

BAXGrid: A software package for the remote analysis of functional MRI data using grid technology

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Introduction

Intensive analysis of brain imaging data such as that of functional magnetic resonance imaging (fMRI) or magnetoencephalography (MEG) often requires considerable computing resources, which in most cases are not readily available in many medical imaging facilities. Moreover, some specialized technical know how are required to use and maintain these resources. Here, we present a software package, BAXGrid, for the analysis of fMRI data using remote computational servers. The package makes access to the remote servers transparent to the users as if all the computations are done locally. BAXGrid is part of the Medical Grid Project (MGP, www.medgrid.org) Testbed formed to study and demonstrate the idea of using grid technology for medical applications. The MGP testbed is composed of several sites in Japan and in the Philippines, as shown in Fig. 1.

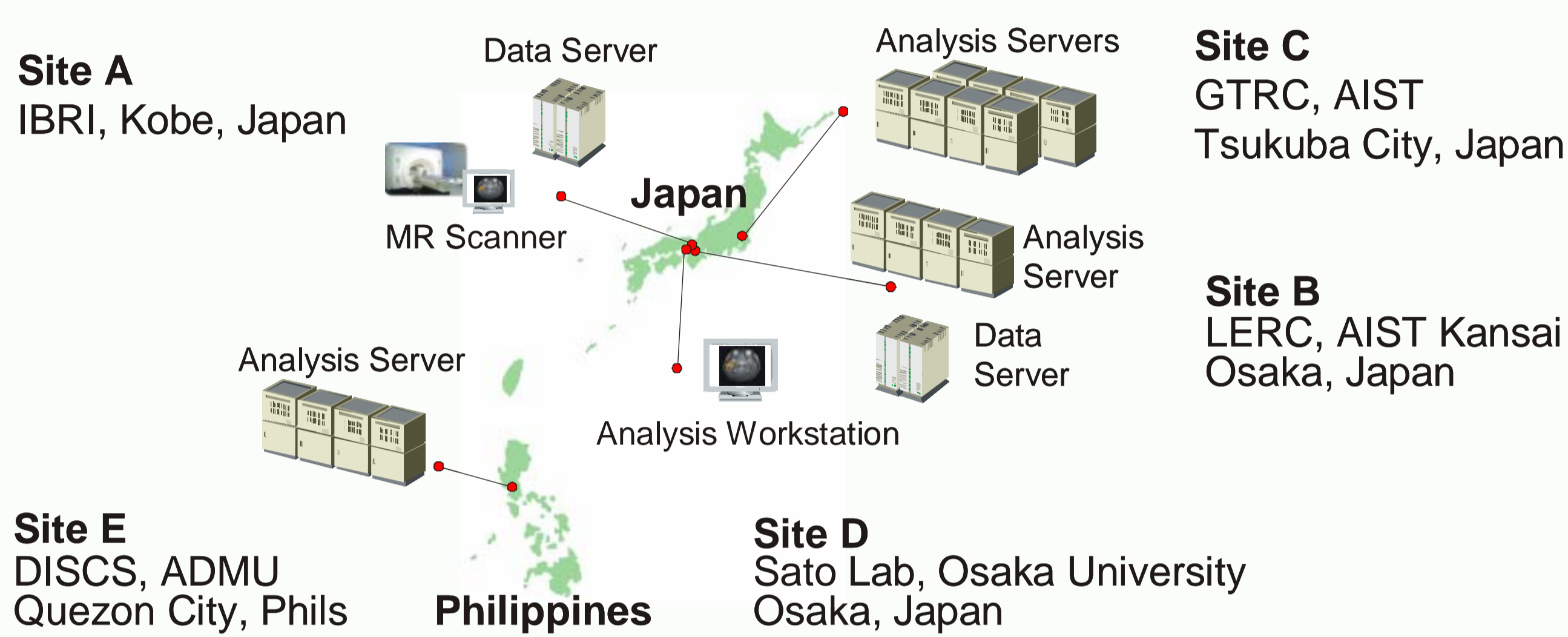
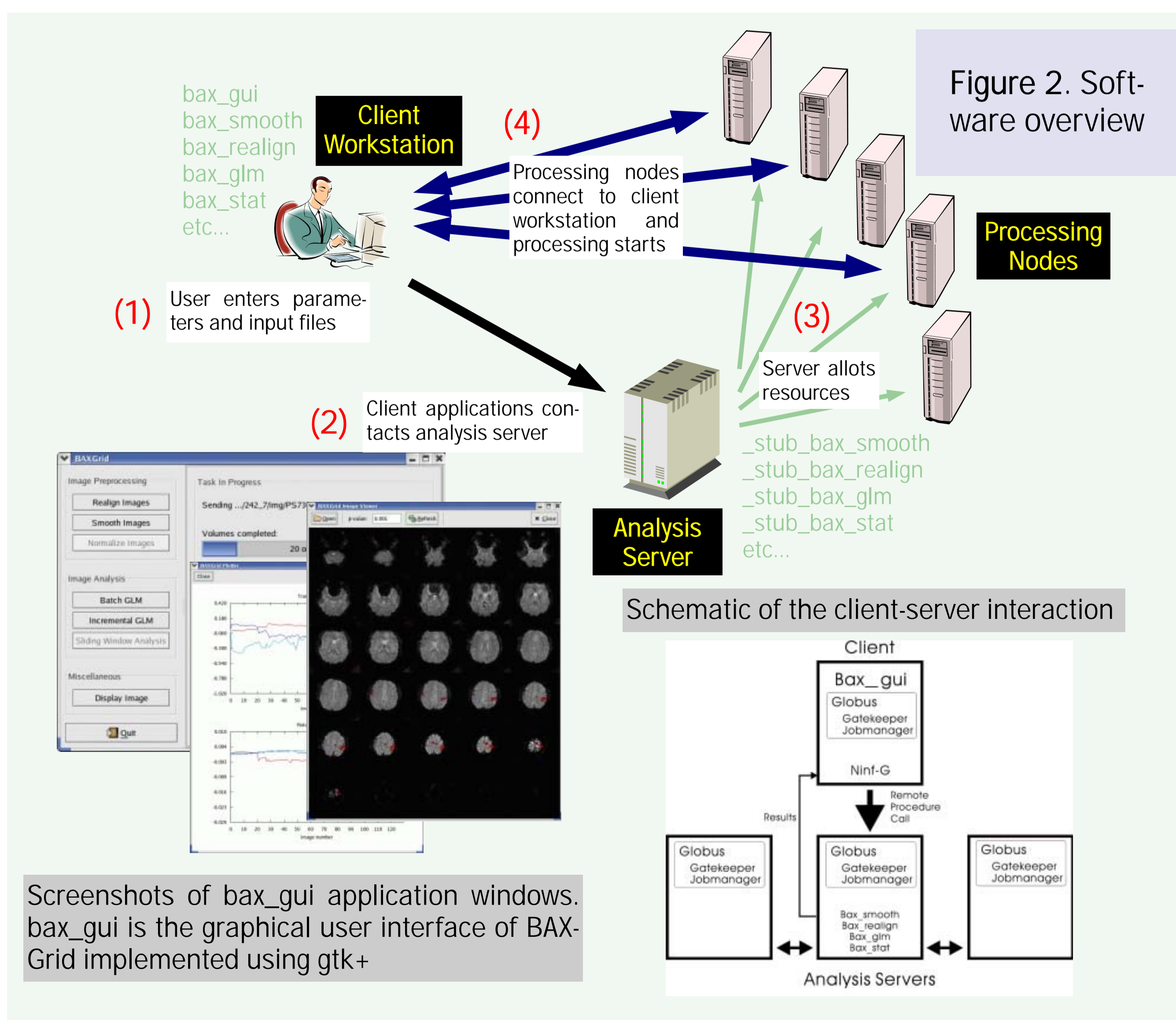


