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EXPLORING THE BENEFITS OF BUYING INDUSTRY LEADING IT INFRASTRUCTURE IN A HEALTHCARE SETTING

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Abstract

IT infrastructure leaders are under growing pressure to balance the demand for new and rapidly changing technologies in an era of fixed or declining IT budgets. They must buy wisely, make sure that every infrastructure dollar is spent wisely, and ensure it all fits into a preconceived plan that supports the organization's mission. This research looks at the IT literature, develops a qualitative research methodology and presents findings from a new study of IT infrastructure decision making in the healthcare industry. The findings show that healthcare technology leaders are building critical components of their infrastructure using the top two hardware manufacturers in the market. When infrastructure components are deployed abundantly, technology leaders tend to be less committed to the market leaders. The data shows flexibility is not related to hardware manufacturer and appears to be a function of budget and strategy.

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CHAPTER 1 – Introduction

One of the most significant challenges faced by a healthcare technology leader today is acquiring computer hardware to satisfy changing business and compliance needs. With an array of new technologies and healthcare reforms, managers must prioritize all technology acquisitions based on not only performance, but also budget and compliance issues. This chapter describes the setting and demands that influence the hardware buying decisions and the nature of the problem to be solved. The first chapter provides a view into the environment within which the technology leader works and describes the problem this research is intended to solve.

1.1 Impetus for Buying Wisely

The job of building and maintaining an information technology infrastructure in a healthcare setting can be a daunting task for even the most experienced technology leader. A tsunami of new technologies is straining the limits of healthcare IT departments across the nation. For example, new clinical information systems ask clinicians and physicians to routinely order and document patient information online, scan barcodes before administering medications, pull biomedical equipment data into electronic medical records, and follow up on alerts to prevent errors. Some level of technology supports every aspect of the clinical worker’s day. Software and hardware manufacturers are focused on filling every niche with tools to support the delivery of patient care.

While creating new opportunities for more efficient healthcare delivery and lifesaving intervention, new technology acquisition presents many challenges. Healthcare technology strategists are under tremendous pressure to identify, implement and maintain that ideal combination of technologies that will allow them to get the most out of their infrastructure and operational budgets, while achieving the highest levels of availability and performance, and protecting their staff from burnout.

The challenges of long-term planning cannot be underestimated. Long-range infrastructure planning requires that a technology leader constantly evaluate the impact of their technology selections against their ability to support a variety of business needs. The business demands a high performing and highly available IT infrastructure and innovative solutions that allow the organization to move quickly and respond to the competition. Capital and operating budgets seem to be under such a strain that no room exists for mistakes or time to start over. When building the infrastructure, the technology leader must ensure that every piece of hardware or software purchased fits into an enterprise architecture; like pieces of a puzzle. Rarely can an entire architecture be thrown out and replaced.

Compliance and new healthcare reforms are also impacting IT adoption and investment. Healthcare IT is receiving significant attention through the federal government's bailout and reform plans, which are intended to pull the country out of its economic recession while making healthcare more affordable. The American Recovery and Reinvestment Act of 2009 (ARRA) and the HITECH Act of 2009 have introduced new legislation that expands the use of electronic medical records, increases the security controls to safeguard them, and requires new integration between disparate information systems. This legislation creates new users, and a variety of new technologies to support the expanded use and integration of electronic medical records. In addition to the pressure to build an infrastructure to meet internal business demands, this recent legislation has significantly increased the anticipated reach of the infrastructure's architecture. An organization's technical infrastructure can no longer stand alone. It must be built to meet internal and external demands.

New converging healthcare technologies are another source of pressure upon the technology decision-maker. Yesterday's assortment of handheld devices, each developed separately for a different purpose, can now be found in a single multipurpose device. Biomedical technology was once an appliance that was repaired using a screwdriver, a new circuit board, and a knowledgeable engineer. Today, those biomedical systems are made up of servers, clients and databases. Likewise, engineers within hospital plant operations now must deal with information systems that run their building environmental equipment, fire suppression, and physical security systems. These new information systems are becoming the property of the IT department.

Data volume growth continues to create additional challenges. Data is collected non-stop from patient monitors, digital imaging equipment, and clinical workers documenting care being delivered around the clock. This constant stream of data collection relentlessly calls out for bigger network pipes, more powerful servers, and more online storage.

Additional pressure comes from the organization's desire to negotiate with high-dollar specialty physicians that use technology as a bargaining chip. Biomedical and informational technology is often used to attract and retain specialists. Physicians will often shop for the finest technology. Therefore, the hospital that assembles the best package often wins. Hospitals competing within the same service area are often unknowingly positioned against one another by the physician looking for the best compensation package. That compensation too often includes promises for new technology that may or may not be within the budget and capability of the existing infrastructure. Similar to the hospital benefits described in a previous paragraph, healthcare technology can make the physician more efficient and more effective. When a physician is more efficient and effective, they are more satisfied and have healthier patients.

Today's infrastructure technology leader needs to find the right combination of technologies to relieve these pressures. Healthcare IT must become more efficient to enable faster delivery of care while eliminating unnecessary costs. It is a classic case of having to do more with less; while maintaining the highest levels of availability and performance within the technical infrastructure. These conflicting pressures are coming together to create a perfect storm that has the ability to sink the most attentive technology leader. The biggest challenge is learning to balance the demand for change and flexibility with the need to keep the existing infrastructure healthy, which is further complicated by the fact that for healthcare IT there has never enough budget or resources to satisfy them all.

