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Proposal for Research Distribution of Gigabit Network Technology

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Proposal for Research Distribution of Gigabit Network Technology

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Abstract

In 1993, ARPA funded a major program at Washington University to create gigabit networking technology and create a gigabit testbed based on this technology. This program is now nearing the end of its first year and is making excellent progress towards its research and technical objectives. This note a proposes a program that would lead to the export of this technology to research groups in networking and gigabit applications with an interest in using it to further their own research activities.

Proposal for Research Distribution of Gigabit Network Technology

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Washington University is in the process of designing and implementing a gigabit testbed based on a novel ATM switch architecture and a high speed host-network interface design. The testbed will include six ATM switches supporting link speeds of 600 Mb/s, 1.2 Gb/s and 2.4 Gb/s and will be used to implement a variety of demanding applications. This project is being supported primarily by ARPA and NSF. The switching systems support general multipoint communication and can be remotely controlled from a workstation residing on the network. The host interface will provide highly efficient data transfer to and from system memory on Sun workstations, allowing the potential for sustained, full-duplex data transfers to/from applications at 600 Mb/s. We expect to test prototypes of the key components during 1995 and complete the testbed in 1996.

The technology components being created for the project can provide an attractive research vehicle for groups interested in pursuing work on switch control, higher level network control, gigabit applications and even hardware design alternatives. We propose that ARPA, perhaps in cooperation with NSF and/or other agencies, sponsor a program that would allow a variety of different groups to obtain *Gigabit Network Kits* consisting of a switch and four interface cards, for use in gigabit networking and applications research projects. The kits would also include a basic software package that can be used to control a switch from a workstation, a complete documentation package, including high level descriptions of the system architecture and principles of operation, as well as details of the design and implementation. Draft copies of the current system architecture documents for the switching system and ATM Port Interconnect Chip (used for the host interface card) are included as appendices, to indicate the level of detail that will be provided to researchers. In addition, there will be descriptions of physical characteristics and a tutorial on how to set up and begin using the gigabit network kits. Washington University would manage the production of the kits, provide a set of seminars and training sessions for technical staff from the supported research teams, would provide basic support services and would manage a mailing list to disseminate information and updates and answer common questions.

The gigabit switching systems being created for the project have eight ports each that can run at speeds of up to 2.4 Gb/s. The initial configuration will be packaged in a desktop unit, approximately the size of a workstation system unit. It will comprise a main circuit board that includes the core ATM switching components and six line interfaces. The remaining line interfaces will reside on two line cards that will each be about half the size of

the main board and mounted parallel to it. The six line interfaces on the main board will be implemented using Hewlett-Packard G-link chips and 850 nm optical interfaces. They will operate at either 600 Mb/s or 1.2 Gb/s (selectable by separate on-board jumpers for each port). Two types of line cards will be implemented. One will consist of a pair of G-links and associated optics operated in parallel to give an effective 2.4 Gb/s link. The second type of line card will include two SONET interfaces, one at 150 Mb/s and another at 600 Mb/s. These will share a common port on the core switch but can be operated completely independently. The 150 Mb/s interface will be a multimode fiber interface, satisfying the ATM Forum specification and the 600 Mb/s interface will be single mode, at 1320 nm, making it compatible with standard SONET equipment. We propose that a basic network kit include a switch with two of the G-link pair line cards, plus one of the SONET line cards. The host-interface cards will also be implemented using G-links that operate at 600 Mb/s.

The G-link interfaces are being implemented with 850 nm optics which can operate at distances up to 1 km. This choice was made to reduce costs and is not expected to limit the research value of the equipment. However, the selected optical devices have pin-compatible equivalents at yy nm, allowing users to replace them if there is a need to operate over longer distances. Detailed instructions can be provided to users who wish to exercise this option.

The switching system is designed to be controlled from a remote workstation that sends specially formatted control cells over the ATM links. Since these kits are intended as a research vehicle, we do not propose to provide a complete signaling software package, but rather a minimal set that would give research users complete flexibility in operating the switches as they choose. While it is expected that a certain amount of higher level software will also be available, as a result of ongoing research activities, these packages will be distributed but not necessarily supported.

The interface between the line card and the main switch card will be fully documented to permit research groups who wish to, to design and implement alternative daughter cards. This can provide a vehicle for implementing experimental congestion control hardware, without interfering with the core switch functions.

Experimental programs can be expected to fall in one of several categories.

- *Application experiments.* Research groups might implement parallel or distributed applications on top of the gigabit network kit. For most such groups, a single kit consisting of a switch and four host interfaces should suffice. Other groups might require several kits to mount an interesting demonstration.

