Remember the "Tele" in Teleradiology
By: Howard Reis

Advances in telecommunications have propelled teleradiology to the next level and contributed to a much higher quality of patient care.

Advances in telecommunications have propelled the use of medical imaging to the next level. Teleradiology is a great example of how telecommunications advances combined with an increase in the dependence on medical imaging have allowed for a level of quality patient care that has never been previously available.

The role of telecommunications in the development of teleradiology

Teleradiology would not be a viable business enterprise without the availability of affordable high speed data transmission capability. For decades, telecommunications companies have realized that medical imaging would push the envelope of high speed data transmission. Nynex Corp., one of the companies that evolved into what we know today as Verizon, conducted trials with four prominent teaching hospitals in Boston in the early 1990s to gain experience and understanding of end user needs in the transmission of medical images.[1] These trials included scientific studies regarding the acceptability of the use of compression for medical image transmission and also led to the first commercial teleradiology business through Partners HealthCare.[2]

Today, there are over eighty commercial providers ranging in size from sole proprietorships to large public companies with annual revenues of $100 million. These companies rely on high speed data communications for their radiologists at home and for their clients to transmit large volume files for interpretations. In some cases, gigabit Ethernet networks provide connectivity to secure co-location facilities. Applications such as Voice over IP (VoIP) and Instant Messaging are increasingly part of the normal workflow process.

The following table shows the size of several modalities of medical images and the time it takes to transmit them in both un-compresses and compressed fashion.

	X-Ray	**CT**	**MR**	**Mammogram**
Size of Exam	30 MB	300 MB	90 MB	150 MB
Compression Ratio	25:1	7:1	6:1	10:1
Size of Compressed Image	1.2 MB	42 MB	15 MB	15 MB
Transmission Time – Uncompressed (seconds)				

DSL	720	7200	6480	3600
Cable Modem	480	4800	4320	2400
T1	320	3200	2880	1600
10 MB Ethernet	50	500	450	250
SONET (OC-3)	36	360	324	180
Transmission Time – Compressed (seconds)				
DSL	28	980	350	350
Cable Modem	19	665	238	238
T1	13	455	163	163
10 MB Ethernet	2	90	25	25
SONET (OC-3)	0.1	3.5	1,3	1,3

Some conclusions from reviewing the table include:

1. Medical images are getting larger, due primarily to the number of studies included in an individual exam. This has a direct impact on transmission speed.
2. Studies have performed to determine acceptable compression ratios which do not have an adverse effect on the diagnosis delivered. Compression is critical for the timely delivery of images to the reading physician.
3. Many hospitals have increased their network capacity and the weakest link in the equation is the connectivity at the individual physician residence. That said, a cable modem or a DSL line is still sufficient in receiving a steady flow if images through the night.

Telecommunications and teleradiology in the early years – old data tables

Advances in telecommunications and medical imaging

While typical transmission speeds have not changed in the past 20 years, the biggest changes have been in the areas of availability and price. At the hospital end, most facilities have high speed Ethernet available at an affordable price. At the residential end, the technology has evolved from DSL to cable modem to high speed fiber optic lines via services like Verizon FiOS. Home-based radiologists usually have a choice of transmission media and can often contract with two separate service providers to guarantee connectivity.

Of all the advances in medical imaging, two important developments have had a significant impact on teleradiology. First, as technology has evolved from single slice machines to as high as 256 slices, the number of images per study has sharply increased. Typically, 80% of the exams read by a teleradiology company will be Computed Tomography (CT). It is not

uncommon for there to be 1,000 images in a single CT exam, which creates a file of approximately 500 million bytes.

The second development is the proliferation of Picture Archiving and Communication Systems (PACS), which are currently installed in approximately 80% of U.S. hospitals. In its most basic form, a PACS receives image data in Digital Imaging and Communications in Medicine (DICOM) format, stores it on a hard disk, and allows remote systems to retrieve copies via standard DICOM query/retrieve commands.

Larger studies combined with hospital wide digital systems have created an environment where additional bandwidth is always necessary. It is often the hospital radiology department which is pushing the IT department to obtain additional bandwidth. Data communication companies are most happy to oblige.

Teleradiology provides better quality patient care

Prior to recent telecommunications advances, the cost of bandwidth, and the occasional loss of connectivity prevented many radiology groups from considering teleradiology as a viable solution. Today, teleradiology has become dependable and somewhat ubiquitous and offers groups a more reliable, cost-effective solution that actually improves patient care.

Previously, radiologists-on-call needed to stay close to the hospital in case they were called in to read a study – a process that often took over an hour. The teleradiology industry standard turnaround time for an emergency radiology exam is thirty minutes. If the case is a stroke or a stat, the standard turnaround time is usually less than ten minutes.

Teleradiology has also seen the proliferation of the multi-specialty group. Teleradiology groups can offer a wide variety of subspecialty expertise which their customers can draw upon to interpret many difficult exams. If the case requires a radiologist trained in a certain subspecialty area, a group with distributed expertise is best able to have a subspecialty trained physician available to read that particular exam.

The need for telecommunications redundancy

Despite impressive uptime rates, telecommunications technology isn't always reliable. If high-speed lines are unavailable, the process could come to a halt and patient lives could be at risk. There are various redundancies to employ to ensure that things run smoothly in case problems should occur. There is more than one way to effectively replicate high speed data lines:

- Each critical facility can be connected via an alternative path to the company data center. Those paths can be provided by a single carrier or by an alternate carrier which, by definition, will be connected to an alternate data center.
- The data center itself can be backed up at a second location on the network, or at an off site location provided by a third party provider. These sites can be places where data can be stored and recovered, or can provide a hot backup for complete operations.