Failing to reduce the amount of time and budget spent on operations and maintenance will eat into an infrastructure team's ability to innovate. Regular improvements are the life blood of a technology team. Without periodic innovation, the technical infrastructure will not be in a position to respond to ever changing business needs, and your best team members may begin looking toward other organizations. Carving out time to innovate is of the upmost importance given that the implementation of those data hungry applications is not slowing down and physicians will continue to look for the technology that makes their daily tasks easier. Federal regulations, technology convergence, and the organization's requirement to maintain a competitive advantage, stand out among the reasons why the infrastructure technology leader must learn to build wisely.

1.2 Problem Statement

Two schools of thought seem to permeate the practice and theory on building an information technology infrastructure. The first school argues that one should build an infrastructure using 3rd party knock-offs of the industry's leading hardware manufacturers. They point out that hardware is a commodity that can be easily imitated and obtained, so there is no need to spend the organization's limited capital on the more expensive hardware.

The second school of thought argues, however, that the only way to get the most out of your infrastructure is to have the enterprise architect build the technical infrastructure using industry leading hardware manufacturers, which would ensure reliability, scalability, high performance, and a strong product line future.

1.3 Hypothesis

Is there a build strategy that permits the IT leader to be both a good steward of the organization's budget dollars, while building a solid infrastructure that meets internal and external demands? Although showing signs of advancement, the existing literature is often dated and no longer reflects the modern IT infrastructure demands. If not outdated, it often looks at the entirety of IT instead of the impact of the infrastructure only when evaluating the value of IT to the organization. There has been some up-to-date research, similar in purpose to this project, that attempts to measure the value of the infrastructure, but it stops short of comparing industry leading manufacturers to third-party knock-offs. This study attempts to redress this situation by examining the relationships between critical infrastructure performance metrics and market leading hardware manufacturers.

This researcher's hypotheses are presented as follows:

Hypothesis 1: When building a highly available infrastructure, it is most beneficial to build using industry leading brand names versus building with knock-offs or third-party imitations.

Hypothesis 2: Over time, the total cost of ownership is lower when building an IT infrastructure using industry leading brand names versus building with inexpensive knock-off or third party imitations.

1.4 Data and Measures

To test these hypotheses, this researcher sought to explore the benefits of using industry leading hardware to satisfy the many pressures the infrastructure technology leader faces today. Infrastructure build techniques and impacts have been evaluated against budgets and staffing levels in an attempt to support the previously stated hypothesis.

The research proceeded in three phases. Phase one reviewed existing literature. It examined the forces within healthcare that drive a technology leader to purchase wisely, the details of the current theory and practice, as well as a review of the market leaders.

In the second phase, an online questionnaire was assembled to gather budget and inventory information, and seek technology leader ratings about infrastructure performance, reliability and break/fix. The online survey was constructed in a way that encouraged participation by busy technology leaders, and was posted from February 1, 2010 through March 31, 2010.

In the third phase, survey findings were analyzed. A qualitative research approach was used because the purpose of the study was to investigate linkages between key IT infrastructure indicators and organizational benefit. This researcher evaluated the contributions of the technology leader’s buying decisions, operational practices and opportunities for innovation. Each of their individual successes and failures contributed to the overall picture of the relationship between infrastructure buying decisions and benefits to the organization.

This research study targeted technology leaders. Chief information officers, vice presidents, and directors have offered budget data, sized their infrastructure, rated the impact of their decisions on availability and dispatch, and shared staffing data. Ethical considerations were eliminated by making the online survey anonymous.

1.5 Summary

A healthcare technology leader today faces pressures never seen before in the industry, ranging from compliance to physicians using technology as a bargaining chip. These pressures force the IT leader to balance budget with existing operational responsibilities while ensuring timely responses to new organizational needs. This research intends to give the technology leader insight into effective infrastructure buying decisions and assistance in managing these conflicting priorities.

CHAPTER 2 – Review of the Literature and Research

In the first chapter we saw that healthcare technology leaders face a variety of competing infrastructure priorities. Organizations are asking for new or updated information systems from their IT departments with minimal impact to budgets, staff and performance. The federal government commands that we expand and integrate the use of electronic records. Finding solutions that satisfy data-hungry applications and implementing an infrastructure that can support the technical convergence between IT, biomedical and plant operation information systems are challenges today's healthcare technology leader must manage daily.

This chapter will review academic and trade literature that assesses the value of IT to the organization. The first section reviews current theory, while the second section of the chapter reviews current practice and the market leaders. The theoretical examination covers financial themes, the value of enterprise architecture, and work that defines what makes infrastructure valuable. The examination of current practice covers what technology leaders are actually doing today and the challenges that they are facing. The final section highlights trade press that identifies the industry leading hardware manufacturers.

2.1. Current Theory

2.1.1. Investment and Performance

Do investments in IT improve business performance? The first group of literature seems positive in this regard. Rai, Patnayakuni and Patnayakuni (1997) examined the extent to which IT investments improve organizational efficiency and productivity. The authors pointed out factors, like the quality of management that influenced the return on assets and value of IT investments. They claimed that past studies measured IT as a whole; however, they too chose to measure a variety of elements beyond IT infrastructure. But their study showed its age with a focus and a bias toward client/server architecture. They found positive associations between hardware investments, firm output and labor productivity. Their overall positive results suggested that IT has succeeded in improving productivity of all personnel. But they warned that IT investments may not show benefit in poorly managed organizations.

Chung, Byrd, Lewis, and Ford (2005) pointed out that it is important to understand the IT infrastructure factors that lead to success because "on average 58% of an IT budget is spent on infrastructure" (Chung, Byrd, Lewis, & Ford, 2005). Given the high percentage of budget allocated to infrastructure costs, the CIO must make it a priority to ensure that every dollar is wisely spent. It is not uncommon to see healthcare IT budgets range from three to six percent of the organization's gross revenue. In a 2009 financial report, the InfoTech Research Group asserted that the healthcare median for the operational budget as a percent of revenue is 1.99%, while the median across all industries is 3.69%. The healthcare median for capital budget as a percent of revenue is 0.59%, while the median across all industries is 1.43% (InfoTech Research, 2009). These percentages represent significant dollars to a healthcare organization. They must be spent prudently because all of the non-IT leaders are watching.

