component for all other managers. Its role is to create, delete, and manage the PNNI logical nodes. It also handles configuration data with the operator interface.

<u>Topology Manager</u> maintains the topology database for a PNNI logical node. It generates local topology information, and adds remote topology information through the hello process, database synchronization and flooding process with other nodes..

<u>Routing Manager</u> generates a proper route for a path request from the signaling. For a route generation, we use two algorithms together: precalculation and on-demand calculation algorithm.

<u>Protocol Manager</u> converts the internal control messages from the Message Handler into PNNI routing packets and converts the PNNI routing packets from adjacent nodes into internal control messages.

<u>Message Handler</u> distributes internal control messages between the *Protocol Manager* and correspondent processes defined in *Topology Manager*.



Fig. 4. PNNI Routing Software Structure

4.2 Path Selection Algorithm

ATM connection requirement possess the various characteristics in the traffic type, bandwidth, QoS, etc.. Therefore, it is difficult that we find the path having various connection characteristics in source node. The path calculation of PNNI will accomplish the optimal path after due consideration of reachable address, QoS, Generic Call Admission Control(GCAC) algorithm, etc..

The PNNI choose the destination as "Longest Address Prefix Match". In large network, it is possible that a various path to be possible selection exists at the same time, and the final one path selection among these is decided by the routing algorithm. In PNNI routing protocol specification, the routing algorithm calculating a routing path is not defined. As the routing algorithm is an key element in call blocking probability indicating service quality and connection establishment delay, it is desirable that we use a fit algorithm.

Although Dijkstra algorithm supplies a method to select a shortest path by using one QoS parameter, the researches of path selection about additive QoS parameters(such as delay, cost, bandwidth, cell loss, etc) do continuously^{[5, 6].} However, the path selection to optimally satisfy about the additive QoS parameter is known as NP-complete[Garey, 1979].

For selecting the path, the routing protocol must know the connection characteristics and status of node within network. The characteristics of connection are known from Information Element(IE) to be got loaded on call establishment message(setup message), and the information of network resource is known from the PNNI topology information.



Fig. 5. QoS Routing Algorithm Flow

Fig. 5 is the rough flow about routing algorithm. *The Routing Manager* is searched a new path directing to destination node by referencing the destination address and DTL.

- In the case of call to occur in a current node, this call search destination node by analyzing a reachable address in order to create a new path directing to destination point.
- Calculate the path by using a destination node and QoS parameter(4.2.1 reference), and perform GCAC(4.2.2 reference).
- If a reasonable path is decided, construct DTL and require a call connection through finding a local port about neighbor node.
- If it is not the call to be occurred at current node, create a routing information(DTL) about a new entered peer group through expanding DTL information.

4.2.1 The Path Calculation Scheme

The PNNI support two type of path calculation schemes. As one is pre-calculated scheme, it previously found out a path supporting various connection characteristics about from any node to all object nodes that it is possible to reach. The precalculated scheme is proposed for somewhat decreasing the processing overhead to find a possible path to select. As another is on-demand scheme, it is a scheme to apply when it is not satisfied with precalculated scheme about the connection characteristics for users to require.

As the routing algorithm applied to switching system has characteristics to choose real-time path, it is desirable that pre-calculated scheme together with on-demand scheme is used.

In this paper, it is prepared a possible establishment routing paths within network by using Dijkstra algorithm with a Administrate Weight (AW) parameter when the routing table is constructed by PNNI routing protocol in the switching system. When the connection established by signaling request, the calculation for selecting the routing path is not done, and find out a path satisfying among the previously calculated routing paths. If it does not find out a path satisfying QoS to require of signaling among the previously calculated paths, it calculates the path satisfying QoS by using on-demand scheme. Even the network is composed of multi-level, regard a peer group of higher level as one node(LGN), it does the path calculation by scheme similar to single level through using the Up-Link.

4.2.2 Generic Call Admission Control(GCAC)

Generally, as the Call Admission Control(CAC) algorithm is dependent on implementation, it implement with each different type in ATM switches. Therefore, if we consider from PNNI protocol point of view, we do not forecast whether each nodes are selected what call admission standard, and each nodes on DTL of the selected path at source node do not exactly correspond to the physical node, and correspond to the logical node to be expressed by aggregated information. Therefore, the very exact CAC algorithm is not drove in PNNI, rather judges whether nodes receive the call.

We accept the GCAC concept by considering these limits. The GCAC is performed in order to find out whether the nodes exist in possibility to accept a connection. That is, as it does forecast the possibility of call admission, it is not exactly perfect. Therefore, it dose occur the case that the call is failed among the DTL nodes of selected path at source node, and in this case crankback procedure is used for re-routing effectively.

Therefore, the PNNI selects the paths supporting a connection which user required according to GCAC algorithm that among the various paths.

4.3 Designate Transit List(DTL) Handling



Fig. 6. DTL Handling Flowchart

The DTL handling function judges whether first of all current node is ingress node, or transit node, or egress node about appropriate call in the case of receiving a request from the PNNI signaling protocol. If the current node is not ingress node, it finds the local port information necessary call establishment after it looks for a neighbor node being routed with the received DTL. If the current node is ingress node, it updates the DTL by performing the path selection function for finding out a new path toward destination point.

5. Conclusion

In this paper, we described a dynamic routing based source routing for PNNI protocol application on ATM network.

The source routing scheme is that the source node decide the hierarchical path connecting from a source to an object node on End-to-End. In this case, for choosing the reliable path in source node, the information about reachable to each addresses and the topology information about available resource that each nodes have, are advertised periodically within network.

It is difficult that we find out a path to be guaranteed QoS in the source node. The path selection to optimally satisfy about the numerous QoS parameter is known as NP-complete, and there is necessity for the path selection scheme that we select an optimal path about one QoS parameter(AW), guarantee a various QoS parameters to satisfying that path.

As the routing algorithm applied to switching system has characteristics to chooses real-time path, it is desirable that path pre-calculated scheme together with on-demand calculation scheme is used.

Even the network consist of multi-level, regard a peer group of higher level as one LGN, it does the path selection by a scheme similar to single level network through using the Up-Link.

In the future, we continuously research about path establishment techniques for PtMP and satisfying various QoS parameters.

References

- [1] ATM Forum Specification, "af-uni-0010.002 : ATM User Network Interface Specification Version 3.1", Sep., 1994.
- [2] ATM Forum Specification, "af-sig-0061.000 : ATM User Network Interface Specification

Version 4.0", Jul., 1996.

- [3] ATM FORUM " ATM Private Network/ Network Interface Specification, Version 1.0", af-pnni-0055.00, Mar. 1996.
- [4] J M Scoot. and I G Hones : 'The ATM Forum's private network/network interface', BT Technol J,Vol 16, No 2, April. 1998.
- [5] Shigang Chen Klara Nahrstedt, "On Finding Multi-constrained Paths", IEEE ATM'98 proceedings, pp874~879, 1998.
- [6] A. wata, R. Izmailov, D.S. Lee, "ATM Routing Alogrithms with Multiple QoS Requirements for Multimedia Internetworking". IEICE Transactions on Communications, Vol. E.79-B, No. 8, pp9999~1007, August 1996.