

# The Dynamics and Strategic Analysis of Wireless Communications Technology in the Healthcare Industry

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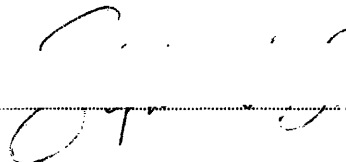
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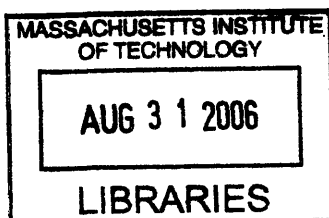
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**Submitted to the MIT's Alfred P. Sloan School of Management on May 12, 2006  
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**Abstract:**

The healthcare industry like other industry is on the cross roads as a result of rising demand for healthcare delivery and service, the industry is facing declining revenues and increasing cost. As a result, one of the industry's strategic arsenal to avert the continual declines in revenue and increases operating cost is to effectively use modern technology in form of wireless computing and communications technology to change the paradigm shift to improve outcomes of clinical services, enhance physician and nurse productivity and work flow efficiency, reduce supply chain cost, improve revenue collection and practice profitability. This report presents the dynamic and strategic analysis of wireless communications technology in the healthcare industry, by first evaluating the wireless technologies, industry standards and regulations, applicable standards for the healthcare information systems and innovative healthcare technologies.

Based on an in-depth technical analysis of the wireless technology, I analyzed the market and industry by applying frameworks including Porter's 5 forces and The Delta model and system dynamics models presented to illustrate contributing factors affecting new technology adoption in the healthcare industry and a holistic view of a healthcare IT system architecture. Lastly, I analyzed emerging wireless technologies including WiMAX, UltraWide –Band and RFID, and reviewed market opportunities in the healthcare industry through 2011.

**Thesis Supervisor: Henry Birdseye Weil**  
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# Introduction

Today's medical communities with its practitioners are sophisticated and highly mobile people that are eager to connect to real-time network communication systems that has reliable and available access to mission-and-life critical information from anywhere, anytime. Thus, senior healthcare management executives are challenged to select technologies that can help address both business and clinical objectives that optimizes patient care while delivering real measurable values to the stakeholders. Wireless communication technology has both fixed wireless systems and a mobile wireless systems, as a result mobile communication is not always synonymous with wireless communications. The evolution of newer wireless technologies with the commitment and support by globally recognized standards setting body, like the Institute of Electrical and Electronic Engineers (IEEE) made up of technology experts from industry to develop a consensus standard across the value chain eliminates ambiguities that might have existed. Wireless technology is being globally adopted and it's predicted that billions of people will gain high-speed access to the internet seamlessly within the next decade, thus we'll review emerging wireless technologies such as 3G, Wi-Fi, RFID, WiMAX and Ultra-Wideband coexistence and networking capabilities for the healthcare industry. In addition, my thesis research report will examine the dynamics and strategic analysis of wireless communication technology in the healthcare industry in five sections and concluding remarks. **Chapter two** of the report focused on the technical overview of the wireless communication technology that includes review of the three core wireless networking protocols, systems dynamics model illustrating the dynamics of a healthcare IT systems architecture, an overview on industry standards and regulations, defined standards for healthcare information systems and innovations in the healthcare technologies.

**Chapter three** addresses the market and industry analysis including a perspective on the U.S. healthcare IT market revenues, using the Porters 5 forces and the Delta model frameworks to



analyze wireless technology in the healthcare industry. Lastly, a system dynamics model illustrating the dynamic effects of new technology adoption in the healthcare industry was reviewed. In **Chapter four**, I had an extensive discussion on the emerging wireless communications technology including WiMAX, Ultra WideBand, and RFID Sensor Networks. Trend analysis of the wireless communications technology through 2011, and projected market opportunities with specific examples in **Chapter five**. Concluding remarks with a case study example of integration of wireless technology into a healthcare group's IT systems to improve clinical workflow efficiency, reduce supply chain costs and enhance billing capture were discussed in **Chapter six**.

## Chapter 2.0 Technical Overview

### 2.1 Wireless Communications Technology

Healthcare providers are working to change the dynamics of current challenges in medical information systems by consolidating fragmented patient and treatment data into centralized clinical management systems. Wireless communications technology is the disruptive innovation that is capable of radically changing delivery and services of patient care through out the healthcare value chain. Wireless technologies are now been integrated and deployed into all market segment of the healthcare industry irrespective of size and location today and in the very near future place of treatment would be irrelevant as a result of availability of long range, high speed wireless communication technology that will bridge the current digital divide gap. Hence, the emerging broadband wireless communications technology would be invaluable in the delivery of quality healthcare systems with point-of-care applications and solutions to improve clinical outcomes, increase productivity of physicians and nurses, improve revenue collection and productivity of overall healthcare community's daily operations. There are three primary application scenarios for wireless computing and communications technology they include: Wireless Local Area Networking (WLAN), Wireless Personal Area Networking (WPAN), and Wireless Wide Area Networking (WWAN), a fourth application scenarios converges the metropolitan area networking (MAN) and wide area network into an emerging broadband fixed and mobile wireless communications denoted WiMAX or Worldwide Interoperability for Microwave Access.

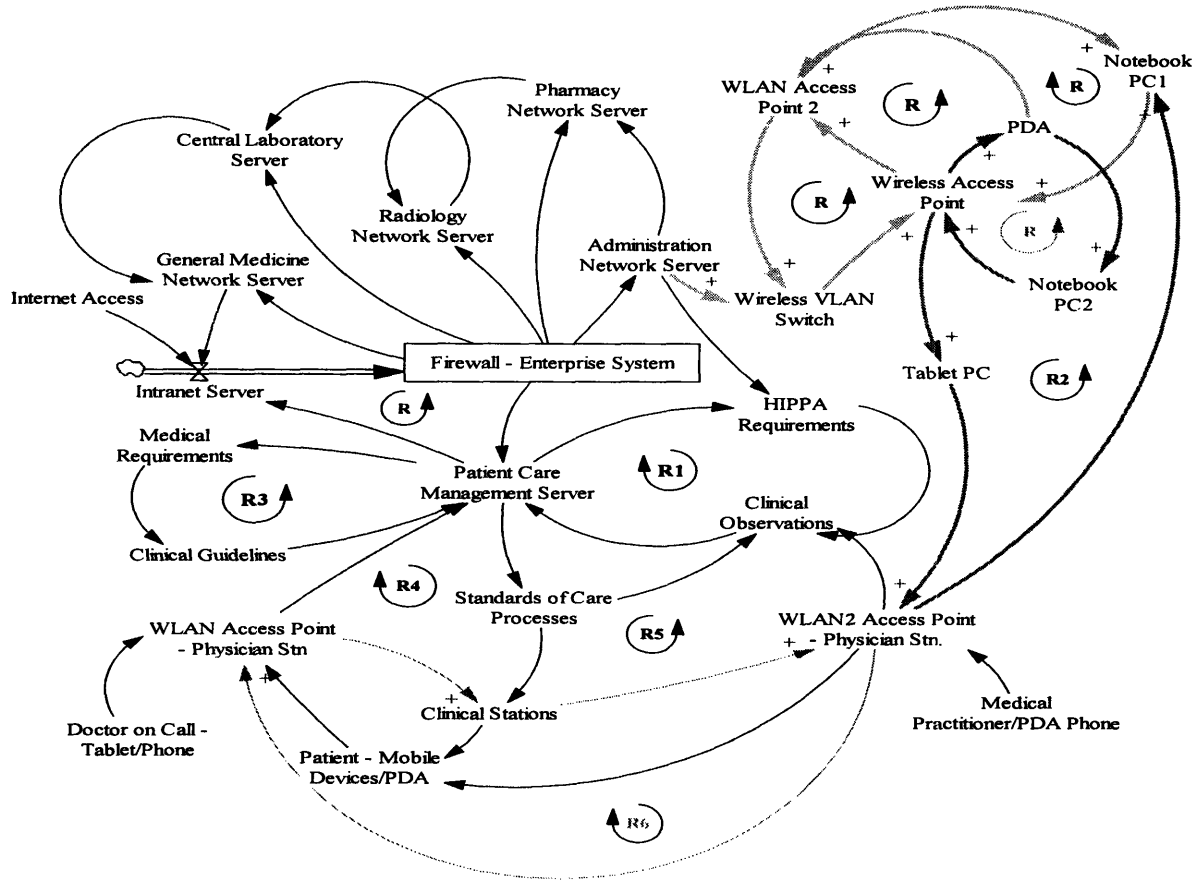
## 2.2 Wireless LAN Communication

Wireless LAN (WLAN) based on the IEEE 802.11x standard addresses organizational connectivity different from traditional wire based LAN connections. WLAN technologies provides workgroup members access to corporate network resources such as shared data, shared application in a way that does inhibit a user's mobility. The focus is on a permanence of the wireless connection within a defined region such as a hospital facility/campus or medical office buildings with a cluster, thus implying access points has finite region of coverage. Wireless LAN technology is a classic disruptive technology that is increasingly replacing traditional wired local-area-network (LAN) technologies commonly used many locations and establishments. WLANs are designed to transmit and receive data over the air using electromagnetic waves, and reducing the need of any kind of wired connections. WLANs permit data connectivity and user mobility with simplified configurations and its being recognized as general-purpose connectivity alternatives for a broad range of business applications. A transmitter/receiver (transceiver) device also known as access point is connected to the wired network from a fixed location using standard Ethernet cable. The access point enables mobile devices within a range of about three hundred feet to access the wired LAN, wireless LAN can be accessed by user devices using wireless LAN adapters such as PCMCIA interface cards that connects to a notebook PC or built-in ASIC or fully integrated devices such as personal digital assistant (PDA) handhelds or Tablet PCs.

## 2.3 Dynamics Model for Healthcare IT System Architecture

The dynamics model for healthcare enterprise IT systems architecture depicted in figure 1.0 below shows the complexity of a typical networked healthcare distributed systems, integrated Wireless Virtual LAN Switch with sub-network of access points and mobile devices connected a departmental host server of a medical center's IT network. Per this example all host or

departmental servers are interconnected through a firewall enterprise system server for security and privacy reasons.



**Figure 1: System Dynamics Model of Healthcare IT System Architecture**

as the gatekeeper for security reasons for all data flows to and from all sources within healthcare IT systems architecture, here each departmental server are inter-connected to networked servers, storage utility network, wireless virtual LAN switches, and wireless access points at strategic locations that enables portable wireless enabled products and devices such as notebook PC, PDA, tablets among others to gain access to the computing and communications network within a defined local area of the facility using approved protocols such as username and password to sign-on or connect to the network seamlessly given the level of authorizations by the health center's IT systems administrator. This process create a reinforcing loops (denoted R) continuously between the departmental servers for access to integrated

point-of-care solutions may include patient-care activities such as online clinical decision support suite that combines expert diagnostic, treatment and prescription support tools with clinical management software applications accessible by a practitioner with a mobile device like a handheld PDA or tablet PC. However, the mobile hardware products and devices has to have compatible software applications to ensure interoperability with access point or hand-off devices to communicate with the farm of host servers for close-loop data communication. Realized benefits of integrated networked point-of-care systems include improvements in clinical services, physician and nurse productivity, revenue collection and higher profitability.

- *Improved outcomes in clinical services:* Making accessible real-time patient information, diagnostic data and expert decision support to mobile care providers through wireless enabled devices and systems. Enables direct entry of lab results and medication orders through POC systems eliminates the delay and error of manual processes and accelerates delivery of patient care.
- *Enhanced physician and nurse productivity:* Automating routine data collection, eliminating manual entry processes, improving staff communication, and reducing cycle times for data collection and patient treatment.
- *Improved revenue collection and practice profitability:* Ability to capturing billable service and supply charges directly at the place and time of delivery, along with context information for accurate coding.

## 2.4 Wireless PAN Communication

Wireless Personal Area Network Communication (WPAN) based on the Bluetooth specifications. IEEE licensed the wireless technology from the Bluetooth SIG IN 2002 and adapted as an IEEE 802.15.1. The approved IEEE 802.15.1 standard is fully compatible with

the Bluetooth v1.1 specification. The Bluetooth technology defines specifications for small-form-factor, low-cost wireless radio communications among notebook computers, personal digital assistants, cellular phones and other portable, handheld devices to connect to the Internet. Thus, addresses usage scenarios that are inherently personal in nature with the emphasis on instant connectivity between devices that manage personal data or that facilitates data sharing between small groups of individuals, such as synchronizing data between a PDA and a desktop computer and vice-versa or a spontaneous sharing of documents between two or more people. Wireless computing and communication technology adds value for these types of usage scenario cases by reducing complexity like eliminating the need for cables connecting systems and devices.

Bluetooth is a radio frequency (RF) specification for short-range, point-point and point-to-multi-point voice and data transfer, the new technology enables users to connect to a wide range of computing and communications devices without the need for proprietary cables that often fall short in-terms ease-of-use. Bluetooth technology offers an opportunity for the industry to deliver wireless solutions that are ubiquitous across a broad range of devices, as an emerging wireless personal area networking (WPAN) technology Bluetooth complements wireless LANs and could coexist in interoperate with WLAN in the healthcare community.

#### 2.4.1 WPAN Technology Benefits

Rational for choosing Bluetooth wireless technology or IEEE 802.15 is that the Bluetooth wireless technology is a simple choice for convenient, wire-free, short-range communication between devices. It's a globally available standard that wirelessly connects mobile phones, portable computers, cars, stereo headsets, MP3 players, and more. Bluetooth enabled products do not need software drivers installed to interoperate in WLAN environments and its the only proven short-range wireless technology on the market today shipping over 5 million units weekly

with an installed base of over 500 million units estimated by the end of 2005 per industry reports.

**Globally Availability:** Manufacturers from many industries are busy implementing the technology in their products to reduce the clutter of wires, make seamless connections, stream stereo audio, transfer data or carry voice communications. Bluetooth technology operates in the 2.4 GHz at throughput speed of 1.2 Mbps version 1.2, and up to 3 Mbps per version 2.0 +EDR. The Bluetooth technology operates within unlicensed industrial, scientific, medical (ISM) radio bands hence there is no cost for using the Bluetooth technology. However, one must subscribe to a cellular provider to use wireless wide area networking topologies like the TDM, GPRS, GSM or CDMA. Lastly, there is no cost associated with the use of Bluetooth beyond the cost of your hardware or mobile device.

**Operating Range of Device:** Bluetooth technology is available in an unprecedented range of applications from mobile phones to automobiles to medical devices for use by consumers, industrial markets, enterprises, and more. The low power consumption (class 2, at 2.5 Mw of power), small size and low cost of the chipset solution will enable Bluetooth technology being used in the tiniest of mobile or fixed devices.

**Ease of Use:** Bluetooth technology is an ad hoc technology that requires no fixed infrastructure and is simple to install and set up. You don't need wires to get connected. The process for a new user is easy, acquire a Bluetooth branded product, check the profiles available and connect it to another *Bluetooth* device with the same profiles. The subsequent PIN code process is as easy as when you identify yourself at the ATM machine

**Globally Accepted Specification:** Bluetooth wireless technology is the most widely supported, versatile, and secure wireless standard on the market today. The globally available qualification program tests member products as to their accordance with the standard. Since the first release of the Bluetooth specification in 1999, over 4000 companies have become members in the

Bluetooth Special Interest Group (SIG). Meanwhile, the number of Bluetooth products on the market is multiplying rapidly. Volumes have doubled for the fourth consecutive year and are likely to reach an installed base of 500 million units by the close of 2005.

**Secure Connections:** From the start, Bluetooth technology was designed with security needs in mind. Since it is globally available in the open 2.4 GHz ISM band, robustness was built in from the beginning. With adaptive frequency hopping (AFH), the signal “hops” and thus limits interference from other signals. Further, Bluetooth technology has built-in security such as 128bit encryption and PIN code authentication. When Bluetooth products identify themselves, they use the PIN code the first time they connect. Once connected, always securely connected.

## 2.5 Wireless WAN Communication

Wireless Wide Area Network Communication (WWAN), unlike WLAN that has a defined region of connectivity. WWAN is capable of covering much broader area than the wireless LAN. The wireless wide-area network communication technology facilitates connectivity for mobile network users, thus enables these users access to work related information or applications while traveling or away from the office.

Today, most wireless data communications occurs across the 2G cellular networks systems such as the TDMA, CDMA, and GSM or through packet data technologies over the old analog systems such as CDPD over AMPs technology. WCDMA 3G (third-generation) digital cellular networks are fully integrated for data and voice wireless communication at a higher transmission speed compared to legacy 2G communication technologies. The 3G technology consists' of networks that provides harmonious transmission and delivery of bandwidth to healthcare providers to support remote clinical and administrative needs of the medical community including patient care management and other telemedicine applications. A scenario of the WWAN 3G networks delivery through cellular and content providers provides voice, video, and



medical data as needed to support patient treatment at remote location. 3G implementation could be invaluable in situations involving extended amounts of transport times or multiple transfers between distant locations. 3G enabled patient care solutions could provide help in both maintaining and improving patient's healthcare care needs through two way facilitation between patient and doctor. 3G wireless networks, unlike the 2G or 2.5G could expand the use of telemedicine in patient care delivery through its broad geographical coverage and wide infrastructure.

### 2.5.1 Wireless WAN (3G) Growth Challenges

**Pricing - Devices and Services:** Adoption of pricing models is beneficial to capturing revenue premium of content/applications. Thus, this is likely to be a significant challenge for providers, as 3G technologies become prevalent, business models for premium applications are likely to change where firms are likely to evaluate creative pricing models. Creative revenue models involving cost per download and pricing need to be addressed.

**New Service Adoption:** Competitive pricing and increasing voice and video applications are symptoms of the maturing wireless domain. Despite the increases in the number of 3G devices and network users, subscriber penetration seem to be saturated, leaving reduced growth potential for new subscriber adoption. Although voice communications may continue to dominate segments such as network usage, growth and profitability will come from the successful deployment of value-added services. Success for 3G services depends on the number of users that could be attracted and retained in the network. Information-based and entertainment-based applications frame the foundation for 3G services. A major challenge would be to offer services concurrently, in a personalized manner that is unique to the user.

**Timing of Release:** Applications released early or before the technology can adequately support the application may never be able to recover from an initial negative experience for the

customer. Additionally companies releasing applications late are also likely to miss out on opportunities, since the major challenges would be to determine the services that could be popular in the 3G environment and the timing of release.

## 2.6 Overview on Wireless Standards and Regulations

The IEEE 802.11 standards were approved in 1997 that consist of three different standards based on infrared, frequency hopping and direct sequence with throughput speed of 2mb/s, infrared offered point-to-point throughput speed of less than T1 speed and while the direct sequence speed (DSS) had a throughput speed of 2mb/s respectively. The three standards never gained much market acceptance. In 1999, the 802.11b standard was then approved and quickly and became a dominant standard. However, 802.11b standards features did not include frequency hopping capability, but the new 802.11b standard was developed to include the direct sequence speed, and complementary code keying (CCK) with throughput speed of 11mb/s at 2.4GHz frequency rate. IEEE 802.11a standard was then introduced following 802.11b with coverage or support for orthogonal Frequency Division Multiplexing (OFDM) enabling a much higher throughput speed of up to 54mb/s at 5GHz frequency rate. However, the 802.11a standard is not backwards compatible with 802.11b that already has highly adopted in the industry and shipping in high volume products.

