TELEMEDICINE

by:

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Telemedicine

Prologue

Since those early days when care was provided using a wireless set at either end to those families that lived and worked on their remote farms located in the outback of western Australian by those legendary flying doctors, practical application of information technology in the health care industry has come a very long distance.

During those days, every farm had a well-laid and well-maintained airstrip. Whenever any person on the farm had any health-related problem, they could call up their doctor on the wireless radio that every farm had. The patients would explain their condition and seek advise. The illiterate amongst them had a picture of a man and a woman with numbers referring to the various parts of the body in front of them. They would use these pictures to point out to their doctors as to where exactly their problem lay. The doctor would communicate via the wireless as to how relief may be sought. Each farm had a well-stacked medicine chest with numbers identifying each medicine. A concurrent list was also maintained by the doctor. The doctor could then inform the particular medicine number and advise the patient how and when to take it. If however the situation so warranted, the doctor would physically fly out to the farm and do the needful as warranted. Then there was the sick-at-sea, and I am not hinting at mal de mer. Ships and boats which could not afford to have an on-board medical personnel for paucity of space or otherwise would telegraph or, when it became available, radio to the ports for the land-based doctors to advise them regarding the care to be administered to the ill-person aboard. In both the above cases it was the good old telegraph or the radio that was put to good use in getting medical consultation. Even today, there are numerous instances when the telephone (and fax) is used for the very same purposes. Perhaps without realisin g it, you might have called your GP or family physician on your phone in the middle of the night to about that high fever your child had or the pain in the tummy that was keeping you awake. Your GP might have asked you to fax some additional information and you might have suggested e-mail instead. Without realising it to be so, you were putting telemedicine to good use!

Telemedicine is nothing but a very serious attempt at extending these very same concepts on a much more wider and deeper scale. One will still be using these machines and then some. Such as the good old PC, cellular phone, computer notebook, the Internet - all backed up with efficient, user-friendly and highly interactive softwares. Some provider of care would still need to be physically present at the side of the patient to actually deliver the care (in the form of nursing, taking samples for investigation, noting the vitals (vitals include pulse rate, respiration rate, temperature, blood pressure, size of pupils, etc.), or do dressings, etc.. The expert or the consultant-in-charge may however be physically present at great distances away. Every doctor treats his (the masculine includes the feminine, the singular the plural - this convention has been used throughout this dissertion) patients by seeing, hearing, talking, touching, reviewing and judging. Telemedicine allows the opportunity to perform all of these things except actually touching - though the technology involved with virtual reality will one day allow the doctor to get a “virtual” feel.

Telemedicine literally means "**distance healing**" being derived as it does from the combination of the Greek word "**tele**" meaning "distance" and the Latin term "**mederi**" meaning "to heal". It employs information technology, through the judicious use of computers, related softwares, and telecommunications systems comprising of compatible telephone lines, fibre-optic cables and satellite link-ups, etc., to provide premium quality health care. To the patient, it facilitates the availability of the best of health care at anytime from anywhere at his place of residence. To the providers of the care it allows an excellent vehicle for obtaining continuous medical education (CME) at all times throughout the year. With the tremendous explosion and advances in computer technology along with computing power, combined with the application of computers for nearly everything, it is perhaps only to be expected that medical sciences would also not remain immune from being influenced by it. In fact, in another ten years one is most likely to see a at least a PC as commonly, and probably in as many places, as one sees the telephone and mobile phones these days.

Currently, computer technology is helping medical personnel in delivering more efficient health care in lesser amounts of time and consequently at lesser expenses. Existing technology is helping in faster and better diagnosis and management of a patient even if the concerned specialist is physically located several thousand kilometres away.

Distance is no barrier to better diagnosis and management of a patient with this technology. It is envisaged that the consulting doctor would be physically located at great distances away from the patient and still be able to not only see, speak, diagnose and treat but also operate on the patient through telerobotics. In fact telepresence surgery, as detailed above, is already a reality. One could sit in the comfort in one's home and yet actively participate in the training process of any emerging medical technique being carried out at a place which is half-way round the globe. You will be able to ask questions and the surgeons at the other end can answer right back to you. So, it is a technology that would allow better trained doctors to be present anywhere on a continued process.

Telemedicine or "**healing by wire**" (Time Magazine)] is the term given to the u se of modern telecommunications and information technologies for the provision of clinical care to individuals located at a distance and to the transmission of information to provide that care. In other terms, it is remote telemetric health care.

Though some refer to this application of information technology as being 'futuristic' or 'experimental', telemedicine with all the technological gadgetry, as we have come to recognise it today, actually enjoys a history that dates back to the 1950s, starting with pioneering projects at universities, hospitals, and a Red Indian reservation. Telemedicine systems today, of equivalent competency and relevancy, operate in many countries besides USA. Since the early part of 1990s, this technology is fast becoming a much favoured tool in enriching the ever widening repertoire of the medical specialist.

Telemedicine is not one specific technology but a means for providing health services at a distance using telecommunications technology, medical expertise and computer science.

It spans every echelon of health care, from the first responder (e.g., GP) or emergency medical systems to tertiary (Third level - usually refers to the hospital, i.e. institutions, in medical sciences) medical speciality consultations to performing invasive and/or surgical procedures to delivering home care.

A large-body of people world-wide residing in remote and rural areas are still struggling to gain access to timely and speciality medical care. This is perhaps one of the largest failures of the international community, and a human tragedy of epic proportions. When man could be placed on the moon in early 1970s, it is iniquitous that even in late 1990s we are as yet unable to provide quality medical care to a considerable population of the world. Although WHO has made it its goal to deliver "health for all by the year 2000", that dream still remains as elusive today as it was when it was first thought of unless something radical and proactive is not initiated without delay.

Telemedicine seeks to reduce the burdens on valuable resources (particularly in those areas where they are sparse) by improving availability to medical care for those sections of the population who have sub-standard access to quality health care, no matter where they are physically located. In areas where quality health care is available, this technology would make it possible to allow access to even higher standards of health care.

The technology uses electronic signals to transfer medical data in real time from one from one site to another overcoming all geographical barriers. The medical data so transmitted may be in the forms of high resolution photographs, picto-micrographs, radiological images and scans, sounds, 'real-time' video pictures, patient records (in textual and audio-visual form), video conferencing, etc. This transfer of medical data may use the Internet, intranets, extranets, PCs (desktops, laptops, etc.), satellite and microwave link-ups, videoconferencing equipments, telephones, mobile, data/ voice/fax modems, ISDN lines and ordinary or fibre-optic cables. In near future, ADSL {Asymmetric Digital Subscriber Line, which converts twisted-pair phone lines into digital "pipes" that allow up to 6.1 MBPS downstream to the client (90 times faster than ISDN), and up to 640 KBPS upstream from the client. This operates through a separate data network at the phone company's central office, and requires special modems which is currently about $4,000/pair, with prices dropping dramatically. Price should be competitive with ISDN. Pac Bell and GTE have recently begun ADSL trials} technology is expected to revolutionise this process further.

Already telemedicine is being increasingly utilised by health care providers by a growing number of medical specialities like dermatology (study of the diseases of the skin), oncology (study of cancerous diseases), radiology, surgery, cardiology, psychiatry and home health care. A trend in USA is the use of telemedicine in correctional facilities in which time and money for inmate transportation are reduced while safety for health care personnel and the public at large is concomitantly increased.

The technology is also expected to fine tune the overall management of health care and resource allocation for remote health care emergency programs by transmitting images to medical centres for long distance evaluation by the appropriate medical personnel. It will permit medical professionals conducting clinical research to be linked together despite geographical separation, sharing patient records and diagnostic images while exchanging information online on a video/ teleconferencing basis. Improvement of medical education in the form of continuing medical education is also made possible by linking several community hospitals together with the sponsoring medical institution.

In summary, telemedicine is a high-tech solution to the universal problem of access to health care. Due to this technology, geographical isolation need no longer be the insurmountable obstacle that was present to catering to the basic needs of timely and quality medical care.

By the term **telemedicine network**, one refers to a set of functional relationships among telemedicine facilities, which in turn refers to locations where telemedicine services are provided and/or received.. A telemedicine network usually contains a hub and at least one spoke, but may contain multiple hubs and spokes. A network can contain several different projects with distinctly separate funding sources. As a sum of all these parts, the network provides and obtains telemedicine services such as consultations.

History

While the explosion of interest in telemedicine since late 1980s makes it appear that it is a relatively new use of telecommunications technology, the truth is that telemedicine, within its wide definition of ‘distance healing’, has been in use in some form or other for more than sixty years.

Telemedicine, in its crudest possible forms were practiced when ship-to-shore communiqué’s took place for quarantined ships and ships having ill sailors/passengers on them who needed medical assistance but were not enough close enough to shore to allow the ship to seek that assistance from a medic in person. Most of these communications were carried out through the wireless via Morse code. Then came the age of the radio which allowed voices to be transmitted back and forth. This technology was put to excellent use by the flying doctors of the Australian outback. With the advent of telephone things certainly became easier and simpler.

But nothing perhaps has contributed as immensely as has been the quest of man to go gallivanting around in outer space. When manned space missions were launched, the mission controllers on ground had to know all that was going on aboard the space craft, particularly how the various life processes behaved in the weightless environment. Thus the R&D people at the space agencies had to devise ways and means to ‘see-listen-hear’ in such a fashion that would make it appear that the mission controllers are not actually several hundreds and thousands of kilometres away but as if they were sitting inside the space craft along with the astronauts. Thus came all the innovations, inventions and discoveries that has made telemedicine and telematics in health care a reality today.

The efforts of the various space administrations in telemedicine began in real earnest the late 1950s. These early efforts and subsequent enhancements in communications satellites fostered the development of telemedicine and many of the other medical devices in the delivery of health care as are available today. NASA provided much of the technology and funding in the USA for early telemedicine demonstrations. There were however several other pioneering efforts not only in the US, but all over the world.

A few of these are *ut infra*:

Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) programme, where a van staffed by two paramedics carried a variety of medical instruments including electrocardiograph and x-ray. The van was linked to the Public Health Service hospital and another hospital with specialist by a two-way microwave telemedicine and audio transmission;

Nebraska Medical Centre at the Nebraska Psychiatric Institute was one of the first facilities in the USA to have closed-circuit television in 1955. In 1964 a two-way link between the psychiatric institute and Norfolk State Hospital were set up, almost 180 kilometres apart. The psychiatric institute also experimented with group therapy. The link was used for education, and for consultations between specialists and general practitioners. In 1971 the Nebraska Medical Centre was linked with the Omaha Veterans Administration Hospital and VA facilities in two other towns;

Massachusetts General Hospital/Logan International Airport Medical Station which was established in 1967 to provide occupational health services to airport employees and to deliver emergency care and medical attention to travellers. Physicians at MGH provided medical care to patients at the airport using a two-way audio-visual microwave circuit. The medical station was staffed by nurses 24 hours/day, supplemented by in-person physician attendance during four hours of peak passenger use. Evaluation of diagnosis and treatment of the nurse-selected patients was made by participating personnel and independent physician observers. Analysis was also made of the accuracy of microwave transmission. Inspection, auscultation, and interpretation of x-rays and microscopic images were also performed quite satisfactorily. Necessary hands-on procedures were however performed by the nurse-clinicians;

Alaska ATS-6 Satellite Biomedical Demonstration that took place in 1971, the primary purpose of which was to investigate the use of satellite video consultation to improve the quality of rural health care in Alaska. Satellite ground stations permitting transmission and reception of black and white television were installed at four locations, and a receive-only television capability was installed at the Alaska Native Medical Centre in Anchorage. All five sites had two-way audio. Two of the locations had no resident physician. Simultaneous two-way video capability was not available, although the one-way video could be switched for transmission from any site except Anchorage. The project established that the satellite system was workable, could be used effectively by health aides at the various locations, and could be used for practically any medical problems except emergency care (emergencies could not wait for scheduled transmission times). It was also determined that the "unique capabilities of the video transmission may play a critical role in 5-10% of the cases selected for video presentation. Otherwise, there was little measurable difference between the effect of video and audio consultation";

In a further study conducted by NASA in 1974 to determine the minimal television system requirements for telediagnosis established the fact that there was no significant difference in remote treatment designations as a function of TV system type that would cause detriment to patients;

The Memorial University of Newfoundland (MUN) was an early participant in the Canadian Space Program. Since 1977, The Telemedicine Centre at MUN has worked toward developing interactive audio networks for educational programs and the transmission of medical data. Among the guidelines followed were: use the simplest and least expensive technology; be flexible; involve the users from the beginning of the project; seek administrative support in hospitals, clinics and other agencies; and include evaluation. The MUN project has been an effective demonstrative model for the judicious and low-cost use of telemedicine technology. They have proven that many times there is no need for the higher-end, higher-cost video-conferencing equipment;

The North-West Telemedicine Project set up in 1984 in Australia to pilot test a government satellite communications network (the Q-Network). The project goals were to provide health care to people in five remote towns south of the Gulf of Carpentaria. Two-thirds of these people were Aborigines or Torres Strait Islanders. The Q-Network consisted of 20 two-way earth-stations and 20 one-way (television-receivers only) earth stations. The hub of the network was the Mount Isa Base Hospital. All sites were supplied with a conference telephone, fax, and freeze-frame transceivers. Evaluation for the project showed that the technology did improve the health care of these remote residents. While it was impossible to calculate the operating costs of the telemedicine network separate from the other functions of the network, some health care costs were reduced. Fewer patients flew to and from these remote areas for routine consultations, and fewer patients were evacuated for emergency reasons.