- *Switch control.* Projects that experiment with software that creates and modifies multipoint virtual circuits dynamically could be carried out using a single kit. The kit would support work on new models for network signaling or novel distributed operating system models that directly control network resources to provide higher level user services.

- *Routing and congestion control.* Researchers who wish to carry out research on network level routing (including multicast virtual circuit routing) and congestion control

will likely require multiple kits in order to carry out interesting demonstrations. This might be handled by distributing single kits that can be used for development and testing and then bringing several groups together, along with their network kits. for a "bake-off" at a gigabit technology workshop.

- *Gigabit hardware design.* Since the chip set being designed for the gigabit switch and the APIC is being fully specified in VHDL, there is some possibility for research groups with the appropriate expertise to create custom modifications, in order to implement novel features.

- *System software.* The host-network interface that will be supplied with the kits can be used in a variety of different ways by operating systems and higher level software. Researchers interested in experimenting with distributed-shared memory models of communication or management of multimedia streams will find that the kits provide an appropriate platform for such research projects.

- *Host-network interface design.* The APIC can provide the basis for a variety of different device interfaces, including direct display interfaces, direct interfaces to mass storage devices, etc. Research groups with the appropriate expertise could obtain additional copies of the APIC to support novel host interface designs, while using the gigabit network kits as a base upon which to build and as a concrete example of a fully implemented design to help guide their own design efforts.

The cost of building the gigabit network kits will depend strongly on the number that are produced. For the small quantities we plan to produce for our gigabit testbed, we currently estimate that it will require about $40,000 per switch, for switches with only G-link interfaces and $5,000 per host-interface card. This leads to a per kit cost of $60,000. If several tens of kits were produced, we expect this could drop as low as $30,000, based on reduced parts costs due to larger quantity purchases and likely reductions in component costs over the next year. In addition to the direct parts costs associated with the project, there would be costs for technical staff to do final assembly, testing and shipping, as well as providing on-going support. We expect that the cost of these additional services would be approximately $300,000 over two years, assuming between twenty and thirty kits were involved. If a larger number were required, these costs would increase somewhat, but the incremental costs of building additional kits and providing continued support over two years would be unlikely to exceed $5,000 per additional kit. Using these estimates, a program that provides for the production of 25 kits would require about $1.3 million and additional kits might cost $35,000 each, implying that a $2 million program could support the production of 45–50 kits.

From a contractual standpoint, this could be added to Washington University's existing ARPA contract by modifying the statement of work and adding a supplementary budget. Negotiations on these terms could be completed by the end of this year, but I would prefer to leave some flexibility in the budget to allow for fluctuations in parts costs. The bulk of the costs would be incurred at the end of 1995, but some funding would continue through the end of 1998 for ongoing support of the funded research groups.

We propose that ARPA (perhaps together with other agencies) initiate a program inviting research proposals from groups around the country, describing research programs that would take advantage of the gigabit network kits. While the program would be targeted primarily at university researchers, it could also include researchers from various government labs and even industry. The program could be structured as a straight equipment grant program or could be coupled with additional research funding to the proposing organizations (or a combination of these). Washington University would provide background information packages for proposing groups, would respond to technical queries during the proposal preparation phase, and could assist in the proposal evaluation, if desired. Groups selected for awards would be expected to participate in regular workshops to report on their activities and to publish their results in research conferences and journals.

A possible timetable for the program would include announcement of the program by March of 1995, with proposer workshops taking place through March and April, with proposals due by July 1, 1995. During the summer and fall of 1995, the proposals would be evaluated and final decisions would be made on the number of kits to be produced, based on the number and quality of the proposals, results from initial prototype evaluation and updated parts costs. Awards could be announced by the end of the year, training seminars for winning research groups would be held in early 1996 and kits would be shipped during the spring of 1996.

Projects should be selected on the basis of the novelty and potential value of the research ideas contained in the proposals, together with the competence of the individual researchers, sources of related support and the likelihood that the research team can meet the obligations contained in the proposal. The selection process for these awards could be made by either government reviewers or a panel of peer reviewers. For a program of this nature, mail reviews do not seem to be necessary. I would recommend that proposals be kept short, to permit the review panel (however constituted) to gain a comprehensive understanding of all the proposals, allowing them to be ranked appropriately.

We believe that the program outlined can have a significant impact on the quality and quantity of research activities in gigabit networking and applications throughout the United States, could enable a broad cross-section of university faculty, research staff and graduate students to pursue experimental research on advanced networking technologies and could promote more rapid transfer of gigabit technologies into commercial products. Washington University is eager to participate in such a program and stands ready to take an active role in ensuring its success.