Clinical Grade – A Foundation for Healthcare Communications Networks

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Abstract **– Healthcare is adopting information technology as an integral part of clinical workflows and processes themselves. This places substantial demands upon the performance and behaviour of such networks, especially as the paper records systems are retired, leading to the fundamental attributes of Clinical Grade networks for healthcare.**

I. INTRODUCTION

Healthcare expenditures are a significant issue in many countries of the world, with rising expectations, rising demand for care and ever-rising costs. Healthcare is now placing significant strain on the economics of many developed, developing or about-to-develop nations. For instance the USA now spends in excess of $2Trillion per year on healthcare, or more than 14% of the Gross Domestic Product (GDP). Other developed countries have expenditures in the region of 6-11% of GDP. In addition the number of deaths at least partially due to medical errors was assessed as being between 45,000-90,000 deaths per year for the US a few years ago [1], well above the death rate due to automobile accidents in the US (about 42,000 per year). In addition adverse drug-reaction induced injuries are estimated at 770,000 per year [2].

Solutions to the problems of healthcare affordability and quality are difficult and complex, requiring multiple approaches, such as population "wellness" education, new more effective clinical procedures and more. The current paper-based information capture and dissemination used throughout Healthcare impedes rapid movement of data, as well as the use of correlation tools, decision support tools, etc. Slow movement of data and difficulty in gaining access to data are major causes of operational ineffectiveness in healthcare, slowing clinical processes, and causing a lot of rework to correct for errors or simply to recover otherwise unavailable data. At the same time most medical errors appear to occur due to lack of information, not lack of competence or motivation, with competent clinicians making decisions based upon the facts they have, not the complete set of facts they could have or could need. Any improvement in clinician effectiveness, such as may be possible by bringing the information to the clinician instead of making the clinician hunt for it, should reduce both costs and medical errors.

Hence 21st Century healthcare will provide new healthcare initiatives such as wellness (illness avoidance) and more effective treatments, with enhanced treatment-productivity, whether that be via new procedures, new drugs or simply providing clinicians with full, easy access to the information retrieval, knowledge referral, capture, decision support and order entry tools they need, at the point where they need these capabilities, and in a reliable, consistent and easy-to-use manner. Clinicians are extremely busy individuals whose primary focus is Healthcare and not Information Technology (IT) or Network Communications systems. Adoption of clinical information systems has been hampered by poorly designed human interfaces or poor integration with the workflow, but also by network issues such as wireless coverage, system reliability, network availability, and application availability. This paper will examine and highlight these issues from a network perspective, and propose a framework for their mitigation characterized as "Clinical Grade Networks."

II. WHERE CAN IT IMPACT CLINICAL SERVICES?

IT has been used in Healthcare for many years as a support, administration, scheduling and billing tool in the back office but not as an integral component of the clinical processes themselves. Applying IT infrastructure into clinical processes and areas of the facility such as a Point-of-Care patient-clinician encounter offers opportunities for clinical process improvement but puts substantial demands on the behaviour of the network, both from a technical aspect and from a human factors perspective. The resultant "Clinical Grade" requirements are analogous to "Carrier Grade" requirements, but find their definition from within the requirements of the clinical community and not the carrier/telco community.

Figure 1 shows the breadth of application required for a mature clinical IT network designed to engage into the clinical processes themselves. It touches all clinical functions within the hospital as well as providing clinical information connectivity to outlying clinics, doctors' offices, passes necessary clinical information on an authenticated as-needed basis between the hospital, other hospitals and test labs, etc. It includes connectivity to data centers both