The Changing Face of Telemedicine

Telemedicine is a technology that permits medical data to be stored, retrieved, exchanged and analysed with ease anytime anywhere. With all the tools, both hardware and software, already in place and continuously arriving in the market by the day if not b y the hour, telemedicine is not destined to remain merely the high value offering to the patricians by the elitist providers as it currently is. It's proper destiny is to be the value added offering to the plebeians by the GP sitting in the centre of the marketplace.

Telemedicine's destiny is to be a communications device dedicated towards providing the best of available health care to anyone anytime anywhere. It's back-end is a RDBMS with a suitable front-end that is user-friendly, if anything, and is based on client -server technology. The various clients/servers are connected to the scanning machines, microscopes, analysing instruments, video cameras, scopes capable of recording even the faintest of sounds, and other equipments (e.g., ECG machines, pulse oximeters, etc.). This would allow all of the functions that telemedicine promises to be carried out and some more.

However, in order to achieve all that is possible, the different developers of the system must ensure that the various front-ends from where data is being manipulated is compatible with each other. This is the most important one, even more than other important concerns like security.

For instance, consider an electronic bill sent to a purchaser of care services as a claim for care provided to a patient. For the purposes of ensuring that the message is delivered and acknowledged, the message must contain such data items as:

- the patient identification
- the items for which payment is claimed
- the date(s) when and place(s) where these services were rendered
- the amount of payment claimed
- the identity of the account to which payment is to be made

In order to make it possible to process such claims quickly and efficiently, the various contents need to be laid out in a standard format, so that the receiving system can automatically scrutinise the message, detect errors and improbabilities, verify details (such as that the patient is insured by that purchaser, and the current reimbursement rates for those services), and dispatch funds to the correct account. In short, process the information with the greatest possible accuracy within the shortest interval of time.

It is even necessary for the structure of the data within each of those defined data elements to conform to a certain pattern. E.g., the date might be required in the 'ccyymmdd' form (e.g., 19980601 for 1st June 1998), and the professional services rendered might be required as alphanumeric data.

Alternatively, the message from the laboratory providing the results of a request for a full blood count. This would also require a predetermined data set, laid out in a standard form, such as the Read Codes. In addition to dates., the numeric values for the various types of blood cell, together with a text report would have to be included in the message. Say the haematocrit of the patient is 45%; the figure '45' has therefore got to be incorporated into the message. It is vital that recipient should recognise this as a haematocrit value, and should not be able to mistake it for the platelet count (x 10,000) or the patient age, or indeed any other element at all. Any material that is not essential to the transmission is omitted, and the remaining content is reduced wherever possible to compact and concise the codes. In case of a full blood count message, the names of the attributes (e.g., Total White Cell Count per millilitre, or Haemoglobin in grams per decilitre) are predefined and therefore known to both sender and receiver: they are therefore not required to be transmitted. What is required is the value of that attribute in the full blood count.

Thus the following statements can be made about a message:

- every type of message has a defined purpose
- each message type requires a predefined set of data elements to fulfil that purpose
- every element has a defined meaning (e.g. ICD or as in a national data dictionary or Read Code)
- the data elements must be in a predefined position in the message, indicating to what they relate

- each data element must be presented in a predefined way (i.e., a preferred format) coupled with predefined ‘dimensions’ (e.g. x10,000 cells per mm^3, grams/Litre, etc.)

messages are to be kept as short as possible for four reasons:

- to minimise network traffic and therefore peak traffic capacity required
- to minimise connection times and therefore user costs
- to minimise the probability of an error arising in the transmission
- to make it easier to find an error in a rejected message

Thus one can plainly see that there are enormous number of parameters that must be harmonised into one grand orchestra capable of playing not mere chamber music but a full symphony flawlessly every time without fail.

In order to achieve efficiency maximisation of telemedicine the following points needs to be kept in mind:

- Use the simplest and least expensive technology
- Be flexible
- Involve the users from the beginning of the project
- Seek active administrative support from all the professionals who would actually be the eventual end-users
- Include evaluation so that all niggling cobwebs and bugs that always have the rather irritating habit of rearing up at unexpected times.

Analysis & Assessment

Telemedicine is certainly not rocket science and neither a sci-fi representation by a few bunch of loonies whose ideas have gone ballistics, certainly not any more.

However, one must not expect the sky when going in for it. Apart from a cool and rational assessment of the follow-on and abandonment options for a given organisation, the investors must realise that as with the implementation of any other revolutionary and innovative technology, implementation of telemedicine too would face teething problems. There might be equipment failures, which when and if it should at all happen, though one most sincerely hopes that it does not all too often, it would prove to be more than a handful. Furthermore, since this technology is still evolving and as no pre-set standards as such have been defined as yet, telemedicine might necessitate to be re-invented as time goes by. It is not (manna from heaven), but given patience and time it could jolly well be.

The road to implementation will be long and arduous. Several pitfalls would have to be sensitively and carefully negotiated, and critical choices made after very careful considerations. Many perilous roads would appear seemingly out of nowhere and must be negotiated with extreme prudence and dexterity. The inevitable pot-holes and rough roads would have to be deftly manoeuvred or smoothened out and when and wherever necessary.

Already a number of very serious efforts are being made for making telemedicine a reality. Several problems have been identified by various project leaders. It is very meaningful to run these pilot projects, most importantly to identify the areas of application, problems, acceptability, usefulness and identification of the possible remedies thereof. However it is also equally important, as these projects are being run, to develop products that can be used in real life instead of the controllable environment of a pilot project. Sponsors have to come forward and in a very big way.

Furthermore, technology per se has this inherently annoying ability to awry on a lark (remember those famous Murphy's laws?), and when they do, they are real killjoys. No connection can always and forever be true. During peak hours one must have noticed how many times the telephone call does not get through. Those of us who have used the Internet at all sorts of hours have faced the omnipresent problem of delays and loss of connection due to being "timed out". Even the various 24 hour news channels with all their correspondents and analysts world -over who cover their stories through telephone and satellite connections and gizmos of all shapes, sizes and hues have faced the problems of loss of the communications link and having to break off while bringing on a "live" event mid-way. Communication links during telemedicine consultations may also suffer such ignominies from time to time. But when it works, it is wonderful, magical, and quite simply right out-of-this-world.

Telemedicine is still largely experimental though this situation is expected to change very soon with the technology moving out of the desktops of the researchers/developers on to the desktops of the doctors and his patients. A number of very serious efforts at developing and implementing various telemedicine projects is on right now in various parts of the world. Such projects are demonstrating the feasibility of the different formulations that may be offered to the users and help in identifying the various problem areas (both actual and potential). The only thing that is lacking is the overall shape that telemedicine would ultimately take. One is still not sure whether it is to be used only for referral purposes or for communications between the care providers or for the continuous monitoring of patients or for the development of CDSS or for the maintenance of virtual patient records or for providing CME to medical professionals or for a combination of these all. Fortunately, sooner rather than later, we shall see telemedicine in our homes, affecting our day-to-day lives, and one which will prove to be indispensable by all involved.

Telemedicine has had a very long gestation period and has been born only recently. As it passes through its childhood, it will be a problem child. The question mark in the BCG matrix. What will its future be? It currently has a low market share with an expected high technology growth rate. It is a cash sink at present. It will cause large **negative DFCF**s right now. Once it can be transformed into a star with high market share and growth rate of the technology, it will definitely produce large **positive DFCF**s as its overall overheads would be low. It will become a cash cow before its technology growth rate falls. Of this I am fairly confident.

The computer is now being used for all sorts of purposes under the sun. Fax, exchange of information of all sorts of purposes, cyber-shopping using cyber or e-cash, trading in shares and other commercial commodities, e-mailing (both textual and visual). You name it, it is being done. One is then forced to ask, why not use the same medium to deliver quality health care at anytime from anywhere? It can and must be done.

In conclusion, all I can say with the maximal of all convictions that I can muster is this - **telemedicine is the future of medical sciences**. Surely you agree. Could and should we perhaps better name it as e-medicine or e-health care or e-care, or even, e-medicine (in consonance with e-mail, e-biz, e-cash, etc.)?

Evaluation

Every organisation that can be categorised under the health care industry will not be able to survive unless they have some communicating link between them which is beyond the ordinary telephone, fax, courier service or face-to-face. The sheer pressures caused by the ever-relentless march of technology and the demands of the customers of the service would force even the most reluctant ones to embrace what t he modern technology offers.

The technology that telemedicine offers not only allows for easier and better patient management while concomitantly offering better supervision of the prescribed care. Offering this technology would allow a particular service provider to create innovativeness of their product mix as well as in developing a core competency in an area that would allow it to carve a distinct market niche. By the time the other providers manage to copy this idea and offer the same service, the provider that enters this market early would be able to establish a better competitive advantage and would not have to suffer from learning and experience curve defects that inevitably accompanies when any new technology is introduced for the very first time into any new environment, both macro and micro-microenvironment.

The initial investment cost is on the higher end of the scale. Thus, every provider has to make a very careful study not only of its free cash flows for a period of at least five years. But the provider must not allow itself to be swayed solely by the computation of the results of its free cash flows, NPV and/or IRR. He must also study the follow-on investment option as well as the abandonment option. This is because the investment into a new and emergent technology like telemedicine today would allow the provider to exercise a call option in five years time. This investment would also be possible since this technology, which is definitely here to stay, would allow itself to be upgraded with a better product to provide better services. That investment would not only cause a fresh set of in ward free cash flows to occur allowing the provider to continue to ensure it growth in profits but also to accrue the benefits (financial and otherwise) from going in for this technology today.

The abandonment option is an evaluation of the effects of going in for an investment which, even if found to be not viable enough, normally has a residual value of considerable proportions to justify the initial investments to acquire the asset. The abandonment option evaluation allows one to calculate the overall profitability of the in vestment if the investment is abandoned at some point of time and the various assets hived off for cash.

