

Handling extremely large data sets



The data explosion

Image overload may be the single biggest challenge to effective, state-of-the-art practice in the delivery of consistent and well-planned radiological services in health care today.¹

The performance of medical imaging modalities has been rapidly increasing in recent years. The progress in terms of increased resolution and decreased scan time, especially for CT and MR, has enabled higher diagnostic quality and improved procedures in the radiological services. As the standard procedures change, the sizes of the standard data sets grow rapidly. Not long ago, a standard CT examination contained 100 slices, corresponding to 50 MB or 40 books of data. Today, a more adequate stack size is 2000 slices, which is 1 GB or 800 books. In the near future, an image volume of a beating heart² will contain 1TB or 800.000 books in one single image!

These extremely large data sets require new practices for the diagnostic work at a radiology department, but also completely new technical solutions for the distribution and display of these images. For the health care provider, it is crucial to select a PACS that can handle both the enormous amount of data, but also an arbitrary number of dimensions in the data. The traditional view of medical images is as stacks of 2D slices. Since modern imaging modalities can deliver a resolution equal in all dimensions, the natural way of looking at a stack is as a 3D volume. The functional examinations that time series can offer is constantly gaining ground, resulting in 4D images. Furthermore, multiple MR sequences of the same anatomy are common, resulting in several additional value dimensions.

The Sectra data retrieval interface

Sectra has invented a new way of retrieving image data of extreme size and arbitrary dimensions, patent pending. This data retrieval interface is typically implemented between clients and servers in a PACS.

There are a number of great challenges for data retrieval that cannot be solved by traditional systems. First, the interface should allow retrieval of an arbitrary 4D region at arbitrary resolution in all dimensions. This ensures that the output image data can be adapted to the current need, avoiding the performance penalty of sending data that will not be used anyway. A second problem is that the overhead at the client side must be minimized. Imagine a 4D data set, a 512^3 volume with 1000 time frames. If the data is accessed as individual 2D slices, the client would need to know the size and position of 512,000 slices. Even if this is just a few bytes each, the overhead is enormous. The performance penalty is even more pertinent if merely a small region of interest in low resolution is needed. Another challenge is to make an interface prepared for future technical progress. Being bound to a specific data representation means that future advances in image processing cannot be incorporated without rebuilding the whole system. This is the case for traditional systems, where there is a firm connection to the 2D slice format.

The main characteristics of the Sectra data retrieval interface are:

- **Support for arbitrary number of dimensions and values**
The interface can handle the data set types today and in the future.
- **Independent of data representation**
Improved image processing and new representation formats can be easily introduced. The same interface even if the data retrieval is customized for specific needs.
- **Handling of extremely large data sets**
The data set information overhead is minimized and does not grow as the data set size grows.

¹ Katherine P. Andriole. *A position paper from the SCAR TRIP™ subcommittee.*
http://www.scarnet.net/trip/pdf/TRIP_White_Paper.pdf

² Assuming an image volume of 1024^3 voxels (volumetric image elements), captured at 100 frames/second for 5 seconds.

- **No sending of redundant data**
The client specifies the required region of interest and resolution, which is often less than the full data set. One reason is hardware limitations, such as the amount of graphics card memory.
- **Minimal communication overhead**
With a single retrieval query, the client gets all the data needed. Since there usually are a large number of clients connected to a single server, the number of queries directly affects the performance of the system.

Technical details

We assume a setup where there is a central server storing the original image data and there are viewer clients connected over a network. The clients request image data to be shown to the user. In the Sectra data retrieval interface, the client's query to the server consists of three parts:

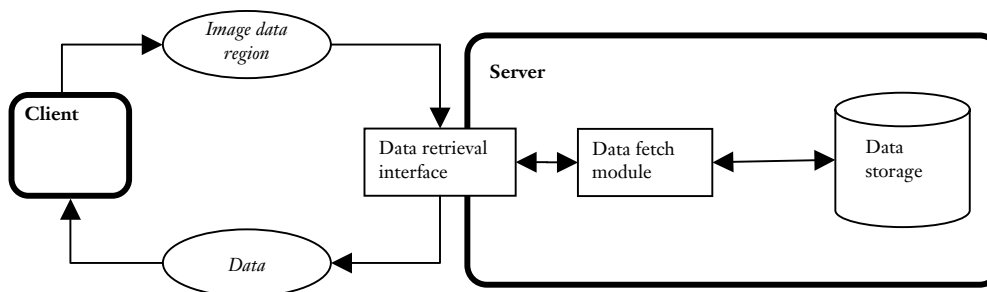
- Coordinates for a 4D region of interest
- Suggested resolution for all dimensions
- Suggested quality for all dimensions

The client determines the wanted resolution depending on how the data will be used, typically given by the size of the image view port on screen and hardware limitations. When processing the request, the server may use a different resolution than the specified one if this is more appropriate. With these inexact queries, the data retrieval can be optimized for the current data representation, without transferring representation information to the client.

The resolution requirements does not have to be global, they can vary across the dimensions. The resolution requirements can be specified manually or determined automatically. A CMIV research project has shown the effectiveness of varying, automatic resolution control³.

The data retrieval process through the proposed interface can be described as:

1. User actions on the client leads to the need to display an image
2. The client determines the specification, the image data region, for this image view. The specification describes the requested region of interest, resolution, and quality.
3. The client executes the data retrieval request by sending the image data region to the server.
4. The server fetches the requested data, potentially tweaking the client's requirements in order to achieve optimal performance.
5. The image data is sent to the client, along with the image data region actually used.



³ Patric Ljung et al., *Transfer Function Based Adaptive Decompression for Volume Rendering of Large Medical Data Sets*, Proc. IEEE Visualization 2004

The quality system of Sectra Imtec AB conforms to the Quality Management Systems standard ISO 9001:2000 and TickIT. All Sectra Imtec AB products meet the provisions of the Medical Devices Directive 93/42/EEC. All Sectra Imtec AB products placed on the North American market have obtained FDA market clearance. Sectra, the Sectra logotype, the Sectra Imtec Handshake picture and the Sectra circles are registered trademarks of Sectra AB. Pronosco and Pronosco X-posure System are registered trademarks of Sectra Imtec AB. Orthostation is a registered trademark of Sectra North America, Inc. Sectra PACS, Sectra MicroDose Mammography, IDS5, WISE, ImageServer, Clinical Solutions Network, Sectra Medical Interfaces, Clinical Application Interface and Cross Platform Worklist are trademarks of Sectra Imtec AB.

Windows is a registered trademark of Microsoft Corporation in the United States and other countries. UNIX is a registered trademark of The Open Group in the United States and other countries.

All other names/products by ® or ™ are registered trademarks of the respective manufacturer.

Sectra PACS is a concept consisting of workstation products, server products and recommended hardware solutions. Workstation products are included in the medical device family of Sectra IDS5 Radiology Workstations. Server products are included in the medical device Sectra PACS Core. Recommended hardware solutions are compliant with the specifications of the device.

Note: This is a marketing material and may be changed at any time without prior notice. Sectra will not be held liable for any errors or misconceptions herein.

SECTRA

Sectra World Headquarters

Sectra Imtec AB
Teknikringen 20
SE-583 30 Linköping, Sweden
Phone: +46 13 23 52 00 | Fax: +46 13 21 21 85

Sectra North American Headquarters

Sectra North America, Inc.
2 Enterprise Dr., Suite 507
Shelton, CT 06484, USA
Phone: +1 203 925 0899 | Fax: +1 203 925 0906

Email: info.imtec@sectra.se | Home Page: www.sectra.com