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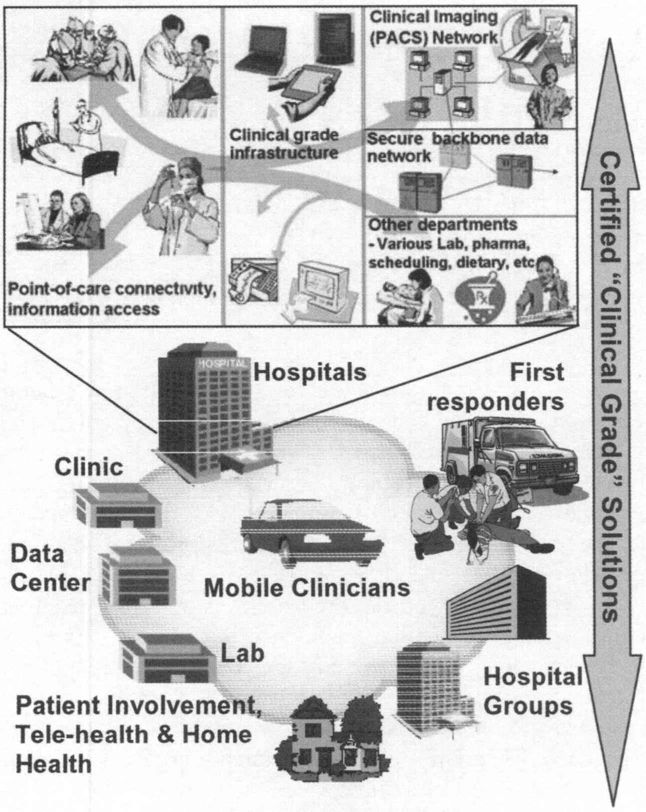

Figure 1 Scope of Clinical Grade Healthcare Network

for routine archiving and retrieval and to ensure business continuance and disaster recovery is possible, all of these being under a strict umbrella of information security, and with only authenticated access. In future these capabilities will continue to also be extended more and more to first responders, to provide the paramedics with more Emergency Room support at the site of first response and to prepare the emergency room for what is coming, as well as reaching into clinician practice or clinic and ultimately the home for on-call access.

The key applications for an IT network within the clinical workflows themselves are:-

1) Medical history record capture, storage and retrieval
2) Patient treatment, tests results, evaluations, diagnoses for the current admission session
3) Secure storage, retrieval and modification of the long-term and current healthcare data
4) Enabling multimedia collaboration between clinicians
5) Providing access to knowledge bases for immediate access to information and expertise.
6) Workflow engagement where the network provides services enhancing clinical applications / workflows
7) Information exchange to facilitate pharmaceuticals and drug dosage management
8) Laboratory test orders and integration of results into the overall patient treatment record/history
9) Ability for clinicians at their point of practice (clinic, office) to draw on, and interact with, the resources of hospitals or other medical facilities (test labs, pharmacies, other clinics)
10) Remote patient monitoring, monitoring of mobile patients
11) Mobile seamless Wireless access support to first response teams, mobile staff or in-transit clinicians
12) Online collaboration between regionally or globally dispersed experts for leading edge diagnostic and surgical treatment of patients
13) Dependable secure clinical function support during emergency situations such as natural disasters, major accident events, terrorist strikes, etc. This may require the deployment of auto-configuring network extensions (e.g. to a strike point triage capability).

These applications and uses have a number of common factors, such as need for security, access only by identified authenticated personnel, absolutely dependable data (and voice) delivery characteristics, predictable responses so that clinicians can intrinsically trust the system behaviour, ability to support non-repudiatable transactions, guaranteed transaction completion, and seamless communications support with mobility.

III. WHAT IS CLINICAL GRADE?

The key attributes of a Clinical Grade network, which are applicable to an information and communication network that can fully support clinician's needs and would actually be embraced by them are: -

- Virtually no downtime from a user's perspective
- Guarantee confidentiality and integrity of information and guaranteed access to that data but only by properly authenticated personnel
- Guarantee accuracy of information transfer within a specified time period, without silent corrupted or incomplete transfers
- Respect Service Level Agreements for throughput, responsivity, coverage, availability, etc.
- Convergence to support multimedia communications
- Manageability of the network and of the network attributes as well as the services carried over the network
- Interoperability between industry-standards-based with an evolution path for new solutions
- Usability of solutions implemented across a Clinical Grade network – while Clinical Grade cannot reach into the detail design of the applications running across the network it can offer performance guarantees and advanced capabilities that make the use of those applications easier, more consistent and dependable.

Information security is a critical aspect, since security breaches can create network downtime in addition to loss of data integrity plus loss of patient and clinician confidence and violations of privacy legislation such as the Health Insurance Portability and Accountability Act (HIPAA) in the USA. Clinical Grade requirements are applicable to either end-to-end, or database/transaction management, or the access mechanism that carries them, unlike Carrier Grade and other requirements which may strictly encompass the performance of the network path mechanism alone.