The IEEE 802.11g standard was then introduced with support for OFDM as 802.11a above, the new 802.11g standards consist of OFDM requirements for high throughput speed capability of 54mb/s and other similar features and functionalities comparable to 802.11b at 2.4GHz frequency. Thus, the IEEE 802.11b and IEEE 802.11g are both backwards compatible and could interoperate between systems and mobile devices inter-changeably. There are number of 802.11x standards specifically developed to enhance the performance of 802.11b standard. The standards includes: 802.11c, 802.11d, 802.11e, 802.11f, 802.11g, 802.11h, and 802.11i - features discussed below

- **802.11c:** Developed to improve the media access and control (MAC) layer and support bridging software applications.
- **802.11d:** Developed to modify the physical layer to meet regulatory requirements in countries that restricts the 2.4 GHz spectrum.
- **802.11e:** Developed to add quality-of-service (QoS) capabilities and wireless VOIP
- **802.11f:** Developed to improve interoperability of access points from different vendors in a distribution systems.
- **802.11g:** Developed to enhance speed of 802.11b, enabling speeds of at least 54 Mbps and support for OFDM.
- **802.11h:** Developed to add dynamic frequency selection and power transmit control onto 802.11a to meet regulatory requirements in Europe in the 5 GHz band
- **802.11i:** Developed to enhance the security levels for wireless LAN.

|                                   | <b>802.11a</b>                                     | <b>802.11b</b>                                     | <b>Open Air (802.11)</b>                 |
|-----------------------------------|--|--|--|
| Relay Technology                  | Orthogonal Frequency Division Multiplexing (OFDM)  | Direct Sequence Spread Spectrum (DSSS)             | Frequency Hopping Spread Spectrum (FHSS) |
| Transmission Range                | Max. 150 feet with linear data rate drop           | Max. 150 feet with Linear data rate drop           | Max. 150 feet with linear data rate drop |
| Frequency                         | 5 GHz UNII (Unlicensed)                            | 2.5 GHz (Unlicensed)                               | 2.5 GHz (Unlicensed)                     |
| Max. Data Rate                    | 54 Mbps (Friendly)                                 | 11 Mbps (Friendly)                                 | 2 Mbps (Friendly)                        |
| Low Data Rate                     | 6 Mbps (Hostile)                                   | 2 Mbps (Hostile)                                   | 1 Mbps (Hostile)                         |
| Hospital Use                      | Tablet PC/Cart Mounted<br>Screen Relay to Ethernet | Tablet PC/Cart Mounted<br>Screen Relay to Ethernet | Legacy PDA Applications                  |
| Telemetric Interference Potential | Low  | Low/Medium   | Low/Medium                               |

- Friendly implies noise-less and indoor radio environment *Source: Adapted from Frost & Sullivan*
- Hostile implies noisy indoor or partially outdoor/obstructed radio environments

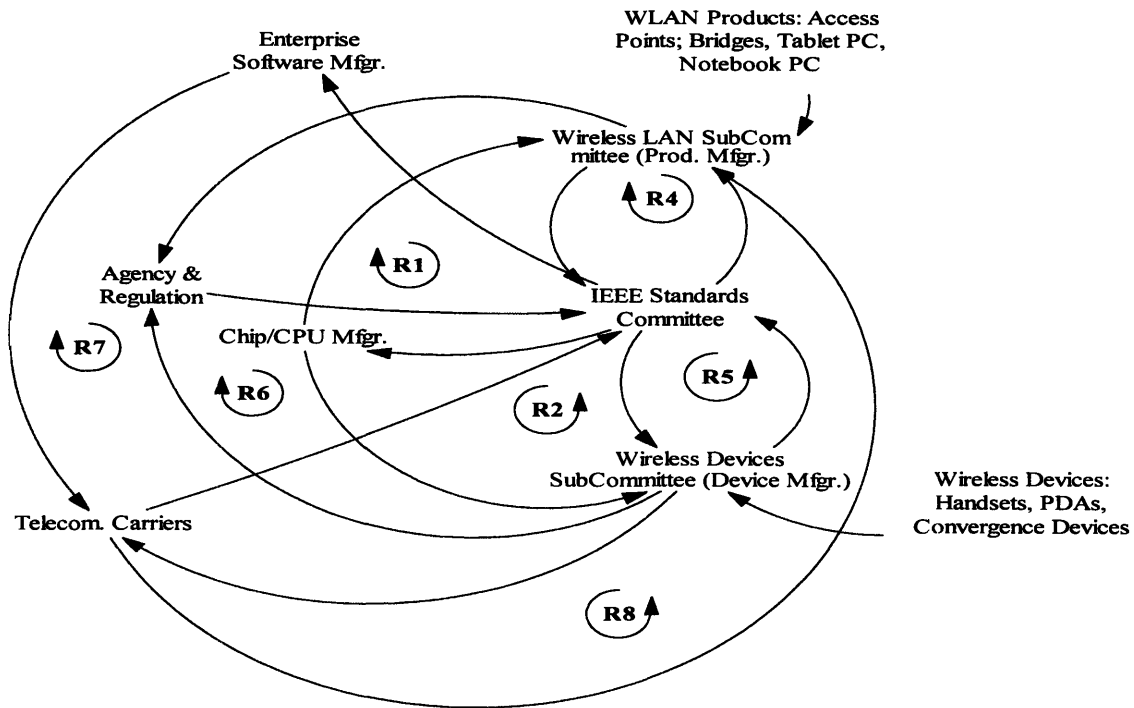
**Table 1: IEEE Transmission Standards - Healthcare Industry**

**IrDA:** Is an infrared technology, its used in very limited applications, because it requires line-of-sight (LOS) it had no adoption possibilities. Competes directly with Bluetooth, but has number of shortcomings that makes it more difficult to use than Bluetooth. However, enhanced IrDA support is expected in Windows 2000 which will enhance usability for file transfers and synchronizations. This technology would continue to be integrated into notebook computers and other mobile handheld devices. However, as the install base for Bluetooth grows the need for IrDA will likely decrease, there would be no cost benefit to integrating IrDA in devices, this is however not expected to change for another five years thus I expect coexistence of both IrDA and Bluetooth technologies during this period likely.

## **2.7 Dynamics of IEEE Standards Committee:**

The IEEE Standards Association is a globally recognized standards-setting body that develops consensus standards, through the use of open process to bring together diverse bodies of experts with like minds and shared interest in the industry to develop a comprehensive protocol that ensure products, systems, sub-systems, devices and software applications to recognizes the existence of each other and to communicate using a common and or translated software languages in form of hardware firmware, software drivers and enterprise software applications. Participants of the standards committee are in most cases technologist or subject experts from leading companies, academics, government agencies among others that gets together to ensure all diverse interest are represented in the technology and application specification and design.

**Figure 2: Dynamics of IEEE Standards Working Group**



Depicted in figure 2 is the system dynamics model that addresses working frameworks of the IEEE standard's working committee consisting of sub-committees, agency and regulatory bodies and dominant technology drivers/companies such as the CPU/Chip manufacturers driving to form alliance with hardware and software manufacturers to adopt its computing and communications processors. In this model, the principal dynamics model are loops R1 and R2, here the CPU manufactures first engages manufacturers of wireless LAN products and mobile wireless devices on forming alliance under an IEEE standards committee umbrella, then a standards sub-committees or special industry groups (SIG) are then formed by market segment or product category to develop standards or guidelines for specifications, sales and marketing programs around the technology for both the consumer and commercial markets. The standards committee in this case serves as the governing body to direct the efforts of the sub-committee, specifically to the healthcare industry SIG members with a focus in this industry

would champion developing industry standards addressing all potential restraints/constraints such as security and privacy issues, clinical data integrity, compatibility and interoperability of wireless enabled devices and systems for patient care.

## 2.8 Standards for Healthcare Information Systems

**Standards governing data integration with clinical information systems:** There are high number of standards governing the presentation and transfer of data in a form that is understood by sender and the receiver of the information, thus Interoperability across system platforms is an important factor in view of these standards adapted for healthcare operations – Data exchange/messaging standards, terminology standards, documentation standards, conceptual standards, software application standards and systems/network architecture standards respectively.

**Data Security:** There is concern about the protection of patient data and privacy policies that needs to be taken care of to ensure a smooth data transfer process. It needs to be ensured that the systems in place ensure authentication and authorization of users of patient information databases. Systems should have firewalls that grant only the authorized users to patient's records, internal encryption is another methodology that ensures data security and compliance with regulations. Data encryption has traditionally been used to secure data transmitted over external links including integration of hospital systems.

**Health Insurance Portability and Accountability Act (HIPPA):** HIPPA and the Sarbanes Oxley Act are both data security standards. HIPPA mandates the use of standards for clinical data transfer and there has been much debate regarding the standardization of terminology and messaging platforms for clinical data. Final compliance of the HIPPA standard by small, medium and large healthcare providers is scheduled for April 2006.

## 2.9 Innovative Healthcare Technologies

**Mobile Emergency Kits:** The innovative mobile emergency kit is used for monitoring vital signs of patients in case of an emergency. The vital signs of these patients are then transmitted to the clinics or hospital using wireless technology to enable the medical doctor analyze the findings and advise the paramedic or emergency staff to administer immediate treatment prior to the patients arrival at the hospital. This is an invaluable innovation, useful for field applications such as rural areas, aviation, offshore diving support vessels etc.

**Mobile Devices for Medical Doctors:** Medical doctors are increasingly adopting the use of mobile handheld devices, such as PDAs, and Pocket PCs that provide complete real time access to patient records, updated schedules and dictation capabilities at any location, anytime. This solution also enables medical doctors to monitor a patient's condition even when he/she is making the rounds or is out of the clinic or hospital premises, now armed with real-time access to tools and data to provide treatment and or make recommendations.

**Clinical Applications of Wireless Technology:** There are many applications suited for use on wireless-enabled mobile devices that fulfill both clinical and administrative functions. The objective of these applications is to enable clinicians' or practitioners' real-time patient information at point-of-care at anytime and anywhere. Available clinical applications include prescription writing and transmission, data capture and entry at point-of-care, image transfer and access, alert messaging, and charge capture.

**Prescription Writing and Transmission:** The key advantages of electronic creation and communication of prescriptions are speed and accuracy. It can either eliminate handwriting, or at least convert handwriting to text, thus eliminating one of the major causes of errors in prescriptions, a problem that has resulted in some patient deaths worldwide every year. Digital

capture of prescriptions information enables statistical analysis to be conducted without the need for converting data from hand-written prescriptions to electronic format.

**Data Capture and Entry with POC:** Point-of-Care (POC) can cover a broad range of types of information that could be entered onto a mobile wireless device for transmission to the information system in the hospital and or its enterprise network. It has the benefit of reducing the need for hand-written notes, and the requirement for later data entry task. It also allows the healthcare provider to order laboratory tests on a patient and view the results thus saving time and cutting down on documentation use while spending quality time on patient care.

**Image Transfer and Access:** Image transfer and access enables new generation mobile wireless devices to do what was very difficult before: allowing images to be sent to and read on these devices. There are limitations, caused first by the storage capability of the device as well as its screen resolution and, second, by the inability of WLAN standard to transfer data at more than 11 Mbps. However, that adoption of 54-Mbps WLANs has made this possible.

**Alert Messaging:** Alert messaging application enables patients to send a message to a physician or nurse and vice versa to alert them of any piece of information in similar fashion. Information exchange through this medium could be more than just an alert and can include patient data as well as results of test or other medical protocol.

**Charge Capture:** Charge Capture application is used for recording diagnoses at the point-of-care rather than later. It is widely used and provides more accurate and complete information about diagnoses and where charging is involved that can have financial benefit. It also removes the need for later information transcription.

**Security Solutions:** Preservation and protection of patients privacy is a major medical responsibility. Thus, the security of the data transmitted represents a major component of the design and development wireless technologies for healthcare, to ensure that the network is



secure from any kind of “eavesdropping”. Thus, the solution must ensure that data is encrypted prior to transmission to avert any kind of hacker interception, and also in adherence to the Health Insurance Portability and Accountability Act. (HIPPA) regulations passed into law by the U.S. Congress April 13<sup>th</sup>, 2003.

## Chapter 3.0 Market Overview

### 3.1 Healthcare Revenue

According to Foster & Sullivan (2005), the U.S. healthcare services market generated \$1.53 trillion in revenues in 2005, driven largely by the increasing healthcare cost, thus given this trend the healthcare industry will continue to grow over the next several years. The growth in the industry over the years has fueled technology investment by the healthcare community in order to enhance the flow and management of information among various stakeholders within the value chain of the industry. In addition, regulatory changes governing the healthcare services industry are also creating the need for greater technology spending to ensure regulatory compliance.

### 3.2 Healthcare Expenditure

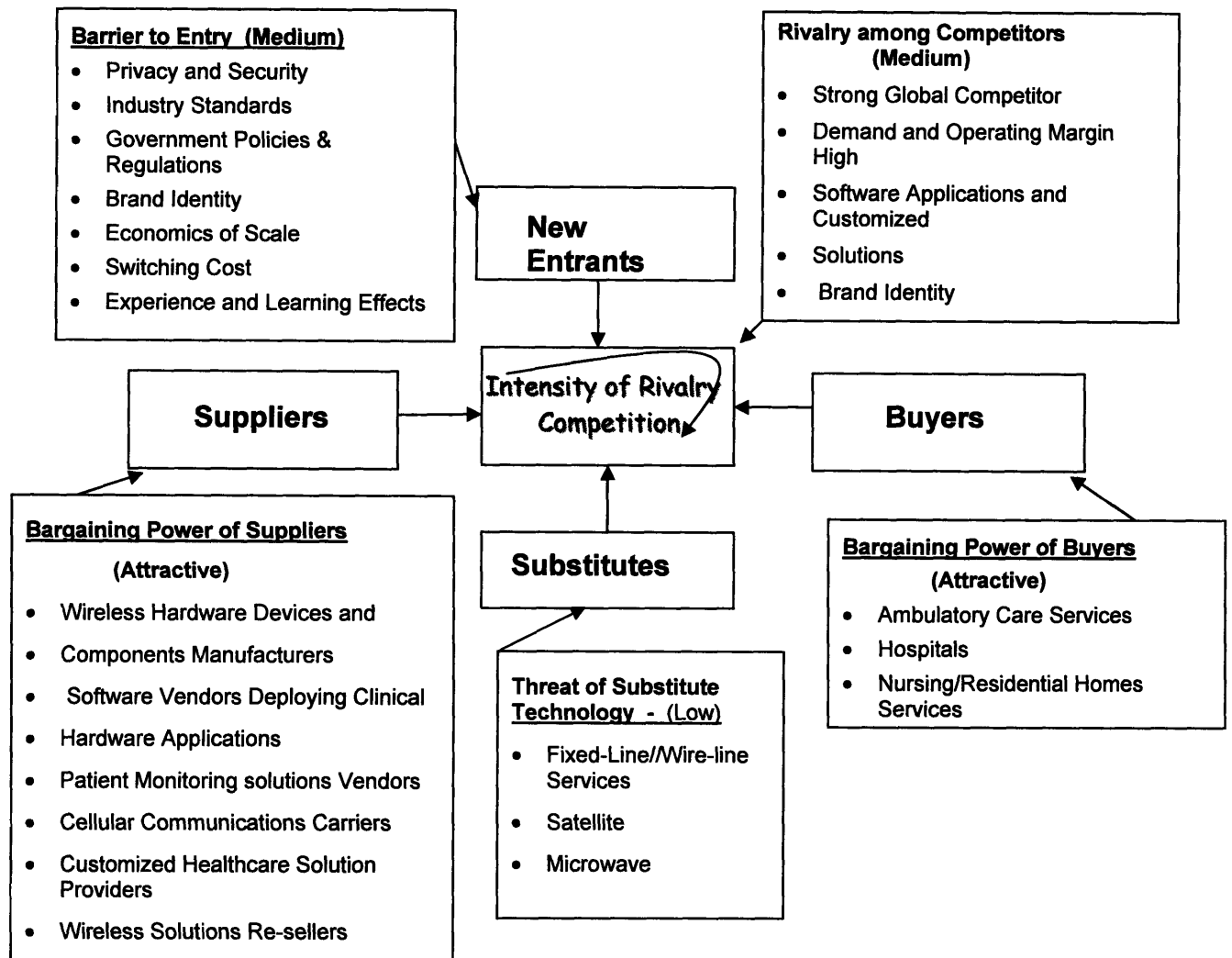
The national expenditures for healthcare services reached a total of \$1.6 trillion in the year 2003 growing at 7.7% year-over-year, and representing 15.3 percent of the GDP, compare to 14.9 percent previous year. United States has by far the most expensive healthcare system in the world, based on health services expenditures as a percent of gross domestic product (GDP). Overall government spending on healthcare services represented more than 45 percent of the total expenditures in the year 2003, and is expected to reach 50 percent in the next 10 years (Frost & Sullivan 2005). The increase in government spending is expected arise as a result of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (NMA), which drastically increases the federal share of spending on prescription drug expenditures from 13.8 percent in 2005 to 38.3 percent by 2014

### 3.3 Industry Analysis

The wireless LAN and wireless devices industries attractiveness were analyzed using Porter's five forces framework depicted in figure 2.1. Here an analysis of the competitive landscape of the industry was undertaken by evaluating the bargaining power of the suppliers or vendors of the wireless products and solutions, bargaining power of the buyers in the healthcare industry, threat of new entrants into the healthcare IT market, and impact or threat of substitute technologies such as legacy solutions.

**Bargaining power of suppliers:** Bargaining power of suppliers of wireless products and solutions to the healthcare industry is attractive as a result of relative continual growth of wireless technology adoption across this industry. Thus, opportunities exist to continue to seek out new markets outside of North America, and both the European and Asian markets still nascent it is important to look to those for future revenues. Identifying new market niches and applications in the older WLAN markets would be a competitive advantage. In addition, offering superior customer services, both before and after the sale, differentiate oneself from the competition. Lastly, keeping prices competitive is important for home and SOHO markets. Whichever solution a company adopts will depend on what its own capabilities and how it fits in with its corporate strategy.

**Threats of new entrants:** The threat of new entrants is medium as a large sum of capital investment/resources required to support needed tangible and intangible assets to support extensive privacy and security R&D, economics of scale hurdles across the value chain of the new entrants' business operations could be a barrier. In addition, cost disadvantage is another barrier to entry as a result of effects of learning curve, continual changes and compliance issues on industry standards against proprietary technology and lastly differentiations for from well-known brand veterans.



**Figure 3: Porter's 5 Forces for Healthcare Industry's Wireless Products and Solutions**

**Bargaining power of buyers:** The bargaining power of buyers in the healthcare industry is high as total cost of ownership continues to drop for wireless technology. Prices for WLAN equipment in the home and SOHO markets have continued to fall dramatically over the last year, thus creating massive growth of wireless LAN deployments in those markets with very high adoption rate. Consumers are very price sensitive and are reluctant to try out expensive new technologies. With lower prices, the amount of risk involved in a purchase of wireless LAN and Devices is lessened. Another contributing factor is standardization and strong competition.

In addition, the more vendors in a market, the higher the economies of scale and awareness of the technology by the market overall, thus achieving acceptable price points for consumers is a crucial step towards ensuring the viability and longevity of WLAN technology in the marketplace.

**Threat of substitutes:** The threat of substitute technologies is low at best long term and unattractive cost/benefit value proposition for the mass market base such as the SOHO, home market segments and select industries like the Healthcare community that requires real-time mobile data and voice communication and accessibility anytime, anywhere with very low total cost of ownership.

### 3.4 Challenges in the Healthcare Services Industry:

The healthcare industry's growth over years continues to negatively pose numerous financial and operational challenges to some business segments of the industry. The challenges includes rise in business operating cost resulting from uncollected medical bills, to high malpractice insurance cost of implementing programs to improve patient safety and security, to decline in number of people insured, as a result of budgetary cut backs in both the private and public sector programs, and increasing regulatory oversight to erroneous insurance claims affecting healthcare service provider's revenues per Frost & Sullivan (2005).

Thus, the number of leading challenges faced by the healthcare industry's business segment could be detrimental or impact the adoption and implementation of wireless LAN and mobile wireless devices in the ambulatory care, hospitals, nursing homes/residential care and social assistance care, the findings does not include challenges faced by the health insurance providers, or pharmaceutical companies and medical equipment/supplies providers.

### 3.5 Healthcare Market Segmentation:

The healthcare services industry market segmentation includes only organizations offering healthcare and social assistance to individuals, these includes the ambulatory care services, hospitals, nursing and residential care, and social assistance. Excluding personal healthcare related services likes aerobic classes and non-medical diet and weight reduction or management centers, which are typically not delivered directly by licensed medical practitioners, find below an overview of the four key healthcare services market segments:

**Ambulatory Care Services:** This segment offers healthcare services directly or indirectly to ambulatory patients and do not usually provide inpatient care services, health practitioners in this segment offers outpatient services with its facilities and equipment contributing less to overall patient care services. Ambulatory care services consists of clinics, physician's offices etc., and it represents close to 70 percent of the total healthcare industry in terms of establishments. In terms of revenue, it represents around 40 percent of the total healthcare industry revenues, posing as direct competition to the hospitals as they offer out-patient treatments like the hospitals. Thus, the growing number of aged people requiring frequent health check-ups and physician visits are driving the rise in spending in the market segment. In 2003, the segment's revenue was \$525.5 billion close to 40 percent of the healthcare industry revenue.

**Hospitals:** This segment offers medical, diagnostics, and general treatment services that include physicians, nursing, and other health services to inpatients and specialized accommodation services required by inpatients. Hospitals offer out-patient services as a secondary activity. The inpatient care services delivery by the hospitals utilizes specialized facilities and equipment that forms the fabric of total healthcare delivery process, however this segment represent a meager 1 percent of the total healthcare services industry's establishment,

but revenue from this segments represents 40 percent of the industry's revenues. In 2003, the hospital segment revenue was \$536.3 billion, and a result of consolidations the number of hospitals continues to drop, on the bright side revenues continue to rise in this market segment.

**Nursing and Residential Care:** The nursing and residential facilities segment offers residential patient care combined with either nursing, supervisory, among other patient care required by the resident. Facilities in this segment contributes' to the production process and the care offers a mix of health and social services with health services largely consisting of significant amount of nursing services. This market segment represents 9.6 percent of the total healthcare industry, per Frost & Sullivan (2005) the nursing and residential care market segment revenue in 2003 was \$126.7 billion. In terms of revenue growth, the nursing and residential care facilities as well as social assistance providers are likely to experience higher growth compared to ambulatory care providers and hospitals, as a result of aging U.S. population and the increased need for long-term care are likely to drive greater revenue growth for nursing home services providers.

**Social Assistance:** The social assistance segment offers a wide variety of social assistance services directly to their clients. The segment services' does not include residential or accommodation services, with the exception of short stay basis. Social service includes rehabilitation centers for drugs and alcohol abuse as well as other facilities that provide short term stay for patients, revenue in this market segment grew to 19.8 percent of the total healthcare industry with 2003 revenue of \$93.6 billion per Frost & Sullivan (2005).

### 3.6 Healthcare Wireless Investments:

According to Frost and Sullivan (2005) total healthcare service sector spending on wireless voice and data communication reached a total of \$1.24 Billion in the year 2005, and is estimated to reach \$2.10 Billion. The wireless services segment is expected to realize the strongest spending growth within the healthcare provider sector with a growth rate of 9.1 percent during

the year 2005 – 2011. The use of PDAs for healthcare applications is expected to be a major driver for growth in wireless communications spending. Wireless voice and data services consist of services from the use of wireless phones, laptops/notebook PC, personal digital assistants (PDAs), handsets, wireless tablets, and other wireless devices that use wireless voice and data services.