Considerations for the calculations of Discounted Free Cash Flows would depend upon the DFCF of high and low demands as determined by the possibility of potential gain or loss of market share due to the failure on the part of the provider in offering this technology and a competitor doing so instead. A decision tree analysis may be performed to help in assessing the various payoffs and the opportunity costs involved to help in choosing the ideal-fit solution. The abandonment option is essentially a put option. The high demands are reflected by the increased market share while the low by the decrease of or unrealisation of increase in customer volume.

The question that naturally springs to mind is that while this technology is indeed a most impressive, almost a fantastic one, where would its application be most beneficial?

The answer to this question lies in two parts:

Whether a particular provider can afford (or not) to have such a technology on hand for improved patient management, and

Whether or not this technology would prove to be of any benefit as far as improvement patient management is concerned.

The first fact has already been dealt with when the opportunity of follow-on investment or a call option and an opportunity of abandonment or put option for this technology was discussed ut supra. It is the second part which is discussed in some more detail below.

There is enough evidence to suggest that productivity can actually decrease when information systems simply mirror existing manual systems. If telemedicine technology is built and used merely an extension of an MIS with hardly any interactivity, no “intelligent” data retrieval and analysis system in the form of data query analysis possibly by the use of SQL, or no electronic mailing system nor scheduling, then investing in such a system is a colossal mistake.

Furthermore, even though the introduction of information systems was supposed to revolutionise office systems and create a paper-less office, in reality the amount of use of paper has gone up. However, the interactivity and fast access and multi-point data handling has offered the opportunity of having up-to-date, as well as old, documents readily available, no matter where they exist or from where the request is made, a s long as they are electronically linked up from the point of delivery to the processing of the request.

Also, the volume of information generated and required to be available as quickly as possible also determines the requirements for telemedicine or an equivalent information system. The questions that must be appropriately handled here should be:

Whether one can safely say that this technology is useless or unnecessary, even when it exists and is available, and a customer can indeed be treated better (or with equal competence) and is in fact better off without the use of information systems.

Telemedicine embraces within its ambit the whole concept of information systems in health care industry, plus some more. Not only data can be accessed and exchanged without any hindrance across all geographical boundaries at a very fast rate without inconveniencing the customer and the provider much, but this technology would make it possible that better management and care may be delivered which would otherwise have been quite impractical, time consuming, expensive, and highly improbable as well at the very least.

Moreover, getting a second or expert opinion is very important in many situations that arise in health care. With this technology, the expert may be available at the point of delivery of the service at all times even if the is physically located half-way around the globe. By the use of telerobotics, it is even possible to perform procedures at long distance.

Put very simply in my honest opinion, 'telemedicine' is the vehicle for delivery of the very best of quality health care of the day to patients physically located anywhere in the world by combining communications technology with medical expertise at any time. Telemedicine is an emerging field that could have a revolutionary impact on the delivery of medical care. Advocates envision the development of a global grid of medical service providers and consumers linked by telecommunications networks for the exchange of medical information. The goal is to improve access to and the delivery of high-quality medical care at an affordable cost. However, policy makers, health care organisations, and providers are successfully challenged to distinguish excitement and hyperbole from the practical implications of this new suit of technologies and applications.

Therefore, it is abundantly clear that telemedicine would definitely help in providing complete and accurate diagnostic opinion by the best available specialist residing physically anywhere who could then suggest an effective management plan for the patient.

It will not only dramatically reduce the costs as a result of less time and money being spent on travelling but also through obviating the necessity of maintaining specialists whose expertise is infrequently called upon. Overall expenditure control is exercised through maximisation of all round efficiency helping in optimising costs, and therefore prices, while increasing the overall productivity, profitability a nd competitiveness, is also made possible by the judicious use of this technology.

Imagine, if you will for a moment, an environment where a doctor is able to consult with another halfway across the globe at the touch of a button. Telemedicine is a technology that would make this a reality and allow the delivery of the very best of health care and management with the help of a PC (or a network of them) from anywhere to anywhere as long as they are linked to each other by a valid telecommunicating connection. That is the power that this technology promises to the health care industry.

However, telemedicine does promise much further -

Quick and efficient diagnosis through Clinical Decision Support Systems, etc.

Ability to maintain constant contact with the medical experts in any discipline from anywhere;

Helping in the reduction of the referrals which could be done 'online' ; increase in confidence, in and in the viability of, remote and rural health care centres; and in the personnel manning them.

Geography would not be an encumbrance to providing quality health care and management anymore.

Invariably a few cobwebs are present that still needs serious attention, cleaning and polishing. Current technological limitations lead to slow transmission rates while faster and more acceptable speeds are available at a price which is not yet cost justifiable. This situation is however bound to change very soon, possibly by the year 2000, if not earlier.

The omnipresent problem in the shape of data security, especially of the sensitive data concerning the patients whose confidentiality is of paramount importance to the doctors concerned.

Added to all this is the unavailability of congruent software and relative lack of computer awareness amongst the various constituents of the health care industry has led to the creation of serious barriers for the carers to offer this technology to the payors. Hopefully, with the increase interest in this technology and all that it can do for the health care industry, the ground conditions would alter favourably.

The real challenge to the various software manufacturers (and, I hasten to add, the hardware ones too) is for them to look at their strategic objectives and lunge headlong into this field in all seriousness that it demands. As with every innovation, there has to be pioneers and there has to be followers. Some make a pile and some lose a pile. High technology areas are treacherous when they are simple, and telemedicine is most certainly not.

Let me annotate the parable of the three cowboys. This is particularly pertinent to those organisations (including the manufacturers and suppliers of equipment, hardware and software, as well as the service providers) and is meant to enlighten them of the downsides they could expect.

There is this story of the three cowboys. I heard this anecdote from my professor in finance, Prof. Ronald P. M. Poppe, Belgium. They all went for the mountain of gold, one following the other. The first one found the gold and while bringing i t home got scalped by the savages. The next one found it lying around the body of the first. He was also scalped while he was near to his home yet so far. The third one then picked it all up and brought home the booty, his scalp and all very much intact. All three positively contributed towards finding and eventual gain from the gold but it is the third one who actually accrued any benefit from all this hullabaloo.

There are several other additional challenges to seriously ponder about. Cultural barriers require to be overcome in certain areas of the globe where this technology could well be viewed as “foreign”. Successful implementation and wider acceptance by the users elsewhere would no doubt help in bringing down these barriers sooner rather than later.

High costs, at least initially. The equipments required are costly and therefore high capital inlays are required initially along with continued maintenance costs.

Coupled with these is the additional cost due to the requirement of constant presence at the patient’s side of at least one qualified health care personnel to actually administer care.

Furthermore, when computers and network connectivity do not work as they should, they can try even the patience of a saint. If you have used the Web, on several occasions you must have found that while most of the times they work pretty fast, sometimes they simply refuse to do so. This results in the modem connections being 'timed out' , lost messages due to errors in transmission, garbled data being received, etc. At such times one can certainly get most frustrated.

So equanimity is required in all such matters. Especially at the initial stages when the system is in the process of getting stabilised. Once the system becomes 'critical' and things begin to work as they ought to, these problems would mostly be few and far between. Improved equipments are constantly coming in to the market and such obstacles shall largely be a thing of the past world over.

Further developments in the technology is however expected to see to it that both the costs of acquiring the technology and the maintenance thereof would be well within affordable ranges, with the investment costs being recovered within a financially viab le period, while the use of personnel required to run it being progressively lessened till such time when they are mostly required during emergencies, if at all.

Telemedicine would definitely help in research and development of better management protocols, Clinical Decision Support Systems (CDSS), efficient and detailed epidemiological studies, statistical analysis, and through well designed data warehousing techniques the eventual building of a health data mart from where data could be mined for various purposes.

General efficiency of the health care system can be created by the use of this technology with successful computerisation yielding many tangible benefits to the health care management. Relevant information diffusion is accelerated so that the provision of overall care is improved and the demands for information of various natures are met. The decision-making proce ss streamlined and made more efficient through the active participation of the payors themselves. Telemedicine would also help in transforming the health care industry into an integrated system as a whole supporting the continuum of health care.

The technology would definitely help to reduce professional isolation and provide the ideal medium for the deliverance of Continued Medical Education (CME) on a continuous basis with the latest information being available literally at the touch of a button. With CME being available at any time at anywhere, even from the comfort of one's home, the need to travel and spend time away from work simply to re-train and hone one's professional knowledge and skills would be eliminated. The care provider can hone his skills in laparoscopic or endoscopic or other non-invasive procedures by watching "live" events online. Such "live" events may be recorded and replayed endlessly, even in slow motion if necessary, so that one gets the hang of it to his heart\rquote s content.

It positively contributes towards the safety of out-of-hours care by less skilled personnel even in areas demanding high skills. This is as a direct consequence of online supervision by skilled personnel. The technology would allow the supervisor equal oppo rtunity, whether he is in the next room or half-way across the globe and in the sky. The only drawback being his inability to directly intervene on-hand should, God-forbid, the need for it ever arise.

Increased job satisfaction amongst health care workers in the rural and remote areas as a consequence of their involvement in the ongoing care of patients in their own community is bound to happen. As a direct consequence, their experience and knowledge levels would concomitantly increase. Remote access to archived electronic scans and patient-related health data as well as other relevant records, and the provision of health care information (pre-operative, antenatal care, various support groups, etc.) direct to patient's home would also be made possible through this technology.

Emergent technology (ET) in the field of Information Systems (IS) will further enhance the quality, quantity and efficiency of telemedicine. It is rather the acceptance of the technology by the health care professionals and the administrators that happens to be the main stumbling block that needs very careful handling. The reasons for this is because these professionals still view telemedicine as a threat to their livelihood, disruptive in their otherwise normal day-to-day functioning, and a n overall challenge to their own understanding and expertise in a subject area in which they are expected to be a master.

Telemedicine allows the active participation of the family in the management and care process of the patient concerned. This invariably increases the overall effectiveness of the healing process.

It would also be an additional revenue generator by way of additional patient consultations as they may now "virtually" visit the health care providing organisations from within the comfort of their homes.

It would also cause increased patronage by the remote and rural centres allowing the organisations possessing telemedicine technology to export their various skills to them. Since telepsychiatry has been found to be a much less threatening consultative medium than the real one, increased customer volumes would doubtlessly result. Effective and ability to treat incarcerated felons in a secure environment is also possible with this technology as the need for transporting them to h ealth care facilities would be reduced thereby reducing the risk of these offenders of the law of the land, some of whom are of the most dangerous nature capable of committing the most heinous of crimes, to escape.

Thus we see that telemedicine appears to yield such benefits that the possession of it would prove to be a boon rather than a burden on the organisation even with the still lingering, and essentially niggling, downsides. This one technology truly can create an effective global health village, albeit in "virtual reality", and make health for all a real possibility.

Telemedicine is not only mutually congruent with health care industry, but if successfully and carefully implemented, telemedicine would inevitably prove to be a real asset to the organisation in possession of it and would definitely help in transforming it into such an industry the likes of which has never been seen before. All the inhabitants of this world of ours would have an equal opportunity to receive the very best of medical attention and care that is available every time he is in the need of it.

Once telemedicine is accepted and used as a viable technology, with the utilisation of existing technology and facilities, it would soon be able to demonstrate its usefulness to the health care industry and its customers and provide an ample glimpse about its immense potentiality. Initially, the components of the industry and the final customer in his home may be linked up using the existing telephone lines with narrow bandwidths. This hinders the quick exchange of transmission, especially the video part, thereby extinguishing the magical charm of telemedicine and frustrating the various end-users.

Thankfully the situation is changing quite rapidly. Larger bandwidths are already being offered by the telecommunications departments/providers in an ever increasing number of countries through the laying of fibre-optic cables and ISDN (Integrated Services Digital Network - now being offered by many phone companies, this can offer 56Kbps or 128Kbps, depending on the hardware) lines. Already T1 (common for links between Internet servers; roughly 1500 Kbps, or 12 times faster than ISDN) lines are being used to provide CME. Soon the more innovative ADSL technology is expected to revolutionise it further by bringing down the transmission times and thereby the variable costs in the long term.

