PNNI And The Optimal Design Of High-Speed ATM Networks

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In addition to being well-dimensioned and cost-effective, a high-speed ATM network must pass some performance and robustness tests. We propose an approach to ATM network topology design that is driven by the performance of its routing protocol, PNNI. Towards this end, we define performance indicators based on the time and traffic required for the protocol to first enter and subsequently return to the meta-stable state of global synchrony, *in which switch views are in concordance with physical reality. We argue that the benefits of high call admission rate and low setup latency are guaranteed by our indicators. We use the PNNI Routing and Simulation Toolkit (PRouST), to conduct simulations of PNNI networks, with the aim of discovering how topological characteristics such as the diameter, representation size, and geodesic structure of a network affect its performance.*

1 Introduction

The size of operational ATM clouds continues to grow at an increasing pace. Both in anticipation of this changing scale, and to insure smooth inter-operation of these networks, the ATM Private Network-Network Interface standard (PNNI) was recently adopted (ATM Forum 1996). PNNI defines a set of protocols for *hierarchical* networks of ATM switches, and is designed to provide efficient and effective routing. In the long term, however, the degree to which PNNI succeeds in this regard will depend crucially on two factors:

First, because PNNI does not mandate specific policies for call admission, route selection, or topology aggregation, these aspects of the protocol remain "implementation-specific". Clearly the degree to which PNNI meets the challenges posed by tomorrow's ATM networks will depend significantly on the success of *switch designers* in devising effective algorithms for the admission and routing of connections, and for the aggregation of topology information.

Second, *network designers* must have the tools and information necessary to design ATM network topologies that are (i) capable of meeting anticipated traffic demands, and (ii) *optimized for performance under PNNI.* In this paper, we shall not address the first of these two issues, that of dimensioning networks to satisfy known costs and traffic demands. Our investigations begin at the point where a network designer, having been given projected traffic profiles and switch/fiber specifications, has arrived at a set of candidate ATM network topologies which appear equally adequate. We argue that although two topologies may appear indistinguishable in terms of the mathematics of QoS requirements, the PNNI protocol exhibits significant differentiation in their performance. Understanding how the PNNI protocol affects network performance is a necessary first step to determining how the adoption of PNNI *should* affect ATM network design. In subsequent sections, we shall describe our simulation experiments and begin developing guidelines for ATM network topology design that take into consideration the specific nature of the PNNI protocol.

2 PNNI Performance Indicators

There are many candidate performance criteria for evaluating the relative merits of network topologies. Here we shall assume that topology design is motivated by increasing the ATM network's call admission rate and decreasing the average connection setup latency. Additionally, we desire that the background traffic due to the PNNI protocol itself, should not be excessively high.

Setup Latency. In the absence of crankback, setup latency within a peergroup is seen to be linearly correlated with the number of hops in the selected path (Niehaus et

Topology name	16/3	16/5	32/3	32/5
Chain length	8	8	32	32
Hierarchy structure	16,8,1	16,8,4, 2,1	32,16,1	32,16, 8,4,1
Boot time	90.27s	120.32s	75.49s	150.32s
Boot traffic	587K	611K	1420K	1717K
NNI boot traffic	1.8K	3.1K	3.9K	6.8K
Resync. time	0.24s	0.16s	0.51s	0.38s
Resync. traffic	233K	215K	1191K	638K

Table 11: Simulation results for several hierarchy configurations.

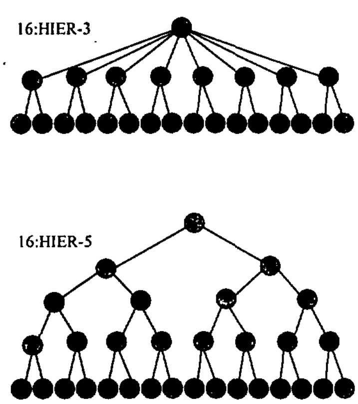

Figure 14: Two examples of hierarchic structures simulated.

boot and resynchronization traffic and introducing hierarchy results in improved resynchronization time and traffic, although it has a minor side-affect of increasing the boot time.

Peergroup size and hierarchy structure are two of the most importance choices a network designer must make. In our future research efforts will focus further on these two parameters. As we have shown in [section 3.7] there is an optimal value beyond which reduction of peergroup size results in increased resynchronization traffic, due to the re-aggregation and downward flooding of higher level links in response to changes at lower levels. We intend to precisely quantify both this optimal value, and the relative tradeoffs between peergroup size, hierarchy structure and resynchronization traffic and time.

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