In a 2009 paper, Yang, Wang, and Cheng discussed the benefits and risks of budget slack, which is often referred to as padding one's budget. They asserted that managers often make it a practice to overestimate expenses to create a budget for innovation, or simply to ensure they have plenty of wiggle room in their budget. Their arguments against the use budget slack for innovation describe creating a culture of waste, inefficiencies, and a lack of managerial discipline. Their research showed that budget slack appears to have a moderating effect on quality and innovation performance. Arguments for budget slack state they create budget for investments in R&D; however, in the end "budget slack tends to encourage poorly conceived rouge projects" (Yang, Wang, & Cheng, 2009) with diminishing levels of discipline. Conversely, they purported that a low level of budget slack creates well run projects and a higher level of discipline around innovation.

Prahalad and Krishnan (2002) claimed that controlling costs was often at odds with flexibility and IT's ability to respond to change, and that success cannot be achieved without a recognition of the "trade-offs between efficiency and innovation." They concluded that to recognize and manage these trade-offs the technology leader must understand what makes up the cost elements of infrastructure.

Rai, Patnayakuni, and Patnayakuni (1997) stated that "IT infrastructure has generally been defined as including hardware, software, development environments, shared databases, common applications, and human skills and expertise." Despite the age of their research, their description of the IT infrastructure elements remains relevant. But this researcher viewed the study as incomplete because it fails to take into account the people and their processes that have a significant impact on infrastructure costs. Huang (2007) created a much more applicable listing of the infrastructure cost drivers. Table 2.1 through Table 2.3 lists the systems, hardware, and support drivers Huang identified.

Table 2.1

System Cost Drivers.

Cost Driver	Description
Service call response time	The time required, or agreed, to respond to a technical support ticket opened by the customer.

Cost Driver	Description
Reimplementation / redesign	To re-architect, to enhance some/entire functionality of the systems in question.
Client/Server compatibility	The handshakes or cohesiveness of communications between its clients and the server. Would be there any hiccups at the network communication level.
Security	The company compliance level of the systems in question.
Server redundancy	A hot-standby (disaster recovery) server for the primary server of the same functionality.
Business continuity	High availability of the systems infrastructure overall.
MTTR (mean time to recovery)	The average amount of time required to resolve most hardware or software problems with a given device.
TCO (total cost of ownership)	Cost to purchase and maintain software over time.
SLA (service level agreement)	Formal agreement between a service provider and customers to provide a certain level of service. Penalty clauses might apply if the SLA is not met.

One of the most intriguing aspects of Huang's research was his ability to capture the soft costs of maintaining and operating an IT infrastructure. A large percentage of the total cost of ownership can be found in elements like compatibility, redo and mean time to recovery. Many of Huang's driver descriptions pointed to the importance of an organization's willingness to tolerate risk. An organization's level of compliance, adoption of high availability technologies, or willingness to create a culture that delivers service level agreements will all impact the cost of to maintain the infrastructure.

Table 2.2

Hardware Cost Drivers.

Cost Driver	Description
Seamless integration	The smoothness of the coordination between two or more hardware components.
Component volatility	The rate of stability of the component.
Component application complexity	The level of complexity of a component's functionality and operations.
Interface complexity	The level of effort to interact with another hardware component.
Product Support	The hardware warranty provided by the hardware vendor.
Experience with component	The overall technical experience of the engineers handling the hardware.
Learning rate	The overall technical experience of the engineers handling the hardware.

Cost Driver	Description
Reliability	The probability of performing a specified function without failure under given conditions for a specified period of time.
Confidence level	The level of comfort of having this hardware live within the current system infrastructure.

Huang captured the softer side of hardware costs. It is typically the indirect costs that make an infrastructure highly reliable or perform well. By including elements like level of complexity, integration, and confidence level he has illustrated his understanding of the importance of architecture decisions on the cost of an IT infrastructure. The fact that he has recognized the importance of these elements made his work very relevant to this research project.

Table 2.3

Support cost drivers.

Cost Driver	Description
Learning rate	A measure of the technical personnel mastering the maintenance in relation to some specification of time.
Professional experience	The technical expertise from the staff or the vendor technical support team to escalate all the issues that might arise.

Cost Driver	Description
Cost	The annual monetary spending for maintaining the current server infrastructure.
Repairs	The frequency rate of fixing any hardware component or software.
Call center	The 24/7 surveillance center for monitoring any server failure and coordinating the failure to the appropriate teams.
Upgrades	The rate of upgrading the current server infrastructure design or functionality.

Table 2.3 does not mention the size of the IT staff, which is the one element of support that an inexperienced technology leader would most likely call out first. Huang stated “I cannot estimate how often I have witnessed companies underestimate the costs related to their IT infrastructure needs (Huang, 2007).” His research argued that the department’s capability to maintain IT infrastructure is a primary contributor to the cost of the IT infrastructure. Seemingly unrelated decisions about the way in which the enterprise architecture is implemented can make an infrastructure expensive and overly complex or trouble-free and easy to manage.

In a similar study on infrastructure costs, the InfoTech Research Group (2008) compared the infrastructure cost of local area network (LAN) and wide area network (WAN) using Nortel and Cisco hardware. Among their conclusions, they neglected to consider that elements other than hardware cost that need to be taken into consideration when building an infrastructure. Reliability, manufacturing quality control, and meantime between failures, are all elements that impact the total cost of ownership of an organization’s infrastructure. A focus on cost appeared to be the primary driver of the InfoTech research.

