Archive - Potential NGI Applications

Distributed Positron Emission Tomography (PET) Imaging: sponsored by The National Institutes of Health

Categories

Medicine, Distributed Computing

Vision

Enhance the ability of biomedical scientists to conduct animal research through the development of high resolution PET scans and ATM transmission of the resulting reconstructed 3-D images.

Why NGI?

Studies using PET imaging techniques typically generate data sets of 4 gigabytes. Times for data acquisition and 3-D volume rendering are dropping dramatically with advances in technology, leaving transmission time as the rate-limiting factor in these studies In order to eliminate this week link, speeds associated with the NGI are necessary.

Description

In collaboration with the Nuclear Medicine Department and the Positron Emission Tomography Department of the NIH Clinical Center, DCRT is developing methodology and providing parallel computing and high speed networking support that is contributing to the development of the world's first production animal PET scanning facility. Such a facility could become an unprecedented tool to investigate physiological, behavioral, and genetic manipulations that might otherwise be inaccessible to conventional (and usually destructive) measurement methods. The development of such a facility poses many technological challenges since the resolution required for

such studies is on the order of 1 mm. Conventional PET imaging systems are only capable of providing 4-5 mm resolution reconstructions. In this facility, a small animal is placed between detectors and slowly rotated for several hours, producing very large data sets. The data is transmitted to available parallel supercomputers where it is used to generate a 3-D volume image. The performance of a parallel supercomputer is needed to implement the novel expectation maximization algorithms used in the 3-D reconstruction process. The 3-D reconstructed image is transmitted from the supercomputer back to the biomedical scientist for visualization and analysis.

Rationale

The mission of the National Institutes of Health is to provide for advances in medical care. Many of these advances will be dependent on the presence of a high speed, low latency, secure digital information infrastructure as represented in the NGI program. Medical advances discovered by the NIH have traditionally been transitioned to the private sector for further development.

Requirements

Bandwidth:
OC3 ATM links (155 Mbits/sec) would provide the minimum required bandwidth. Future developments in detector technology and data acquisition methods would result in large volumes of data that would require OC12 ATM links (622 Mbits/sec) performance. A typical study consists of 10 scans, each of which produces up to 50 million 8-byte counts, for a total of 4 GB of raw data per study. The time required to reconstruct the 3-D volume from this data is about one hour using 16 nodes of an IBM SP-2 parallel supercomputer; however, this time will drop substantially as faster hardware becomes available in the future. The time required to acquire the data will also drop dramatically due to advances in detector technology. Therefore, the time required to transmit the 4GB of input data into the computer can become the rate-limiting factor in the speed of processing an entire study. An OC3 ATM link, which can transmit 4GB in about 5 minutes, would be considered the minimum requirement. However, as mentioned above, future developments would require OC12 ATM links.

Latency:
The transmission of large data sets is not an interactive application, so latency is not a critical issue. However, it should be noted that sliding-window protocols such as TCP/IP perform significantly worse on networks with very large bandwidth-delay products, so the need for relatively low latencies is important to achieve full utilization of high-speed links.

Security:
The data transmitted for this application are typically for open research studies that are not sensitive in the same way that patient data might be, so security is not a primary concern. However, appropriate security precautions must be taken if any proprietary

research data are being transmitted, or if the technique is extended to human clinical applications.

Reliability:
High reliability is not a major issue in this application because the network is used as a bulk data carrier, not a real-time control system.

Scalability:
The bandwidth available on the network should be scalable so that the capacity can be increased in the future in response to potential increases in demand. Certain networking technologies easily support scalable bandwidth; for example, simply establishing additional switch-to-switch links increases the bandwidth between two ATM switches. (An example of a non-scalable network technology is Ethernet, which disables redundant links instead of balancing the offered load across them.)

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URLs

http://www.nlm.nih.gov/research/telfront.html