Clinical Grade responds to clinical needs the way that Carrier-Grade responds to carriers' requirements. Clinical Grade will have to be defined in several areas where Carrier Grade is silent, being far more closely coupled in to the clinical applications and processes dependent upon it. Clinical Grade will include a network component and a system or applications component.

Clinical Grade solutions must be fit for use where clinicians are making critical decisions about patient treatments or taking critical actions in furtherance of those patients' treatments. This means that the clinical grade systems must offer high coverage, be highly functional, reliable and dependable without being obtrusive. Clinicians need to be thinking about their patients and their treatment, not about some finicky technology. It also means that the clinician terminal will often have to be mobile because clinicians migrate around the hospital and between hospitals as well as their point of practice almost continuously. Hence bullet-proof seamless mobility for both voice and data services is vital because the clinicians have to be able to get access to the data wherever they are.. As the workflows evolve the reliability of the clinical grade network and especially the availability of the clinical grade network to the clinician's location will become of paramount importance. A Clinical Grade network also has to support a wide range of other aspects, giving rise to a set of fundamental Tenets of Clinical Grade.

IV THE KEY TENETS OF CLINICAL GRADE

The 10 key Tenets of Clinical Grade Networks are: -

a) Available/Resilient

Clinical Grade networks should generically provide better than 99.99% network availability at given connection points, not including hand-held terminal availability (i.e. downtime should be less than 53 mins/year). Protection/redundancy should be used to limit geographical area impacted by any failure. Site-wide unavailability in large sites should be less than 0.001% (5mins/yr). Availability of the network (hardware and software) as-presented to the clinician's hand-held device has to be concatenated with the availability of the clinical software which is outside the control of the Clinical Grade network and this definition does not include unavailability due to the clinician running the battery down in the hand-held device, although approaches to mitigate the effects of battery exhaustion are recommended and are planned.

It is anticipated that, by developing, testing and evaluating clinical software in concert with network hardware and software prior to deployment, a more durable, dependable and functional solution will emerge. Further, network monitoring and management solutions for proactively identifying and bypassing network trouble spots before the customer discovers them will enable significant reduction of network downtime.

For instance adjacent or nearby terminals must either have links back to different hub switches or the hub switches must be protected. A Wireless Local Area Network (WLAN) Access Point (AP) failure may be covered by planning the WLAN cells to overlap so that neighbour AP's can pick up the load – this places more spectral demands on WLAN planning, giving a preference for a WLAN deployment to IEEE 802.11a standards over 802.11b/g for reasons of channel count, allowing for less common channel interference issues and less "other uses of spectrum" issues.

b) Secure

Access should be granted only to authorized authenticated users, using biometric or other key secure identifiers to keep out intruders, keeping access to specific data to the those who have a reasonable need to know, so as to meet the HIPAA (in the USA) and other equivalent privacy and security policy requirements on protecting patient data privacy and to prevent data tampering, falsification and theft. Aggressive measures are required to keep intruders out, to shut down intrusion attempts and to physically locate intruders (e.g. by triangulating on their WLAN signal location). Secure encryption is required on all accessible paths to ensure that the content cannot be downloaded by unauthenticated and/or non-reputable sources.

Personal medical information stored on portable devices is a major issue. Interaction with the network can prevent loss or theft of this information, such as by wiping memory when a security breach is detected by the network, backing up transactions and information on the network, or by using network-centric computing that allows for no / minimal information on the portable device.

If auto-configuring networks are deployed (e.g. during a crisis) then these will have to secure.

c) Quality of Service (QoS) / Service Level Agreement (SLA)-based

Thorough, proper network design, traffic planning at deployment phase combined with QoS based prioritization of content, ensuring delivery of mission-critical content, and handling of voice, video and data, allowing the setting of contractual Service Level Agreements (SLA). This will allow for bandwidth guarantees and other network performance guarantees, hence providing controlled and consistent transaction times as long as the network is properly dimensioned for the traffic load, requiring a complementary traffic planning (and ongoing traffic monitoring) activity.