The existent technology already allows PCs, laptops and workstations to communicate face-to-face using the not-so-costly-anymore video e-mail and the easily-available Internet phone. Increasingly “virtual” offices are being encouraged in a number of organisations and telemedicine is an extension of the very same concept to the realms of health care industry with the providers and the providees communicating amongst themselves at various levels.

Digitised pictures of the various radio-diagnostic scans (e.g., X-rays, UltraSound, Computerised Tomography or CT Scans, Magnetic Resonance Imaging or MRI) as well as the pictures and/or picto-micrographs of pathological specimens are already being sent over in ever increasing volumes. One can even scan them prior to sending/storing instead o f using the expensive digitisers for the very same purpose, though this is dependent on the type of photographs being “captured” electronically and there is a distinct diminishing of the overall image quality. Video e-mail would allow videoconferencing where not only sound but live video pictures are transmitted/exchanged over phone lines/satellite link-ups in real-time between the patient and/or his doctor/carer communicating face to face with the expert as in a real consultation setting.

In fact, the technology promises further. Since it would allow anyone to see, hear and talk to anyone at the other end, all one needs is to have proper equipment(s) to “hook up” the body to the piece of instrument so that the various vital signs may be telemetered through to the other end. This would allow medical personnel to assess/monitor the “hooked up” patient from a distance and manage him without any difficulty at all.

As with any technology, telemedicine too should be gradually be ‘phased-in’ as the older and essentially conservative system is ‘phased-out’. This point should be noted and followed with the utmost of convictions and care, else the organisation introducing telemedicine would be in a state of constant turmoil at least in the initial stages beset with the various teething problems. This in itself would ensure the certain premature demise of telemedicine, at least within that organisation.

As the infrastructure is built up and eventually put in place, the usefulness of telemedicine increasingly appreciated, the demand for newer and better techniques would automatically grow. As the growth of ancillary technology continues to become better a nd more cost-effective, the telemedicine product-mix on offer can change accordingly and newer, and hopefully better, facilities may then be provided.

Several very important strides in the field of telemedicine have already been initiated. The introduction of the so-called 'virtual patient record' coupled with the development and use of Read Codes, International Classification of Diseases (ICD), Diagnostic Related Groups (DRGs) with its 23 chapters of Major Diagnostic Categories (MDC), and Health Related Groups (HRGs) have in themselves gone a long way in making a comprehensive telemedicine a real possibility.

Currently there are about 100,000 preferred terms and a further 150,000 synonyms or index terms. They cover the whole length and breadth of clinical medicine from subjective and objective findings, diagnoses, procedures and treatment, to administrative arrangements, all using the form and language which clinicians normally use in their day-to-day activities.

The use of smartcards, which the patients could carry on their person like any plastic credit card, enabled with flash memory chips would be of immense advantage. These cards would allow access to the information stored within through a password known only to its owner. Relevant information like a summary of the last visit to a health care providing centre, vital statistics, summary of significant past history, details of investigations and findings thereof, etc. could be downloaded on to these cards and handed over to the patient. Since such cards are now coming with memory chips that can hold files in binary format, it is possible to have even images and sounds to be downloaded to, and subsequently uploaded from, them at will whenever the need for doing so arises.

For the general public without access to a PC and a modem-linked POTS (Plain Old Telephone System) at hand, information kiosks or cash-point like machines could be used for contacting medical personnel by the patients for advise and treatment whenever they require. PC Keyboards with suitable interfaces for reading smart cards/fingerprints are already available commercially, and the medical professionals may be consulted "on-line" from the comfort of the one's residence.

Additionally, telemedicine would allow an organisation to position itself favourably in the market. The competitors would certainly strike back, but as the entry cost are high, both due to the capital expenditures and the learning curve involved, the strength of their attaining a sustainable competitive leverage leading to the establishment of serious advantage is bound to be low.

The buyers would be attracted by the quality of services which would undoubtedly go up. If the organisation can truly practise 'value pricing', it would be able to create a strong customer loyalty which the competitors would find very hard to counter at least in the short-to-medium term.

ERP in the Health Care Industry

The by-word of the latest market focusing techniques is 'one-to-one marketing' wherein an individual is identified and that individual-specific services and products are developed so that most, if not all, of his demands for products and services may be taken care of. This remit however is extremely high on promise and abominably low on deliverance. In theory all one needs is to identify and analyse all the needs of a particular individual and then devise the various products and services that the individual might require. This however is next to impossible to carry out in practise in the health care sector, especially without any Enterprise Resource Planning support.

Trying to build a complete personal profile of a customer, who might turn out only to be merely a potential one, is a time and labour intensive process. Since any organisation of decent size is bound to have at least several hundreds to quite possibly millions of customers, innumerable man-hours will have to spent and literally copious quantities of midnight oil have to burnt as the organisation wrestles hard in building such an exhaustive profile. Unless there is a sound and comprehensive ERP and a Customer Synchronised Resource Planning (CSRP) system on as extensive extent as possible in place, efficient management of all the data and support in the analysis thereof would almost be impracticable.

The ERP systems that are currently available are said to belong to the client-server era. These systems are built with a clear separation of the various functional components. Graphical User Interface (or GUI, as it is commonly referred to) concepts and techniques are implemented as the front-ends on the client machines. Powerful back-ends are present on the server machines that host the databases and run the different business logic, which are written as server procedures.

The databases are built using relational database technology while the business logic is split depending on the product architecture to be executed on the client or server or both the machines. Increasingly, the various software manufacturers are emphasising on the concepts of objects and implementing the same using OOP (Object Oriented Programming). This has further improved performance in terms of efficiency, speed of transmission, data acquisition as well as manipulation thereof, and, perhaps the most important of all, data security - the one thing that is giving maximum heartburn to the doctor and his patient alike.

With suitable communications infrastructure, these systems could be deployed in a distributed environment and the business processes may span across multiple geographical locations.

The current generation of database systems is based on relational technology (RDBMS). These database systems support data seeking using standard query language known as Structured Query Language (or SQL - pronounced as *seequell*). Business logic which specify the set of actions that need to be performed (such as checking stock situation, etc.) is written using SQL and is invoked when the user performs a particular action. These database systems support access of multiple data sources and allow synchronisation of data manipulation across these sources.

ERP systems built on this technology will support organisations with the need to setup distributed systems that have considerably less dependence on a centralised information resource location.

Use of the Standard Query Language will enable organisations to perform post-implementation maintenance confidently. Since the systems in place are not tied to any proprietary languages and are essentially cross-platform, it essentially means that they will work equally well on all types of databases that support them. This would eliminate the need for the end-users to be overburdened and frustrated in trying to find out the necessary information as quickly as possible.

The skills required to perform this activity will be at a premium in the market place. Scalability issues would need to be addressed since sizing of the required hardware may have to be done to cater to a particular business process activities performed at a specific location. Addition of new locations must not lead to the disruption of the older locations.

In concert with simultaneous data warehousing on a global scale, ERP will allow the analytical manipulations of the atomic data contained within them. This is possibly the biggest and the most valuable of all payoffs.

Datamarts and Data Warehousing in Health Care Industry

A data warehouse has been defined as a collection of data in support, principally of, decision making process that is

1. subject-oriented,
2. integrated,
3. time-variant, and
4. non-volatile

Essentially, a data warehouse solution ensures consistent and cleansed information to plan and to make everyday decisions for smooth functioning of an enterprise. The challenges faced in accessing the information are:

- Retrieving facts takes too long and is often out-of-date
- Analysis disrupts daily operations and interferes with transaction performance
- Data is raw and unrecognisable, not in an easily understandable format
- Data is subject to constant change and is seldom consistent
- Ad hoc queries are difficult to process

The Decision Support Systems have the ability to:

- Provide a multi-dimensional, conceptual view of data
- Create complex criteria sets which allow pinpoint access to required information
- Provide rapid response to queries and the ability to support ad hoc queries
- Support for hierarchical consolidation of data, and the ability to “drill down” into detail
- The ability to leverage existing investments in information technology
- In other words, the data warehouse is a database designed specifically to meet the needs of decision support systems (DSS), rather than transaction processing systems (TPS).

The broad differences between Transaction Processing and Data Warehousing are as follows:

1. A datamart has data specific to a business area/development. It contains only a subset of the enterprise data that is value to specific business unit or department areas of an enterprise. The data may be captured from operational systems or enterprise data warehouse. The analysing is only to an extent of a single business area unlike an enterprise data warehouse, which can analyse data across multiple business areas of the enterprise.
2. Metadata is an information repository of the datamart. The metadata stores the definitions of source data, target data and source to target mappings. Management if information about the enterprise data is as important as the data itself. Metadata is to a data warehouse what a road map is to a navigator. It is an integral part of the decision support system (DSS), which must be constructed alongside the datamart.

An important aspect of the data warehouse environment is the metadata. Simply stated, metadata is data about the data. Metadata keeps track of what is where, in the data warehouse. Typically, the things the metadata store tracks are:

- the structure of data in the transaction processing environment
- the structure of data within the datamart
- the source of data feed into the datamart
- the transformation information of the data as it passes into the data warehouse
- extraction information
- update information in periodically updated datamarts
- Extraction is the first phase of moving operational data into the datamart. The operational data can be in form of records in the tables of a RDBMS or flat files where each field is separated by a delimiter. The datamart should be able to selectively retrieve from a variety of disparate databases on incompatible RDBMS and file systems. The datamart tools should make the process of extracting data from the source a simple exercise.
- Next comes transformation wherein the population of the datamart changes the structure of data storage. The transformation process is carried out after designing the datamart schema. It is a process that ensures that data is moved into the datamart, it changes the structure of data suitable for transaction processing to a structure that is most suitable for DSS analysis. Datamart tools should be able to automatically perform complex transformations such as date, arithmetic, character, lookup, encoding, conditional, and multi-step through simple visual interface.
- Loading (or populating, as it usually termed) of the datamart with the transformed data is an iterative process. The datamarts have to be populated continually and incrementally to reflect the changes in the operational system. The datamart tools should have the ability to automatically load the records into the target tables, schedule the start and end timings of the load and number of rows loaded into the datamart with the changes in the operational data.

In a data warehouse environment, the data that is collected on a daily basis is analysed and a summarised snapshot of the information is also stored. Such summarised reports have the capability of being “drilled down” to as fundamental level as required. Since most persons require a summary report to help in most of their decision-making process and very rarely need to refer to the detailed figures/information, such snapshots prove to be more value than any other collection of data.

Datawarehouses and Datamarts in the Health Care Industry - Uses

Let us now consider the following situation. A doctor wishes to see the details of the past illnesses of a patient. He refers to past records of course, but does he need to see each and every detail on every occasion? I should think not. Maybe, out of every ten times, he requires to see them twice or three times maximally. The rest of the seven or eight times he might want to take a brief glimpse at the summary, or look at the diagnosis. The information is lying all over the place, for the patient is a frequent traveller you see and who more often than not suffers from tummy upset.

The poor doctor waits, waits and then waits some more as the data are collected from the various sources, it is simply impractical to have a central server to house the medical (and other related) data and support find and seek solutions at the same time for anything beyond ten thousand patients (the costs and processing speeds required would be simply out of this world, i.e., astronomical), and presented to the doctor in a meaningful. If the doctor then seeks some additional details, then he qui te simply has had it.

It would far better and simpler if the data is available in a summarised form when first requested with suitable options that allow linking to other data in a “drilled down” fashion. This summary is created as soon as the particulars of a patient are entered into the database. The report is generated as a web page that may be accessed using a suitable browser by anyone connected to the system, after undergoing various security checks. I describe a possible sequence of data storage/ retrieval/analysis using data warehousing and datamarting technology below.

1. Patient comes in and after various security checks (through crosschecking of electronic fingerprinting/smartcard/optical data disk etc.) is logged on.