What Huang was able to capture, but the InfoTech Research Group did not, were the elements that make the IT infrastructure costs sustainable in the long term. A sustainable cost model is one where the infrastructure elements fit together like pieces of a puzzle. Healthcare organizations cannot afford to redo unsuccessful or recklessly implemented architectures. Each infrastructure investment must be made wisely and support a predetermined enterprise architecture. Literature contained within the next group of articles examines IT infrastructure investments.

2.1.2. How to Choose IT Investments

The second group of research seemed to focus on how to choose IT infrastructure investments wisely. Weil, Subramani and Broadbent (2002), in surveying business initiatives in 89 enterprises, argued for building a framework for making decisions to help ensure coordination between the business lines and IT leadership. They cited that senior executives needed to understand which infrastructure initiatives are connected to which business initiatives. From their research came a framework for delivering 70 different infrastructure services. Their research begins to lose some relevance in the details of their service framework because of the date of the research. However, their argument for an infrastructure framework, built around services, was leading edge thinking for the time. The research by Weil, Subramani and Broadbent appeared to be aligned with the growing momentum behind service oriented delivery. A paradigm shift to managing IT using the ITIL (IT Infrastructure Library) was well underway in the late 1980s and early 1990s (itSMF, 2007). Many organizations today continue to struggle with the service management framework presented by Weil, Subramani and Broadbent nine years ago. For far too long, IT has spoken to the business using the language of IT. Service management, service delivery or a service oriented framework changes the way in which IT communicates to the business. Instead of communicating about technologies that mean little to senior executives, IT leadership is slowly learning to put forward services that the business can understand and care about. Weil, Subramani and Broadbent purposed that IT infrastructure services can and should be offered to the business in the same way. The details of the framework built by Weil, Subramani and Broadbent in 2002 may no longer have relevance, but the service oriented framework is just as important today as it was nine years ago. Technology leaders must determine the types of services offered by their infrastructure teams and align them to business initiatives and the applications that support them. They argued that without a framework for choosing infrastructure initiatives, technology leaders run the risk of choosing the wrong infrastructure technologies, which will waste time as well as valuable human and financial resources.

2.1.3. The Value of Enterprise Architecture

The third group of research focused on the value of enterprise architecture. Shah and Kourdi (2007) defined enterprise architecture as “a holistic vision of a system’s fundamental organization” with additional elements of people, process, applications, relationships, and guiding principles. They concluded that enterprise architecture eliminates waste and allows budget for innovation.

Nyrhinen (2006) emphasized that “architecture provides a model for continuous design, building and analyzing of the IT infrastructure.” In her thorough exploration of enterprise architecture, Nyrhinen explained that enterprise architecture contains layers of resources that interact and support one another. The structure and standards of enterprise architecture, the researcher noted, bring organization to a technical infrastructure that would otherwise be chaotic. Nyrhinen concluded that architecture is valuable when it is flexible, capable and effective (Nyrhinen, 2006).

According to Pereira and Sousa (2004), enterprise architecture can be built using the Zachman Framework. They asserted that an architectural framework provided “a way to pass from chaos and disagreement to order and structure”, it “enables an integrated vision”, and “becomes the bridge between the business and technical domains” (Pereira & Sousa, 2004, p. 1366).

All of these works have the creation of a universal vision or enterprise architecture in common. Whether Zachman, The Open Group Architectural Framework (TOGAF) or another enterprise architecture framework is used, the key point that emerges is that the enterprise is committed to working together. Layers of the architecture connect business, data, application, and infrastructure strategies. Technologies fit together because the enterprise architecture anticipated the business, data, application and infrastructure requirements.

Woolfe and Blosch (2002), however, noted that creating enterprise architecture will not be a completely pleasant experience. The challenges they listed included long development times, high costs, and working through the tensions that inevitably develop among stakeholders. Despite these challenges, they concluded that the benefits of the enterprise architecture far outweigh the disadvantages.

2.1.4 Flexibility, Reliability and Availability

The fourth group of literature on the value of IT infrastructure focuses upon flexibility and reliability. Kuman (2004) claimed that “the effectiveness of an IT infrastructure can be evaluated using criteria such as reliability, the ability to operate with low downtime; flexibility, the ability to quickly and economically adapt to changing business requirements; and upgradability, the ability to quickly and economically adapt to or deploy multiple, complex technologies as required" (Kuman, 2004, p. 12).

Some of the earliest work, within which infrastructure flexibility is addressed, comes from Duncan in 1995. Duncan claimed that a flexible infrastructure is distinguished by resources that are sharable and reusable (Nyrhinen, 2006). In 2005, Chung, Byrd, Lewis, and Ford found value in infrastructure when it was quantified by its ability to be flexible and enable change. They asserted that flexibility and robustness allow an organization to embrace mass customization (i.e., the ability to make a customer's experience personal). A modular infrastructure can easily accept changes to hardware and software. The degree to which an infrastructure can connect, share data, and accept changes determines its flexibility (Chung, Byrd, Lewis, & Ford, 2005).

Byrd and Turner (2000) touted that flexibility was a critical component because organizations are faced with rapid change, and a flexible infrastructure allowed them to be competitive. Byrd and Turner also noted that a flexible IT staff adds value. Nyrhinen (2006) also asserted that an abundance of skills, competence and knowledge, from both the technical and managerial staff create value (Nyrhinen, 2006). If an IT department must seek help every time their infrastructure needs to flex, they will be slower to respond to the organization's needs; therefore, impact the organization's ability to compete.

