Introducing Grid technology in health care applications opens up for new possibilities in the medical domain. Grids provide seamless access to diverse resources across enterprise boundaries with a defined service quality. The PACSflow application developed together with the Norwegian Rikshospitalet University Hospital shows a way into modern exchange of diagnostics data.

Grid technologies are being introduced in many applications, including medical applications. For medical applications the Grid is an infrastructure that provides resources to the medical personnel. These resources may include computational resources, storage, equipment (e.g., scanners, lab), or human resources (specialists). The Grid technology builds an infrastructure to access these resources seamlessly, and following a work flow that follows the necessary policies in health care.

PACSflow
The PACSflow is a web-based application for medical personnel to transfer PACS data and EPJ data in a one-step procedure. PACSflow is an interoperable and standard-compliant web based application, which gives clinicians a user-friendly interface to transferring medical images and data along with the data from the EPJ.

The Department of Cardiology at the Rikshospitalet University Hospital in Oslo and the Department of Internal Medicine at the Sørlandet Sykehus in Arendal make clinical use of the system. Tests indicate that the use of PACSflow reduce the time to prepare and transfer data by a factor of 3; most of the improvement comes from reducing manual intervention in the transfer process.

While the PACSflow improves the transfer of medical images, this solution cannot claim to be a Grid system. Clinicians still need to negotiate with their colleagues, and to know who can perform a second opinion for a certain case. In a Grid system, this issue would be handled automatically, insuring that procedures and policies are followed, e.g., performing certain procedures twice independently, or use CAD methods.

**Second Opinion Application** using Grid
Transferring medical images for the purpose of a second opinion to another hospital requires large bandwidth between the hospitals. Though PACS-to-PACS transfer is implemented there still exists a rather manual work flow, including agreements over the phone, and fax transmission of data from the Electronic Patient Journal (EPJ) before sending the PACS data. This procedure is based on manual work flow, which is labour-intensive, and may cause errors during handling.
Since the Grid technology was conceived at institutions with high computing power demands for simulation tasks (e.g., at CERN), Grids are often mistaken for being large, distributed super-computers. However, the stress in Grid technology is on seamless access to resources across organization boundaries, and providing a QoS regime.

**Grids**

The name «Grid» comes from the metaphor of «Electrical Grids» and the idea to get access to a resource (e.g., electricity) by using a plug. Likewise, the access to a medical resource could be given to the clinicians when entering a case into the Grid system, and get an answer according to a service agreement which includes that policies in health care are followed.

There is no unified definition of the term «Grid» available, and the common definitions often address different application areas, like super-computing. For the medical domain the definition by the NGG Expert Group on European Grid research may give the most suitable definition from an application point of view: «A Grid provides an abstraction for resource sharing and collaboration across multiple administrative domains ...». While technicians often refer to the Grid as a «computational Grid» that provides high computational resources in a seamless manner, the general meaning goes much farther.

**Standards and medical grids**

For the Grid the standards OGSA and OGSI are used: OGSA describes the architecture, while OGSI describes the infrastructure of a Grid, using a service architecture. The infrastructure is based on open standards, e.g., web services that employ standards like XML, SOAP, UDDI, etc.

Usually applications are built on top of Grid middleware. Typical tasks for this middleware are the packaging of individual application tasks into suitable pieces of single work units, and workflow management.

DICOM, developed by NEMA is a widely used standard for the interoperability of medical imaging equipments. DICOM addresses the storage and sharing of digital imagery between medical imaging equipment and other systems. Being a standard by an interest organization of manufacturers of equipment, DICOM is developed out of practical considerations. DICOM is linked very closely to other technologies, and includes these explicitly into the standard. Although this approach results in a standard that is well-defined, it lacks flexibility with regard to new technology development. E.g., DICOM includes explicitly the use of the TCP/IP stack, instead of referring to an abstract service layer interface. Therefore, making the DICOM-standard Grid-aware would require changes in the DICOM standard.

From the viewpoint of information technology, medical applications are of the most demanding multi-media applications with high data volume, high processing demands, the need to transfer these data, very high security demands, and very often hard synchronisation and latency demands. Grid technologies support many of the specific properties of the medical data, including work-flow, load balancing, service quality, and security policies.

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