2. The doctor/carer collects all the necessary details from the patient

3. He feeds in these informations into the system

4. The data gets stored physically into the server, after suitably broken down into their atomic state

5. A snapshot summary in the form of web page(s) with suitable links for seeking of the data, that is collected and inserted, is compiled and stored immediately (hence the necessity of having computers equipped with fast processors for such servers)

6. This very summary is also displayed on the screen of the doctor and he may immediate ly use this summary for analysing the case that is presented by the patient.

7. He finds that he needs further information about some ailment that the patient had suffered around six months ago

8. He clicks on the link that helps him in getting to the information that he seeks, it is automatically found and presented in its web page(s) form on his screen, even though the information was retrieved by traversing large geographical boundaries and establishing communication link with the server which is housing the data

9. The doctor requires further information about, say, the tracing of the ECG that was taken at that time for he feels that he needs to find out more about this since the patient is making a complaint that could be explained only after a brief but proper review of the tracing.

10. He clicks at the link on the web page that displays the ECG tracing. This data is stored in that server or a data warehouse that collects every data which emanates from a locally connected server. Further links are available to help in the interpretation or display of the findings of the ECG tracing.

11. The doctor feels that needs to see a graphical depiction of the records of the blood pressure and pulse rates over the past five years. He makes a series of clicks on interconnected links that helps him get to exactly the information as he wants it.

12. He is interested in the heart and chest sounds as they were auscultated six months ago. He makes another series of clicks which presents the desired sounds "live". He wishes to replay a section of the sound but after filtering out all extraneous noises and amplifying it by a factor of 5. He makes another series of clicks and he achieves the desired result without any difficulty.

13. A 2D-echocardiography was also carried out a year ago. The patient does not remember the date, but the data stored within the smart card of the patient accurately noted it. The doctor accesses the images, and then with the help of the telemedicine package he is able to render a 3D image from the 2D images. He is then ready to make his assessment.

14. He looks at the medications that had been prescribed before. He alters the dose of one, discontinues two and re-introduces three more.

15. After he is satisfied with the summary report, he stores it and the accompanying data permanently into his server.

16. Thereafter the patient's smart card is updated with the currently obtained data. A new summary report is prepared specifically for the smart card by the software programme and this is also inserted into the card.

As one can see, the doctor is requesting the details of only a few particular items from past records. There is always a possibility that he might want to see each and every little details that were collected at that time and this too is easily displayable if necessary. Most of the times however, the doctor will be satisfied to see the principal complaints, date and time of the complaints, broad negative/positive physical and investigatory findings, diagnosis made, treatment administered and the various medicines prescribed.

The only detail that perhaps should normally be available without the requirement of any further linking, and consequently further delays, would be that of the dosages of the various medications prescribed since this is sought by most of the doctors for deciding on the management of the present complaints. Many a times certain medicines need to be avoided if they have previously prescribed and found to be unsuitable (and I am not merely referring to allergic reactions to medication) or are absolutely contraindicated. Decision support systems are another important area of application of computers in medicine. Data warehouses and datamarts are vital for the sound development and implementation of such systems that would go positively a long way towards providing the best of care.

Need for Data Warehouses & Datamarts in Enterprises

The increase in availability of data has created a challenge for organisations to utilise it at the appropriate time for optimal decision making. Data warehousing technology helps in effective management of scattered data, by validating and organising it at one place - the data warehouse. Information needed to by decision-makers to reply to ad hoc queries can thus be shared by authorised users at various levels of the enterprise.

Consequently, an increasing number of organisations are rapidly embracing data warehousing for faster solutions to ad hoc queries and business problems, The data warehousing technology significantly changes the way information system (IS) departments function. Data warehouses shift the load of responding to user queries to the users themselves and allow the IS departments to concentrate mainly on storing data consistently and maintaining the systems. The users can analyse their queries and retrieve data themselves even as they are thinking about the problem. The IS departments still retain the responsibility of monitoring user access, thus controlling the access and protecting the data.

The advanced tools that all data warehousing systems must provide for are flexible solution for ad hoc reporting, multi-dimensional analysis, advanced metric computation, and collaborative information sharing, thus enabling informed decision making across the enterprise.

Networking the Datawarehouse/Datamart

The traffic movement of such a telemedicine network will have to be as foolproof as is possible. The various checks for authentication too need to be equally watertight. In this section I provide an insight into the possible modes for transmission and verification for telemedicine network.

The Internet is probably the easiest mode of transmission since the technology is already in place. However, since it is as easily accessible to anyone armed with a PC, a modem and a telephone line connecting him to the nearest ISP (Internet Service Provider), it is dangerously open for hackers of all hues to breach through several levels of security and gain access to restricted information of all sorts. Thus, the security of information has got to be most carefully devised.

Smartcards with encrypted security codes in the form of passwords are one level only. Such cards should only have the vital statistics (names, unique reference number valid for telemedicine network, pulse rates, BP, temperatures, and respiration rates for the past year,), and such information only that are required for emergency purposes only (like drug allergies, presence of diabetes/

haemophilia/hypertension, etc.). This impro ves the overall safety of the information contained for no one may be able to know beyond what is already present without the user's express consent. Added to this, should the users at either ends, i.e., both the patient and the health care service provid er (HCSP), be forced to use their own codes/passwords to gain access to the information then the security depth is definitely increased.

The software manufacturer may provide further protection. This may even be at the level of individual datas. Restricted viewing of data will allow ultra-sensitive data to be permanently masked to all unless it is the person who put the data in originally or the person whose data is being put in.

Instead of a smartcard, one may use miniaturised flash-ROM chips capable of storing large amounts of information of a variegated nature ranging from the details of driving license to a complete recording of one's favourite song. Such chips may be housed on such objects that a person happens wear daily and possibly continuously (e.g., a ring, a bracelet, a dog-tag) or even be implanted under the skin (e.g., left arm, etc.). Specialised equipment will however be required to read from and to these chips. The good part is that the chances of loss or some unscrupulous person gaining wholly unwarranted access to the information contained therein is almost negligible. The bad part is that you have allowed, consciously or inadvertently, the "big brother" to watch you continuously.

The ultimate payoff has to be decided by the society a t large, but quite frankly I will be more comfortable with a card stuck to my lapel or ring on my finger that I can take off at will, rather than have some foreign object stuck underneath my skin. Viola! With such gurus like Mr. Nicholas Negraponte of Media Lab, MIT, USA, et al, working hard at more innovative offerings at every conceivable time of the day, it is most likely that we shall be able to lay our hands onto a safer and yet more accurate means of storing all our frank and the dark little secrets without fear or worry that someone might get them in their dirty clutches without our explicit as well as implicit consent. The world is truly awaiting for some wonder chip to appear in this area and make our lives a far less stressful one.

In my opinion, the owner of the data is the person himself. After all, it is his information that is being put in and one must have total control over the same. It is he who must decide what he wishes to reveal and have the rest of the world to know about.

The responsibility of verification and authentication of the data however lies with the person who actually collects computes and inserts the data. It is he who must make the final decision as to whether the data is representative and the accuracy of the version of events as they have actually occurred. He must also decide when and what to insert. Thus, it should be these two persons who should have as complete as possible control over the data. The patient in consultation with the doctor who examined him must decide who else should be able to view the datas.

There is always the opportunity of building up a separate network dedicated wholly, solely and exclusively to telemedicine network. However, this would require a yeoman's effort, to say the least, and since too many players would have to agree on the various modalities and rules of the game, as it were, it could jolly well prove to be a non-starter. Theoretically, this is the best option, but practically? Well, direct person-to-person connection is possible. The major flaw is how could data be then shared amongst the various players? The whole concept of telemedicine along with the full exploitation of its overall capabilities would then collapse.

Administrative Issues

Administration of the telemedicine network should however not be in the hands of the state. It must lie with a competent NGO on whom the medical fraternity and the patients have complete trust. My recommendation is that the NGO should be the World Health Organisation (WHO). Since it has a presence at nearly all levels of nearly every state of the world. As the medical fraternity is in direct contact and in constant interaction with it, practically on a daily basis, the state-level medical councils must act as the liasing body to such a network.

The WHO can set up a global taskforce which will interact with the various medical councils responsible for the licensing of the medical p ractitioners who will have access to the network. The software manufacturer(s) who will actually develop the system must have such security features built into the software so that these bodies may have the freedom to lock or unlock areas of information t hat the various end-users may have access to. The various payors would not necessarily be interested in every detailed bit of information that exists within the network but might seek information on certain details from time to time. Hence, the informatio n access requirement of every payor (whether they be first party or third party) should be kept in mind while detailing the accessibility and security clearances for them.

Else, telemedicine network may be built on the lines of the Internet which no one owns. In fact, it can have a genesis that is parallel to the development of the Web. A dedicated telemedicine network may be developed and then opened up for the whole world . Alternatively, one can choose to use the Internet itself to connect the various hub nodes and exchange data. This would certainly make use of the infrastructure that is already in place, and save the hassles and expenses involved in developing a dedicated telemedicine-only network.

Actually, there are already a number of excellent application softwares built for the purpose of EDI in the market and the various stakeholders of the health care industry and entities with vested interest may choose to ride piggy-back on the Internet of today to “get connected”.

Legal Issues

There would however be the requirement for monitoring of the ultra-sensitive data and the legal compulsions of treating a patient who not only happens to be residing in a foreign country but is actually a citizen of yet another foreign country. E.g., say a Japanese subject is residing in the USA and is consulting a British doctor who happens to be flying on an Australian plane over South Africa at that very moment. Who will then be legally responsible for cases of negligence, etc.? In my opinion it is the WHO that is the best agency to effectively deal, co-ordinate and administer it, albeit to a limited extent, as it sees fit since it is absolutely vital that agreement amongst the various state governments and the licensing authorities would not only have to be reached and b ut effectively implemented as well.

Ideal Software Solution

Since hardly any software solely dedicated for telemedicine purposes is available in the market, though a number programmes are there which if seamlessly interconnected then could be made into a fully functional telemedicine product, I am enumerating the ideal components and the capabilities of such software(s) in this section. This would not only help the software manufacturers in developing quality products that are not wanting in quantity, but also help health care managers, administrators, or the individual doctors to procure products that meet the various requirements and link them together with the idea of building their own telemedicine systems.

The ideal software solution for telemedicine would consist of the following components, with their capabilities on an individual basis, are as ut infra:

RDBMS database back-end built with any one of the following: Oracle, MS Access, MS Foxpro, Powerbuilder, Sybase SQL anywhere, etc. That is, any back-end that obeys SQL instructions and allows ODBC seamlessly. The database structure should allow for the data to be stored in an atomic manner, the database tables are multi-dimensional in their structure, the level that the various users work is on views rather than on actual tables - this helps in fine-tuning the performance and minimises chances of data corruption.

The database is physically located on a local server. The server is connectable by way of extranets to the outside world. There are suitable firewalls built to guard against hostile data access. So in essence there will be an intranet at an organisational level (represented by the chamber/clinic/hospital/institution etc.) which is accessible to the outside world also.

The front-end is ergonomically built with any suitable programming language/interface but must be able to process information to display data and graphics on screen, generate and print reports and labels on the fly, automatically format or generate and then display HTML-based web pages that are enabled with suitable Java/JavaScript/ActiveX controls and links to datas and other related information which could be web pages of previous medical details, etc. Payment, charges, insurance and other financial details are also available. The doctor should be able to directly store the data after verifying the details, therefore he should be able to edit them. The package must allow for intelligently querying of the database. Automatic generation of summary, tools for analysis of data (textual as well as graphical), capability to download and upload data from and to floppy disks, optical disks, communication ports, etc.