d) Pervasive Coverage of the Facility and beyond

Service coverage throughout the entire facility area to be covered must be at a QoS above the guaranteed minimum – it is not satisfactory, for instance, to have "good" Radio Frequency (RF) power everywhere in a WLAN deployment within a building or campus, if that results in high common channel interference and consequently to a low data throughput. The QoS and resultant SLA must be end-to-end, including the effects of the WLAN, WLAN coverage, since a busy clinician cannot distinguish between the effects of a WLAN non-coverage event and a loss of a data switching node – to the clinician all that he sees is that his tool is broken and so his workflow is disrupted. This requires setting coverage goals on both wired and wireless infrastructures. Coverage goals close to 100% of an area are difficult to do in the wireless domain due to lack of control of the transmission path. Coverage can be improved by using various current and future techniques including 802.11a with a 12 channel (later ~22 channel) plan together with a dense AP deployment grid, so handheld devices can "see" multiple AP's without incurring Common Channel Interference (CCI), by the adoption of multipath tolerant or multipath-exploiting technologies such as Multi-Input, Multi-Output (or MIMO) transmission, etc.

e) Seamless mobility with session adaptation

Furthermore sessions should seamlessly migrate between WLAN segments and ultimately when a clinician leaves the building or campus, migrate from WLAN to the Wireless Metropolitan Area Network (WMAN). This requires coordination between the in-building WLAN and the cellular service providers. Seamless transition from wired to wireless communications should also be possible, as also the support of presence-based communications. When migrating between different media the session should be adapted to match the capabilities of the communications medium. For instance large Radiology images should not be downloaded over a WLAN or cellular radio, but smaller reference images can be downloaded over the WLAN. Also, in some high bandwidth scenarios the Graphical User Interface may be rich and heavily image based but in a low bandwidth environment there may be more use of text.

f) Transaction integrity

Transactions cannot be lost, damaged or misrouted. Furthermore, the source and destination must be logged so that the origin, timing and destination of the transaction cannot later be denied – non repudiation. Since network failures even on a highly available network can cause transient losses, this means that the transactions will require local storage at source until a positive acknowledgement is received, with a time-stamp, from the recipient. It must also support the full suite of services that need to be carried across it, giving rise to the series of Quality of Service definitions, mentioned above One important aspect is that it must not silently lose transactions (e.g. a drug order to the pharmacy). This does not mean that the packets that carried the transactions cannot be damaged or lost in transmission during a failure, but, in the event of such an event the system must notify the source of the failure of the transaction to deliver and to trigger a resend of that transaction.

g) Non-repudiation

Monitored integrity can be taken further in that, in a secure, authenticated world, dealing with important data, there needs to be traceability of data so that clinical data entries capturing activities, observations and orders can be tracked to their origin and cannot be repudiated...setting up a trail of who did what. Much of this has to reside in the clinical applications themselves, but these assume a basic set of network behaviours that must be met. This is very important information for determining a root cause of a problem or medical error and to gain relief for Malpractice Insurance rates.

h) Provides ability to evolve – "future-proof"

Support for increased traffic loads arising from more clinician adoption, and usage including new services, especially the expansion of multimedia services and applications that combine communication and sensor inputs. This will also include smart new "convenience" features, aimed at making the clinician interface more effective and user-friendly while assisting the clinician to be more effective. Many of these will be based on precision location, a concept which allows "presence" measurement which will allow many associative services to be offered. Further, auto-configuring networks of IP-enabled devices will soon enter the clinical communications realm, both for conventional use within local areas (e.g. operation theatre) and for emergency use with high civilian casualties.

i) Human-system interactions - ease and consistency

The Clinical Grade system should present its users with a reliable consistent user experience and should enable human-friendly system interfacing by convenience features such as single sign on, automated session transfer, session migration from small handheld to large fixed terminal and back again (e.g. for radiology image viewing).

j) Workflow engaged

The Clinical Grade system should allow for dynamic adaptation to the demands of the applications including prioritization of network resources to ensure SLA's are delivered for critical network demands or by providing network knowledge services such as presence and location to applications to improve workflow efficiency

In addition convenience/efficiency features such as re-configuring clinician communications automatically, based on knowledge of clinician location, automatic tracking and loss/theft control for expensive but readily stolen hand-held devices are adjuncts to (but not part of) the clinical grade definition.

From the perspective of the IT Department supporting the clinical grade network, additional tenets include manageability to allow seamless upgrades, as well as interoperability to enable seamless interaction with other healthcare networks as well as with existing network components.