In addition to flexibility, reliability is also deemed an important component of IT infrastructure. Mahlke and Mukherjee (2007) debated the value of reliability. On the one hand, Mahlke presented five reasons why reliability was a fallacy. He pointed out that reliability was required for mission critical systems like the space shuttle or airplanes; he argued that we should focus on the software because most electronic devices are disposed of before the hardware wears out. Mahlke noted that “transient errors are about as likely as winning the lottery”, and “most consumers accept imperfect electronics.” On the other hand, Mukherjee argued that users care deeply about reliability because they would be unhappy and the greater the number of unhappy users, the greater the number of complaints. Mukherjee also explained that we must attack reliability at every level (Gonzales, Malhlke & Mukherjee, 2007).

An unavoidable take away from the Malhlke / Mukherjee debate was their conclusion that not all hardware components in all industries need to be highly reliable. Only those industries that run mission critical applications may be willing to pay the premium for highly reliable and redundant infrastructure components. The relevance to this research is in the fact that the healthcare industry is one industry in which IT must deliver highly reliable information systems. Malhlke and Mukherjee would most likely agree that there is little debate around the need for a highly reliable IT infrastructure in healthcare. Patient lives are at risk and are dependent upon the reliability and availability of its information systems.

Kuman (2004) stated that infrastructure value depends upon usage. He compared the value of infrastructure transactions to financial transactions. Investments in the infrastructure would increase that infrastructure’s ability to handle more transactions. Kuman argued that a single vendor approach may help with integration, but it may make it difficult to interface new vendors inherited in a merger. He quantified the impact to the infrastructure as jumps in positive or negative events.

When an infrastructure is improved, events such as adding a faster network switch or faster storage are viewed as positive. A negative event can be an infrastructure failure. What Kuman has done here is create a model for assessing the value of reliability and throughput. If an infrastructure can increase the number of transactions it supports, increase the number of positive events, while decreasing the number of negative events, the infrastructure has more value to the organization. A faster and more reliable infrastructure has more value to the organization than one that is slow and fails frequently.

Can value be measured by better patient outcomes? Yoder (2009) claimed that when it comes to quality and safety, better IT infrastructures produce better patient outcomes. He listed a number of technologies that included pharmaceutical dispensing, physician ordering and evidence-based guidelines. Decreases in patient care delays and allowing more time with patients produced better outcomes. He also noted that patient satisfaction scores go up too as their satisfaction with the admission process, test handling and teamwork increases.

2.1.5. Governance

The final group of literature addresses the management challenges facing today's IT manager. Pressures include the need to comply with governmental regulations, the need for life saving technologies, and responding to competition (Prahalad & Krishnan, 2002). Internal pressures not identified by Prahalad and Krishnan included the struggle for resources, converging technologies, and the consumerism of IT. How well management is able to respond to these pressures depends upon how well the infrastructure responds to the demand for change (Prahalad & Krishnan, 2002).

Huang (2007) argued that instead of trying to reduce the IT demands, better models for determining those requirements should be developed. Cramm (2009) argued that there should be measurable value before funds are committed to a project, executive compensation should be tied to realization of value, and we should better use what we have before investing in new technology. She also noted that projects should have a kill switch when the outlook is grim, and that teams should be held accountable for operational costs associated with defects and help desk calls.

In the late 1990s, Rai, Patnayakuni and Patnayakuni recognized that IT staffing represented the largest portion of IT costs. They claimed that investment in IT staff had a positive effect on organizational output and staff productivity (Rai, Patnayakuni, & Patnayakuni, 1997). They backed up their assertion by highlighting the growing need to integrate information systems and deploy them quickly. Their assertion in 1997 would undoubtedly appear prophetic today as the need to integrate IT infrastructures and deploy them in a highly competitive world has grown significantly.

What Huang, Cramm and Rai et al. are making the argument for is better governance. The need for good IT governance is more important today than ever before. New regulations and increased regulatory oversight, data volume growth, and continued budget constraints coupled with the introduction of new technologies are the driving forces behind this governance evolution. They argued that a well-designed governance process will ensure that business leadership and IT leadership are aligned, and they stay that way. It will also ensure that all of the IT teams are moving in the same direction. A high performing healthcare IT department was once able to get away with the absence of governance, but today that high performing IT department is running at the top of their workload capacity, and there is no relief in sight. Business executive participation in the governance process will ensure that IT is focused on the right projects. Business leadership and compliance should have visibility into and participate in choosing where IT focuses their efforts.

2.2. Current Practice

We now turn to the complement of current theory, which reviews the literature that applies to the practice of buying and implementing IT infrastructure. This section is arranged into three groups: financial realities, business leader engagement, and hardware manufacturer market leadership.

Daily, IT leaders negotiate numerous financial and organizational challenges, chief of which is balancing the needs and resources of the organization with the financial strain introduced by rapidly changing technologies.

2.2.1. Understanding All Stakeholder Needs

A financial test for an IT infrastructure leader is choosing the right IT infrastructure investments; those that align with business initiatives while keeping up with the need for rapid change. Paris, Colineau and Wilkinson (2009) proposed that the evaluation of a web-based information system must move beyond whether or not the information system is effective for the end users, but instead the system's effectiveness as a whole must be evaluated. Their assessment method examined the costs, benefits, and to what extent the information system filled the needs of all of the participants.

Prahalad and Krishnan (2002) noted that controlling costs is often at odds with flexibility and IT's ability to respond to change. They argued that success cannot be achieved without a shared agenda and a shared understanding between business managers and IT managers. The shared understanding that Prahalad and Krishnan discussed would ensure that IT spending was focused on the right projects for the organization. The financial reality is that not enough resources exist, which makes achieving a synchronization of strategy more important.