The database tables on the local server is updated at a time when the least data-access work is being processed by the server - this may be automatically determined by the server. The central data warehouse may update the database tables from data extracted from the views located on the local server. The servers would then not have any database tables physically located on them. This would lessen data corruption. The central data warehouse would automatically generate metadata and suitably store them on its own at a time that is suitable to it. The database of the central data warehouse should also store the summary web page(s). These in combination would help in speedy and efficient data-access by other servers that are remotely connected to it via central data warehouses located at other places.

The front-end must allows access to word processing and spreadsheet packages. These may be in the form of built-in connectivity or be provided as a part of the software package itself. Most, if not all, doctors need to use these packages in some form or the other. Additionally, there must be connectivity links for getting on to the Web by clicking on a button, and hypertext and other links to gain access to sites providing CME.

CDSS packages for 'intelligently' interpreting datas related to health. This may be either in the form of a full blown expert system or as an aid for data interpretation, e.g., sound analyser packages with filters which help in magnifying a selected portion of sound, picture analyser packages which help in re-constructing appearance on three dimension (3D) from scanned MRI/CT/USG images which are essentially only two dimensional (2D), allow for repeated zooming in on a selected portion of a pictomicrograph to help in predicting/visualising on as great a detail as is necessary, etc.

A suitable data warehousing package that would help in the efficient administration of the telemedicine system. Software manufacturers could help by providing data warehousing capabilities to their client-server software itself, even if only a limited extent like creation of metadata, the physical storage of data in multi-dimensional form, SQL based querying. However, the package must also be capable to automatically access the local central data warehouse and upload the data and snapshots of summary reports at a specified time.

Information kiosks - the software required for these would need some special handling. Touch-screen sensitive, smart card and/or finger-print reader, Internet connectivity are the absolute necessities. Multimedia capabilities would be an excellent, though optional extra. The information kiosk will only be a watered-down version of the client side of the client-server telemedicine system, i.e., not all capabilities that are typically available on a client is present. The things that would normally would not be present would be the processing or any type of storing, even of a temporary nature as within RAM, capabilities since these information kiosks would normally not have any such facilities. This normally means that these functions would be performed at the server level and therefore such information kiosks would need to be connected to a server located nearby.

Transmission of data - I prefer the object mode of data handling for then incompatibility amongst various softwares installed on to the computers of the end users is minimised.

Automatic data backup, recovery from errors in power supply, comprehensive administrative protocols and tools to maintain the overall health and operability of the system.

There is another area that demands serious consideration that I wish to bring to the notice of the software developers. They are of course very much aware of this problem. It is the problems dealing with transmission. These are of a myriad of natures. Firstly there are breaks in transmission, delayed or non-connection between networks, connections being "timed out" and hence lost, long time periods required to exchange large sized datas like videos, pictures, and sounds (i.e., multimedia files), - sometimes multimedia files might even take upto an hour of uninterrupted connection which can handle high speeds of connection (33.6 Kbps +) to transmit. I would like to add here that the various innovators are already addressing this issue in all its seriousness that it deserves and the transmission problems are being actively sorted out.

Transmission Sequence

The sequence of transmission of messages in telemedicine could take any one of the following processes. The exact process that would precisely be utilised depends on the software manufacturer. Ultimately it will be both the transmission time lag and ease-of-use factors that would determine which method turns out to be the winner. The processes are as ut infra.

Straight-forward transmission of HTML based web pages which can be easily viewed with the help of web browsers. These web pages would indubitably be having JavaScript, Java applets, ActiveX controls and the browsers would need to be suitably enabled to display them. The advantages of this method is that all that one needs is to possess pre-formatted web pages into which the relevant messages may be inserted. This would help in delivering messages in a standardised format thereby allowing for not only ease-of-use but also ease-of-learning. The web browsers that the users would be using to view the pages will already be installed in their respective machines and hence no added products would need to be bought by them. Thus, there is expected to be wider acceptance of such a product. The transmission lag time should not be significantly different from that the end-user already faces in using the Internet and hence end-user should not perceive any significant difference in using this product and any other Internet-related product. The disadvantages are that such a product would be a very simple one and any smart programmer with sound knowledge of the languages involved would easily be able to duplicate it. Hence the manufacturer who comes out with the product first will lose his market-share in no time.

Specialised package which uses a back-end database with a front-end web page-like (similar in its design as in § 1 ut supra). The advantages of this method, over and above those for § 1, are that instead of pre-formatted templates, the proper mode of display may be ensured. This improves the procedures for standardisation and brings about congruity in message exchange. The ability to use SQL will dramatically improve the overall capability of the package. Data will be more secure as only the correct front-end, displayed as a web page on the user's screen, will be able be able to correctly display the information in the right format. If the data is transmitted as objects instead of raw data then it automatically becomes more secure and the transmission time much reduced. Both of these necessarily improves performance. This also helps the software company to protect its product as the customer will have to buy the particular software only from them. Another company may simulate or develop their own package on similar lines but unless they can somehow manage to get into their clutches the actual field formats of the database, they will not be able to sell the very same product. The disadvantage is that any software company who brings the product into the market will have to go in for hard-sell and pour a lot of money into their marketing efforts to convince the respective end-users' that their product is the superior-buy and provides good value for money. A tough proposition indeed.

Similar in concept as in § 2 ut supra but the data being transmitted would be in the form of codes (e.g., Read Codes) which are transmitted as objects and are displayed in the customised web page of the end-user. These codes would be read from the centralised database and inserted in to their proper places automatically. This will further improve overall performance. The disadvantage is that unless the software company can get the rights from the British Crown to use these codes (and I am sure that the annual royalty will be quite substantial) they cannot be used. One may develop similar codes on similar lines but that would take a lot of effort and might even be a fit case for infringement of copyrights. The greatest payoff of using such codes instead of actual data is that not only does it make it more difficult to decode, particularly if they are encrypted during transmission, but also one needs to have compatiable software which can accurately read them too but also it allows for the various end-users to interpret the codes in their own language. Thus, the details of a Japanese patient who was on holiday in the middle east may be read by a Norwegian doctor without much ado. All of the persons involved can read all of the information in their local language and script!

A hub-and-spoke concept is my method of choice for telemedicine networking. This would help in providing all the facilities that it promises. This concept was originally developed for air services so that they could service a large area with the help of small regional/local air services for short haul flights while the large distance flight routes were serviced by larger companies.

A primary hub at the local/zip level is connected to secondary hubs at the district/county/regional level by LAN method and these secondary hubs are in turn connected to tertiary hubs at zonal/state/country level which serve large areas by WAN method. These tertiary hubs are again connected to other tertiary hubs so that a local hub at one end can interact with another easily.

Building up dedicated hubs solely for telemedicine would be a quite costly affair and would in all probability require proper bureaucratic authorisation. All of which mean that there will be delays and difficulties at the level of implementation. The Internet is an entity that is already there and one can jolly well use it. The various security concerns and methods of overcoming them have been addressed in a separate section.

The client-server technology is the method of choice for building up the basic infrastructure. The various end-users will be the "clients", while the data is stored in the "servers". These servers will be connected to the Internet with suitably safe firewalls installed to restrict access to only the authorised end-users. Since these servers would be interconnected, realistically any end-user from anywhere should be able to access it.

How may these demands be met?

Perhaps the ideal solution would be is to have a centralised repository for all information from which relevant datas may be mined and processed as and when necessary. However, in reality, the development of such a system is challenging enough in itself and implementation of the same would most certainly take nothing short of a yeoman's effort.

The realistic option is to develop several concomitantly congruent systems that could seamlessly intertwine with one another as and when every layer is added so that at the end the ideal solution is achieved at the minimum of effort and costs with the maximum of efficiency and speed.

In order to achieve the above objective either a single programming language coupled with a single RDBMS package is taken as the basic platform or a modular approach using multiple languages and packages may be adopted while ensuring that a common standard is adopted so that they may seamlessly exchange data amongst them. There are a of course number of upsides and downsides to either of these methods and the final choice depends on the particular solution provider.

While the former mode allows faster development of products consequent to the freedom of not requiring to continuously debug the individual modules and thereby necessitate several trial runs before releasing the product to the customer, it restricts the developer to using certain preset rules and regulations that have been built-in by the developers of the language and package. The exact opposite is the case with the adoption of the latter mode since the use of multiple programming languages allows the flexibility for the development of a number of modules that are not preset and hence are not rigid, but they take a number of trial runs and debugging resulting in a longer product development cycle.

Software manufacturers are most worried about the shelf-life of their products, so getting one's product first into the market is what is upper most in the marketing/finance department and the management's mind. The normal software of today has a realistic shelf-life ranging 3 to 24 months. If it is a game it normally tends to have the lower end of the range, and if it is an operating system, it tends to have the upper end of the range. It is not such that it will not sell, but if there is no next improvement on the line then that product will be pushed off the shelf with another competing product that does the very same things better with probably several added frills. Telemedicine related software, provided it is a good one, is expected to have a long shelf-life (even upto 5 years). The most important reason for this is that once medical professionals learn a technique, they find it irritating to change. Old habits die hard, and all that, you see. Once a software has been around for a while and is being used by a large body of users, a newer software which does indeed do things much better but requires considerable re-training and unlearning of previous methods is put on market, there is a very good possibility that it will be rejected.

Minimum Requirements for Telemedicine

The following gizmos are required at the end-user level to provide as well as receive telemedicine as it is today. The list is neither exhaustive nor exclusive. Down the way of development process, without any shadow of doubt, several of the named equipments would be found to be redundant and others vital for it.

- Desktop or Laptop PC, having multimedia capabilities, a suitable pointing device (i.e., mouse/ trackball/joystick) and a colour inkjet printer, or an Information Kiosk which is touch screen enabled, and a video-camera attached (plus, for the person who puts in data, which may both be the patient or his doctor, a suitable camera and/or scanner);
- A modem of 28.8 KBPS speeds or higher;
- A telephone line, preferably with fibre-optic cabling or better still ISDN line (though co-axial cables will still make do), or a mobile phone connection;
- Internet connection with e-mailing (more preferably video e-mail) facility;
- Enough computer literacy to be able to use the equipments and softwares with reasonable ease and efficiency.

The computer is used not only for the front-end for input/output of information but also for connecting to the computer at the other end. The multimedia capabilities are necessary to help process audio, video and text based information in a reasonable span of time . Long time lags are a positive disincentive for telemedicine overall as the end-users would not only get frustrated due to endless waiting while the information is exchanged and processed but also due to the very definite possibility of loss in connection as a consequence of timing out as well as high connectivity charges. The video camera is used for capturing "live" video data and transmission in real time, the display of the same being done by the computer screen. Scanners are poor substitutes for capturing still pictures/images but one is certainly better with than without. The audio is captured with suitably placed microphones and the output by the speakers. Since the microphones and speakers are an integral part of all multimedia kits, I have not mentioned them separately. Colour inkjet printers of 600 dpi (dpi or Dots Per Inch - this number represents the number of dots the printer prints per inch to represent a character or picture or whatever; the higher this number is the greater is the resolution and consequently the finer is the quality of the print; 600 dpi or better is considered to be almost laser-like in quality) or better resolution are more than adequate, there is no overwhelming need to invest in expensive laser printers that print in colour, mere black and white printers are simply not good enough, laser or not. Most of the vendors are now offering such inkjet printers at most competitive prices. Remember though, you must shop around for hardware of all descriptions if you want a good deal. If you are patient enough, you will get a very attractive equipment at the most affordable prices.

Modem, or modulator-demodulator, of an acceptable speed is necessary for connecting computers to each other via a valid telephone connection (land-based, satellite-based, and mobile). This gadget converts the signals into a suitable form which can be transmitted. The modulator part converts the signals into a form that can be transmitted, the demodulator part reconverts them back into a form that the computer can "understand". Speeds of less than 28.8 KBPS are not suitable f or transmission of 'live' video pictures and the overall transmission time is also compromised.

