

## Use of the AquariusNET server in a large UK teaching hospital – the Bristol experience

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**B**ristol Royal Infirmary, in partnership with Link Medical, (a UK agent for TeraRecon Inc.) has recently announced the purchase of the first AquariusNET server in the country. The following article describes how the AquariusNET thin-client technology has been adapted for use in this institution with reference to specific clinical scenarios.

Bristol Royal Infirmary is located in South-West England. It is a large, 1,000-bed, acute teaching hospital Trust. The Radiology Department performs about 250,000 examinations a year and possesses two modern multislice CT scanners (Siemens Sensation 4 and 16 slice) and a Siemens Symphony 1.5T MRI scanner. An older Siemens Impact Expert 1T MRI scanner is due to be upgraded to a new 1.5T machine later this year. Both CT and MRI scanners have up-to-date software packages including cardiac applications that can generate thousands of images per study. In addition, a single-slice helical Siemens Somatom Plus4 CT scanner and a Siemens Open Viva 0.2T MRI scanner are based in the oncology centre. The scanners and associated vendor-specific workstations are connected locally via the hospital Intranet. As these are DICOM application entities,

they are not available to local networked computers. The Department does not currently have a single overall picture archiving and communications system (PACS). Short-term storage of images is undertaken on the modality or local workstations with back-up to MOD and longer-term storage to a central hospital SAN with tape back-up.

Our aim has been to use vendor-neutral software solutions for the provision of soft copy image management facilities within the department. Each of these software solutions has their own strengths with regard to the provision of the various elements of a PACS. We have successfully incorporated applications from different vendors for the distribution of images in the department for reporting or review in the wider hospital environment without incurring the major capital expense of a single PACS implementation. However, until recently, these types of software solution only displayed images in 2D although reformatted and post-processed images can also be sent to these applications. Our challenge has been to effectively manage these new large radiological data sets from multislice CT and MRI given that it is not possible to efficiently report these examinations without interacting with the entire data volume.

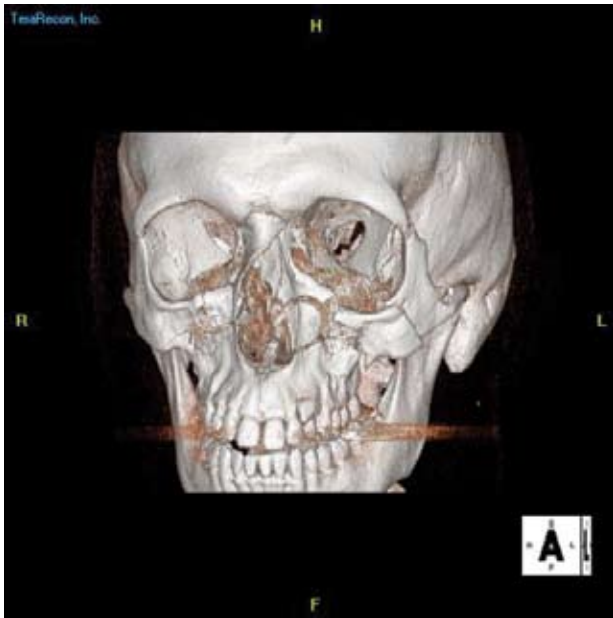


Figure 1a



Figure 1b

*Figure 1. – An example of the utility of the AquariusNET to display volume rendered data, which is useful for pre-operative surgical planning. Figure 1a illustrates a complex fracture of the facial bones, predominantly the left malar complex. Figure 1b shows an abnormal swelling of the left mandible due to fibrous dysplasia. Depending on the template used, the skin surface can also be displayed, which can be a useful adjunct in planning surgical approaches.*

The manipulation of volumetric datasets including multiplanar reformatting and volume rendered imaging has been limited to the facilities available through the vendor's workstations linked directly to the modality e.g. CT or MRI, or through the limited network of departmental workstations. The rapidly increasing workload generated by the scanners and the number of radiologists needing to report these studies has resulted in a bottleneck, competing for resources related to reporting. In addition, as a teaching Department, we have a large number of Specialist Registrars who also require access to effective cross-sectional reporting facilities. The AquariusNET server provided a possible solution to this problem by allowing the reporting radiologist to interact directly with the data volume at a networked computer of choice.