Clinical Grade Certification may be obtained by testing equipment and software within a secure network in a dedicated laboratory environment. Hospital IT departments may require that any new equipment or software is certified as Clinical Grade before deploying within the clinical environment.

V. IMPLEMENTING A CLINICAL GRADE SOLUTION IN A SPECIFIC AREA – HOSPITAL POINT-OF-CARE ACCESS

As an example a typical Wired / WLAN-based Point of Care communication system and supporting infrastructure is shown in **Figure 2**.

A Point of Care communications system involves four key components, all of which/whom must inter-operate successfully. These are the Core Hospital Information System, the Wired / WLAN Point of Care delivery access system, the fixed and mobile terminals to be used by the clinician and the user community itself.

A Point of Care communication system allows clinicians who are in the process of advancing their patients' treatments to interact with the entire available knowledge about that patient, from the medical records, patient records, test and radiology results, general medical knowledge and multimedia consultation with colleagues or specialists. Since these interactions often occur at the patient location it is important that the Point of Care solution be ubiquitously available throughout the entire hospital area frequented by those patients. This can be achieved by providing a large

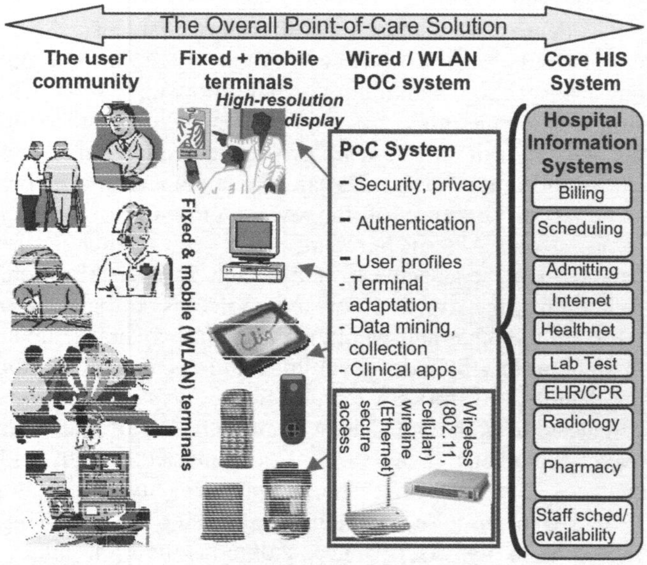

Figure 2 Point Of Care Communications

number of fixed terminals and phones (the "conventional" solution) or can be achieved by providing the clinicians with wireless voice/data terminals (e.g. PDA's/phones, Tablet PC's also running a VoIP client) and building a very high coverage, high throughput, reliable WLAN infrastructure across the hospital or by a hybrid of the two – which is the preferred solution for various reasons. The clinicians can then, by a process of identifying and authenticating themselves, gain access to, and use, the resources of the Hospital/Healthcare Information system, including clinical history, previous treatments, drugs and surgical procedures, etc. This avoids the error prone two-step process of writing notes and then transcribing them later, and also allows for the deployment of real-time decision-support systems, as an example to handle drug conflict detection.

However clinicians are stressed busy professionals, who need to be thinking about the patient and not technology so these clinical applications all have to be supported non-obtrusively with utter reliability, and access security in a solution that clinicians are happy to depend on. For instance, for the case of reliability consider how a hospital that had abandoned its old paper records system would function in the presence of a prolonged IT failure- hence a "clinical grade" solution must respect the fact that hospitals are 24 hour per day, 7 day per week, 52 weeks per year institutions (referred to as 24/7/52) and cannot tolerate service disruptions. Also, consider the likely response of a busy clinician who cannot get a reliable WLAN connection in the middle of a patient care encounter. We have to ensure that the performance of these systems is so good that they become taken for granted – the ultimate goal of "Clinical Grade".