The description of the other equipments are self-explanatory. I have mentioned the Internet, even though I am sure that a lot of pundits will frown on this, since I feel that this network of networks, as it were, can easily be used. Not only is it already in place, but also because the various security concerns can be efficiently addressed without much ado.

The Information Kiosk will possibly not be able to allow any type conferencing other than solely text-based ones. Unless of course these kiosks are video and audio enabled. This would necessitate providing an acoustically secure environment. Sponsoring and/or participating organisations may however wish to significantly alter this situation by providing such machines (akin to cash/credit card points of various banks). An extra spin-off from this would be the establishment gaining a head start in marketing terms.

A few might opine that a Web TV too has impressive possibilities in telemedicine. I doubt whether this technology will be good enough for all round use. In order to fully tap the complete capabilities of telemedicine, one needs to be able to interact in real time face-to-face and preferably one-on-one. Not merely to be deluged with a mountain of information, albeit with a certain degree of interactivity to some limited extent. The hardware must come armed with microphone and video cameras attached to it, a printer and a scanner helping matters further. Today, the best option is the computer-based equipment. I do concede that the TV of tomorrow would actually be a fully functioning computer in itself in all its aspects. Then Web TV or TV or computer whatever gizmo you have, they will all essentially be the same machine with the same functionalities.

Worried? Well, the prices of all the equipments are coming down dramatically with each passing quarter (i.e., three months), fibre-optic cabling and ISDN is becoming more of a rule rather than an exception for all newly laid telephone lines capable of allowing larger bandwidths for improved connectivity and speed of transmission, and the Internet usage growing exponentially. ISPs are already able to provide connections at higher than 28.8 KBPS speeds and thus multimedia applications/programmes/objects are downloadable and playable at acceptable speeds. As for computer literacy is concerned, if you are not may I take this opportunity to wish you the very best of luck. If you think you can survive the next millennium without this almost basic expertise in a world with or without telemedicine, you sadly are definitely in cloud cuckoo-land!

Epilogue

Let us not be afraid or suspicious of all the new innovations that come our way for not all are dangerous even if they appear to be so *prima facie*. If we should develop phobias and deliberately turn our backs on certain technologies because of our apprehension that they would do more harm than good, then one is compelled to wonder what would have happened had fire been never used ever after being discovered simply because someone got his fingers burnt or were afraid of its power for almost universal destruction. What would the consequences for human existence and history of mankind have been if the person who discovered the wheel carelessly cast the device away because his fertile brain could have found no rational use for it? The incessant march of scientific discovery and the motivation for discoveries is derived from the successful implementation of them. These points are made to emphasise that one must be realistic enough to face the facts and use all the available opportunities provided by emergent technologies to make this world of ours a better place to live in. One must not allow oneself to be paranoid enough to develop phobias t o such proportions that forces one to reject an innovation which could jolly well a good one in the long run simply because it looked dangerous at first sight. Remember fire?

Telemedicine is fascinating. It is " hot" and is defintely going to be (unless it already is) the "in thing" in health care. Its implementation would be equally challenging. Its accompanying downsides are certainly not insurmountable, by any stretch of imagination. All it demands, nay merits, is a fair chance for it to be workable. If the health care industry repudiates it because of its present inefficiencies, a golden chance of being able to provide the best of available care anytime anywhere would be lost for a generation or several generations, and that would be one of the greatest tragedies to befall mankind.

APPENDIX

Virtual Reality

[Ref.: Jerry Isdale, Version 2.1, Oct 8, 1993]

Virtual reality is a way for humans to visualise, manipulate and interact with computers and extremely complex data (according to The Silicon Mirage).

The visualisation part refers to the computer generating visual, auditory or other sensual outputs to the user of a world within the computer. This world may be a CAD model, a scientific simulation, or a view into a database. The user can interact with the world and directly manipulate objects within the world. Some worlds are animated by other processes, perhaps physical simulations, or simple animation scripts. Interaction with the virtual world at least with near real time control of the viewpoint is a critical test for a 'virtual reality'.

A number of uses of virtual reality in medicine is currently available. Rendering of 3D images from CT or MRI or Ultrasound scans - like Spiral CT scanning, tele-endoscopy, tele-angiography, etc. Note-worthy points being that CT scans deliver the maximum x-radiation and ultrasounds (till mid-1999) do not all in any manner or form. MRI delivers magnetic radiation and their detrimental effects are still being debated, but are mostly expected to be minimal.

While CT scans are vital for bony structures, MRI is excellent for soft tissues. MRI's cannot visualise bones as well as CTs can, but CT cannot produce saggital (longitudinal) sections of the body, only coronal (transverse) while MRI can. Ultrasound is mostly used in the studies of the foetus since the safety of any other scan (CT/MRI) has not been established to any comfortable levels.

Such machines that are capable of rendering virtual reality images have a prohibitive price tag and undergoing procedures using such machines are consequently expensive. However, as more and more medical professionals opt to use the capability that these machines impart to their effectivity of treatment, it is expected that the use of these machines would become more widespread, their costs would come down and therefore the prices that the patients would have to pay more affordable.

The telemedical network can store these images and they may be retrieved as and when necessary. Hence, even if the patient has to go to some particular place to undergo the procedure, the images can be viewed time and time again by medical personnel having access to the database.

This would also allow for better training of personnel. 3D images an be used for demonstrating and practising various invasive procedures using virtual reality tools like the cockpit/cab compartment or the desktop as the screen and a sensor-enabled glove. The student may devote long stretches of simulation hours of practise in order to perfect his skills without endangering lives. Various situations, all of them taken from real-life, may be encountered and the student evaluated and perfected in his techniques.

There is an interesting area of VR called "haptics", which is the generation of touch and force feedback information. It being a very new science and very few studies done on rendering of true touch sense, almost all systems till 1993 have focused on force feedback and kinaesthetic senses. These haptic rendering systems can provide good clues to the body regarding the touch sense, but are considered distinct from it. They could however allow for "virtual" touching too, and if and when it does so, it shall be none too soon.

Fuzzy Logic

[Ref.: "What is Fuzzy Logic?", © Togai Infralogic, 1993]

Introduced by Dr. Lofti Zadeh of U.C. Berkeley in the 1960s, fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - i.e., truth values between "completely true" and "completely false".

A fuzzy expert system is an expert system that uses fuzzy logic instead of Boolean logic where something either true or false and nothing else. Fuzzy logic essentially is a collection of membership functions and rules that are used to reason about the data. The rules are usually in the form as follows:

if x is low and z is high
then y is medium

where x and z are known data values (input variables) and y is computed data value (output variable), low is a membership function defined on x, high defined on z, and medium on y. The part of the rule between the "if" and "then" is the rule's premise or antecedent, which is a fuzzy logic expression that describes to what degree the rule is applicable. The part following the "then" is the rule's conclusion or consequent, which assigns a membership function to each of one or more output variables. Most tools for working with fuzzy expert systems allow more than one conclusion per rule. A typical fuzzy expert system has more than one rule and the entire group of rules is collectively known as rulebase or knowlegebase.

Next, we need to know how to apply this knowledge to specific values of the input variables to compute the values of the output variables and this process in referred to a s inferencing. In a fuzzy expert system, the inference process is a combination of four subprocesses: fuzzification, inference, composition and defuzzification (optional).

I do not wish dwell too much on this aspect as it tends to become progressively heavier and one would dizzy spells from all this fuzzy stuff. I have mentioned this point here because an excellent area for application of this type of logic is in the field of medical sciences where 2 + 2 can be anything (within a reasonable range, of course). Being an imperfect science, where almost the same signs may either mean the same disease or completely different ones and only progressively costlier investigations and evaluation by experts can actually bring forth the correct diagnosis, Clinical Decision Support Systems (CDSS) need to have a certain degree of fuzzy logic incorporated within it to be of any significant value.

List of Codes

Each of the following have their own distinct use. The visitor is requested to visit relevant sites for detailed discussion on each of these. I plan to write an overview of each of the following in near future.

1. Read Codes - Clinical Classification of Medicine, by Dr. James Read, UK
2. EUCLIDES - European standard for clinical laboratory data exchange
3. LOINC - Laboratory Object Identifier and Numerical Code
4. SNOMED - Systemised Nomenclature of Medicine
5. CPT4 - Current Procedural Terminology
6. ICD 10 - International Classification of Diseases 10th revision
7. ICD 9-CM - International Classification of Diseases 9th revision-Clinical Modification
8. National Library of Medicine (NLM - Unified Medical Language System (UMLS)
9. DRG Databases
10. IUPAC Codes
11. ACR - Index for Radiological Diagnosis
12. NDC - National Drug Codes
13. NANDA - North American Nursing Diagnosis Association
14. DSM-IV
15. UMDNS - Universal Medical Device Nomenclature System
16. NIC - Nursing Intervention Classification
17. NDC - National Drug Codes
18. NLM - Unified Medical Language

Use of Codes

The use of codes makes a lot of sense. Medical professionals, especially doctors are notorious in not only the use of medical jargon but also in expressing the same idea in various ways. {No wonder a number of them have been great literary figures - Sir Arthur Conan Doyle, the creator of Sherlock Holmes was one!}

Unfortunately, this creates an immense problem for such simple creatures as computers are. They are unable to interpret humans at the best of times, (after all their world is so marvellously simple, consisting of a series of 1's and 0's only) and then to figure out semantics and hidden meanings a bit too much.

Such confusion is rampant but the consequences have mercifully been limited because mostly the computers store and retrieve data verbatim and let the humans figure out for themselves what they might or might not have meant. This has its own drawback - the humans are confused instead, thereby defeating the very purpose of the use of such immensely costly systems. If the nurse did not understand 100% what the doctor meant, just imagine what consequences would that have, mind simply boggles at the very thought.

So, a device needs to found out to eliminate as far as practicable this state of seemingly perpetual confusion. The way out is to learn the lesson from the marvellous world of computers themselves. They "talk" to each other through codes, why not use codes (not necessarily a series of 1's and 0's) instead. Some code(s) that can be reasonably understood with less chance of confusion.

The other offshoot of use of codes is the ease of data transmission. Since codes are all that are transmitted, and they being smaller in size, the data loss and development of faulty or cryptic data is minimised.

Moreover, in the telemedical context (particularly in the manner in which I envisage telemedicine to be like, i.e., a world-wide network where medical personnel can freely collect information) the inevitable requirement would be is to find a way whereby a German-speaking doctor could communicate with his French-speaking colleague, each interacting in his own language and the other understanding with equanimity. This is possible because both of them are interacting with the computer using codes.

The same code mean the same thing in the various languages. The downside is that there has to be a translator of sorts that can effectively translate the code into the desired language. Softwares can handle this and because of the high processing power of the present day computers, the time lag is barely significant.

Health Level 7 [HL7]

[I have decided to devote a whole section to this particular topic because I am totally convinced that this one standard is absolutely necessary for any telemedical project to be of any significant value, especially of a world-wide network. Here I have only given the summary. For a more detailed discussion, please follow the relevant links obtainable from most search engines...]

Established in March 1987 on the occasion of a conference held by Dr. Sam Schultz at the Hospital of the University of Pennsylvania, HL7 became an ANSI accredited standards developing organisation in June 1994. Since then HL7 is participating in ANSI's Health Information Standards Board (HISB).

HL7 or 'Level 7' refers conceptually to the definition of the highest level of the Open System Interconnected (OSI) model of the International Standards Organisation (ISO) which is that of an application-to-application interface placed in the seventh layer of the OSI model.

The HL7 standard is primarily focused on the definition of the -

1. data to be exchanged

2. timing of the exchanges, and

3. communication of certain application-specific errors between the applications

The standard currently (1998-99) addresses the interfaces among various systems that send/ receive:

1. patient admissions/registration, discharge or transfer (ADT) data
2. queries
3. resource and patient scheduling
4. orders
5. results
6. clinical observations
7. billing
8. master file update information
9. medical records
10. scheduling
11. patient referral
12. patient care

The primary goal is to provide standards for the exchange of data amongst the various healthcare computer applications that eliminate or substantially reduce the custom interface programming and programme maintenance that may other wise be required.