A demonstration model combining the AquariusNET server and Aquarius Workstation was generously loaned to the radiology department and subjected to extensive testing in the clinical environment to assess the clinical utility of the AquariusNET server in our

institution. The system was found to be highly versatile. It could easily be connected to a wide range of DICOM modalities within the department including the major cross-sectional modalities. The system's forte is the manipulation of large volumetric data sets (especially CT and MRI) but it was also able to display various types of fluoroscopy images, including biplanar cardiac studies, US, CR, DR, and secondary capture images. Nuclear medicine DICOM images were also displayed but with less success and not in a format conducive to easy reporting (Editor's note: Nuclear Medicine support is being enhanced in future releases of AquariusNET). TeraRecon's server-based thin client technology allowed the streaming of these medical images over the hospital enterprise to the radiologist's desired reporting or review location on the hospital Intranet. For reporting purposes, this location tended to be within the department, while for review purposes the location was often external to the department such as the intensive care unit or a clinical meeting room provided a networked computer was available.

The AquariusNET server uses purpose-built Volume-Pro rendering boards to perform processor-intensive image rendering. The screen images are refreshed over the network only when required, which significantly reduces network load and traffic. Indeed, our main problem was in restricting access to the radiology staff since clinicians found the interaction with the data volume potentially very useful. Surgical staff, especially faciomaxillary surgeons, saw the potential uses of volume rendered images for surgical planning, (Fig.1a and 1b). However, the total number of images that can be managed simultaneously by the VolumePro boards is limited. Therefore, all interested users in the hospital could not be allowed unrestricted access to the system.

AquariusNET's ability to handle large volumetric datasets has proven beneficial in interdisciplinary meetings. The versatility of the AquariusNET server has been complemented by the recent refurbishment

of the departmental radiology conference facilities. These new facilities allow clinical images from radiology, cardiology, and pathology, including the AquariusNET images, to be displayed via a digital projector and plasma screen and controlled through a modern touch-screen control panel system. Video conferencing facilities are also available. These integrated networked computing facilities allow clinical decisions made in the multidisciplinary team (MDT) meetings to be documented in real time during the meeting. Multidisciplinary meetings provide the opportunity for key members in the patient's management to come together to make effective decisions on patient care.

However, patients originate from a wide geographical area covering a variety of Trusts. Previously, the only way to review and compare studies from these different organizations was to physically send the hard copy images. However, all relevant images



*Figure 2. – The AquariusNET thin-client viewer in use during a multidisciplinary team meeting illustrating how the image data can be projected. Using the conference room controls, the image can be routed to the plasma screen or both if required. Frequently complementary clinical information such as histology or other test results are displayed on the plasma screen at the same time. (The image is from an article published in RAD Magazine, August 2005. Copyright RAD Magazine)*

were not always provided - e.g. the lung windows might be missing and therefore comments regarding the presence or otherwise of lung metastases could be compromised. This problem has been exacerbated with the advent of multislice CT. With hard copy images, the amount of data omitted from the review is critical since only reformatted thick slices are usually printed. Furthermore, the provision of hard copies for these meetings often require additional film to be printed at a significant cost. It was realised that DICOM images could be written to CD, which is a much cheaper medium, but again often only the thick slices were provided. Even when thin slices are burnt to disc, the vendor software application usually only allows the review of images in 2D. The import of DICOM data between different vendors is also notoriously difficult.

The Aquarius Workstation, however, allowed us to conveniently import the thin-slice data from CDs of other hospitals in the region and then compare them in multiplanar mode directly with similar data from other sources. Multiple studies, current or previous, from the same or different hospitals, can be compared simultaneously with real time MPR manipulation during the meeting. The radiologist and clinicians can interact with the whole data volume rather than hardcopies or a limited number of reformatted thick slices (Fig. 2). This has greatly increased the ease and value of comparing studies between different hospitals.



Figure 3. – An example using anonymous data to show how multiple data sets can be displayed together using the AquariusNET. The images could be any linked 2D or 3D data set or a mixture of modalities such as MRI and CT. Patient examinations from diagnosis and throughout therapy can be compared directly either within the same Trust or between different institutions as demonstrated here, allowing a better appreciation of disease response.



Figure 4a

Figure 4. – Illustration of the additional networked computers obtained for reporting. Figure 4a shows the set-up of the computer with dual portrait high-resolution 3 megapixel TFT monitors. In this example the thin-client spans both monitors. In Figure 4b the thin-client shows a comparison of CT versus an RF image and in Figure 4c a comparison of CT versus MRI.

**A**quariusNET is intuitive and easy to handle. Separate user groups are created for each clinicrodiological meeting, including MDTs, to which patients can be assigned either by the radiologist or an assistant. The patient data then provides a work list from which images can be reviewed by the radiologist prior to the meeting from any appropriate networked computer. Additional key images or manipulated images illustrating particular features can be sent back to the server to be available for review in the meeting (Fig. 3).