Wireless handsets and personal digital assistants (PDAs) are becoming more widely used and accepted in the healthcare industry among medical doctors and nurses, the demand growth is a definite boost to wireless revenues for both WLAN and mobile wireless devices. Thus, error reduction, data accuracy improvements, and the improvement in the quality of healthcare Future needs in effective methods to cut cost, improve quality of patient care and work flow efficiency shall drive up market for wireless solutions and services for healthcare industry based on the bargaining power of market participants including wireless hardware devices and component manufacturers; software vendors deploying clinical handheld applications; patient monitoring solutions vendors; cellular communications carriers; customized healthcare solution providers; wireless solution re-sellers. Healthcare providers have historically underinvested in technology and telecommunications, but with baby boomers, high technology spending will be necessary to meet the demands of service, consolidation in the healthcare market will increase demand for integration of communications including both voice and data services.

Growth in Telemedicine, Tele-health, and Tele-radiology will increase as the need for wireless local area networks, wireless devices, IP services, streaming video continue exist. For example, home healthcare demand is been growing exponentially, mobile wireless communication devices and services will be needed for patient monitoring and two-way medical communications, HIPAA regulations are increasing the need for reliable security and data transmission solutions.



### 3.7 Wireless LAN Market Adoption Drivers:

Wireless LAN market adoption drivers includes targeting SOHO and home markets sharing broadband internet access with commercial markets, momentum of WLAN ubiquitousness, productivity gains derived from both the mobility and constant access to information, interoperability standards between WLAN products and to reassure end-users, drop in WLAN equipment pricing, faster transmission speeds, ease of use, substantiation of organization's image of itself, availability of internet-enabled consumer electronics devices, and Microsoft's hardware initiatives are all expected to increase the popularity resulting to the adoption wireless LAN Technology depicted below in figure 4

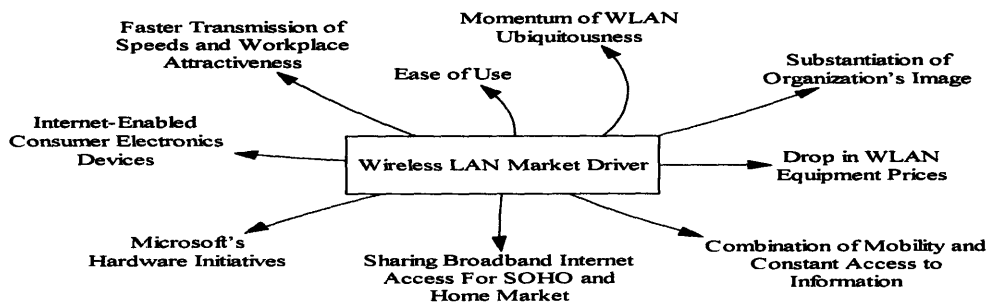


Figure 4: Wireless LAN Market Drivers

#### 3.7.1 Broadband Internet Access for SOHO and Home Markets:

As early as 2002, the home and SOHO markets proved to be the fastest growing segment of the WLAN market. Thus, more and more people realized that WLAN technology was easier and less expensive alternative to wired Ethernet for sharing internet access in their homes. In North America, the number of homes with computers exceeded 50 percent and number of home with at least one computer continues to grow. There are costs savings for sharing one internet account or address amongst several users, with multiple PCs, users are looking at ways to

share internet access rather than the expensive option of provisioning individual access lines for each computer. Thus, the SOHO and home user has a number of networking options for internet access for its computers that includes wired Ethernet, phone networking, power line networking, and wireless technologies. Among these networking options, wireless technology has gain commanding presence as result of ease-of-use and greater public exposure. People want to be connected quickly and easily, thus wireless systems allow them to do just that with the added benefit of mobility within the homes.

802.11 WLAN technology has the added benefit in that it is the same WLAN technology found in the workplace and offices, thus enabling horizontal adoption of 802.11 WLAN technology; as people prefers using the same device at home as they do in the office. Hence the effect of this market driver would continue to very strong throughout the forecast period.

### 3.7.2 Momentum of WLAN Ubiquitousness;

Wireless technology is becoming more common and it's generating a buzz that is going beyond the early adopters into the mainstream. Examples include the fact that public WLAN hotspots are more common around the world, for both consumer and commercial applications. Products are becoming wireless-enabled with technology becoming embedded within them and operating systems such as Microsoft windows XP supporting wireless standards and high number of research and articles been written about the technology. Today, wireless end-user does not need to have a wireless –enabled notebook PC to use the WLAN technology because his/her PDA may have integrated 802.11b Compact-Flash card, thus can use that PDA to download email at work or while making purchases at a wireless-enabled coffee shop on the way to work. The volume of opportunities and its ease-of-use makes WLAN technologies that much more attractive to potential end-users, as the number of wireless-enabled devices and locales increase, the usefulness and value of the technology increases. Experimentation with different applications of the technology is increasing, as more and more people becoming aware of its

capabilities, hence the influence of this adoption driver is currently high and would be gaining a much stronger momentum over time.

### 3.7.3 Combination of Mobility and Constant Access to Information:

Productivity gains derived from combination of mobility and constant access to information drives end-users who works in various physical locations within a building yet need to have constant access to data are those that spearheads the adoption of wireless technologies. Early adopters of WLAN technology were primarily in the manufacturing and inventory management line of business, here WLAN allowed organizations to arm their workers with needed data without having them physically tied in to the network along with its attendant configuration and installation difficulties. The absence of wiring helped to solve an important safety issue when equipment is being moved around. With the advent of portable computers and smaller form-factors for 802.11 WLAN equipment, new end-users such as field representatives, salespeople, customer service representatives and others are experimenting with the technology. Ruggedized WLAN equipment is allowing new niche applications in areas such as oil fields and small manufacturing units where constant changes in equipment layout could result in significant move, add or change charges. WLAN technology allows end-users to access information and to share or use the data as needed. The primary benefit of this WLAN driver is the fact that end-users are enabled to access data quickly and easily without the need for physical network installation. Thus, using WLAN technology, a connection can be established quickly and/or an ad hoc network can be established temporarily, enabling this wireless adoption driver to very strong and is expected to remain this way through-out the forecast period.

### 3.7.4 Interoperability and End-User Assurance

Standards help to ensure interoperability between WLAN products and reassuring end-users, thus one of the biggest fears in acquiring a product that quickly becomes obsolete or fails to work with setup or not backward compatible. The resources devoted to ensuring compatibility by the end-user may well negate any benefits from introducing a new product into their existing infrastructure, and ensuring interoperability between different WLAN products from vendors is a good thing from the perspective of both the buyer and seller. The buyer is assured that they are buying a product that would prove to be beneficial than hindrance, with interoperability comes an increased number of choices that the buyer could have, thus the buyers are not locked in to one vendor particular product line as they can then choose from a variety of products for one the suits their needs. Vendors, in following a standard, will find that they are to more easily overcome buyers' reluctance in purchasing a potential new and unknown product. While, realizing gains in efficiency when following a particular standard and another advantage is the ability to only produce a smaller variety of products that satisfies the need of wider audience, and not develop, produce, market and or support a variety of different products that addresses the same market.

For 802.11 products, the Wireless Ethernet Compatibility Alliance (WECA) ensures interoperability by testing and certifying products as interoperable once the products have passed testing they can carry the Wi-Fi label which identifies them as interoperable with other Wi-Fi branded products from other manufacturers. WLAN vendors are aware of the importance and influence the Wi-Fi label can be when it comes to assuring customers about the wisdom of their purchases. Hence, this adoption driver would continue to be strong throughout the forecast period.

### 3.7.5 Drop in WLAN Equipment Prices

As a result of standardization and increasing number of WLAN products sold comes dropping prices due to economies of scale and increasing vendor competition. The deployment of WLAN since 2002 has become price-competitive with wired LAN technology when considering the total costs of the installation. This involves the hardware, software, installation, troubleshooting, maintenance and others. In some, niche industrial applications wireless technologies are replacing wired LAN installations. However, simple price equivalency does not drive the market for WLAN. Rather, economics, along with other factors such as ease installation, set-up, and security that are relevant to the particular networking situation will decide the final choice of whether or not to adopt wireless. It is very likely that the final decision will depend on the entire LAN solution rather than on one component, lower wireless pricing simply removes one barrier to the adoption of WLAN, hence this adoption driver would continue to increase in level influence over the forecast period.

### 3.7.6 Faster Transmission Speeds and Workplace Attractiveness

The introduction of the 802.11b brought to the workplace WLAN with raw data rate of 11Mbps with an actual throughput of between 4 and 7.5Mbps. This is acceptable for most office data network communication requirement, Ethernet networks based on Category 5 cabling are practically a standard in offices around the world and these carry data at almost 10Mbps. Thus, WLAN transmission speeds are close enough to wired LAN throughputs to be competitive for general purpose networking applications. There is a trend that sees office networks been upgraded to handle speeds of 100 Mbps and eventually 1Gbps, the latter network speed is in experimental phase and virtually all office networking equipment in the market has dual speed of 10/100 Mbps adapters built in. While this may seem to put WLAN at a disadvantage, new emerging standards such as 802.11a and 802.11g both brings raw data rates of 54 Mbps to the

table. Hence these standards will allow WLANs to remain a stronger alternative to wired LAN. In market segments such as SMB, WLAN are seen as an acceptable substitute for wired LANs because of their speed and relatively low cost, in the larger enterprises, WLANs are now being seen as an acceptable extension to the wired LAN while the latter carries data at 100 Mbps, the impact of this driver is expected to grow strong throughout the forecast period as new wireless standards enable wireless technology to continue to compete against wired LAN technology.

### 3.7.7 Ease of Use

Wireless LANs are very easy to use for a high tech product, and are becoming more so. In the consumer market, customers are finding that they are very easy to install, when compared to installing a wired Ethernet network in the home or SOHO. Similarly, in the enterprise market, network managers or administrators are seeing how easy it is to install WLAN, from personal experience and from finding those personal networks set up by individual employees. Network managers appreciate the ease of installing wireless networks in areas where it's difficult to use wired Ethernet. In reference to WLAN software, vendors are working hard to make configuring their equipment as simple as possible. This is the case, in the consumer market as customers usually less technical than their counterpart in the commercial or enterprise market space, easy to configure network software applications also means that there will be fewer technical support calls which brings down costs for the WLAN vendor. Thus, easier to use hardware and software translates into a winning situation. The influence for this driver is currently moderate but increasing rapidly as vendors continue to innovate around user experience. The goal may be in the not distant future, deploying WLAN would be as simple as starting up one's wireless-enabled device and having instant access to one's data from anywhere at anytime.

### 3.7.8 Substantiation of Organization's Image

In industries such as the health care and education, the use of advanced technologies is absolutely valuable, not only to achieve stipulated business goals on a day-to-day basis but also because of how stakeholders in these enterprises' view themselves as leading the rest of the economy in new ideas and practices. For example, there are healthcare facilities who are adopting WLAN technology for both in-patient and out-patient care to provide wireless internet access to clinicians. The deployment of advanced technologies such as WLAN can be instrumental in attracting and retaining quality people, thus this demonstrates how the healthcare community's progressiveness and forward thinking is bringing together new technologies and qualified personnel, resulting to significant gains in morale and confidence for the organization. Substantiation of organization's image as a driver to adopt wireless technology is classified low and stable, because it could help drive the decision making process of adopting this technology given the scenario discussed above.

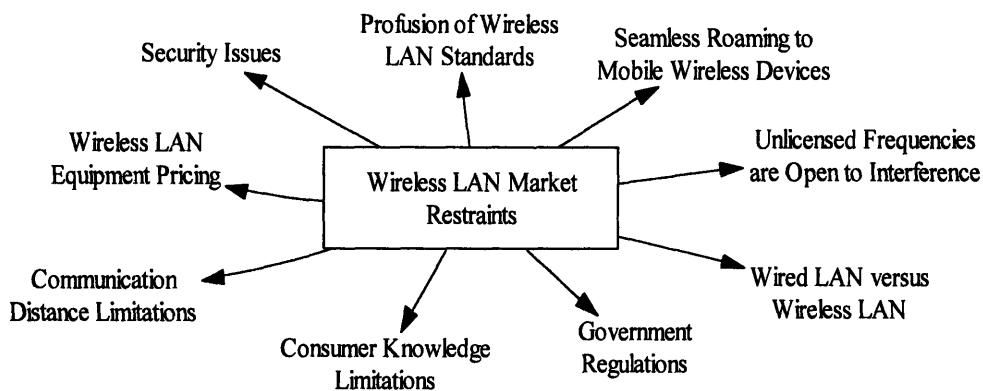
### 3.7.9 Microsoft's Hardware Initiatives

Microsoft released its windows XP, in October 2001 with support for Wi-Fi specification, wireless LAN hardware vendors were pleased and felt that Microsoft's operating system (OS) software support for the 802.11b specification would enable the future growth for WLAN be much brighter. The expectation was that the new OS would spur more interest in wireless networking, thus increasing the adoption of wireless technology. Consumers were unfortunately not adopting wireless LAN technology because their operating system supports it rather consumers were adopting wireless technology as result of its lower acquisition cost and ease-of-use. Based on this lesson, Microsoft decided to announce new line of WLAN hardware based on the 802.11b that would make it easier for the consumer to access and share broadband internet services with the expectation that the PC, handhelds, printers, TVs and stereos will all be

connected and controlled by the PC sitting at the heart of the home network, a remote office and or laboratory. According to Frost and Sullivan, Microsoft's initiative will have more of an impact than simply operating system support for wireless technology. Microsoft has proven to have excellent track record in regards to hardware devices, thus there is no reason to believe otherwise to make a success out of the new wireless LAN hardware, thus being able to closely integrate their OS and the software within the devices would allow them to achieve their goal of simplifying the home-user's wireless use experience, hence this adoption driver would benefit WLAN market over the forecast period.

### 3.8 Wireless Adoption Restraints

Wireless communication technology adoption restraints in the healthcare industry depicted in figure 5 includes the lack of security, high price of WLAN equipment, communication network distance limitations, limited knowledge of the wireless technology, government regulations, unlicensed frequencies are open to interferences, profusion of wireless standards, increasing competition from wired LANs' speeds, and seamless roaming challenges.



**Figure 5: Wireless LAN Market Restraints**



### 3.8.1 Security

Lack of security has been holding back wireless adoption in both the consumer and commercial markets. Thus, one of the greatest issues in networked computing is control. For example - a network manager or administrator wants the flexibility to undertake numerous amount of task in parallel, quickly and easily on their systems, such as the ability to control employee access to the network, or create accounts with appropriate access to network resources for particular users, or control network planning, enhance system performance, prevent, detect and proactively solve network problems among many other task. Hence, security could be considered the most important aspect of network computing control, security is offered through an optional security protocol called Wired Equivalent Privacy (WEP). It's optional, because Wired Ethernet Compatibility Alliance (WECA) body certify vendor's equipment as Wi-Fi compatible, This Wi-Fi compatibility logo affixed to products following all stipulated qualification testing by a WECA laboratory also test for WEP compliance.

Reported security vulnerabilities of the 802.11b wireless LANs and, by extension, all IEEE 802.11x wireless LAN products include WEPs relatively short 40-bit encryption keys. It's possible for those with relatively modest computing resources to conduct brute-force attacks to break the encryption. Secondly, WEP protocol's use of an Initialization Vector (IV), which is a non secret binary vector, along with the encryption key to encrypt plain text, thus the more often a particular IV is used the more likely that a pattern will be noticed, given that WEP utilizes a 24-bit IV which may be repeated each day. Lastly, the default authentication process is an open one, hence the name Open System Authentication (OSA). A client cannot participate in a wireless LAN unless that client has been authenticated, with Open System Authentication the entire authentication process is done in clear-text, and a client can only associate with an access point even without supplying the correct WEP key.

### 3.8.2 Wireless Equipment Pricing

Wireless equipment pricing have continue to drop over the years, thus enabling the wireless technology to very attractive value proposition for most consumers. The drop in prices is attributed to standardization of the 802.11x products, strong competition among vendors who adhere to those standards and shear economies of scale. Vendors have indicated that there are certain price points which, if reached, normally result in a surge in demand. However, it's not a very strong restraint because prices continue to drop due to aforementioned standardization and economies of scale. There is the possibility, though, that pricing in the marketplace may slow their downward trajectory, and this may happen if something, such as a fragmentation of the marketplace between wireless standards and emerging wireless technology standards, this disruption may influence economies of scale. Hence, fragmentation of the market place will force manufacturers to introduce numerous variants of wireless LAN products to address different levels of demand, thus creating an inefficient market in process.

### 3.8.3 Distance Limitations

Distance limitation of WLANs may literally restrict wireless technology adoption. The distance over which radio frequency waves can travel depends on the product design (including the transmitted power and receiver designs) and the propagation path. In ideal conditions, an 802.11b wireless access point can transmit almost 400 feet indoors and 1,000 feet out doors. These conditions can be affected by physical obstacles such as walls, organics, windows, doors, furnishings and weather. The composition of these obstacles affects the ability of radio frequency waves to penetrate and the waves deflected, absorbed, and even blocked entirely depending on the number and manner of the physical obstacles between the transmitting and receiving devices.

Typically, a site survey would be done prior to the installation of any local area network (LAN) in order to determine whether or not to proceed with a wired or wireless LAN, thus the adoption of a particular LAN technology may also depend on other factors such as the application itself. In a clean room environment for a pharmaceutical industry, WLAN systems may be less expensive and better suited for communication purposes from within the clean room itself to outside environment, than wired solutions. The distance limitations of the different IEEE systems standards may be countered by the use of additional access points, and bridges in order to extend the signals being used. More advanced IEEE systems standards, upon encountering obstacles such as distance or interference are able to compensate for weakened signal strength by stepping down the through-put that's being transmitted, systems can, in case of an 802.11b system, ratchet down from 11Mbps to 5.5 to 2 and even as low as 1 Mbps. Thus, distance limitations, depending on variety of factors, may prove to be a restraint, however this is not a sole determinant of whether or not a wireless LAN solution needs to be purchased, its one of the many factors including cost, ease-to-install and use, security, compatibility with existing network solutions and other systems.

### 3.8.4 Knowledge Limitations on Technology

Limited knowledge of WLAN technologies restrains adoption by the mass market, since wireless networking is a relatively new phenomenon to the home and SOHO markets, thus hardware vendors are finding that they are engaged in educating the average consumer about various wireless networking technologies and standards that are available. Thus, at the home and SOHO markets moves away from the early adopters, who tend to be more technologically literate, wireless LAN vendors are finding their jobs to becoming more difficult when it comes to educating consumers about how these new networking technologies can be applied in their environment. On the commercial side of the WLAN market, business customers had anecdotal evidence that wireless solutions were more economical than wired ones in some cases. Thus,

studies have been done which quantifies the cost savings that can be gained by adopting a wireless solution.

In sum, there are a high number of customers in both commercial and consumer markets are still unfamiliar with the topic of wireless networking and its full benefits, thus significant research and programs being implemented by wireless hardware vendors at various channels to reverse this trend. Vendors are employing their websites, conducting marketing campaigns, and educating resellers such as retailers, distributors and value-added resellers (VARs), thus the effects of this restraint is currently moderate and is expected to drop slightly as the vendor indirect education process continues. The adoption of wireless LAN technology will speed up as consumers become more aware of the technologies involved and their applicability to their particular situation.

### 3.8.5 Government Regulations

Governments can influence development of markets and this is no more apparent than in the wireless LAN marketplace. Here, governments decide not only the spectrum that can be used but also more obscure details such as the power used for transmissions. Market participants have to work within government regulations to develop to products and solutions, thus for wireless LAN hardware vendor the fact that each country's government can have different regulations pertaining to wireless LAN hardware means that they have to design and develop equipment to conform to those regulations.

Failure to do so would mean that they could be locked out of a particular market. At the same time, different governmental regulations can also lead to a fragmented WLAN equipment market with different equipment destined for different markets. The industry is fortunate, though, that most of the regulations are relatively similar with minor differences between countries. This is the reason why 2.4 GHz WLAN equipment works without modification in most parts of the world,

the impact of this market challenge where companies have to balance growth with adherence to governmental regulations is relatively moderate and is expected to ratchet down over the forecast period as regulations harmonize. Governments do recognize the growing importance of wireless LAN technology and are willing to consider changes as required.

### 3.8.6 Wireless LAN Standards Profusion

Profusion of WLAN standards can create market confusion. The wireless LAN market is in constant change and nothing shows this more plainly than the recent profusion of different standards, speeds, frequencies, security features, frequency modulations, chipsets, and proprietary extensions that have emerged over the past few years. IEEE standards are joined by other wireless standards such as Open-Air in the commercial market and HomeRF to support the consumer market segment. This goes counter to what has made the wireless LAN market to be a success. Up until only recently, there were few choices available and WLAN adopters were relatively clear on the features that they would enjoy with a particular standard. Now, consumers have to navigate through an assortment of products based on different standards with different features. This raises questions about compatibility, interoperability and upgradeability.

It is understandable that the industry has to move forward in addressing the various needs of its customers by introducing new features, at the same time, though, it cannot move so far ahead in different directions that it risks alienating its customer base. The challenge comes in the form of balancing technological progress with customer education.