2.2.2. Looking for Cheaper Hardware

Technology leaders are frequently pressured to look for opportunities to lower IT infrastructure costs. An argument by the Info-Tech Research Group (2008), an IT research organization, was made for buying cheaper infrastructure hardware in a Cisco vs. Nortel comparison. They asserted that the Nortel equipment can be purchased at a savings of 50% over that from Cisco Systems. Their research was rather limited and mostly focused on a comparison of current costs and failed to consider vendor financial stability. When choosing a hardware manufacturer the technology leader must choose a partner who is financially strong and is able to maintain a long-term partnership. Nortel declared bankruptcy one year after the Info-Tech Research Group published their study (Nortel, 2009). The technology leader who partnered with Nortel is now experiencing unanticipated interruption and costs.

Yager (2003) appeared to support a throwaway hardware approach as he painted a picture of an IT industry in dire straits and looking for alternatives. His intention was to give the reader options for running IT on the cheap. The article's tag line included the words "what do you gain and what do you lose by taking the budget route (Yager, 2003, p. 40)." Yager outlined challenges that IT shops are solving with open source, outsourcing, and cuts in staffing and square footage. Despite all of these alternatives, IT shops are still losing the battle, which Yager used as justification for suggesting it is time for unorthodox hardware purchases. He promoted buying stacks of inexpensive 1U servers as a practical and inexpensive strategy (Yager, 2003). The most sensible advice Yager provided was to buy at the sweet spot of a server model's lifecycle. The sweet spot is between a model's end of production and when the manufacturer is clearing the shelves of inventory. On the whole, Yager's advice for building IT on the cheap was sound and reasonable. However, he did not appear to pay enough attention to the disadvantages of going cheap, which will be explored in much greater detail later in Chapter 4.

2.2.3. Rapidly Changing Technologies

Rai, Patnayakuni and Patnayakuni (1997) noted the importance of a close examination of IT budgets because of the demand from the business for short term benefits and an accelerating rate of obsolescence. Reid, Riemenschneider, Allen and Armstrong (2008), looking the ability of state IT departments to manage technological change, argued that CIOs must adapt to change or risk obsolescence. Furthermore, they noted that the secret to understanding and absorbing change into the organization is in its ability to gain pathways to external information. They concluded that “IT managers must constantly stay alert to new developments that may affect their field” (Reid, Riemenschneider, Allen, & Armstrong, 2008, p. 302).

2.2.4. Business Leadership Engagement

This second group of studies examined how business leaders are engaging in the IT infrastructure conversation. When IT and business leadership teams share a roadmap that supports the business initiatives, budgets become aligned with organizational goals. Cramm (2010) identified three reasons why organizational leadership says IT is important, but then act differently: 1) they do not want to work with IT; 2) they do not have time; 3) they don’t know how to work with IT. She noted that IT spends a significant amount of time making IT “business-smart,” but IT does not spend enough time making the business “IT-smart.”

Nyrhinen (2006) came to a similar conclusion. She identified four different views that IT business leaders take as it relates to IT infrastructure: 1) management objectives are not related and the IT infrastructure is built for something unrelated; 2) the organization should only invest in IT infrastructure if it saves money; 3) IT infrastructure is driven by business strategy; and 4)

IT infrastructure is a core competence and it enables options. Both Nyrhinen and Cramm emphasized the importance of having business leadership engaged in setting up IT budgets, because IT infrastructure expenses can account for over 58% of the IT budget. Failing to establish an understanding with business leadership could risk budget cuts or even project failures. According to Prahalad and Krishnan (2002) business managers often report that their inability to respond is often related to the poor quality of the IT infrastructure. They may blame incompatible applications, poor data, response time, or security.

A common theme throughout the literature has been that it is important to link IT infrastructure to business initiatives. Cramm (2010) reminded us that it is important to understand how your organization views IT infrastructure. Often Chief Financial Officers do not want to invest capital into something they do not understand. However, Cramm warns us to be careful because the benefits are not always commensurate with the costs. Projects are often too big and cost too much because there are too many features or they are underutilized. Business leaders must be able to connect a right-sized IT project with the organization's initiatives.

2.3. Market Leaders

The focus of this research is to ultimately offer guidance to the technology leader so that the most cost effective infrastructure is purchased for the organization. That is accomplished in large part by choosing the right hardware manufacturers. Information crucial to being able to make that case rests in an understanding of who the market leaders are.

2.3.1. Personal Computer Market

Beginning in 2009, Hewlett-Packard (HP) has put together a string of six quarters of control over the personal computer market to displace Dell in the number one spot. They rose 25% over the same quarter the previous year, which gave HP the number one ranking in global

PC shipments. Wilkins of iSuppli, a market research firm, noted that “Hewlett-Packard has capitalized on its strong channel presence and its strength in the fast-growing notebook PC segment, allowing it to attain and maintain market leadership” (iSuppli, 2008). Dell sat in the number two spot. In March 2010, iSuppli reported that Dell nearly slipped to number three, and was nearly replaced by Acer, but HP remained “king of the hill” (Freeman, 2010).

2.3.2. Server Market

Early in 2010, market researcher IDC published a report on worldwide server revenues. Due to a larger global economic recession, the overall market was down for 2009, but showed a slight upswing in the last quarter. IBM remained the market leader in combined platform server revenues, and HP was a close second. However, sales of midrange servers ($25,000 to $250,000) fell over 23% and that has been the sweet spot for IBM. During that same period, Linux servers and Windows servers (x86) grew in market share. HP led that market with a 39% market share, followed by Dell with 20% and IBM with 19%. Blade servers represented over 21% of the x86 server market. HP was ranked in first place with 52% of the blade server market, followed by IBM with 28% (O'Gara, 2010). In a similar study by market researcher Forrester Research, HP, IBM and Dell were listed as the top three, respectfully. Forrester cited that “there's no bad choice among these competitors (Staten, 2009).”