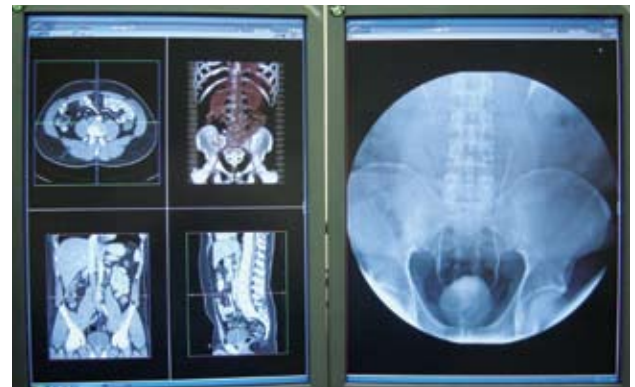


Figure 4b

AquariusNET has also complemented the existing soft copy reporting facilities and image processing software available throughout the department. Although a standard hospital networked computer with an appropriate resolution monitor is sufficient for review purposes, AquariusNET allows diagnostic quality review of radiology images by simultaneous users. The available facilities include real time 2D, 3D and 4D review, multiplanar reformatting tools, MIP, curved planar reformatting, and image fusion abilities. These features account for 80% or more of the most commonly used functions of specialised



Figure 4c

modality workstations. Having shown that the server/thin-client combination worked effectively over the hospital enterprise our next step was to obtain a number of additional high quality networked PCs. These stations are supplied with dual high-resolution 3 megapixel TFT monitors to facilitate diagnostic quality reporting of CT, MRI and other modality images using AquariusNET (Fig 4). Where multiplanar reformatting or volume interaction is not critical for reporting, the radiologist still has access to the department's other networked soft copy solutions. This has significantly relieved the chronic shortage of diagnostic quality reporting stations in the department at a fraction of the cost of vendor-specific workstations. As we do not have an integrated RIS-PACS system, there is no reporting workflow for the radiologist to follow. With the recent software updates to the thin-client, we envisage being able to filter the incoming examinations based on the reporting radiologist field to automatically assign studies to a radiologist's own group thereby creating a current patient list for reporting.

A third area in which the thin-client application has proven useful is teleradiology. Security of patient data over the Internet is an important concern. We use a Cisco server and software (Cisco Systems VPN Client Version 4.0.5) to create a secure VPN connection and portal of entry using a secure token and additional user defined numerical security code. The outgoing connection is via a 2MB line. Most radiologists now have Broadband Internet connection at home which varies in speed from 500KB to 2MB or more depending on the ISP and geographical factors e.g. distance from the local telephone exchange. A high quality laptop with UXGA screen resolution (1600x1200) is used for image review but there has been some progress towards using a desktop PC unit with a good quality monitor. Using this arrangement, studies can either be sent to the AquariusNET database directly for review or the modality queried remotely using the remote DICOM server facility tab on the AquariusNET search page. Using the default compression level of 75% and by choosing a suitable increment in the cine function, e.g. every 3rd image, we have been able to review complex CT studies in an interactive MPR mode from home with only minor delays in image refresh rate. We are aware of

the issues regarding image quality using lossy JPEG compression and emphasize that this scenario be considered a review situation intended for junior radiologists to seek advice from the covering consultant when on call.

There are, of course, major differences between the UK and the US markets. The UK market is affected by financial constraints and the consequences of the National Programme for Information Technology (or NHS Connecting for Health as it is now known). While the National Programme is dedicated to providing every Trust in England with a PACS, including our own trust, there will still be considerable capital costs. The number of workstations to be provided for each Trust is based on the size of the Trust. However, the general consensus is that the availability of specialised reporting facilities, especially with high performance multiplanar reformatting and volume rendering capabilities, will be limited with extra licences available at extra expense. The AquariusNET system provides an opportunity to acquire additional cost effective reporting facilities that can easily be integrated into existing or proposed PACS facilities. In this respect increased integration into the workflow, in respect of IHE conformance, could improve the appeal of the AquariusNET system as an independent adjunct for reporting. For example, the thin-client in association with an AquariusNET server linked to the RIS and with several terabytes of local storage capacity, could temporarily continue to support soft copy report and review functions in the event of a major PACS failure.

In conclusion, we have found the AquariusNET thin-client server solution to be a significant, user-friendly, valuable, and cost effective addition to our institution. AquariusNET, with its capacity to handle large volumetric data sets set amidst rapidly increasing workload, is the most efficient solution to our institution's limited soft copy reporting resources. We look forward to commissioning our AquariusNET server imminently and to future advances in the abilities of the thin-client.