An important question to consider - what will an hour (or day, or week) of down time cost and what am I willing to invest to guarantee that it does not happen? In any case, a Disaster Recovery Plan that includes recovery exercises and updates is crucial.

As with the hospital, the home-based radiologist also needs to have a disaster recovery plan. Alternate communication lines, such as a cable modem and DSL from separate providers, are recommended.

The future of telecommunications and teleradiology

For telecommunications and IT providers, health care is an attractive market. INSIGHT Research projects that the US healthcare telecommunications services market will grow from $7.5 billion in 2008 to $11.3 billion in 2013 at a CAGR of 8.4 percent over the forecast horizon due to growth in every healthcare segment.[3] Medical Imaging continues to be an application which is a major driving force within the healthcare segment.

I invited a number of industry experts to comment on future trends they saw at the intersection between telecomm and healthcare. Their insights were enlightening:

> *I think the big issue of telecom in healthcare is the development of high speed wireless broadband This is going to change the way that providers link to clinical information (such as radiology) and extend far beyond to all diagnostic information. I also see it changing the way patient care is provided. As we see two-way personal conferencing grows as the bandwidth gets more ubiquitous it will enter the healthcare space.*
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> Bill Montgomery - Healthcare Consultant at The Aeries Group

> *I think the biggest impact is wireless technology. Right now large files of data need a hardwire network, but as things progress into 4G and eventually LTE, wireless will allow remote access to medical images. Then the issue becomes the growth of the backhaul network from the cell tower. All of the cellular carriers are looking for ways to increase the backhaul from the planned 6 T1s to the 20 T1s and eventually GigE. These types of on-demand services will allow medical professionals to quickly information any time, any place.*
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> Ed Morea – Director, Managed Services at Alcatel Lucent

> *Telecom will enable a revolution in home health care. The expansion of broadband into the home allows for real time, wireless monitoring and with the new IPv6 coming soon, there will be no problem assigning IP addresses to any number of medical monitors (blood pressure, sugar, heart rate, blood oxygen, etc.) In addition, the low cost, high quality video cameras that are already used by millions for video chatting can be applied to help doctors and nurses communicate with a patient to determine if a hospital visit is necessary.*
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> Robert Feuerstein – Principal Architect at Level 3 Communications

Call Center Technology is beginning to play an important role. New technologies can quickly link the customer to "wellness" info as well as fast answers for health concerns, e.g., drug interaction, etc.

Jerry Morrison – Partner at M2 Technologies

And some insights presented cautionary notes:

~~The biggest impediment I see to this paradigm shift is the expected resistance to change to the status quo from the Luddites of modern day medicine -- namely physicians -- who see their inflated salaries as being in jeopardy. But just as history as proven many times, the process of "creative destruction" can be stymied but not stopped and will continue to move forward. There will be tumult in the industry, followed by reluctant adoption of new business methods, and later eventual acceptance of the new modus operandi as being simply better. Healthcare costs will go down and quality will improve. Americans will again benefit from the Invisible Hand -- capitalism reigns supreme yet again.~~

~~Dr. Andrew E. Gomes – President Casper Teleradiology~~

I routinely (unfortunately) obtain MRI and xray studies for my son. I send them electronically to consulting doctors to review, which saves us the delay and hassle of visiting each doctor and/ or having to wait for a mail delivery. For the most part, I believe this is a good development, but there are some drawbacks. While it's good that high-speed, global networks and videoconferencing can make expertise available anytime / anywhere, which means I can get studies to experts without delay, it's bad because it seems to change the traditional equation of dealing with one, or a few, doctors who are completely responsible for treating my son's case. Now, responsibility and expertise are spread out, and when problems or detailed questions arise, it is more difficult to track down and coordinate the responsible expert(s).

David Brenner - Executive Director, Dysautonomia Foundation

Another encouraged me to explore the International implications of worldwide expertise, tremendous medical needs in third world countries and ability of telecom/ healthcare to solve some of these challenges in light of tremendous challenges.

The real model for healthcare is being built in the under-served populations of the developing world. All innovation is moving offshore to serve the growing middle class of Asia (China and India) and eventually, Africa. Cell phones with special widgets in them will remind teenagers with AIDS to take their medications. These phones cost a mere 25¢ (which includes messaging) in South Africa. Care will be delivered in teams and linked to education and job training. What works there will be the norm for the world.

Nathan Felde - Chair, Design Dept., Art Institute of Boston at Lesley University

Closing statements

Teleradiology is an excellent business model for the integration of telecommunications technology and medical imaging that provides improved patient care as well as a successful business. Future developments may extend to other medical specialties that are image dependent, such as dermatology and pathology, and may also take advantage of other radiology technology developments such as RIS/PACS integration and 3D reconstructions. As long as the technology proves to be dependable, and imaging continues to proliferate, teleradiology can maintain its position at the leading edge.

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Notes:

1. Reis, H., Brenner, D., Robinson, J. Multimedia Communications in Health Care, published in Volume 670 of the Annals of the New York Academy of Sciences, December 17, 1992.

2. Telemedicine and Teleheath Networks Magazine. August 1997. Boston Center Extends Telemedicine Branches. P. 26-29.