2.3.3. Storage Market

In March 2009, Fox Business announced that according to the latest *IDC Worldwide Quarterly Storage Software Tracker,* EMC was the world leader in the storage software market for eight consecutive years with 23% of the market. In the same month, IDC announced that EMC was the number one provider of disk storage as well (PR Newswire, 2010). According to IDC, the largest area of growth for EMC in 2009 was for data recovery and data protection software. Symantec sat in second place with 17% of the storage software market share and IBM was third with 13% (Roe, 2010). In the network-attached storage market, Information Week found that EMC sat in first place in the open networked disk storage market with 27% followed by IBM with 16% (Gonsalves, 2010).

2.3.4. Network Market

ITnews.com reported Cisco's market share declined by over 4% to 68% in 2009, while HP grew by 3% for a total of 8% market share. The reason for HP's growth was largely due to its acquisition of 3Com, making it a "clear challenger to Cisco" (Muncaster, 2010). Hilton (2010) reported that HP believed it will continue to chip away at Cisco's dominance as they pulled in 3Com's newer, better and cheaper networking hardware. Furthermore, he noted, combining number two and number three will have little effect on Cisco's large market dominance.

2.3.5. PBX Market

According to MZA Consultants (2009), the number of corded PBX extensions was down 22% in 2009; however, over 13 million extensions were shipped during that year. IP desktop deployments accounted for over 29% of the total extensions. Cisco led the world market all four quarters of 2009, and was followed by Panasonic and NEC. For PBXs with less than 100 extensions, Panasonic was the world leader. Cisco held the number one position in North America, but was not within the top three in Latin America, Asia Pacific or EMEA (Europe, Middle East, Africa), which were much more fragmented markets.

2.3.6. What Makes a Market Leader?

Tellis, Yin and Niraj (2009) examined the reasons for high-tech market leadership. One group argued that a hold on market dominance may be due to the rise in the consumer's perception of the utility of a product. A technology that gets an early lead in a market may lock-out other competitors due to a monopolistic hold on the market (network effects). Conversely, the other group argued that network effects did not protect the market leader and argued that quality was the principle driver in high-tech market dominance. Four major takeaways in their discussion can be summarized as: 1) market leaders typically hold their position 3.8 years; 2) a change in leadership is usually associated with a change in quality; 3) network effects and quality have an effect on the market, but quality is more important; and 4) network effects primarily enhance the transfer of information within the market.

It is important to understand why each of the market leaders retains its hold on market share. Taking advantage of a customer base with a utility-like perception of the product or rushing the product to market may artificially push one manufacturer to a leadership position.

2.4. Summary

To assess the benefits of buying industry leading infrastructure it was necessary to understand the theory relevant to the financial elements of IT infrastructure, what makes IT infrastructure valuable, and governance. To understand these pressures in the technology leader's daily life, studies describing key practices were included.

The value of the literature review was in large part dependent upon the age of the literature and whether or not it had an 'IT as a business' or 'IT infrastructure' focus. Each author made a contribution through IT operational experience or from an academic perspective. The literature contained an abundance of information on assessing IT costs and IT architecture, but only contributed to a framework from which to govern an IT infrastructure. This left a gap when it comes to selecting and buying the specific hardware components that make up an IT infrastructure. This research aims to fill this gap by linking the purchase of market leading hardware to positive organizational benefits.

The next chapter begins to dive deeper into this gap. It conveys the design and methods used, which were inspired by the literature reviewed in this chapter.

Chapter 3 – Methodology

Chapter 2 provided a framework for understanding the financial, architectural and operational challenges IT infrastructure decision makers face daily. In the second phase, an online questionnaire was assembled to gather budget and inventory information. This chapter describes the methodology used to further expand upon the research performed by others. It describes the survey participants, tools, approach, and data handling methods used to carry out the research.

Measures taken were chosen to test the hypotheses identified in Chapter 1. Each of the hypotheses assert the value of buying IT infrastructure from industry leading manufacturers because doing so is more beneficial to the organization. The participants and measurement instruments were chosen to look for relationships between the various factors that indicate the health and effectiveness of an IT infrastructure and those manufacturers that sit at the top of their respective markets.

The chapter is divided up into five sections. The first three sections describe the setting, participants, and instrument used to carry out the online survey. The last two sections address validity and reliability, followed by data collection and analysis. This chapter lays the groundwork for succeeding chapters.

3.1. Setting

To provide a means for technology leaders at any location an opportunity to participate, an online questionnaire was chosen as the setting for gathering key metrics and behaviors. Site interviews were considered, but due to the necessary travel requirements doing so seemed as though it would artificially limit participation. Additionally, site interviews may have made the participants uncomfortable due to the sensitive nature of some of the questions. It was believed that the online setting created an atmosphere of anonymity and encouraged honest answers. The online questionnaire was hosted by QuestionPro. Much more about the online survey will be covered in the Measurement Instrument section.

3.2. Participants

Technology leaders with a healthcare background were targeted as survey participants because this group is charged with management of current and future IT hardware and would thus be the most likely to provide the kind of detail needed to test the hypotheses. Ideally, each participant would have many years of experience leading infrastructure teams with final-approval budget and infrastructure strategy.

The sample of participants was chosen as a purposive sample where only qualified participants were asked to participate. A core group of this researcher’s colleagues not only participated in the survey, but they also helped grow the size of the sample group by recommending additional contacts. Each request for participation was completed through an email message to the potential participant. To grow the sample set, each participant was asked to suggest other potential participants. From the nine invitations sent, the online survey attracted 19 participants. Eight surveys were eliminated from the study because the online surveys were incomplete, which left 11 usable surveys.