### 3.8.7 Unlicensed Frequencies Open to Interference

Globally, there are a couple of frequency bands that have been set aside by governments of these countries to be shared by whoever has the equipment to transmit and receive information in those frequencies. The frequency band includes: 915 MHz, 2.4 GHz to 2.497 GHz; 5.15 GHz

to 5.35 GHz and 5.725 GHz to 5.875 GHz. Within these bands, unlike licensed frequencies, there are no provisions made for interference from other user's signals. The most popular WLAN technology, 802.11b works within 2.4 GHz band. This band also happens to be used by other devices such as microwave ovens, cordless telephones and Bluetooth devices.

Manufacturers have to continually design systems that will detect interference and work around the sources of such interference, thus given enough interference, consequences can range from decreased throughput to a complete loss of transmission. In some cases, a solution might be as simple as providing the offending devices enough physical space so that their signals do not interfere with one another. Increasing popularity of 2.4 GHz, or 802.11b devices has resulted in situations where interference is occurring in heavily populated areas or locations like Los Angeles or London. Thus, with the introductions of 802.11g and the gradual increase in Bluetooth devices popularity, both operates in the 2.4 GHz frequency range the situation is expected to worsen, hence the eventual move to 5 GHz to alleviate the situation given 802.11a's higher number of non-overlapping channels and greater room. The impact of this restraint is low at the moment, except in the areas mentioned above, however is expected to grow over time as wireless technology becomes more popular and wireless devices proliferates.

### 3.8.8 Wired LAN versus Wireless LAN

Even as wireless LAN technology's speeds have made them competitive with wired local area networks they are facing new generation that is even faster for general networking applications, making it more different from wired LAN. However, wired LAN technology is not sitting still. Virtually all modern Ethernet network interface cards (NICs) today come in 10/100 Mbps versions, Fast Ethernet is quickly becoming more common and Gigabit Ethernet is making an appearance in certain office environments. In those environments, large file transfers such as for off-site backup and medical imaging, require the fastest technologies possible.

Wireless LAN technology is evolving quickly too, thus products based on 802.11a have appeared and are providing a data rate of between 22 and 24 Mbps while 802.11g products which promise similar speeds or better are currently shipping. It is obvious that neither 802.11a nor 802.11g provide anywhere close to the speed achievable by wired LAN technology. Fortunately for wireless LAN vendors, general networking applications at the moment do not require high speeds and most consumers are satisfied with the speeds being achieved at the moment. However, wireless LAN hardware vendors have to face the prospect that, by the end of the forecast period, wired LAN speeds will be much further ahead. The impact of this challenge is currently mild but is expected to grow over time.

### 3.8.9 Seamless Roaming to Mobile Wireless Devices

Much like cellular phone users, those with wireless-enabled devices want to be able to use those devices wherever and whenever they want. Unfortunately, the wide-scale implementation of wireless networking beyond specific traffic corridors and corporate environments is a significant undertaking. Doing so would entail the construction of an infrastructure that can provide sufficient throughput to end-users on the move over wide geographic areas. It would also require the development of a centralized management service to keep track of the network's end-users and handle back-end functions such as account management and billing. Such a centralized management service may also provide a single billing solution for all service providers by sending their subscribers just one invoice. This would prevent subscribers from having multiple invoices from the service providers whose networks they may have accessed in their travels. Furthermore, software would have to be developed and included with wireless products to ensure ease of switching between networks. The effect of this challenge is currently minor. Most consumers still have relatively low expectations of where and when they can use their connections. This is changing, as wireless LAN technology and accompanying public

hotspots becomes more common, wireless LAN service providers who can amalgamate both the front-end of services with the back-end of billing can expect to reap enormous rewards.

### **3.9 Wireless Applications and Uses in the Healthcare Industry:**

Wireless applications and its' uses in the healthcare industry will be a Big Boost for wireless voice and data revenues as physician use of handheld devices include the use for transactional and or informational purposes such as inquiring about patient medical information and consulting with other medical employees. Wireless handheld devices and personal digital assistants (PDAs) are used by many physicians and nurses to research healthcare information, view medical records, diagnostics, charting, admissions, billing, emergency services, check email, prescribe medications, reference schedules, and more. Packet data services are seeing the highest growth over cellular and mobile services, privacy and security concerns are the major barriers for healthcare professionals and physicians using wireless devices to access internet and web-based interfaces. Despite the hesitations, e-prescriptions are also being used more with the use of handheld devices, data accuracy improvement, reduction of errors, and improved patient care will be the key drivers for wireless use in healthcare as wireless services are proven to be more secure and reliable.

### **3.10 Wireless LAN Products**

A healthcare facilities implementation of wireless technology is rarely a one-stop shop. There are several integral components that comprise an entire wireless solution. For full-scale connectivity, each hospital must have wireless hardware infrastructure in place, in order to deploy their full wireless software applications and capabilities. On the hardware side, integrated point-of-care products such as access points, PC cards, and bridging units are vital to the deployment of a wireless solution. Thus in order to leverage their capabilities, organizations



must implement software applications for usage on notebook PC, PDAs, mobile wireless carts, or tablet PCs depending upon their preference.

**Access Points:** WLAN access points provide the framework for which wireless connectivity is procured. Today, most top-of-the-line vendors design access points that support the 802.11a, 802.11b, and 802.11g frequencies simultaneously. On average, list price for access points can range anywhere from \$500 to \$900 depending upon specifications and vendor. Frost & Sullivan (2004) indicates that access points on a whole comprise of estimated 63 percent of wireless hardware spending in the base.

**PC Cards:** PC cards are another vital component of a wireless solution. As clinicians utilize PDAs, tablets PCs, and mobile wireless carts, PC cards within these devices provide the wireless connectivity from the access point, thus enabling the access and transfer of information from anywhere within the access points range of functionality. The average list price for PC cards cost between \$70 and \$100. Frost & Sullivan (2004) indicates that PC cards comprised an estimated 35 percent of wireless hardware spending in 2003. Growth rate of 12.0 percent expected over the next few years.

**Bridge Units:** Bridge units have been the latest products to provide wireless connectivity within a WLAN solution. As healthcare facilities begin utilizing these products, connectivity can be enhanced to move outside the hospital as well, thus connecting remote clinics, physicians' offices, and mobile healthcare units which are within line of sight, back to the healthcare facility. List pricing for bridge units may start at \$4000 and continue upward. Frost & Sullivan (2004) indicates that bridge units comprise of an estimated two percent of wireless hardware spending in 2003, and an anticipating annual growth rate of at least 16.0 percent over the next few years.

**Tablet PC and Mobile Wireless Carts:** As the utilization of tablet PCs and mobile wireless carts continue to grow in adoption in the healthcare industry, software applications that run on them are expected to be more sophisticated as well. Frost & Sullivan research indicates that

software for tablets and mobile carts comprised an estimated 59 percent of wireless software spending in 2003, thus, we are anticipating annual growth rate of at least 10.0 percent over the next few years. Though mobile cart adoption has remained strong in the industry, tablet PCs have not experienced the same amount of adoption. This can primarily be attributed to their larger size and lack of mobility. Clinicians have preferred PDAs over these devices due to their small size and ability to fit within a pocket when examining a patient.

**Personal Digital Assistant (PDA):** With ease of mobility becoming a greater issue for physicians and nurses, the popularity of PDAs has in fact surpassed the tablet PC, and is continuing to gain ground within the healthcare facility. One restraint that has hindered their adoption has been their insufficient screen resolutions, which often produce unflattering images for clinicians. As these issues become resolved, we expect healthcare professionals to continue adopting the use of applications on these devices at a steady rate. Frost & Sullivan (2004) indicates that software applications for PDAs comprise of an estimated 41 percent of wireless software spending, with an anticipating annual growth rate of least 10.0 percent over the next few years.

### 3.11 Hardware Pricing Strategy Trends

Pricing structures and trends for the various WLAN hardware formats differ considerably in respective to their sub-segments like the wireless devices, however pricing overall, continues to drop as competition and economies of scale exert their downward pull. This is especially true for 802.11b hardware products geared towards the consumer market where pricing is the primary differentiator. While pricing for 802.11b products continue to fall quickly, the 802.11a situation is quite different. Here, prices have held relatively stable for the short period of time that 802.11a products have been available. A couple of reasons can be attributed to this phenomenal; first, with only one chipset provider the economies of scale and competition are simply non-existent

and, second, systems vendors have positioned their 802.11a products as high-end products that should command healthy margins. The gap between 802.11b and 802.11a product pricing is been closing since late 2003 when a lot of 802.11a products become available and there was increased competition from 802.11b/802.11a combo products. More competition may be forthcoming as the 802.11g standard is ratified and products based on that standard become available. It has to be remembered that pricing is not the sole differentiator. Even in the retail market or mass market adopts the technology, factors such as ease-of-use and availability of product, are important ingredients for success long term. Pricing does not play much of a role in deployment decisions in the commercial market segment, factors such as service, support, security, manageability, interoperability and feature sets takes more precedence.

## 3.12 Wireless Industry Market Leaders

### 3.12.1 Wireless Hardware Vendors

The competitive landscape for this market features a large volume of vendors, but very few possessing a substantial market presence. The three networks and communications companies that have emerged as the market leaders for wireless infrastructure sales includes Cisco Systems, Symbol Technologies, and Proxim Corporation. These firms can attribute their established presence within the healthcare market to their early integration initiatives in the market. Though their total market share within the industry has reduced due to competition, they still remain the primary hardware vendors in the industry. Other vendors such as 3Com Corporation and Nortel Networks are making presence in the wireless LAN space for healthcare and are likely to continue doing so along with similarly established wireless vendors that are now beginning to view healthcare as the untapped IT market. Many of these vendors have also opted to engage in mergers and acquisitions, thus using this strategy to substantially increase

their market presence and share. A profile of the three market leaders in wireless LAN market are outlined below.

**Cisco Systems, Inc.:** Headquartered in San Jose, California, Cisco Systems is the premier provider of network infrastructure, comprised primarily within router and switch architecture for network linkage and Internet functionality. Cisco has established itself as the market leader in the healthcare industry by acquiring emerging Wireless LAN companies to increase its market share for WLAN and WWAN solutions. The company offers healthcare organizations a complete wireless solution enabling them to utilize wireless connectivity within a facility through the implementation of access points, PC cards, and adjoining wireless infrastructure as well as outside the doors of the hospital through the incorporation of wireless bridges for remote wireless connectivity. As the adoption of wireless technology continues to expand along with its functional capabilities in the healthcare industry, Cisco's market penetration continue to surpass the competition, thus sustaining the firm's presence as the wireless hardware market leader.

**Symbol Technologies, Inc.:** Headquartered in Holtsville, New York, Symbol Technologies has been the pioneer of bar code technology across a wide host of industries, with substantial penetration occurring in the healthcare marketplace. Symbol's handheld scanners are implemented anywhere from the hospital loading dock for an accurate measure of supplies coming in, as well as the bedside for utilization by nurses for vital patient information gathering and display at the point of care. Symbol is a premiere provider of WLAN infrastructure and wireless voice over IP technology, and sells primarily through partners such as GE healthcare, McKesson, and Meditech.. As the industry leader in wireless LAN technology and supply chain management technology, Symbol's on firm a foot in the healthcare marketplace is poised for much growth as adoption rates continue to increase throughout the healthcare industry.

**Proxim Corporation:** Headquartered in Sunnyvale California, Proxim Corporation is a leading provider of local area network (LAN) and wireless LAN (WLAN) hardware infrastructure for to

the healthcare industry and a host of other industries. Proxim's WiFi products have the potential to enable wireless solutions within the healthcare facility through the integration of enterprise class access points and PC cards. In addition, Proxim has taken wireless connectivity one step further by enabling wireless access outside the hospital through the implementation of wireless-bridging solutions. Its products possess the potential to improve hospital's ROI in less than 12 months of implementation. Proxim equipment has penetrated over 1000 institutions including large mega institutions as well smaller doctors' offices and clinics. Similar to their wireless hardware counterparts, the company delivers its wireless products through system integrators and value added resellers, and they anticipate a strong future growth and increase in market share as the adoption rate increases within the healthcare industry.

### 3.12.2 Wireless Software Application and Mobile Device Vendors

The market for healthcare handheld software applications has been the largest by far amongst the wireless components. It is the primary driver for wireless capability, providing clinicians with software solutions leveraged over wireless infrastructure accessed through PDAs, tablet PCs, and or mobile carts depending upon the physician or nurses' needs. PDAs have been the most popular choice among clinicians due to their compact size and easy of access. Tablet PCs; in contrast have been the least popular due to their bulkiness, while mobile carts continues to gain popularity and high demand within the healthcare industry, as the new wave of physicians finish medical school, rapidly increasing adoption rates and demand for these modern solutions is anticipated. The current market for PDA-based software consists of three to four substantial participants and many smaller niche firms within the space. Those continuously gaining ground and establishing market leadership includes: Allscripts Healthcare Solutions; GE Medical Systems (Data Critical); and Patient-Keeper. Lastly, the two mobile wireless devices companies that have emerged as the market leaders with integrated and convergent mobile devices and solutions suited for the healthcare industry include Motorola and Nokia, these firms can attribute

their established presence within the healthcare market to their early integration initiatives in the market.

**Allscripts Healthcare Solutions:** Headquartered in Libertyville, Illinois, Allscripts Healthcare Solutions is a leading provider of prescription management software and services to the healthcare industry. Specializing in e-prescribing and charge capture, Allscripts offers an innovative solution enabling clinicians access to vital information regarding drug interactions, patient drug history, as well as generic alternatives from its wireless handheld device. In addition, the company gains its greatest consumer demand for their Touch works EMR product offering. Leveraging this solution over wireless technology, physicians can access solutions regarding charge capture, dictation, prescribing, and labs all from their PDA or tablet PC, depending upon what type of screen they desire. Allscripts software is platform agnostic, thus providing clinicians with flexibility regarding their application integration. The company's solutions are sold through value-added resellers including the electronic medical records (EMR) products delivered directly into the market. As physicians continue to embrace wireless solutions at the point of care, increased adoption and market share of Allscripts solutions are expected in the near future.

**GE Healthcare:** Headquartered in Waukesha, Wisconsin, GE Medical Systems is the premier provider of imaging, patient monitoring, and information technology solutions to the healthcare marketplace. Leveraging its size and quick ability to penetrate any market, GE has gained substantial ground in the clinical handheld application space through their Pocket-Chart product offering. Utilizing a mobile handheld computer or PDA, physicians can document a holistic range of patient information directly at the patient's bedside. This solution is compatible with both the Windows CE Pocket PCs as well as Windows CE handheld personal CPU. GE's latest edition of the Pocket Chart, its trauma edition, is customized for specific trauma scenario usage. Users of the Pocket Chart feel that one of its' primary attributes is the ability to customize the

software solutions templates to meet each individual's specific patient documenting needs. As the anticipation of greater clinical handheld adoption grows with the incoming flood of technology savvy medical students and residents, GE can continue to expect substantial demand and adoption for their point-of-care handheld applications.

**Patient Keeper:** Headquartered in Brighton, Massachusetts, PatientKeeper is a leading provider of mobile software applications for physician handheld devices within the healthcare industry. Clinicians utilizing PatientKeeper's charge capture suite can save vast amounts of time by undergoing these procedures through their handheld device, at the point of care. Not only is time saved, but lost revenue due to improper billing is eliminated as well. Supplementing the charge capture solution is the Clinical Application Suite. Thus, enables physicians to access a holistic set of patient information ranging from patient lists and lab results to patient vitals and time critical patient alerts.

**Siemens MSHS:** Headquarters in Malvern, Pennsylvania and Erlangen, Germany, Siemens Medical is a leading global provider of clinical products and solutions to the healthcare industry. Unlike many smaller firms, Siemens could leverage its size and capabilities to integrate holistic enterprise-wide technology solutions within the healthcare industry. This enabled it to an easy penetration of mobile clinical applications for wireless technology implementation by Siemens' substantial client base. This integration can be expected to continue as greater amounts of wireless infrastructure for mobile applications are installed within hospital facilities.

**Meditech:** Medical Information Technology; Headquartered in Westwood, Massachusetts, provides integrated software solutions to meet the information needs of health care organizations around the world. A global leader in the health care information systems industry for 37 years, thus understand the complexities of health care organizations and develop the informatics tools needed to deliver patient care safely and efficiently. From large integrated delivery networks to community hospitals, with software solutions support for entire continuum

of healthcare value chain including Ambulatory Care, Hospitals, long-term care facilities, home health agencies, and behavioral health facilities.

**McKesson Information Solutions:** Headquartered in Alpharetta, Georgia, McKesson Information solutions is a leading provider of pharmaceutical and medical supplies, information solutions, as well as services and automation technology. McKesson leverages its vast product and service offerings to gain substantial penetration within the healthcare market over a broad spectrum. As wireless technology started becoming more prevalent in healthcare, McKesson deployed its mobile care rounding and messaging solutions. Through these solutions, clinicians can access critical patient data as well as intelligent alerts and notifications on their handheld device, regardless of location. As patient volumes continue to rise, the need for faster and more efficient access to data is expected to be in high demand, thus incorporating much adoption for McKesson' mobile clinical applications.

**Cerner Corporation:** Headquartered in Kansas City, MO, Cerner is one of the fastest growing providers of clinical technology solutions to the healthcare industry. Comprehending the potential of wireless point-of-care technology, Cerner leverages its Millennium Mobile product offerings to enable physicians to access a wealth of patient information onto their mobile device, directly at the POC. The integration and advancement of these applications are expected to increase with a strong anticipated growth expected across its markets.

**Motorola:** Motorola is a market leader in mobile phones and comes second to Nokia in worldwide handset sales. Motorola's phones include TDMA, CDMA, and analog terminals for the U.S. market. Its core business areas focus on providing integrated communications solutions and embedded electronic solutions for consumers, network operators as well as commercial, government, and industrial customers. Motorola has pioneered the growth of wireless technologies such as CDMA and has also developed iDEN, a technology used by

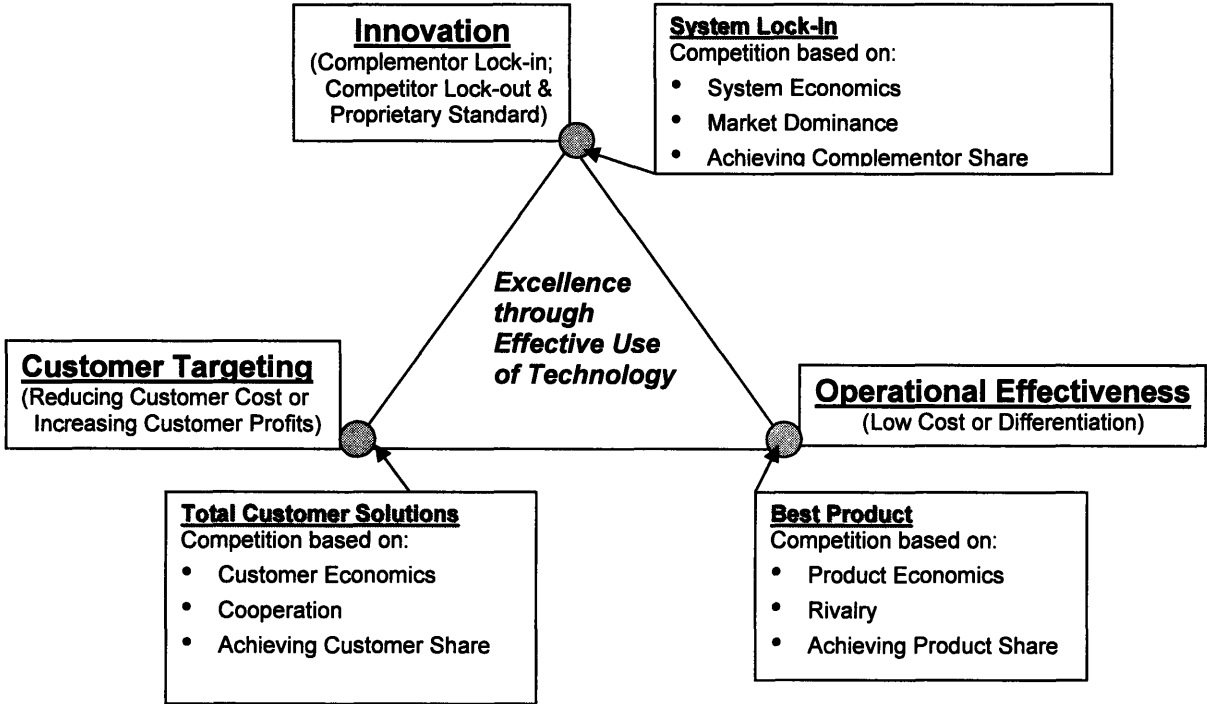


Nextel to provide mobile services. Recently, Motorola has expanded its solutions portfolio to provide GSM infrastructure.

**Nokia:** Nokia is a market leader in GSM and TDMA mobile phones and a leading provider of mobile, fixed, and Internet Protocol (IP) networks, and also, related services as well as multimedia terminals. Nokia's core business focus is the manufacture of operator and service provider driven solutions to enable mobile communications and the manufacture and marketing of mobile terminals. Nokia is the pioneer of the GSM technology, but has a strong presence in TDMA and analog network solutions. Nokia's core business revolves heavily around its Mobile Phone Division which constitutes about 72 percent of overall revenues.