The required network availability has to be provided across a mobile-oriented, wireless-connected hospital clinical information network, demanding both much higher availability and higher, more consistent coverage than has traditionally been the case with conventional Wireless LAN infrastructures. Furthermore this physical layer availability has to be concatenated with the clinical application availability numbers to achieve true solution availability – the availability the clinician sees. In a Clinical Grade WLAN a new parameter, that of "Coverage", is defined to ensure that as many as possible Point of Care encounter sites in a hospital or medical facility receive suitable calibre signals. Since this can mean treatment of emergencies, which can happen everywhere, this requires a close-to-ubiquitous coverage of the hospital with Wireless LAN. This is very difficult to obtain with 802.11b deployments because of the limited spectrum and hence limited channel-counts available at 2.4 GHz but is more practical at the 5+ GHz frequencies in 802.11a, with its larger and likely growing spectral allocation. . Coverage resiliency may be realized by using WLAN Access Points (AP's) with overlapping coverage, so that coverage is maintained with an AP out of service. The trade-off would be the increased cost to the network operator.

Wireless systems based on Wireless Wide Area Network (WWAN) cellular data, if deployed in hospitals without indoor transmission aspects being dealt with appropriately, can suffer from poor coverage and may even have imposed restrictions on usage due to potential RF interference with medical equipment. As dual-mode and multi-mode devices emerge it will become required to allow mobility between WLAN and WWAN.

But it is not just high coverage and low failure rate/high availability that denotes a clinical grade network. The manner in which it fails is also an attribute. It should fail in a resilient manner so that it is partially self repairing – for instance the WLAN AP channel plans and locations must be such that, in the event of an AP failure, all the dependent remote units can attach to adjacent AP's without loosing transactions and without causing AP or network overload.

An implementation of a WLAN Point of Care system is shown in **Figure 3.**

This solution provides secure voice and data communications between authenticated, identified clinician users and the core hospital information system via a range of hand-held devices and a WLAN link. The edge devices consist of Tablet PC's, Laptop PC's, or PDA form factor devices for data delivery, or the same devices with VoIP clients for voice/data delivery or a range of VoIP phones and hands-free badges for voice communications. All of these are linked to the core IT network via a Wireless LAN infrastructure, putting considerable demands upon that infrastructure. Hence a Clinical Grade Wireless LAN Point of Care communication system has to be backed up by a core Hospital Information System that itself is a "Clinical Grade" solution in terms of functionality, security, reliability, etc.

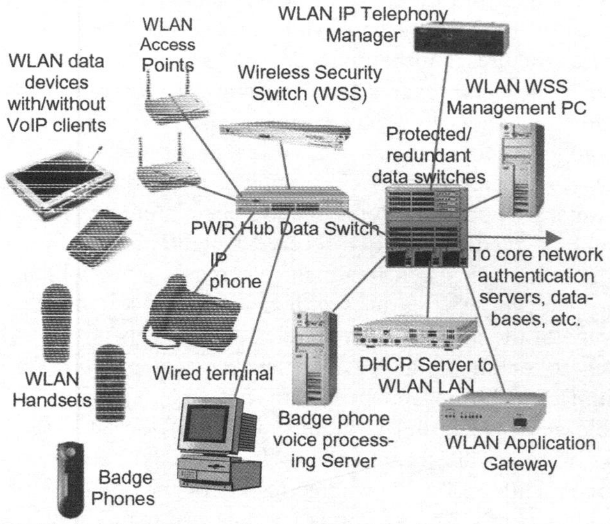

Figure 3 Implementing A Wired and Wireless-Connected Point Of Care Communications Sub-System

Experience with WLAN has shown that, in order to achieve good coverage and good "radio-shadow" in-fill, an array of relatively small, highly overlapping cells is required, both to overcome shadowing and to cover against AP failure. This is not readily implemented in an 802.11b infrastructure since this has only 3 orthogonal channels, leading to Common Channel Interference (CCI) if the system is densely deployed and loaded with traffic. Experience with regular cellular networks in the largely two-dimensional deployments that are represented by city-wide deployments has shown the need for 6-7 channels for a high coverage solution, and to fill all the shadows due to terrain.

WLAN deployments in hospitals are decidedly not two-dimensional, with leakage from floor to floor rendering a 3-D channel deployment to be necessary – hence the 12+ channels of 802.11a is to be preferred over the three channels of 802.11b/g.