The message formats prescribed in the HL7 encoding rules consist of data fields that are of variable length and separated by a field separator character. The rules describe how the various data types are encoded within a field and when an individual field may be repeated. The encoding rules will be applied where the environment does not include relevant software to do the encoding.

The data fields are combined into logical grouping called segments. These segments are separated by segment separator characters. Each segment begins with a 3-character literal value that identifies it within a message. Segments may be defined as required or optional and me permitted to be repeated.

Individual data fields are found in the message by their position within their associated segments.

All data is represented as displayable characters as in ASCII displayable character set (hexadecimal values between 20 and 7E, both inclusive) unless modified in the message header segment. The field separator is required to be chosen from the ASCII displayable character set. All other special separators and other special characters are also displayable characters, except that the segment separator is the ASCII CR (carriage return or Enter) character.

A special point of interest is the fact that HL7 standard allows one to use any code, even one that has not been created yet, to be used for transmission of data. The only point that must be taken care of is that the receiving system must be able to recognise the code and interpret the code correctly.

Now, if the above does sound confusing, if not downright intimidating, perhaps I can use a corollary to try and describe what is going on.

If you care to remember, DNA strands are nothing but a sequence of nucleic acid bases that are nothing but codes, which give rise to specific proteins. A particular set of DNA with a string of nucleic acid bases interlined in a specific manner determines what it ultimate protein or sequence of amino acids that it will translate itself into.

Without going into too much detail, it may be recalled that the DNA by itself does not do anything. It is the tRNA (transfer-RNA) that copies the bases (or codes) from within the nuclei. The tRNA chain then comes out of the nuclei in to the cell and is again copied in to mRNA (messenger-RNA). Both the tRNA as well as mRNA have a beginning (initiator) code and an end (terminator) code. This code is made up of sequence of three nucleic acid bases, and a specific set of bases cause a particular amino acid to be tagged. Different amino acids tagged on to each other in a specific sequence gives rise to a specific protein. The presence or absence of even one amino acid could at times prove lethal as the protein so formed could be incompatiable with the healthy existence of the organism in which it has been formed.

All that the ribosomes, which actually does the reading and translating of the code and then generating the specific protein from the amino acids, actually does is to read the initiator (or the header) base of the RNA string as brought to it by the mRNA (messenger-RNA) and then tag the various amino acids according to the bases of the RNA on to each other.

Once the terminator (or footer) base is encountered, the ribosome ceases to tag any more amino acids on to the protein and releases the protein as being complete. If, for any reason there is any fault in the copying process (DNA to tRNA or tRNA to mRNA) or in the DNA base sequence itself, whereupon faulty proteins are generated, it really is not the ribosome's problem.

All codes may be thought of as the nucleic acid bases, and the HL7 as the DNA or RNA. The ribosome is the programme that reads the codes and the protein as the regenerated original data that the code represents. As faulty proteins could be life threatening, faulty decoding of the data could prove lethal too.

Mother nature has made elaborate arrangement by way of natural laws for the accurate generation of proteins. It makes common sense to create a standard that may help in accurately reading data, especially medical data. HL7 is currently in revision 2.3 (mid-1999) and understandably requires careful consideration and handling.

Natural Language Processing (NLP)

The area of use of NLP in medicine could be in medical transcription and feedback from the computer. Medical personnel would be immensely benefited if they could interact with the computer by using speech. Manipulation of the images would definitely require the use of some pointing devices (like the trackball/joystick/mouse/pen/touch-screen), but the machine could still provide the feedback using voice.

The doctors could of course feed in/retrieve data or query the database using their own voices and the machine would present the data in an useful manner (i.e., talk back or ask for further clarification in cases where such are necessary). Graphical depiction of statistical data and analysis thereof.

Video-Conferencing

The current telemedicine facilities use tele-conferencing technology to allow people (medical personnel, administrators, insurers, health care providers, patients, their relatives, etc.) in various locations to meet for improving health care without travelling. The current practice incorporates the use of medical image (x-ray/ultrasound/CT/MRI scans), video-conferencing consultations, multi-disciplinary and specialist support, along with CME.

Such telemedicine facilities are basically video-phones (i.e., phones that allow the callers to see each other while talking) most commonly done using digital telephone lines. It is expected that this will necessarily lead to faster diagnosis and early start to the treatment.

Increasingly, tele-conferencing is used by major medical conferences to connect delegates world wide and also demonstrate procedures (also carrying out "live" surgeries) where every move made by the surgeon is seen by all. Simultaneous question-answer sessions can also be held. This has not only greatly enhanced the effectivity of such conferences but also allowed for faster upgrade of one's skills and knowledge base without having to travel a lot.

Not only procedures but also presentations by delegates may be made - with the presenter being in London and the actual conference in Canberra (the presenter may have bleary eyes since there is around 9-hours difference between the two, well, nobody is perfect and neither all situations!) or vice-e-versa.

Tele-imaging systems send images from one point to another through digital computer assisted transmission, typically over standard telephone or ISDN lines, satellite connections or over a local area network. The images can be retrieved from imaging modalities directly, or by digitising films, or digitising video signals. Special digitising equipments are available for digisiting films while video cameras may be directly hooked on to computers using e.g., a video card. These images may then be transported directly, or through imaging gateways, and sent to a variety of medical imaging modalities, such as archives, display stations, and print spooling devices. It is now coming to include the interfacing with HIS/RIS systems in the process of transporting digital images.

Only a few technical details follow. The current video-conferencing standard is H.320. Picture-in-picture monitors and autofocus with pan-tilt-zoom controlled cameras and audio at 7 kHz full duplex are the basic machinery required. Standard data ports are used for data transmission. Standard 128 kbps lines using 64 kbps ISDN lines are preferred for connection.

Some additional definitions:

[Ref. From the PACSpage by Eric John Finegan]

PACS - Picture Archiving and Communication Systems

It offers:

1. picture viewing at diagnostic, reporting, consultation and remote workstations

2. archiving on magnetic or optical media using short or long-term storage devices

3. communications using local or wide area networks or public communications services, and

4. systems that include modality interfaces and gateways to healthcare facility and departmental information systems offering one integrated system to the user. [Source: NEMA]

DICOM - Digital Imaging and COmmunications in Medicine

The DICOM standard is a set of rules that allow medical images to be exchanged between instruments, computers, and hospitals. It establishes a common language that guarantees a medical image produced on one vendor's machine will be displayable on the workstation from another vendor.

Telemedicine

Telemedicine is the process of using present-day telecommunications and computer technology to enhance the performance of medicine, particularly in the area of delivery of medical care. It uses information technology to deliver medical services and information from one location to another with minimal of delay.

Multimedia Patient Records

A multimedia patient record permits the reviewing medical doctor to examine information from current or previous encounters while continuing to interact with the patient.

It also permits the reviewing physician to store-and-forward information from the encounter for review or for progress tracking.

Telemedicine Workstations

While store-and-forward workstations may be as simple as a personal or laptop computer fitted with a modem for the purpose of transferring records of a patient encounter, normal interactive workstations are built on to a personal computer. The computer runs the medical record software and integrates the videoconferencing and file transfer capabilities of the workstation.

The videoconferencing component of a telemedicine workstation is called a codec (short for coder/decoder). The codec understands a videoconferencing protocol and permits the exchange of information between telemedicine systems.

Communications with other telemedicine workstations is accomplished through various types of communications and networking hardware. Many workstations employ a special file transfer card to transmit data to another site. These range from cards designed to communicate via the V.35 protocol to normal modems and ethernet cards. Many ISDN workstations make use of an inverse-multiplexer to bond multiple ISDN lines into a single interface useable by the codec or file transfer board. Other types of communications interfaces includes ATM, TCP/IP, leased lines, and switched-56 circuits.

Robotic Surgery in Cardiology

Recently, voice controlled robotic arms (that respond to verbal commands of the surgeon) have been employed in a reputed institution in India to perform coronary artery by-pass surgery (CABS). There are various advantages to this procedure where only three key-holes needs to be made in the chest near the heart and three robotic probes are introduced. These robot arms perform a number of tasks. It not only responds to the verbal commands of the surgeon performing the surgery but also produces a 3D image of the heart. The best of all is the fact that these robotic probes are able to continuously adjust (based on the same principle that is used in the anti-skid technology by the auto car makers to allow for the simultaneous braking of the four wheels of the car even though each wheel is moving at different speeds - the anti-skid technology allows for the car to "intelligently" interpret the wheel movements and make such adjustments as necessary so as to make all the wheels to behave as if they were moving at the same speed) the image being transmitted so that the surgeon sees the 3D image of a still heart even though it is beating. The surgeon performs the operation as if he were doing it on a still heart and therefore no heart-lung machine is required and the heart does not need to be stopped. This allows for lower morbidity and mortality rate as well as lesser number of indoor stay in the hospital.

In telemedicine, this procedure would allow for remote surgery. And it is not "pilot-less surgery", rather "distance surgery - telesurgery". The surgeon can be sitting next to the patient, the next room, or even half-way across the world. All he needs is a good resolution monitor, ability to speak (using microphone and headphones), and a perfect communication that will not break, and viola!

This whole idea originally came from NASA for they wished to have such facilities in place that would allow specialists to treat the people manning the space station for it was not possible to have a specialist for every medical condition on-board and the 100 odd people in the space station may urgently require medical attention, even operative procedures, which have to be effectively handled from an earth-based station. The Indian institution took up the idea and made it a reality.

Cybersurgery

Somewhere in the contents of this site you must have read that people who matter thought cybersurgery would never be popular as 'pilot-less flying' didn't since who with any sense would allow a surgeon present "virtually" operate on oneself? That was April 1997. In January 2000, it is the latest craze on the Net (according to The Sunday Times, London). That is the speed at which both Information Technology and people's attitude towards it is changing, amongst other things...

Actually, it is not a form of macabre voyeurism per se. It is opined, in the article, that watching such operations could actually help potential patients make up their minds as to whether or not they want a particular surgery to be performed on them. Today, you can e-mail your scanned picture and for a fee get advise on what cosmetic (plastic) surgery you require and what would the costs involved be. Therefore, what was hypothised around three years ago has become reality today.

ADDENDUM

The current emphasis of medical practise is on “Evidence-Based Medicine”. While I do not intend to launch into a discourse on what evidence-based medicine is, the concept of datawarehousing can be geared up to meet the requirements of this type of medical practise. The programme that would administer the data could allow the user to set-up and calculate the various relative risks, odds ratio, confidence intervals, numbers needed to treat, the cost for a particular method of treatment, etc.

The newer mobile phones also hold excellent promises too. Already multimedia messaging systems (MMS) is fast becoming the flavour of communication, after e-mail, video-mail, and SMS. With MMS one can exchange videos, pictures and text. However, it all does not end over here. The next generation mobiles allow for the transmission of live video, just like audio as they all do, and since it is one to one, the transmission is relatively secure. Although, the ones who wish to “snoop in” will always do for they always find a way. With Bluetooth technology it will be possible to achieve quick transmission speeds. Further development in terms of mobile-specific operating systems and programming languages would go a long way in helping matters. Telemedicine is not really off the starting blocks yet (2001 end) due to high initial capital inlays, cost of training of personnel and lack of basic infrastructures, like a decent telephone connection to handle the required bandwidths, in areas where the technology would prove to be most beneficial. Mobile telephony holds a key position as the new mobiles equipped with video cameras, keypads, decent memory capacities, and ability to store and forward audio-visual-textual data are prices at around US$ 500. What is so unique about all this is that it is priced at par with a decent desktop, and has the additional ability to connect with each other by way of mobile telephony without the requirement of modems, bandwidth restrictions, etc.