### 3.13 Delta Model – Market Leaders' Strategic Positioning

The delta model framework is used here to analyze strategic positioning of the wireless LAN and wireless device market leaders in the healthcare industry, by first evaluating and characterizing the three distinct strategic options as distinct sources of profitability for market leaders depicted in figure 6 as best products, total customer solution and system lock-in respectively.

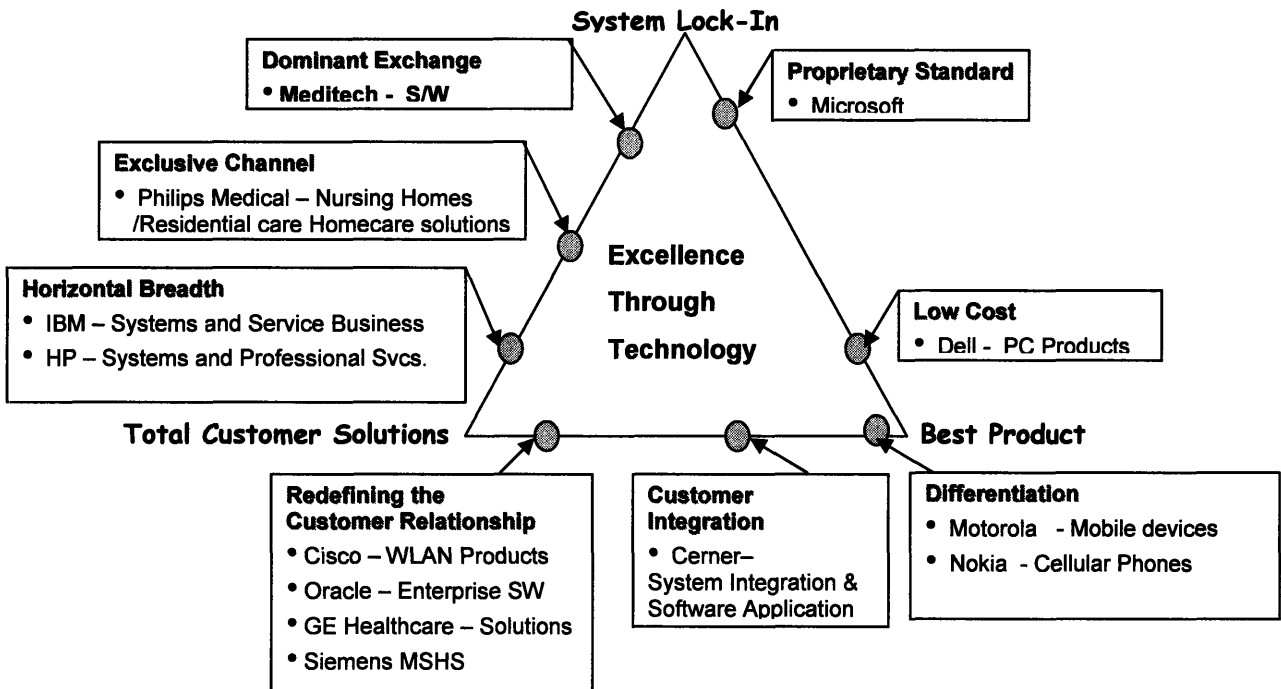


Source: Adopted from Hax & Wilde - The Delta Project

**Figure 6: Delta Model - Three Distinct Strategic Options**

The *best product positioning* attempt to compete through product economics, rivalry and achieving market share by offering low cost or differentiation through operational effectiveness. Total customer solutions seeks long term relationships that enhances customer economics, cooperation and achieving customer share by reducing customer cost of ownership, resulting to or increasing customer profits through customer targeting. Lastly, system lock-in attempts to compete through system economics, market dominance and attracting complementors by offering mutually beneficial opportunities that enhances system performance, with the objective of locking-in customers and locking-out competitors.

Figure 7 outlines how the market leaders for wireless communications products and solutions in healthcare industry are strategically positioned on the Delta model.



Source: Adopted from Hax & Wilde – The Delta Project

**Figure 7: Delta Model - Market Leaders Strategic Positioning**

Dell's strategic positioning as "Best Product" on the triangle is evident by its' operational effectiveness through efficient supply chain and direct customer sales business model. Motorola and Nokia maintains effective economics of scale focus on key differentiation in the product features and functionalities such that their respective product offerings are unique and appealing to the mass wireless communications market. Positioning very well at the bottom of the triangle or between the best products and total customer solutions are GE Healthcare and Siemens MSHS, both leverages its' size, capabilities, brand and global presence to integrate holistic enterprise-wide solutions for the industry, while Cerner as a software solutions and systems integration leader in the healthcare industry positions well on the triangle as "Customer Integration" serves as a bundle of competence to its customers by enhancing customer economics. Cisco and Oracle's strategic positioning on the triangle as "Redefining the Customer

Relationship” aligns with Oracle and Cisco’s strategy of developing intimate knowledge of the customer base leading to an effective customer segmentation and differentiated treatment of each customers based on their findings then develop or acquire companies with needed solutions and services to offer its customers as a “One-Stop” shop offering. IBM and HP strategic positioning on the triangle as “Horizontal Breadth” fit well as both firms are market leaders in the enterprise systems and services with complete set of product and service offerings that fulfills the customer’s entire needs and has the capabilities to customize as needed by the customer. Philips Medical’s strategic positioning as “Exclusive Channel” on the triangle aligns with its leadership position in the chronic disease and elderly care solution that at the interim averts competitors to compete for the acquisition of customers. Meditech’s strategic positioning as “Dominant Exchange” on the triangle is in line with the company’s strategy of a first mover advantage by interfacing first with the core healthcare IT buyers to scope customer needs and work with complementors to offer solutions, thus acting a the prime contractor. There is no one supplier servicing the healthcare industry that could offer a complete turn-key solution without working with complementors. Lastly, Microsoft and Intel’s strategic positioning as “Proprietary Standard” fits well with both company’s leadership position in the industry in the past decade as a result of customers are drawn to their products because of the extensive network of third party complementors design-in products and or offering solutions to work with their products.

### 3.13.1 Lesson Learned from Industry Market Leaders

1. The industry market leaders enjoy outstanding operational effectiveness which produces low cost infrastructure and differentiated products with great quality. Positioning on the delta triangle: *Best Product Position*.
2. The industry market leaders have a deep understanding of their clients which receive a creative and unique value proposition. Positioning on the delta triangle: *Total Customer Solution*.
3. The industry market Leaders have at least one legitimate leadership claim to achieve system lock-in, this normally obtained through admirable innovation and effective use of information technology. Positioning on the delta triangle: *System Lock-in*.

## 3.14 Rational for Technology Adoption

Healthcare communities are adopting technologies that could positively influence the medical practice directly, thus impact revenue and profitability objective. In addition, new technologies like wireless communication are being implemented to realize cost efficiencies as well as improve operation effectiveness in clinical services, administrative and financials and total cost of ownership such as IT infrastructure maintenance and application upgrades. Per Dr. John D. Halamka, CIO of the Care-Group of Boston<sup>1</sup>, his criteria for adopting new technology in addition to the above mentioned objectives includes having a measurable minimum return on invested capital (ROIC) of at least \$5 million over two years, impact to its 3,000 medical practitioners and 9 million inpatient and outpatients clients, and lastly the solution has to be strategic to the hospital (i.e. Pharmacy, OR, Pediatrics etc), and compliance to hospital quality standards i.e.

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<sup>1</sup> CareGroup's Medical Facilities in the Boston area includes the Beth Israel Deaconess Medical Center and the Harvard Medical School.

Sybanes-Oxly, HIPPA among others, A case study on Care-Group's IT initiatives denoted "connecting payers, providers and patients using the wireless communications technology to improve clinical workflow efficiency, reduce supply chain costs and enhance billing capture would be discussed in Chapter 6. Applications of wireless communications technology in the healthcare industry may include -

**Clinical Services:** This segment consist of technology applications such as

- Electronic patient monitoring in intensive care units
- Computerized provider order entry (CPOE) for drugs, lab test and procedures etc.
- Electronic health records control
- Picture archiving and communication systems (PACS) for film-less imaging.
- Results reporting of laboratory and other tests
- Clinical decision support systems
- Prescription drug fulfillment, error-alert and transcriptions
- Electronic mail communication with patients

**Infrastructure:** This segment consist of wireless technology applications such as

- Desktop, Notebook/Laptop; Handhelds and Tablet Computers
- Servers and Network and Communications systems, Wireless Networks
- Voice recognition systems transcription, physician orders and medical records
- Bar-coding technology for drugs, medical devices and inventory control
- Information security systems

**Administrative and Financial Services:** This segment includes the use of technology in software applications such as:

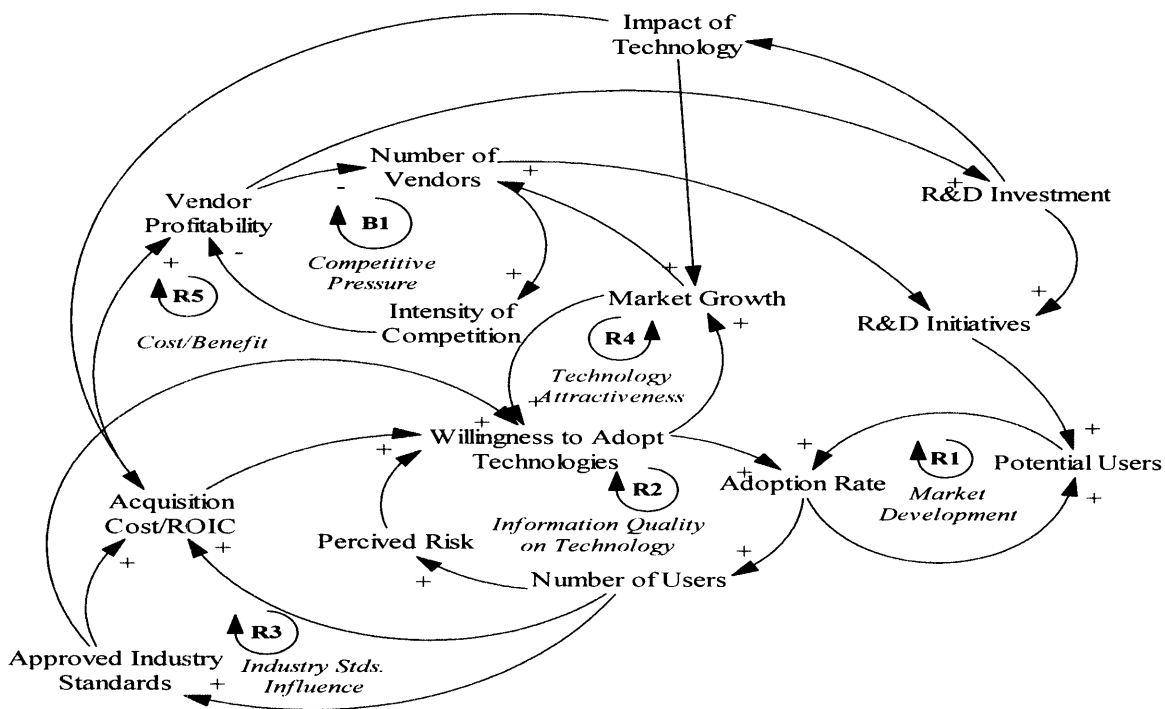
- Billing and general ledger; Cost Accounting systems; Patient Registration
- Personnel and payroll; Electronic Materials Management

A recent survey conducted by the healthcare information and Management Systems Society (HIMSS) and Superior Consultant Group - an IT Consultant & Systems Integration company for the Healthcare Industry affirms the above mentioned rational for technology adoption. In addition, a survey of healthcare technology professionals identified the following IT priorities as rational for adopting wireless technology to support healthcare services operations.

- Reducing medical errors and improving patient safety
- Upgrading security in compliance with HIPPA standards; Replacing or upgrading in-patient clinical systems
- Implementing wireless systems and redesigning processes or workflows
- Connecting IT at Hospital facilities with remote users and locations
- Implementation of electronic medical records systems and training staff in using various technology systems.

### 3.15 Dynamics of Wireless Technology Adoption

In sections 3.7 and 3.8, we reviewed both market drivers and restraints of the wireless communications technology adoption in the healthcare industry, my findings appear to be in parallel with conventional wisdom that market drivers of any program has high number of risks associated especially in the healthcare industry, where potential users could see the value of adopting wireless technology but skeptical and cautious, due to the newness of the wireless technology among others.



Source: Adopted from Weil & Utterback

**Figure 8: Technology Adoption Dynamics in the Healthcare Industry**

The system dynamics model shown in figure 8 illustrates an interesting phenomenon that the adoption rate of a new technology is dependent on number of potential users, and the quality of information on the technology to educate these users impacts willingness to adopt new technology as a result willingness to adopt new technology depends on cognitive and emotional factors including perceived risk, price/performance, and network effects.



**Market Development and Technology Attractiveness (R1, R2 & R4):** New R&D initiatives for wireless technology appeals to potentials users in the industry, thus increases the adoption rate of number of users, as potential users increases, rate of adoption and number of users willingness to express interest to learn about technology increases. As the interest level for education or quality of information transfer to convince skeptics and avert perceived risk of technology grows, the willingness to adopt technology increases a number of reinforcing loops as described for loops R1, R2 and R4 higher market growth for the new technology, this process would eventually lead to increased number of new entrants as more potential users increases the adoption rate as result of new R&D initiatives to enhance solution offerings at competitive cost, number of core users increases, and those willing to adopt technology increases, as market growth increases creating exponential growth as a result of increases in market development, directly improves technology attractiveness resulting to market saturation in process.

**Information Quality on Technology (R2):** The reinforcing loop R2 examines the impact of the quality of information and training on the benefits of the new technology to the stakeholders that addresses concerns such as perceived risk of wireless technology in areas such as electromagnetic interference (EMI), and security issues, thus quality reinforcement of the benefits to the stakeholders would increase number of core users that would see the value of adopting the wireless technology.

**Industry Standards influence (R3):** The reinforcing loop R3 examines the interrelationships between technology acquisition, its' impacts on return on invested cost of capital, industry's willingness to adopt new technology to solve above mentioned challenges in the healthcare communities, rate of adoption which depends very highly on number of core users of the new technology and most importantly the technology meets approved stipulated industry standards

that ensures compliance with government and agency regulations and error free interoperability among wireless LAN subsystems, mobile wireless devices and the enterprise wireless network.

**Cost/Benefit Loop (R5):** The reinforcing loop R5 analyzes the overall cost/benefit of the technology adoption value chain, thus profitability is been driven by R&D investments, resulting in number of R&D solution initiatives that would attract potential users to drive up adoption rate to increase number of cores users as a result improved benefit to the consumer. Increase in numbers of users would translate in lower production or acquisition cost, this would improve profitability to the solution providers.

**Competitive Pressure (B1):** The balancing loop B1 examines the attractiveness of new vendors (entrants) to the market as result of impressive market growth, thus erosion of profitability would occur due to intensity of competition creating stable system effect environment as a result of increased number of vendors.

## Chapter 4.0 Emerging Wireless Technologies

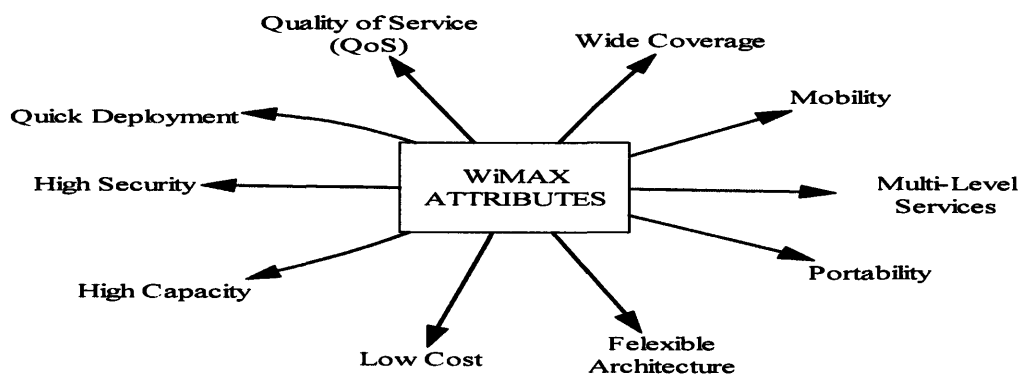
### 4.1 Introduction:

In chapter 2 we introduced the current three primary wireless technologies for computing and communications for local area networking, wide area networking, and personal area networking. In this chapter, we will review the fourth application scenario for metropolitan area networking as the emerging wireless technology denoted WiMAX (IEEE 802.16x). The technology is designed to support delivery of “last mile” broadband computing and communications connectivity over a much larger geographic area than Wi-Fi, by providing coverage to areas ranging from one to six miles wide. In addition to its last mile broadband access supports backhaul for carriers, enterprise campuses such as the medical communities and Wi-Fi hotspots. Other emerging wireless technologies discussed in this chapter includes ZigBee based on the IEEE 802.15.4 standard to offers short-range wireless technology that’s developed for industrial and home automation control systems, the technology offering is designed to compliment Bluetooth (IEEE 802.15), and the Ultra-WideBand (UWB) technology designed for high-speed but for short-range wireless computing and communication technology both classified as personal area networks.

### 4.2 WiMAX Technology

WiMAX (Worldwide Interoperability for Microwave Access) is a broadband wireless technology that is largely supported by both the computer and communications industry as a cost-effective and standards based technology. It is designed to deliver the latest type of ubiquitous fixed and mobile services including voice-over-IP (VoIP), information technology, and video at a very low cost [WiMAX Forum]. The technology is capable of delivering services for large geographical area, up to 50 km and ability to deliver up to 72 Mbps. IEEE standards committee recently approved this new technology as the IEEE 802.16-2004. The technology enables the delivery of last-mile wireless broadband access as an alternative to cable and DSL communication. WiMAX

is intended to operate in the unlicensed spectrum and would provide fixed, nomadic, portable, and, eventually, mobile wireless broadband connectivity without the need for having a direct line-of-sight capability with a base station. WiMAX has the potential to enable the information superhighway to be extended to remote places thereby benefits operators and users in diverse environments such the healthcare industry in geographies and demographics (i.e. urban, suburban, rural), both over the short and long terms. Depicted in figure 9 are the core attributes of the technology the includes high security, quality of service (QoS), quick deployments, supports high capacity, lower cost, flexible architecture, portable, multi-level service, wider coverage and mobile.



Source: Adopted from WiMAX Forum

**Figure 9: WiMAX Technology Attributes**

**High Security:** WiMAX supports advanced encryption standard (AES) and 3DES (Triple DES – data encryption standard). Encrypting the links between the base station and subscriber stations, WiMAX offers subscribers with privacy (against eavesdropping) and security across the broadband wireless interface. The technology has built-in virtual local area network (VLAN) support, which provides protection for data that is being transmitted by different users on the same base station.

**Flexible Architecture:** WiMAX supports several systems architectures, including Point-to-Point, Point-to-Multipoint, and ubiquitous coverage. The WiMAX media access control (MAC) supports Point-to-Multipoint and ubiquitous service by scheduling a time slot for each subscriber station. However, if there is only one subscriber station in the network, the WiMAX base station would communicate with the subscriber station on the Point-to-Point basis. Thus, a base station in a Point-to-Point configuration may use a narrower beam antenna to cover longer distances.

**Quick Deployment:** Compared with the deployment of wired solutions, WiMAX requires little or no external plant construction. For example, excavation to support the trenching of cables is not required, and operators with obtained licensed bands for use or wishes to use unlicensed bands which not file new applications with the government. Once the antenna and equipment are installed and powered, WiMAX is ready for service. In most cases, deployment of WiMAX can be completed in a matter of hours, compared to months for other technology solutions.

**Multi-Level Service:** The manner in which quality of service is delivered is generally based on service level agreements (SLA) between the service provider and the end-user. In addition, a service provider could offer different SLAs to different subscribers, or even to different users on the same subscriber stations.

**Interoperability:** WiMAX is based on international, vendor-neutral standards, which make it easier for end-users to transport and use their subscriber standards at different locations, or with different service providers. Interoperability protects the early investment of service operators since they can select equipment from not one vendor, and it will continue to drive the costs of equipment down as a result of mass adoption.

**Portability:** As with current cellular systems, once the WiMAX subscriber station is powered up, it identifies itself, determines the characteristics of the link with the base station, as long as the subscriber station is registered in the system database, and then negotiates its transmission characteristics accordingly.

**Mobility:** The IEEE 802.16e amendment has added key features in support of mobility. The improvements have been made to the OFDM and OFDMA physical layers to support devices and services in a mobile environment. These improvements which include Scalable OFDMA, MIMO, and support for idle/sleep mode and hands-off, allows full mobility at speeds up to 160km/hr. The WiMAX Forum supported standard has inherited OFDM's superior non-line of sight (NLOS) performance and multi-path resistant operation, making it highly suitable for the mobile computing and communication environment.

**Lower Overall Cost:** WiMAX is based on an open, international standard. Thus mass adoption of the standard, and the use of low-cost, mass produced chipsets would drive down cost drastically, resulting in a competitive pricing that will provide considerable cost savings for services providers and subscribers alike.

**Wider Coverage:** WiMAX dynamically supports multiple modulation levels, including BPSK, QPSK, 16-QAM, and 64-QAM. When equipped with a high-power amplifier and operating with a low-level modulation such as BPSK or QPSK, WiMAX systems are able to cover a large geographic area when the path between the base station and subscriber station is unobstructed.