Moreover there are less interferers (such as microwave ovens, consumer grade 802.11b products) at 5+ GHz. But 5+ GHz does give stronger materials interaction, leading to stronger shadowing, increased multi-path, which actually may in future be exploited by Multi-Input, Multi-Output (MIMO) technology. However, for today, a dense overlapping array of Access Points (AP's) each with a primary service area of radius no more than 70' / 20 meters, dependent upon building construction appears to be the best approach, especially if implemented with an RF control and coordination plane, optimizing AP powers, and load-balancing the traffic to the AP's. This can be done due to the closeness of the AP's and hence the overlapping of the cells they support, which is made possible by the relatively high channel count of 802.11a. Attempts to do this at 802.11b would likely run into severe common channel interference issues, resulting in good RF coverage but very poor data bandwidth coverage.

The dense coverage pattern, with cell overlap, also allows remote units to reassociate with a new AP from the same physical location, should an AP fail, allowing a work session to continue. Of more concern is a failure of the data hub switch or the wireless security switch. While this is not shown in **Figure 3**, the AP's can be dual homed to two core switches or (because of the overlapping cell coverage) every second AP can be connected to core switch 1, the balance being connected to hub switch 2. Then, if a core switch fails, the worst case would be the loss of half of the AP's but the other half would maintain full coverage, albeit in an unprotected mode. A similar solution can be taken for the Wireless Security Switch (WSS), with two WSS's each connected to both core switches, so the failure of one WSS leaves the other to handle the AP's connected to both core switches, but at a lower throughput capacity unless the WSS's were to be over-dimensioned (which they probably should be in this case). Hence, as long as the right clinical software features are in place along with transaction progress tracking, transactions will not be silently lost, instead being recorded as incomplete or undelivered, and the source can then retransmit as soon as the failure has been restored – which usually is just the reassociation time for the Remote Unit to a new AP.

In addition the WLAN must be engineered for an adequate traffic handling situation under a peak demand situation, for instance when the hospital is handling the workload from a disaster. Part of this can be supplied by the dense array of WLAN cells with a suitable core infrastructure but part has to come from the adoption of differentiated QoS (Quality of Service) for voice and data connections, since the two put very different and often conflicting demands upon the Point of Care WLAN delivery mechanism. Part of the problem here is that the 802.11 MAC is bandwidth-inefficient when handling large numbers of small packets, which is the case for VoIP calls. Hence there is value in the system concatenating multiple voice samples into fewer longer packets since this reduces the inefficiency of the 802.11 MAC and leaves more capacity for data connections. Unfortunately voice circuits have a stringent delay requirement on them to maintain usability of the link. Hence VoIP services have to demand a WLAN QoS which specifies a maximum delay, which limits the level of concatenation. Services using large data files on the other hand are generally somewhat more tolerant of delays (fractions of seconds rather than a few 10's of milliseconds) but data transactions must consistently download to the user/upload from the user within the few seconds the clinician is willing to wait – radiologists are asking for a 4-6 seconds delivery SLA on their large images – and the behaviour of the system must be consistent, so that the user can concentrate on clinical matters at-hand. This is an onerous challenge for Megabyte and multi-Megabyte-sized files, for which there may have to be some special treatment to ensure user comfort factors are maintained.

All of this creates a need for a traffic engineering trade-off between the allowable number of simultaneous VoIP connections and the data delivery capability within a WLAN cell, and hence the data delivery capability of the overall system.

Besides the achieving of basic throughput, user identity and confirming that identity (authentication) is an issue in any secure system. Authentication is an issue for clinicians because, while it is vital to maintain security and integrity of confidential and mission-critical information, it can also intrude upon the smooth flow of the actual clinical processes these systems are supporting. Certainly having a clinician enter a user ID and password or biometric input at the beginning of each patient encounter or system activity will be less than ideal –some doctors may have 50-80 patient encounters in a day. Alternatives to provide secure authentication that can rove with the clinician and the clinician's terminal have been proposed. One of these, which is the basis for a very powerful and broad capability is to combine a biometric authentication technology with a precision location technology, capable of tracking the physical location of the clinician and the clinician's terminal within a few inches in 3-D space. As long as the clinician and the terminal remain within reasonable proximity the authentication, once established, can be considered as valid. Should the clinician and terminal become spatially separated according to a policy that relates distance and time of separation, then the authentication is placed in abeyance (or can be revoked) dependent upon time of separation and the policy details. Once authentication is placed in abeyance or is revoked then the remote unit appears inert and displays no material- thereby thwarting any third party information leakage. If the clinician returns during the abeyance period the session is resumes, but if the clinician returns after the revocation time-out the clinician will need to reauthenticate, to resume the session at the point where authentication was revoked. After a further much longer time the actual session itself will be archived and terminated, should the clinician not return to it. Encryption protocols within the WLAN air interface ensure that the data being transmitted on the RF link is secure from hackers. Also, the WLAN systems are protected from intrusion with intrusion prevention and/or intrusion detection software.