Figure 1. The Medical Grid Project (MGP) Testbed for the analysis of functional MRI data sets. MGP is composed of several sites in Japan and in the Philippines and is formed to study and demonstrate the idea of using grid technology for medical applications.

Software Overview and Design

The package is built on top of the Globus Toolkit (<http://www.globus.org>) and Ninf-G (<http://ninf.apgrid.org>). The Globus Toolkit provides the necessary infrastructure (e.g., security, remote access, etc) for running remote applications, whereas Ninf-G hides programming complexities and manages the transfer of data and analysis results automatically. The package is composed of both client and server components. The client component runs on the user's local machine and provides an easy-to-use interface, while the server component is responsible for the actual data processing and runs on remote high performance computers. Figure 2 gives the overview of the package and the interaction of the different components. Currently, the package runs only on Linux machines but extension to other operating systems using the Java language will soon be implemented.



Screenshots of bax_gui application windows. bax_gui is the graphical user interface of BAX-Grid implemented using gtk+

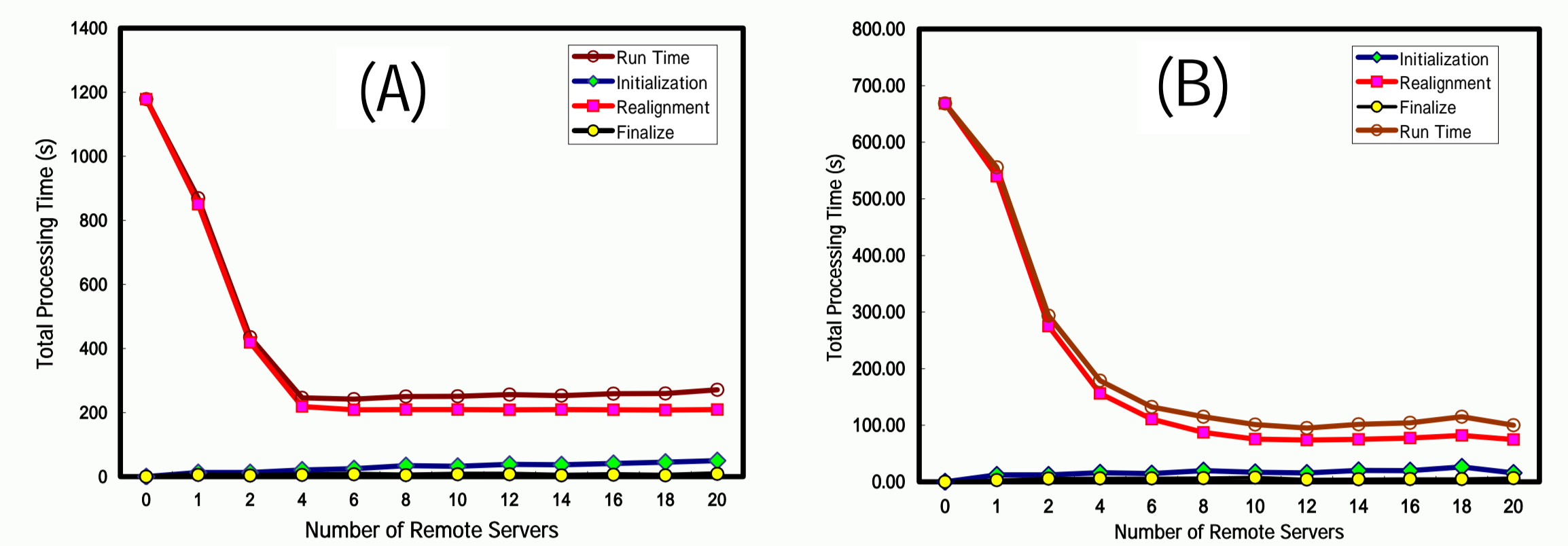


Figure 3. Total processing time in realigning a data set with 130 volumes 128 x 128 x 30 in size as a function of the number of remote servers employed (A) from a client workstation (CW1) in Site D to the analysis servers (AS) in Site C (wide area network), and (B) a client workstation (CW2) in the same network as the analysis servers in Site C (local area network). The value 0 for the number of remote servers means the processing was done locally, that is, within the client machine. (CW1 - PIII 1.0GHz; CW2 - Intel Xeon 2.80GHz; AS - Intel Xeon 3.06GHz)

Performance

Figure 3 shows the timing for a realignment operation for a given data set using remote analysis servers. Using the local machine, processing one volume took around 9.07s for CW1 and 5.14s for CW2. Using a much faster remote analysis server (AS) reduced the processing time per volume to 6.54s (CW1) and 4.15s (CW2). More reduction in processing time can be achieved when using multiple remote analysis servers simultaneously as shown in the figure. The maximum reduction is dictated by the connection bandwidth. This is around 1.61 (s) per volume for CW1 with 6 remote AS and 0.57s for CW2 with 12 remote AS.

Discussion

Using remote computational servers in the analysis of fMRI data offers several advantages. Access to high performance computing resources would allow computationally intensive operations to be performed with minimal processing time. Since most data processing components are centralized in the computational servers, the users don't have to worry about software upgrades. Data processing components can be centrally upgraded in the server which can then be immediately used by the client applications. Moreover, system maintenance and upgrade will be done by the remote server's system administrators. However, the use of remote resources also imposes some constraints. One such critical constraint is the transfer time (data and results) between analysis servers and client machines. To mitigate this problem, Ninf-G is used for automatic data compression. Moreover, recent advances in high-speed network connectivity may soon eliminate this problem. In fact, with a high-speed internet connection, we had demonstrated the feasibility of a real-time fMRI analysis using remote resources [1-3].

Conclusion

A software package (BAXGrid) for the analysis of fMRI data using remote computational resources is presented. It is composed of both client and server components. Access to server applications is transparent to the users and is made possible using grid technologies. It hides the complexities of using and maintaining high performance computing resources so that users can concentrate more on the analysis of the data rather than spending time on the technical aspects of the resources used.

References:

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