**Non-Line-of Sight Operation:** NLOS refers to radio path with its first Fresnel zone completely blocked. WiMAX is based on OFDM technology, which has the inherent capability of handling NLOS environment, which other wireless products cannot do.

**High Capacity:** Using higher modulation (64-QAM) and channel bandwidth (currently, 7 Mhz, with planned evolution towards the full bandwidth specified in the associated IEEE and ETSI Standards). WiMAX system can provide significantly high bandwidth to end-users.

**Quality Of Service (QoS):** WiMAX can be dynamically optimized for mix traffice that is being carried. The service types supported includes unsolicited grant service, real-time polling service, non-real-time polling service and best efforts services and depicted in table 2

**Table 2: Different WiMAX Quality of Services Types**

| Service Types                         | Description   |
|---------------------------------------|---|
| Unsolicited Grant Service (UGS)       | <ul style="list-style-type: none"> <li>UGS is designed to support real-time data streams consisting of fixed-size data packets issued at periodic intervals, such as T1/E1 and Voice over IP</li> </ul>     |
| Real-Time Polling Service (rtPS)      | <ul style="list-style-type: none"> <li>rtPS is designed to support real-time data streams consiting of variable-sized data packets that are issued at periodic intervals including MPEG video.</li> </ul>   |
| Non-Real-Time Polling Service (nrtPS) | <ul style="list-style-type: none"> <li>nrtPS is designed to support delay-tolerant data streams consisting of variable-sized data packets for which minimum data rate is required including FTP.</li> </ul> |
| Best Effort Service (BE)              | <ul style="list-style-type: none"> <li>BE service is designed to support data streams for which no minimum service level is required and which can be handled on a space-available basis.</li> </ul>        |

Source: Adopted from WiMAX Forum

### 4.3 Overview of Network Access Technologies

Explosive high growth rate of the Internet has led to unbelievable high demand for broadband access thus, over the last few years many types of broadband access technologies have been adopted for implementation. These last-mile access network technologies include the digital subscriber loop group of technologies that are generally referred to as xDSL, hybrid fiber coaxial also known as HFC network, which is popularly known as the cable network, and the fixed

broadband wireless access network (FBWAN) and the emerging WiMAX network (worldwide Interoperability for Microwave Access) a broadband wireless technology that is largely supported by both the computer and communications industry as the most cost-effective and standards based technology.

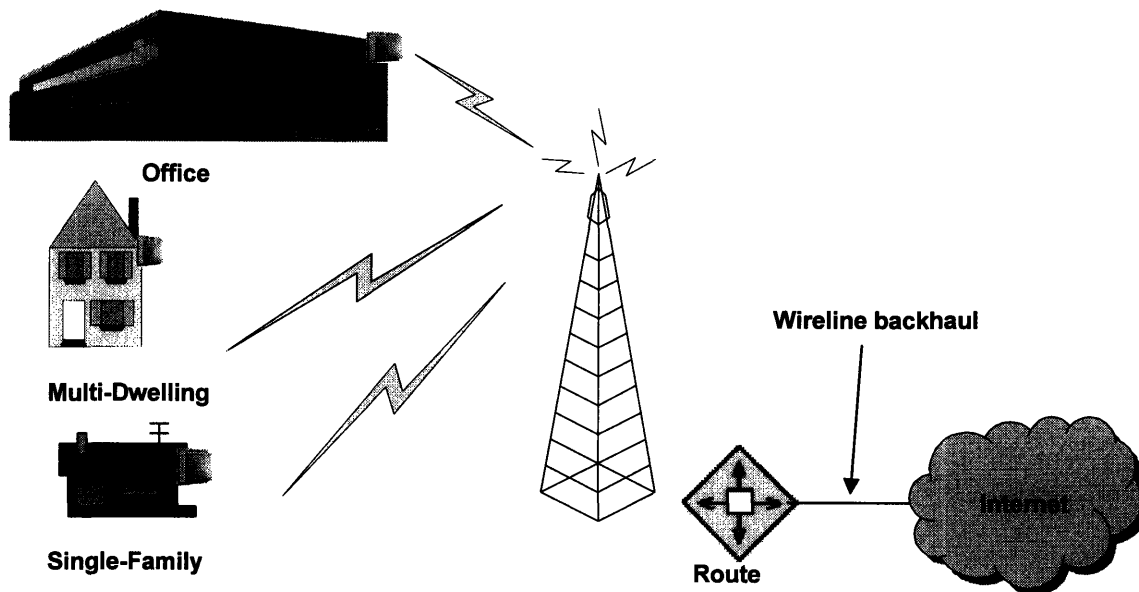
**The Digital Subscriber Loop (xDSL)** is a group of technologies is based on the twisted copper pair used to provide plain old telephone service. They require a copper length of no more than 18,000 feet (or about 3.4 miles) between the home and the central office. This distance limitation makes them unavailable in many locations. Also, they are predicated on copper wire and cannot be provisioned over optical fiber. Finally, they cannot be supported on many aging twisted pairs that need to be reconditioned before they can support the xDSL service. The technologies are used mainly by companies that operate telephone service, such as the PTTs.

**Hybrid Fiber Coaxial (HFC)** provides a local area network type of connectivity over existing cable TV networks, it requires the existence of a traditional cable TV network for implementation, and it supports asymmetric traffic service whereby more bandwidth is allocated downstream - from the head end or cable service provider's programming center to the homes, as compared to upstream covering the home to the head end alternatively.

**Fixed Broadband Wireless Access Network (FBWAN)** uses a small customer premises equipment (CPE) located at the user's rooftop to connect to an access point located a base station. It has many advantages over the other two technologies. First, there are many places where the infrastructure required to support the other two types of access technologies is not available. These include rural areas with low population density, remote geographical areas that are not easily accessible and developing economies that generally lack all forms of communication infrastructure.



**WiMAX:** The first version of the FBWAN was the IEEE 802.16 network, was called the *Wireless Metropolitan Area Network (Wireless MAN)* It was designed for line-of-sight (LOS) deployment in the 10 – 66 GHz frequency bands. At such high frequencies, the network can only support LOS, which limited its coverage to no more than a few kilometers in radius. Depicted in Figure 9 is a typical deployment of a WiMAX network assumes that traffic aggregated at the base station is backhauled to the Internet through some wire line system such as optical fiber or a T1/E1 link.



**Figure 10: IEEE 802.16 Fixed Broadband Wireless Network Architecture**

In addition, the standard also supports both frequency division duplex (FDD) and time division duplex (TDD) operations to permit different types of applications to be supported. FDD is optimized for symmetric traffic, such as voice and other stream data applications, while TDD is optimized for asymmetric traffic, such as Internet data service. The IEEE 802.16a standard [3] was adopted as an amendment to the 802.16 standard and is designed to operate in the 2.4 – 11 GHz range, which makes it possible for the network to operate in a non-line-of-sight (NLOS) manner through the use of orthogonal frequency division multiplexing (OFDM). With OFDM the range of operation increases to a distance of up to 40 km and supports up to 70 Mbps in a

single RF channel with multi path compensation. As shown in Figure 10 no structures or tree does pose a barrier for orthogonal frequency division multiplexing networks.

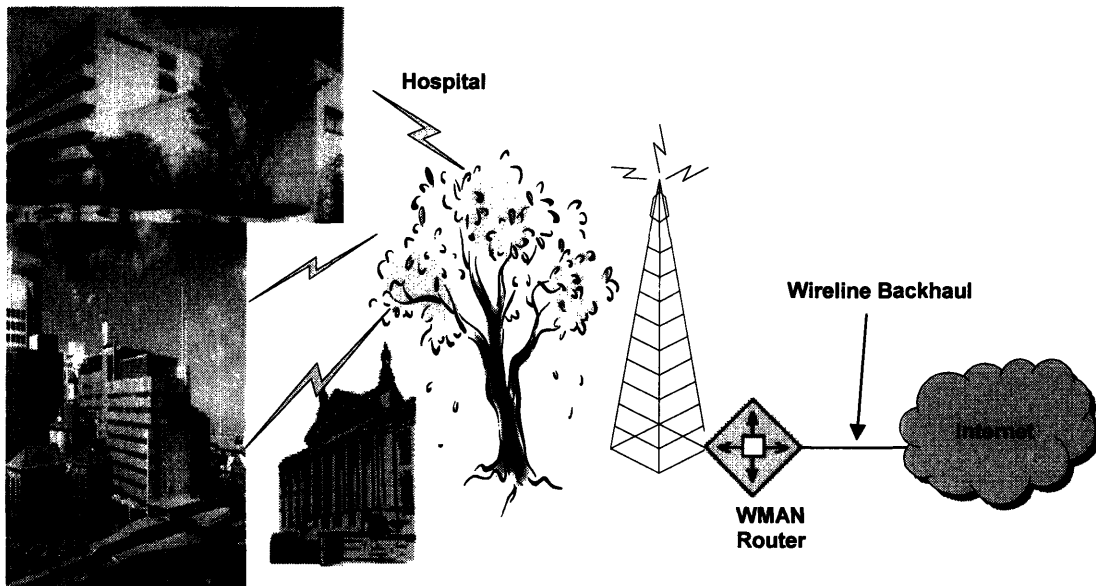


Figure 11: NLOS OFDM-Based 802.16a Network

#### 4.4 WiMAX Applications Based Services

A major attribute for WiMax is that it will succeed in so many applications. The applications can be classified as short-term, mid-term, and long-term. Short term applications are for residential or fixed networks, and the technology could provide backhauling for cellular service networks and this could be considered a short term application with the potential to be durable in the long run. Nomadic access is a mid-term application. This application is similar to fixed access, however, its' like not moving during transmission but it can locate broadband access terminals at different points, which means you are not attached to a particular place in the network. This is an advantage over the DSL and cable. Portable access means that you can be moving during transmission but up to a particular point or at 10 km/hr (pedestrian pace), thus with mobile access one can be moving very fast up to 100 km/hr to 200 km/hr and still have access to communication, hence the nomadic portable access is likely to become an important application

for WiMAX communication. The short-term applications are important, but not revolutionary, while the nomadic and portable access assumes all the qualities of WiMAX high speed network at a relatively lower cost. Evolution from fixed WiMAX to mobile WiMAX is likely to happen at a much faster pace than the evolution of existing technologies. In less than a decade or so, people are going to roam with devices such as PDAs, cellular phones and emerging convergent mobile devices with WiMAX enabled. Technology roll out would be much easier over a metropolitan area, coffee shops like Starbucks would not be providing hotspots capabilities to its customers, content service providers will be providing hot areas instead and It would not be necessary to walk into a coffee shop to gain access to high speed internet, rather the high speed internet access would be available on buses or in downtown areas everywhere seamless like using your mobile telephone today..

**Quality of Service (QoS):** In underserved international markets voice capability is extremely vital. WiMAX includes QoS features that enable services including voice and video that require a low-latency network. The 802.16 MAC enables operators to simultaneously provide premium guaranteed levels of service to businesses. These are T1-level service and high-volume service to homes, the different classes of services are discussed in Table 2.

**Interoperability:** WiMax focuses its efforts on establishing a unique subset of baseline features grouped and referred to as system profiles. All equipment must be compliant with this feature and its' an effort to bring interoperability to broadband wireless access. These profiles look to establish a baseline protocol that will allow equipment from multiple vendors to interoperate, and it enables system integrators and service providers to purchase equipment from various suppliers. The regulatory spectrum constraints faced by operators in different geographies can be addressed by a scheme known as "System Profiles". WiMAX conformance tests combined with interoperability events will enable service providers to choose from multiple vendors of broadband wireless access equipment that conforms to the IEEE 802.16 family of standards.

Operators benefit heavily from WiMAX, because it reduces risk of deploying broadband wireless access systems by choosing interoperable standards-based equipment, hence the economic of scale enabled by the standard helps reduce monetary risk to network operators. As a result, network operators are not locked in to a single vendor's equipment, base stations look to interoperate with subscriber stations from different manufacturers, resulting to a lower total cost of ownership and higher-performance which benefits service operators as equipment manufacturers continuously creates product innovations based on a standardized based platform.

#### **4.5 Economic Benefits of WiMAX:**

WiMAX is a good candidate for deployment in developing (or emerging) economies because it does not require much of the existing communication infrastructure. It can be deployed in hard-to-reach parts of the country, such as those areas where the terrain makes it difficult, if not impossible, to provide wire line services. This means that with WiMAX, rural and inaccessible areas are not cut off from Internet-based services. Enterprising villagers can set up cyber cafes where other villagers can gather to surf the Web and send and read their emails. Bringing the Internet to remote communities means that schools and colleges in urban areas can extend their reach into these communities by providing Internet-based distance learning. Similarly, a local hospital that does not have all the necessary manpower can still provide adequate medical services because specialists need not be resident at the hospital. Instead the specialists can practice at the big hospitals in urban areas and provide service to rural hospitals using telemedicine.

## 4.6 Mobile WiMAX Definition

A new extension to the WiMAX, IEEE 802.16e family, which is called *mobile WiMAX*, and is currently under development. Mobile WiMAX is expected to support both voice and data, and its economic impact is far greater than that of regular WiMAX. It will enable remote areas not only to set up cyber cafes for Internet access but also establish their own telephony companies. Since WiMAX is intended to operate in the unlicensed spectrum, such companies can be established without the interference of the regulatory authorities. This will enable intra-area voice traffic to be handled locally without imposing undue traffic burden on the national or regional PTT network. Thus, WiMAX will enable the creation of islands of local authority telephone networks, where each island can be a single town, group of towns, a metropolitan area or a village. With proper cooperation among the different local operators, the spectrum resources used in one local authority network will be reused in other local authority networks and inter-local authority traffic can then be backhauled to the PTT network. More importantly, the backhaul can also use WiMAX rather than traditional telecommunication infrastructure, which is likely to be the case since it is the absence of such infrastructure that has led to the establishment of the local authority telephone network in the first place.

## 4.7 WiMAX Market Drivers

Market drivers that would enable continual growth of the WiMAX technology includes service offerings, timing, advantages over competing technologies, VoIP standards liberalization, industry standards, and interoperability.

**Services:** A driver could also be a new carrier, who is not a carrier to the broadband business or sector. It could move in or develop more cheaply a network to deliver high bandwidth signal in the domestic or enterprising market. Another major driver is the ability of WiMax to provide

services cheaply and effectively over a few kilometers. This is similar to providing services over an unlicensed band. A major driver is high speed internet with a lower total access costs, this could be something like a public library generating economic activity.

**Timing:** The timing is right at the moment. This gives firms an opportunity to be at the leading edge of WiMax technology and establish themselves. WiMax is an excellent match for core RF capabilities. WiMax radios are likely to come out, which may be a major driver. Introducing new products is always about time to market and much of the success can be attributed to risk management. By developing a reference design firms can be positioned to successfully manage risk for clients. It is likely that there would be a substantial amount of networks installed all over and it will be important to be backward compatible to fixed access networks.

**Advantage over Competing Technologies:** Cable and DSL are the major competing technologies. The DSL has advantage over Cable, as a result of DSL deployment over traditional Wire-line/Telephone line, however DSL has two disadvantages including aging wiring (wire-line infrastructure) and distance limitation of 18,000 feet. While, Cable deployment is limited to densely populated areas around the world where is cost effective to deploy. In this case they are mainly deployed in urban areas or metropolitan cities. Hence, WiMax which has neither of the above mentioned challenges will be cheaper to deploy than cables and DSL.

An economical way of rolling out high speed broadband access in places without infrastructure is through the wireless medium. This is made possible by putting a base station through which a city could be covered, and deployment can be done quickly with 802.16 unlike cable and DSL. The time period is few days when compared to the months required for DSL and cables. It can be deployed in harsh environments, which is advantage. This opens up a possibility for companies to compete in the same province. There has never been a model that made economic sense in the DSL service. The first customers for WiMax are from places where there

is no infrastructure. Initially WiMAX companies will not be a price competitor to DSL and cable as they have more integration and higher volumes.

**VOIP:** Interoperability provides flexibility to all existing technologies. Powerful service support can also be seen. These features haven't featured with the WiFi, which is a driver for WiMAX. VOIP is broadly in use, universities already have deployment of VOIP services. WiFi at the interim does not support VOIP (IEEE 802.11e approved in late 2005, will offer enhancements to the IEEE 802.11x standard to support voice-over-wireless IP) an area which 802.16 covers comprehensively. WiMAX IP solutions offer lower product development risk, lower product development costs, time to market advantage, migration paths to optional features and new derivatives of the 802.16 standards.

**Industry Standard:** Standards always have a positive effect on the market place up to a point; once standards exist, the prices could come down lowering solution ownership costs to the customer. Since most consumers don't understand technologies but are comfortable in investing/buying or adopting as at when standard exists.

**Interoperability:** Interoperability is an important requirement to the WiMax network for a number of reasons, including ease of procurement and lower cost of ownership by not specifying differing brands of equipment for a project. Thus, it could be cost prohibitive and irrational to put product brand X on one and product brand Y on other even if they were both designed to the WiMax standards, a fairly broad adoption of WiMax is expected since most companies in the fixed microwave business would also be having WiMax products in their product line and with a fair amount of proprietary products that do the same thing as WiMax, but WiMax may be the dominant player.

## 4.8 WiMAX Market Restraints

Market restraints that could impact successful adoption of the WiMAX technology include non-availability of tested network infrastructure and compliant products and software applications, quality of service offerings, competing technologies, hype, line-of-sight (LOS) and Interference challenges.

**Non-availability:** WiMAX is not yet up and running. The product will not be in the market until mid 2006. Therefore the first challenge would be to impose WiMax products into the market. WiMAX will have to start deploying equipment to get the momentum rolling and there is high number of companies rolling out WiMAX compliant systems. It's important to show consumers how good WiMax is and what it could do to better people's lives. It is important to bring the cost point lower and lower, resulting to a differentiating competitive advantage. Different vendors align from a technology point of view, thus in every standard there are various ways and different options of implementation. A major challenge is to head companies with different market perspectives and points of view in the same direction. This would be a very difficult driving force. **Mini case example:** IEEE 802.11 was first hyped and introduced as the wireless communications technology consisting of three communicating standards namely frequency hopping with throughput speed of 2mb/s, infrared offering point-to-point throughput speed of less than T1 speed and direct sequence speed (DSS) with throughput OF 2mb/s. It was not too long abandoned to introduce the IEEE 802.11b a couple of years or so later.

**Services:** The technology will have to prove itself in terms of QoS capabilities. There is no talk today as to how the community would react in terms of service providers. The issues of changing service providers and billing are not addressed. If mobility doesn't become a part of what service providers deliver, it could be a significant constraint to the technology. Voice and data service providers should be able to offer services for cell phone, laptop, PDAs with WiFi



and WiMax capabilities that will be a useable model. It will be prohibitive from both a convenience and cost point of view if services have got to be purchased individually.

**Competing Technologies:** As always there are competing technologies in which other companies have invested heavily and for obvious reasons these firms have a vested interest in seeing these technologies succeed. Competition with other technologies is a restraint. This is because technologies such as WiFi or 3G are not static. These technologies are making progress. WiMax at the moment has some advantages over these technologies. Application areas WiMax targets are similar to those of its competing technologies. Hence technical advancements and progress of WiMax is significant. One of the major challenges in the long term is interference. Thus, spectrum will have to be deployed where problems with carriers arises. The challenge is to look at what is being or can be delivered. There is very little about WiMax that will either support voice networks or be cheap. The challenge is there no backhaul opportunity where there is no shortage of backhaul technology. It is unlikely that WiMax will make it any cheaper. Lastly, there are restraints in regard to voice as well a major requirement is voice access for majority of the population the technology doesn't address this efficiently since one of the major challenges in developing countries is people having access to both voice communication and wireless communication systems. WiMax really does not address the voice market neither does it make voice communication cheaper, in comparison to substantially cheaper technologies that provides only voice communication

**Hype:** People are talking about WiMax before anybody has even it in use, as with any new technology there are always concerns regarding generation of excessive hype about the capabilities of the technology, the timeframes in which it will be available, and the total cost of ownership. To some degree many of these concerns are mitigated by a an alliance or consortium of market leaders in the industry, similar to IEEE standards working committee driving the technology presence. This however may also restrict others from entering the WiMax

market, further delaying the adoption of the technology. The mobility aspect has to bypass 3G and 4G and researchers are looking to add voice video and data, denoted triple play, which is going to be a major challenge. This would happen when there are more infrastructures such as base stations and mobility solution offerings by the select mobile services companies with broadband capability to can gain access.

**Line of Sight (LOS):** Broadband wireless has been tried before with non-LoS. Economically it was a constraint as customers couldn't be reached and the installation was harder. There were other problems with BWA being a completely proprietary technology where customers were locked into one supplier and therefore the cost was high. WiMax should be non-LoS. Wavesat has been developing non-LoS for seven years. Wavesat sees it as the only player among semiconductor chip companies with non-LoS technology built-in. The firm's chips used will be smaller, use less power, and cost less. If a developer develops a 802.16 modem it doesn't necessarily mean it is non-LoS. 802.16 will give the tool to be able to do non-LoS. A very simplistic implementation will be an LoS one. The initial phase is influenced by economic factors.

**Interference:** 802.16a can supposedly operate in both unlicensed and licensed environments. For unlicensed operations the number of service vendors will increase, which may give rise to interference. Interference within the same frequency would decline the QoS which is a major problem. Any regulations would directly affect the popularity of the scheme. This would allow only big vendors to play major roles. The major challenge is to get an established infrastructure such as cable and DSL. In a few years wireless is likely to overtake DSL and cable.