A suitable precision location system based upon Ultra Wideband radio tags is shown in **Figure 4**. This approach can measure the location of a person's tag of equipment tag to within ~ 6 inches/15 cm in three dimensions, providing a powerful personal association detection/discrimination function. This function can also be used for multiple other services, especially when associated with a services-controlling presence-protocol engine.

Amongst these services are; -

a) Clinician location-dependent communications
b) Clinician proximity-dependent communications, mobility
c) Clinician-terminal association and session migration
d) Context (patient) aware medical records pre-fetching and display sequencing
e) Rapid "Code Team" formation
f) Equipment-clinician logging and prevention of third party theft

Of course the previous examples have delved a little into the WLAN-Point of Care area of Clinical Grade networks but this was just one example aspect of what needs to be provided in terms of network performance, reliability and usability across the whole network. The entire core network (not described here) has to be designed for a "Clinical Grade" application where "mission-critical" data cannot be lost, delayed, misrouted, disclosed to unauthenticated parties, corrupted or duplicated.

Such a system was demonstrated at HIMSS in Dallas in February 2005.

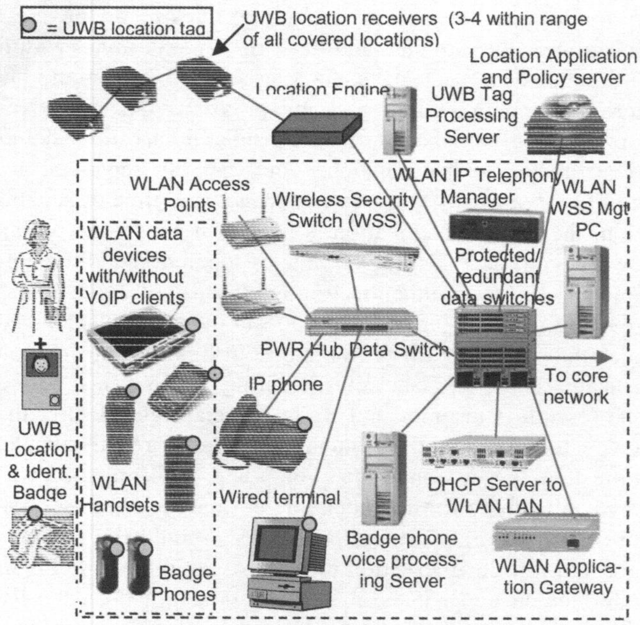

Figure 4 Precision Location Services For Point of Care

VI. Value- the pay-back?

And the pay-back? More information, properly presented in a timely manner both helps clinical efficiency and hence productivity and reduces the incidence of medical errors. Several healthcare information systems trials and tests have indicated substantial improvements are possible if Healthcare IT is brought right into the clinical processes themselves. For instance closed loop medications management has been shown to potentially reduce the Adverse Drug Reaction (ADR) rate by 70+% when properly exploited (e.g. with Bar Code Scanning) as was reported in a paper at HIMSS 2003 [3]. A hospital-wide clinical trial in the Queens Hospital Group, NY, NY achieved increased clinical efficiency and effectiveness – the number quoted by a paper at HIMSS 2003 being ~ 23% efficiency improvement in a specific Ambulatory Department while also cutting turn round times on Radiology examinations and even reducing the amount of repeat work due to unreadable material [4].

The Healthcare industry in the USA and elsewhere, notably the UK, is moving forward rapidly to bring communications and IT technology right into the clinical processes themselves on an industrial scale. How successful this will be, and whether it triggers a backlash from the medical professionals, depends on how fit the resultant solutions are for the task in hand. To that end our industry must work with the healthcare industry to define, develop and deliver total solutions to the Healthcare industry's needs for useable, effective and dependable IT and communications solutions the clinicians will be happy to let their critical decisions depend on. This makes the effort to produce a Clinical Grade technical solution which the clinical community can really embrace to be so worthwhile.

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