## 4.9 Ultra-Wideband Technology

Wireless communications has become an integral part of our everyday lives in the past decade - Ultra-Wideband (UWB) technology will only accelerate this trend with throughput speeds ranging from 100Mbps scaleable to Multi-Gbps. The technology is well suited for a variety of uses including the healthcare industry, office and digital home environments. Wireless communication freedom has been realized by experiencing the use of personal computers, handheld, consumer electronics and mobile cellular phone connectivity medium that enables consumers the flexibility and convenience of seamlessly connecting all types of devices with the use of Ultra-Wideband (UWB) Technology. This power-efficient UWB solution will offer high bandwidth required for current and future consumer devices, personal computers, mobile devices and multiple digital video and audio streams. This short-range radio technology is ideal for WPANs, UWB complements existing longer range radio technologies discussed in this report such as Wi-Fi, WiMAX and cellular wide area communications that brings in data and communications from the outside world, in addition it offers needed cost-effective, power-efficient, high bandwidth solutions for relaying data from host devices to devices in the immediate area up to 10 meters or 30 feet.

### 4.9.1 Rationale for Ultra-Wideband Technology

Emerging digital technologies for the home and office environments are made up of many different consumer electronics (CE) devices (i.e. digital video and audio players), mobile devices (i.e. cellular phones and PDAs) and personal computing devices (i.e. mobile notebook PC, and Tablets) that would support multitude applications generating three overlapping or converging categories as shown in Figure 3.xxx. Traditionally, these devices are kept in different locations and used as required separately. Increasingly there have been innovations that enable these

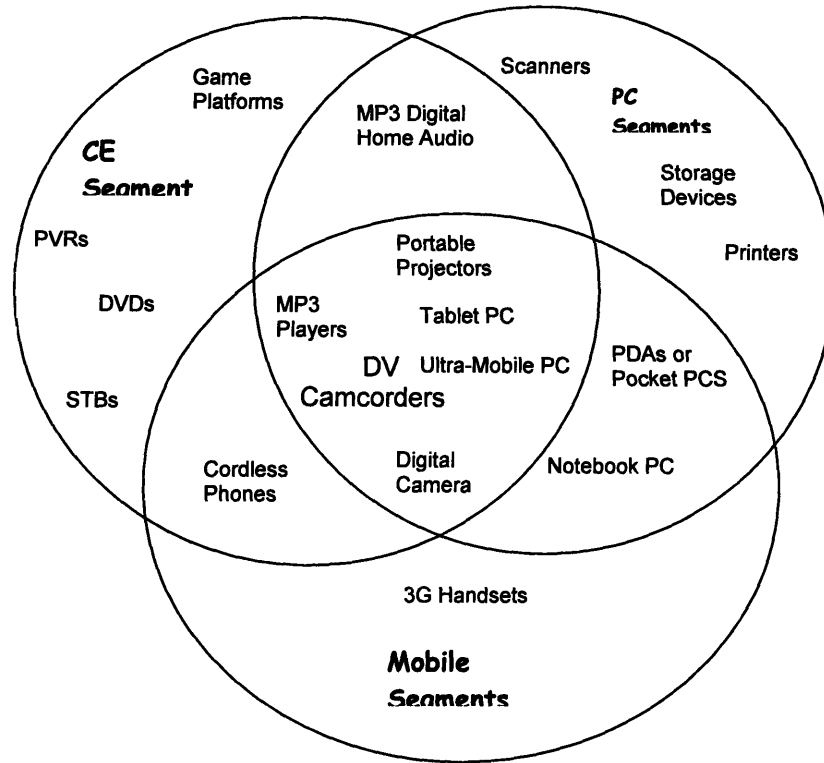
devices to interoperate across disparate devices for example - MP3 players exchanging files with PCs, digital video recorders communicating with set-top-boxes (STB) among others.

Thus, the convergence of these device segments requires common wireless technology and radio frequencies that enables them to easily interoperate and deliver high throughput and accommodate multiple high speed applications. Currently, devices in the segments outlined utilize different interfaces and content formats. Next generation devices in the segment has demand for applications and connection speed that would exceed 1Mbps peak data rate of Bluetooth technology used in many devices with connections to WPAN currently, however is cost prohibitive for the mass market and limited power capability to take advantage of 801.11/a/b/g radios for Wi-Fi networking.

Here, the UWB technology provides needed throughputs by next generation of converged devices in the three segments discussed in figure 3.xxx. In addition, the WiMedia Alliance<sup>2</sup> helps to ensure interoperability across multiple protocols, including IEEE 1394, USB and universal plug and play (UPnP) making UWB a broad technology wireless platform for creating high speed, low cost and low power WPANs.

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<sup>2</sup> WiMedia Alliance is pen industry association that leads the market in commercializing UWB by enabling and promoting the rapid adoption, regulation, standardization and multi-vendor compliance and interoperability of UWB worldwide. Alliance



**Figure 12: Convergence Devices – Market Segmentation Mapping**

#### 4.9.2 Ultra-Wideband Applications

Ultra-Wideband offers consumers the hope of eliminating the maze of wires connecting electronic products in their homes, including large screen displays, set-top boxes, speakers, televisions, digital video recorders, PCs (i.e. desktops, notebooks, and tablets), digital cameras, and smart phones among others. UWB technology can enable a variety of WPAN applications that includes:

- Replacing cables between portable multimedia consumer electronics devices such as camcorders, digital cameras, and portable MP3 players with wireless connectivity.
- Replacing cables on next generation Bluetooth technology devices such as 3G cellular phones, and IP/UPnP connectivity for the next generation of IP-based personal computers, consumer electronics products and mobile devices.

- Enabling high speed wireless universal serial bus (WUSB) connectivity for PCs and PC peripherals, including printers, scanners and external storage devices.

## 4.10 RFID Technology

Radiofrequency identification (RFID) classified wireless personal area network technology is an emerging electronic labeling and data collection system that uses RF signals to identify individually tagged objects or human. This technology provides a quick, flexible, and reliable way to electronically detect, track, and control a variety of items. The RF technology is completely independent of line-of-sight limitations.

A typical RFID system includes transponders, commonly called tags. Readers or interrogators pass data to host computers for processing. A transceiver in the RFID network generates RF signals, an antenna bounces RF signals between the reader and tags and application-specific software. RFID transponders consist of the chip attached to a small antenna and information stored on the chips are transmitted through the antenna to and from the transponder via radio waves. Information on the chip could be encoded, read, and updated at a later date. The RFID technology process starts with a tag made up of the microchip with the antenna and reader. The reader sends out radiofrequency waves that form magnetic fields when joined with antennas on the RFID tag. A passive RFID tag creates power from the magnetic field and uses it to energize the circuits of the RFID chip. The chip in the radiofrequency identification tag sends information back to the reader in the form of radiofrequency waves. The RFID reader converts the new waves into digital information. Semi-passive RFID tags use a battery to run the circuits of the chip. The RFID reader powers the communication process.

RFID tags come in different shapes and sizes. Some are minute with a short read range while others are big with a read range of up to 25 ft. RF waves transfer data between the RFID tag

(attached to an item) and the reader. The host computer is the intelligent part of the system. Typical read-only tags have 32 to 64 bits of ID capabilities, allowing for a large number of unique identifications. The four most common frequencies are 2.45 GHz, 902-928 MHz, 125-132 KHz, and 13.56 MHz, which many manufacturers are moving toward due to its reduced limitations on read speeds, read/write capabilities, and lower cost of production.

RFID is everywhere in the present environment, RFID printer/encoders are used to print bar codes, graphics, and human-readable text on the surfaces of "smart" labels. Radiofrequency chips are found in televisions and cellular telephones and smart packaging displays, and used to track assets in corporate and healthcare environments as well as to grant access to secured areas.

#### 4.10.1 RFID Emergence

In the healthcare industry human errors cause patients at hospitals and clinical settings to be exposed to infected equipments and instruments. This exposure could lead to catastrophic situations in healthcare organizations and situations like this could be avoided by use of advanced technologies. RFID technology along with the use of proper protocols, could utilized to avert outbreaks by ensuring instruments are properly tracked and classified. This and other RFID applications could provide significant benefits to the healthcare industry in terms of ensuring patient safety and improved efficiency. RFID is now generating significant interest in the marketplace because of its robust application capabilities. RFID enables healthcare facilities to improve overall safety and operational efficiency as it operates without line-of-sight limitations while providing read and write capabilities for item tracking. The technology has a strong application potential with medical device companies, who need better control of implants on consignment with hospitals because returns are likely to occur half the time. The technology looks to improves visibility into returns that could enable faster redeployment as the company would know when an unused product could be returned.

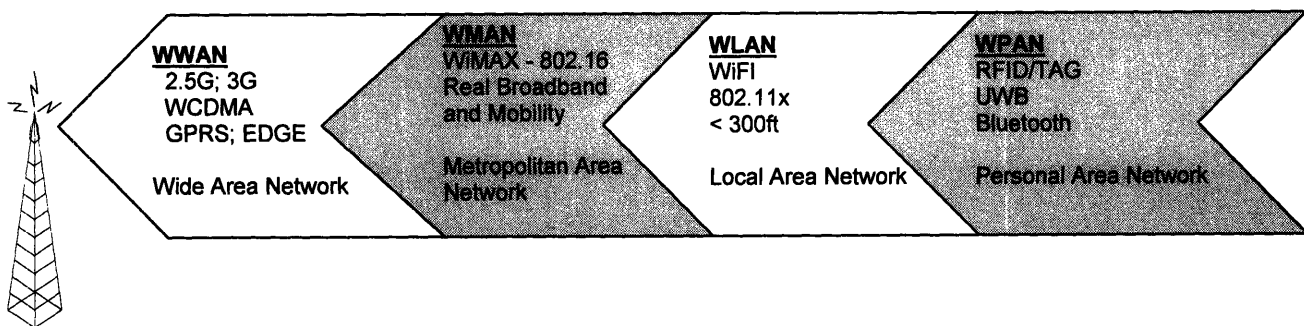
Tags on surgical instruments and readers on sterilization chambers and storage cabinets could validate proper cleaning and help locate the needed instruments. As medical devices are often mounted on portable carts, smart tags placed on the devices and readers installed in the doorways could enable personnel to quickly locate crucial pieces of equipment and immediately determine the significance of their usage. Due to lean technology budgets, new technologies need to demonstrate compelling business cases and short paybacks on investments. Companies in such scenarios will remain skeptical if the costs cannot be offset by the promised benefits. Although RFID technology is considered promising for the healthcare market, usage is expected to accelerate only when prices drop and potential buyers are more confident of its capabilities. Patient safety and asset tracking requirements could drive adoption of RFID technology. RFID could be a promising technology for the healthcare industry if the industry can adjust their processes to leverage RFID's advantages. The healthcare communities however, will have to create their own business cases to determine if the payback is justified. The healthcare industry will benefit from efficiencies provided by the technology, which can translate into an overall healthier industry.



## 5.0 Trend Analysis

### 5.1 Introduction

In the preceding chapters we had understanding of both the technology and market dynamics of wireless computing and communications in the healthcare industry. In this chapter, we would analyze the wireless communication technology trends in market opportunities in the healthcare industry's through 2011 with inferences to at least the past 5 years and in respect to the core market segments discussed in chapter 3 section 5. The industry can be classified currently as been in the fluid phase as was personal computers in the 1980s and the Internet in the 1990s, wireless networking technologies are becoming the next ubiquitous platforms for seamless delivery of desperate technologies and applications for quality patient care. Depicted in figure 12 is a relational map of the four core wireless technologies discussed in chapters 2 and 4 would continue to be invaluable in healthcare delivery and services, the technologies are wireless personal area network, wireless local area network, wireless metropolitan area network, and wireless wide area network topologies respectively.



**Figure 13: The Four Core Wireless Communications Technologies**

### 5.2 Market Opportunities

The year 2011, wireless communication technology adoption in the healthcare industry would be in transitional phase of its technology innovation and industry forces dynamics, thus experiencing significant growth as a result of continual drop in wireless solution acquisition cost,

ease of use, convenience and other market drivers depicted in figure 5 and discussed chapter 3 section 7. In many hospitals and establishments wireless technology networks have replaced or are complementing traditional wired networks. Depicted in figure 1 and discussed in chapter 2 section 3, a system dynamics model an integrated healthcare IT enterprises architecture for a medical facility in a single or multiple buildings, with each department supported with its cluster of WLAN topology based the highest throughput of patients however they interoperate seamlessly. Wireless technology offers unprecedented levels of flexibility for clinicians, allowing them to work anywhere on campus, easily collaborate with colleagues, access to patient's information regardless to location, improve workflow efficiency, dramatically decrease medical errors, improve quality of patient care, while reducing overall cost and improvement in operating margin. Enclosed with the conclusion remarks is a case study of a regional Massachusetts based medical systems enabling the use of IT wireless LAN systems to reduce cost and improve operating efficient.

### 5.2.1 Market Opportunity #1: Hospital Segment

Three core areas within the hospital market segments including integrated point-of-care solutions, clinical handheld applications, and supply chain management technology. The three area of this market segment hold tremendous market or business opportunity, because its' integral to the successful deployment of a world-class wireless implementation within the healthcare industry. As the adoption of wireless information technology continues to grow within healthcare industry and realizes the benefits discussed in previous chapters, higher investment initiatives for wireless technologies across the value chain would be expected with very little or nor effort. Given that issues such as patient safety, improved productivity and greater workflow efficiency act as the primary drivers for wireless technology implementation, the number one goal remains the achievement of ROI in a minimum amount of time to be discussed in chapter

6, case study “IT/Systems connecting payers, providers and patients” and per interview with Dr. John Halamka, CIO, of Caregroup based in Boston, Massachusetts. Hence, the market for *integrated point-of-care solutions* comprises of substantial portion of the overall wireless market in healthcare, it provides the backbone components for the wireless LAN infrastructure networking, as wireless applicability continues to grow, as healthcare practices are likely to continue to integrate this point-of-care infrastructure in their effort to achieve enterprise-wide ubiquity.

*Clinical Handheld Applications* a second growth area support the system platforms with which wireless productivity is attained. These mobile hardware and software solutions enable clinicians to access and retrieve information directly using point-of-care solutions that could be a customized mobile wireless cart, PDA, or tablet PC. Healthcare professionals can gain immediate point-of-care access to a wide range of patient information at their respective patients' bedsides, simply with the touch of a button. In addition, they could have access to information such as lab results, medical history and profile, digital images, allergies, and clinical notations all at the point of care. This provides enormous amounts of benefits, not only to the physician or clinician at practice, but the patient as well.

Charge capture is another application gaining vast ground and adoption in the healthcare space, through charge capture applications, physicians can automate its entire billing process directly on their mobile device instantly after seeing a patient, thus saving valuable time and money and major reduction in the volume of inaccurate claims processed. A final invaluable application for these handhelds for both physicians and other medical clinicians is the capability of having access to medical reference libraries directly on their mobile device this could high pull. Drawing on stored information directly off a central server, doctors, nurses, and medical administrators have the ability to access invaluable amount of reference information as needed, when needed, without having to manually open a medical reference book is highly possible by

2011. The opportunity is high and is largest of all wireless solutions, and would continue to grow as its applicability's enhance as well as physicians become more comfortable using these devices. As the adoption rate of these devices increases and utilized in patient care delivery, clinicians are finding the benefits to include decreased occurrences of medical errors, improved workflow efficiency, and reduced overall costs. The third and important area is the *supply chain management (SCM)*, this is a new area the healthcare industry has applied wireless technology innovation to enhance patient care services. The primary application for supply chain management is derived currently from wireless bar code scanners, which can be integrated directly on handheld devices. This aids not only in the management of medical supplies coming in and out of the hospital, but also carries a direct correlation to the care of the patient. The market and or business opportunity here looks very promising and is currently producing positive results in industries such as retail, pharmaceutical industries. The technology is still in its infancy phase in regards to implementation within the healthcare industry, however, investment initiatives from the healthcare community are expected to be high both short and long term. Integration of SCM holds tremendous value in the management of not only cargo and medical supplies, but patients care delivery and patient drug administration among others as discussed in chapter 4.8 on RFID technology. Given that the market for SCM is still very nascent, only a few established vendors are operating substantially in this space, this we believe would change the level of competition will increase rather quickly and shortly.

*Inpatient monitoring* is not new, is relatively older than its wireless monitoring counterpart, with deployment dating back to the late 1990s. Is still in its fluid phase, the context of technology innovation and dynamics of industry force framework, thus implementation and greater demand for these products has stirred as vast amounts of wireless infrastructure flood hospital departments nationally. The market and business opportunity exist and very attractive for leading manufacturers, as clinicians become more accustomed to utilizing this wireless

technology in their daily practice, the market demand for these devices will grow substantially thus generating increased revenues for vendors, resulting in greater inpatient monitoring wireless applicability as well as improvement in healthcare delivery quality.

## 5.2.2 Market opportunity #2: Nursing/Home Care Market Segment

*The Nursing/Homecare - Remote Patient Care monitoring with integrated wireless technology to complement sensor networks* present enormous business and market growth opportunity. Over the years, the emergence of wireless technology applications within hospital facilities has seen a steady amount of growth and adoption, as medical practitioners become accustomed to utilizing IT as part of their daily patient care tool, as greater amount of applications continue to emerge. This has led to physician use of wireless technology not only for patients within the hospital, but also for outpatient care as well, as a result of hospitals been overcrowded. Industry reports states, the number of people in U.S. dying from cardiovascular disease is on the decline and mortality for cancers is flat, however the number of patients living with chronic diseases is on the rise, other factors include severe nursing staff shortages problems to depleted operating budget. In addition, the country's elderly continue to age at a rapid rate, and the amount of time and money necessary to care to address all these challenges for growing exponentially.

Deployment of wireless homecare technology provides an inherent solution to this quickly growing dilemma, thus enabling real-time wireless remote patient monitoring capability for trained clinician to remotely monitor vital statistics of critical patients while outside the healthcare facility. Wireless homecare or remote patient care services with wireless technology would be a high growth market and or business opportunity by 2011, as at when the four core wireless technologies protocols are fully deployed and system acquisition cost has dropped precipitously in alignment with adoption growth rate. An application scenario could be, a patients being monitored wears adjoining monitors, which will measure his/her vital statistics depending upon their relevant medical conditions. This information is then transferred back to the

physician, where he/she may assess on a real time basis; data is then transferred via CDMA or a wireless wide-area-network. This scheme would require the patient to stay within the cellular or WWAN coverage area. Integration of wireless technology into mobile healthcare is a win-win value proposition and it enables proactive medical practice that benefits society at-large, while reducing overall cost long term healthcare delivery

### 5.2.3 Market Opportunity #3: *Integrated Healthcare Services*

*Integrated healthcare services created for the purpose of this thesis project.* The value proposition of this market opportunity is to offer regional healthcare segments consisting of the Ambulatory, Hospital, Nursing/Homecare and Social Services a secure, 24/7, redundant back-up and restore features for data, disaster-recovery planning, safe and securely protected enterprise wireless healthcare management solutions and services delivered through a menu driven point-of-care or clinical handhelds wireless devices. Members or subscribing medical practitioners would have complete access to a library of drug prescription and health management data, registered patient's electronic medical records (EMR), billing capture, assets management to complete patient history readily available to make error free diagnostics, prescriptions and or referrals.

***Benefits to the healthcare industry:*** Includes 24/7 real-time access to patient records and history, updated medical records including dental, optometry, specialist to improved outcomes of clinical services, enhanced physician and nurse productivity and work efficiency, reduce operations service cost, improve revenue collection, reimbursement errors,, and practice profitability. Reduces or eliminates mal-practice law suits and malpractice insurance coverage for the healthcare industry and practitioners.

## 6.0 Conclusion Remarks with a Case Study

The healthcare industry like other industry is on the cross roads as a result of rising demand for healthcare delivery and service, the industry is faced with declining revenues and increasing operational cost. As a result, the healthcare industry's strategic thrust is embracing wireless computing and communications to avert the continual declines in revenue and increases operating cost by effectively using the modern technology as the enabler, in this case – wireless communications technology to change the paradigm shift to improve outcomes of clinical services, enhance physician and nurse productivity, work flow efficiency, reduce supply chain cost, improve revenue collection and practice profitability. The first phase of the thesis report presented the dynamic and strategic analysis of wireless communications technology in the healthcare industry, by first evaluating the wireless technologies, the three core communications protocols, industry standards and regulations, specific standards for the healthcare information systems and innovative healthcare technology solutions widely used in the industry.

Based on an in-depth technical analysis of the wireless technology, I analyzed the market and industry by applying frameworks including Porter's 5 forces and The Delta model and system dynamics models to illustrate contributing factors affecting new technology adoption in the healthcare industry and a holistic view of a healthcare IT system architecture. Wireless communications is in its' late fluid phase per the frameworks of "the technological innovation and industry force dynamics roadmap", like the introduction of personal computers in the 1980s and the Internet in the 1990s. I am confident that, the healthcare industry would continue to benefit from wireless communication technology as the throughput speed, security and reliability continue to increase, the rate of adoption across the healthcare market segments including ambulatory, hospital, nursing/home care and social service will grow exponentially, as illustrated on the systems dynamic models depicted in figure 1 of chapter 2. The technology has been very well received, used in many medical communities today and it has allowed medical practitioners

to easily make rounds or move freely while connected to the network seamlessly using mobile wireless devices to access valuable patient data and communication with health center managers. A case study of an example of integration of wireless technology into a healthcare group's IT systems to improve clinical workflow efficiency, reduce supply chain costs and enhance billing capture is enclosed below.

**Case Study: CareGroup, Boston Massachusetts:** *Healthcare information technology Systems Connecting Payers, Providers and Patients* - Like many industries in these turbulent economic times, many healthcare organizations are challenged by flat to declining revenues and increasing costs. As a result, a number of healthcare providers are refocusing its IT strategic plans on initiatives that improve workflow efficiency, reduce supply chain costs and enhance billing capture.

The Boston, Massachusetts based CareGroup, has a consortium of 4 hospitals, 3,000 doctors, 12,000 employees and two million active patients, they have focused on cost reduction and revenue enhancement issues while working to improve quality and increase patient care services across the value chain. One of the most significant quality issues facing American medicine today is medication error, an Institute of Medicine report, "Crossing the Quality Chasm", notes that millions of patients receive the wrong doses of medication or experience drug/drug interactions. We've reduced medical error at CareGroup by eliminating all handwritten orders through the implementation of Computerized Provider Order Entry (CPOE), CPOE automatically checks all drug/drug interactions, drug allergies, and recommends the best dose for each medication prescribed for a patient. By using a high availability web infrastructure, including wireless laptops integrated with Wireless LAN adapters in all of our acute care areas, we ensure that all orders go from the doctor's brain to the patient's vein without transcription or interpretation error per Dr. John Halamki. Increasingly, healthcare is outpatient focused. Patients now have ambulatory surgery and go home without a hospital stay, many conditions,



which formerly required a hospital stay, are now treated in the doctor's offices (ambulatory care). Recognizing this trend, they've implemented a web-based practice management and electronic medical record system for their outpatient offices which reduces medical error via an outpatient version of CPOE, improves electronic data capture, and enhances billing capture via electronic submission of claims.

On the customer service and quality side, we've implemented a unique customer relationship management system called patient-site which enables all of our patients to view their entire medical record, make appointments, renew medications and send secure messages to their doctors. Patients and doctors are overwhelmingly positive about the system, which fosters shared decision making between doctors and patients. Thus, to improve workflow efficiency, we've implemented Electronic Data Interchange transactions mandated by the Health Insurance Portability and Accountability Act (HIPAA). By linking payers and providers with seamless electronic workflows for eligibility checking, referrals and claims management, they have reduced transaction costs from \$5.00 to less than 25 cents per transaction. Total cost of ownership of software solutions is an increasingly important metric in a cost constrained environment, although handheld technologies have not been adopted in healthcare as rapidly as predicted due to limitations of battery life and screen real estate, wireless web via lightweight PC laptops and 802.11b has become a very important part of their workflow. All of these applications require robust networks, highly available storage and robust backup solutions. They've built redundant Cisco networks, 100 Terabytes of Information Lifecycle managed EMC storage and a redundant farm of 200 servers spread across a primary and a backup data center. Over the past 5 years, CareGroup has been named the leading healthcare IT organization in America. They've maintained this recognition through constant innovation, high reliability and superior service to patients, providers and payers.

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# List of Abbreviations

|                 |  |
|-----------------|--|
| <b>3DES:</b>    | <b>Triple DES – Data Encryption Standard</b>             |
| <b>AES</b>      | <b>Advanced Encryption Standard</b>                      |
| <b>ASIC:</b>    | <b>Application Specific Integrated Circuit</b>           |
| <b>ARPU:</b>    | <b>Average Revenue Per User</b>                          |
| <b>BE:</b>      | <b>Best Effort Service</b>                               |
| <b>BPSK:</b>    | <b>Binary Phase Shift Keying</b>                         |
| <b>BS;</b>      | <b>Base Station</b>                                      |
| <b>CLEC;</b>    | <b>Competitive Local Exchange Carrier</b>                |
| <b>CAN:</b>     | <b>Campus Area Networks</b>                              |
| <b>CDMA/CA:</b> | <b>Carrier Sense Multiple Access/Collision Avoidance</b> |
| <b>CDMA/CD:</b> | <b>Carrier Sense Multiple Access/Collision Detection</b> |
| <b>CPOE:</b>    | <b>Computer Physician Only Entry</b>                     |
| <b>DES:</b>     | <b>Data Encryption Standard</b>                          |
| <b>DHCP:</b>    | <b>Dynamic Host Configuration Protocol</b>               |
| <b>DS/PPM:</b>  | <b>Direct Sequence/Pulse Position Modulation</b>         |
| <b>DSS:</b>     | <b>Decision Support Systems</b>                          |
| <b>DSSS:</b>    | <b>Direct Sequence Spread Spectrum</b>                   |
| <b>ETSI:</b>    | <b>European Telecommunication Standards Institute</b>    |
| <b>EMR:</b>     | <b>Electronic Medical Record</b>                         |
| <b>FCC:</b>     | <b>Federal Communications Commission</b>                 |

**FHSS :** Frequency Hopping Spread Spectrum

**FTP:** File Transfer Protocol – Used to exchange files over internet

**GHz:** Gigahertz

**HIPERLAN:** European High Performance Local Area Network

**IAPP:** Inter-Access Point Protocol

**IEEE:** Institute of Electrical and Electronics Engineers

**ILEC:** Incumbent Local Exchange Carrier

**IR:** Infrared

**IrDA:** Infrared Data Association

**ISM:** Industrial Scientific Medical

**IT:** Information Technology

**LAN:** Local Area Network

**MAC:** Medium Access Control

**MIMO** Multiple Input – Multiple Output

**MPEG:** Moving Picture Experts Group

**Mbps:** Megabits Per Second

**MCA:** Micro Channel Architecture

**MHz:** Megahertz

**NAT:** Network Address Translation

**NDIS:** Network Device Interface Specification

**NIC:** Network Interface Card

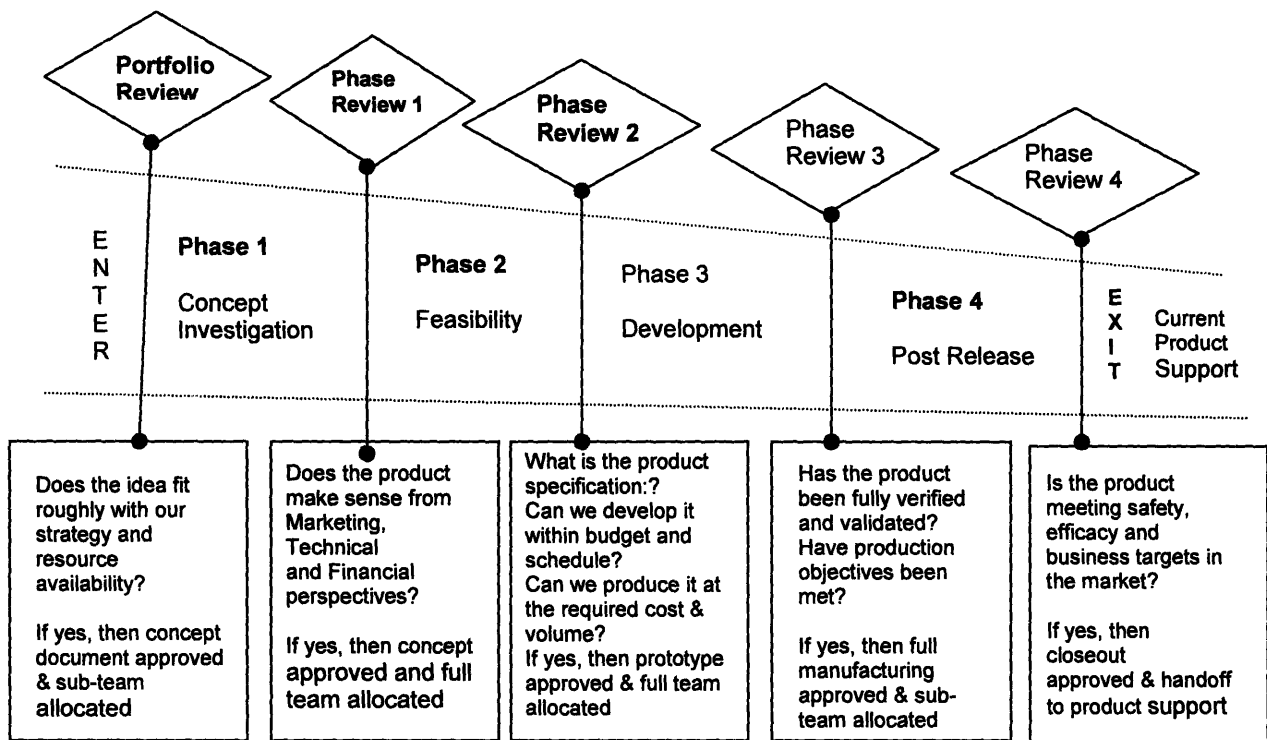
**NID:** Network Interface Device

**ODI:** Open Data-Link Interface

**OEM:** Original Equipment Manufacturer

|                |  |
|----------------|--|
| <b>OFDM:</b>   | <b>Othogonal Frequency Division Multiplexing – Transmission Mod. Technique</b> |
| <b>PACS</b>    | <b>Picture Archive and Communication System</b>                                |
| <b>PCMCIA:</b> | <b>Personal Computer Memory Card International Association</b>                 |
| <b>PEMR:</b>   | <b>Patient Electronic Medical Record</b>                                       |
| <b>POS:</b>    | <b>Point Of Sale</b>   |
| <b>QAM:</b>    | <b>Quadrature Amplitude Modulation</b>   |
| <b>QPSK:</b>   | <b>Quadrature Phase Shift Keying</b>   |
| <b>RF:</b>     | <b>Radio Frequency</b>   |
| <b>SI:</b>     | <b>System Integrator</b>   |
| <b>SNMP:</b>   | <b>Simple Network Management Protocol</b>                                      |
| <b>SOHO:</b>   | <b>Small Office Home Office</b>  |
| <b>UNII:</b>   | <b>Unlicensed National Information Infrastructure</b>                          |
| <b>USB:</b>    | <b>Universal Serial Bus</b>  |
| <b>VAD:</b>    | <b>Value-Added Distributor</b>   |
| <b>VAR:</b>    | <b>Value-Added Reseller</b>  |
| <b>WAP:</b>    | <b>Wireless Application Protocol</b>   |
| <b>Wi-Fi:</b>  | <b>Wireless Fidelity</b>   |
| <b>WLAN:</b>   | <b>Wireless Local Area Network</b>   |

## Appendix A1: New Product Development Phase Review



Source: Lecture note – Professor E. Roberts (MIT Sloan - Corporate Entrepreneurship)

## Appendix A2: Technological Innovation Dynamics and Resource - Based View Strategies<sup>3</sup>

| Force                                      | Fluid Phase   | Transitional Phase   | Mature or Specific Phase   | Discontinuities Phase  |
|--|---|--|--|--|
| Strategies                                 | <ul style="list-style-type: none"> <li>Focus on niche products</li> <li>Build complimentary assets</li> <li>Invest to try and influence the dominant design of the transitional phase</li> </ul>  | <ul style="list-style-type: none"> <li>Focus on differentiated products</li> <li>Make irreversible investment in capacity, brand advertising, process and product R&amp;D in preparation for specific phase</li> <li>Contract with suppliers for equipment or specialized materials that will be needed in the specific phase</li> </ul>   | <ul style="list-style-type: none"> <li>Focus on low cost</li> <li>Emphasize quality</li> <li>Signal commitments by advertising, investing in capacity and R&amp;D</li> </ul>   | <ul style="list-style-type: none"> <li>Ensure compatibility with the old technology if technology exhibits network externalities</li> <li>Take necessary steps to identify lead users</li> </ul> |
| Sample Competences (Resource – Based View) | <p>Ability to –</p> <ul style="list-style-type: none"> <li>Manage projects, Patent</li> <li>Unlearn old competencies and acquire new ones</li> <li>Make sense out of chaos</li> <li>Work with suppliers to modify general purpose equipment to unique needs</li> <li>Decipher customer needs and translate to products</li> <li>Make sense out of customer feedback</li> <li>Communicate with complimentary innovators to understand how they can provide complementary products</li> </ul> | <p>Ability to –</p> <ul style="list-style-type: none"> <li>Design products that meets customer needs</li> <li>Know where to make irreversible investments</li> <li>Negotiate contracts with specialized materials and equipment that are needed in a specific phase</li> <li>Synthesize emerging customer needs</li> <li>Develop installed base, distribution and service networks</li> <li>Build network of complementary innovators</li> </ul> | <p>Ability to –</p> <ul style="list-style-type: none"> <li>Design for manufacturability</li> <li>Reduce cycle times</li> <li>Effect process in and incremental innovation expertise</li> <li>Integrate innovations from suppliers to own processes</li> <li>Sell</li> <li>Create new distribution channels</li> <li>Co-ordinate innovations with complementary innovators</li> </ul> |  |
| Strategies (Resource – Based View)         | <ul style="list-style-type: none"> <li>Focus on key customers, especially lead users, and their needs.</li> <li>Build technical competencies, project management skills and endowments such as patents</li> </ul>   | <ul style="list-style-type: none"> <li>Focus on skills for product differentiation</li> <li>Focus more attention on marketing than in the fluid phase</li> <li>In preparation for specific phase, advertise to establish brand recognition</li> </ul>  | <ul style="list-style-type: none"> <li>Focus on competencies that assure low cost and profitability from it.</li> <li>Boost process innovation and incremental product innovation skills</li> <li>Scan and prepare for invading technologies</li> </ul>  |  |

<sup>3</sup> Adapted from: Alan N. Afuah and James M. Utterback, "Responding to Structural Industry Changes; A Technological Evolution Perspective", Industrial and Corporate Change, Oxford University Press, 1997, Volume 6 Number 1



## Appendix A3: Technology Innovation and Industry Forces Dynamics<sup>4</sup>

| Force                               | Fluid Phase   | Transitional Phase  | Mature or Specific Phase  | Discontinuities Phase  |
|-------------------------------------|---|---|---|--|
| Dynamics of the Phase               | <ul style="list-style-type: none"> <li>Uncertainty in products and markets</li> <li>High rate of product innovation and high degree of flexibility</li> <li>Fast-growing demand; low total volume</li> <li>Greater importance of product functionality than brand names</li> <li>Little direct competition</li> </ul> | <ul style="list-style-type: none"> <li>Appearance of dominant design</li> <li>Increase clarity about customer needs</li> <li>Increase process innovation</li> <li>Importance of complementary assets</li> <li>Competition based on quality and availability</li> </ul>  | <ul style="list-style-type: none"> <li>Strong pressure on profit margin</li> <li>More similarities than differences in final products</li> <li>Convergence in product and process innovations</li> </ul>  | <ul style="list-style-type: none"> <li>Invasion of new technologies</li> <li>Increasing obsolescence of incumbent's assets</li> <li>Lowered barriers to entry, new competition</li> <li>Convergence of some market as new technologies emerge</li> </ul> |
| Rivalry Among Existing Competencies | <ul style="list-style-type: none"> <li>Low since products are highly differentiated and often unique</li> <li>Maybe increased by campaigns to win dominant design of the transitional phase</li> </ul>  | <ul style="list-style-type: none"> <li>Low – but the emergence of a dominant design increases rivalry leading to an industry “shake out”</li> </ul>   | <ul style="list-style-type: none"> <li>High because the commodity nature of the products</li> <li>May be reduced by such things as tacit collisions</li> </ul>  | <ul style="list-style-type: none"> <li>Low or high depending on the reaction of incumbents</li> </ul>  |
| Threat of New Entrants              | <ul style="list-style-type: none"> <li>High – Given high markets and technological uncertainty, it is difficult to erect barriers to entry</li> <li>Threats from alternate technologies with comparable price/performance</li> </ul>  | <ul style="list-style-type: none"> <li>Differentiated products assures some level of protection from new entrants but threat increases with the emergence of standard or dominant design</li> <li>Low if “winners” of dominant design keep technology proprietary (close standards)</li> <li>High if “winners” of dominant design license technology generously (Open standards)</li> </ul> | <ul style="list-style-type: none"> <li>Low – because of measure such as irreversible investments in capacity, brand name, patents special licenses; reputation and retailing</li> <li>There may also be a threat for alternate technologies with better price/performance potentials</li> </ul> | <ul style="list-style-type: none"> <li>High since new entrants can use the new technology to enter</li> </ul>  |
| Bargaining Power of Suppliers       | <ul style="list-style-type: none"> <li>Low – Since materials and equipment used are usually of general purpose</li> </ul>   | <ul style="list-style-type: none"> <li>Higher than in the fluid phase since materials and equipment become more specialized</li> </ul>  | <ul style="list-style-type: none"> <li>High for major suppliers of specialized materials and equipment who are also source of innovation</li> </ul>   | <ul style="list-style-type: none"> <li>Low since their specialized materials and equipment may be replaced soon by general purpose materials</li> </ul>  |
| Bargaining Power of Customers       | <ul style="list-style-type: none"> <li>High – Since products are still unique and more users are lead users</li> </ul>  | <ul style="list-style-type: none"> <li>Higher than in the fluid phase since products are no longer unique</li> </ul>  | <ul style="list-style-type: none"> <li>Higher since product is more or less a commodity</li> </ul>  | <ul style="list-style-type: none"> <li>High since discontinuity leads to fluid phase with its unique products</li> </ul>   |
| Threat of Substitutes               | <ul style="list-style-type: none"> <li>High – Especially from old products that are still viable substitutes in many applications</li> </ul>  | <ul style="list-style-type: none"> <li>Higher than in the fluid phase as products become more standard</li> </ul>   | <ul style="list-style-type: none"> <li>High specially from invading technologies</li> </ul>   | <ul style="list-style-type: none"> <li>High</li> </ul>   |

<sup>4</sup> Adopted from Alan N. Afuah and James M. Utterback, “Responding to Structural Industry Changes: A Technological Evolution Perspective”, Industrial and Corporate Change, Oxford University Press, 1997, Volume 6 Number 1

## Appendix A4: Technological Innovation Dynamics and Strategies for Collaboration<sup>5</sup>

| Force                    | Fluid Phase   | Transitional Phase  | Mature or Specific Phase  | Discontinuities Phase   |
|--------------------------|---|---|---|---|
| Priorities               | <ul style="list-style-type: none"> <li>Development and preservation of technology (with focus on product development and aggressive patenting)</li> <li>Promotion of proprietary technology as industry standard</li> </ul>   | <ul style="list-style-type: none"> <li>Realignment of technological capabilities with the dominant design</li> <li>Continued exploration of technological opportunities</li> <li>Pursuit of a growth strategy (through aggressive capacity building or by establishing a close relationship with suppliers and customers)</li> </ul>              | <ul style="list-style-type: none"> <li>Cost controls throughout the value chain</li> <li>Strong customer focus</li> <li>Lean and efficient organization</li> </ul>  | <ul style="list-style-type: none"> <li>A need for incumbents to identify new technologies and realign core competencies.</li> <li>An option for incumbents to exit the market</li> <li>Attackers need to gain market recognition</li> <li>Attackers need to focus on product development</li> </ul>   |
| Strategic Alliances      | <ul style="list-style-type: none"> <li>Formation of alliances to promote technology as the industry standard</li> <li>Adoption of licensing strategies (say, open source licensing to users)</li> <li>Formation of marketing alliances (with key players of the supply chain or with one industry leader)</li> <li>Formation of technology alliances with established companies, often coupled with equity investments</li> </ul> | <ul style="list-style-type: none"> <li>Winners aggressive licensing to customers and to companies that lost the dominant-battle</li> <li>Formation of joint R&amp;D ventures with companies in the market</li> <li>Formation of marketing alliances, signing of supply agreements to guarantee consistent quality, price, availability</li> </ul> | <ul style="list-style-type: none"> <li>Formation of joint R&amp;D ventures to share risks and cost of technology development</li> <li>Formation of marketing alliances to attack latent markets or lure customers away from competitors</li> <li>Manufacturing alliances to ensure availability of essential products</li> <li>Open alliances with suppliers and customers</li> </ul> | <ul style="list-style-type: none"> <li>Attackers formation of marketing alliances to gain market recognition</li> <li>Attackers agreements to supply technology leaders</li> <li>Incumbents acquisitions of the disruptive technology through license agreements</li> </ul>   |
| Mergers and Acquisitions | <ul style="list-style-type: none"> <li>Acquisitions of start-ups by well-established technology companies from more mature high-tech industry</li> <li>Corporate equity investment by well established high-tech companies</li> </ul>   | <ul style="list-style-type: none"> <li>Acquisition of competitors by the winners of the dominant-technology battle</li> <li>Acquisition by established technology companies entering the market</li> </ul>  | <ul style="list-style-type: none"> <li>Horizontal mergers between companies with complementary products and services</li> <li>Divestiture of manufacturing capabilities that are essential</li> <li>Acquisitions of technology start-ups making products that are difficult to develop in-house</li> </ul>  | <ul style="list-style-type: none"> <li>Possible equity financing for attackers from established technology companies</li> <li>Established companies move into new markets through acquisition of enterprise that have related product capabilities</li> <li>Divestiture of companies as priorities shift with market convergence</li> </ul> |

<sup>5</sup> Source: Adapted from Edward Roberts and Wenyun Kathy Liu, "Ally or Acquire? How Technology Leaders Decide", MIT Sloan Management Review, Fall 2001