Characteristics like race, religion, and socioeconomic status were not considered and should have had no impact on the data collected. Due to the confidential nature of the information being disclosed, participants were either close healthcare colleagues or one level removed from that relationship to the researcher. The nature of the selection process did not appear to bias the data collected because the sample set included technology leaders from small, medium and large healthcare organizations. Small healthcare organizations supported less than

5,000 users, medium-sized supported between 5,000 and 15,000 users, and large organizations supported greater than 15,000 users. This researcher was aware of who participated, but was unable to connect the participant to their survey responses due to the way in which the online survey was built.

The total survey size consisted of 19 participants. They were from variety of IT leadership positions and different healthcare organizations. On two occasions attempts were made to expand the size of the sample set. Two samples of the requests for participation can be found in Appendix A. Recruitment for new participants lasted for the two month duration of the online survey. In the end, however, requesting participation via trusted colleagues appeared to work best.

3.3. Measurement Instrument

An online survey, hosted by QuestionPro, was used to gather key metrics, ratings, and opinion from technology leaders. The survey questions focused on: a) demographic characteristics such as the number of associates and physicians supported; b) financial details such as capital and operating budgets for three years; c) two multi-part questions on infrastructure inventory; d) staffing; and e) information on scalability, reliability and flexibility of their infrastructure. Table 3.1 shows the type of information that gathered and how the groups of questions were related to one another.

Table 3.1

Question purpose and relationships.

Question Group	Information to be Gathered	Relationship
Demographic	Size of organization.	Baseline for comparing all other information.
Financial	Budget availability and constraints.	Compared to demographic, inventory and staffing information.
Inventory	Size of infrastructure.	Compared to demographic, financial and staffing information.
Staffing	Size, skills and training of staff.	Compared to demographic, financial and staffing information.
(all others)	Seek opinions on scalability, flexibility, reliability, and dispatch rates.	Identify relationships between ratings and opinions on infrastructure “strength” to demographic, financial and staffing information.

The entire survey can be found in Appendix B.

The survey was available over a two month period from February 1st through March 31st 2010. Participation levels were checked every few days during the period, but results were not compiled until it was believed that all participants had an opportunity to participate.

3.4. Approach

A qualitative research approach was used because the purpose of the study was to reveal the true relationship between infrastructure indicators and organizational benefit. When a strong relationship was found between the infrastructure data and organizational benefit, the interpretation of the results uncovered a buying pattern, or architectural practices that allowed the IT leader to achieve positive organizational benefits. The analysis of the data allowed this researcher to judge the benefits of the policies, practices and innovations of each technology leader. Furthermore, the research approach was a grounded theory study. The buying and implementation conclusions were constructed from the analyzed and processed data.

3.5. Validity

For the purposes of this research, validity was defined as the ability of this research to truly *generate an understanding* of the relationship between infrastructure buying and build decisions and the benefits to the organization. These new insights or perspectives are validated by the organizational benefits of:

- Lower Total Cost of Ownership
- Higher Infrastructure Availability
- Lower Staffing Levels
- Fewer Interruptions to End-users
- Less Complexity
- Higher Levels of Scalability

- Lower Training Costs
- More Responsive and Flexible Infrastructure

3.6. Data Collection and Analysis

Once the survey was closed, online software tools were used to run basic reports and to export the data for further manipulation in Microsoft Excel 2007. From the raw survey data, a number of different values were calculated or compared to one another as this researcher looked for the relationships and trends noticeable within the calculated information. Most often when a meaningful trend was visible, it was visible in a graph or table. Examples of the calculated values included: 1) the total size of an organization was calculated as the sum of associates and physicians supported; 2) whether or not their capital budget was trending up or trending down, over the last three years; and 3) the total number of components, within each layer of the infrastructure technology stack, was weighted and totaled to create an 'infrastructure size' value. Not all infrastructure components were considered equally important. Therefore, it was essential to create a single infrastructure value that reflected the total size of the healthcare organization's infrastructure.

A requirement to evaluate the relationships between the baseline data, ratings and open text feedback was crucial to the success of this research. Examples of the relationships evaluated included:

Capital to Size – Does the capital budget have any relationship to the size of the organization? Do larger organizations tend to have more capital?

Flexibility – How did technology leader ratings about infrastructure flexibility correlate to indicators like budget trend, budgets spend per associate, budget spend per infrastructure component?

Satisfaction Indicators – Key satisfaction indicators were identified and analyzed for each participant. A participant's satisfaction level was then compared to their choice of hardware manufacturer.

Seventy three pieces of data were collected or calculated about each participant. Thirty-eight different types of relationships were examined. The primary goal of the data analysis phase was to organize the data into meaningful groups, and to look for relationships and major themes within the data.

3.7. Summary

This chapter described the setting, participants, survey instrument, data collection and analysis that were used to complete this research study. This qualitative study was carried out to prove or disprove the assertions made in Chapter 1. Only simple statistical analysis such as range, mean and standard deviation, was performed on the data. Major themes and relationships discovered during the data analysis are covered in more detail in the next chapter.

Chapter 4 – Results

Chapter 4 picked up where Chapter 3 left off by analyzing the data collected. All of the findings are organized around the survey questions. The aim of this chapter was to continue to expand upon the ideas uncovered during the literature review phase of this research. Those ideas included financial impacts, flexibility, reliability and the use of market leaders within the participants' IT infrastructures. Satisfaction indicators for each participant are included at the end of this chapter to align key results with the benefits of using industry leading infrastructure solutions.

4.1. Respondent Characteristics

The first group of research questions was created to gather participant demographics data. Table 4.1 summarizes the general demographics data of the participants. The online survey attracted 19 participants; however, eight surveys were eliminated from the study because the online surveys were incomplete.

Table 4.1.

Respondent characteristics.

Demographic	From Range	To Range
Participant Locations	CO, NE, PA, TN, WA	
Employees Supported	200	74,000
Physicians Supported	200	8,000
Total Supported Users	1,700	82,000
Capital Budget (mid)	$250,000	$25,000,000
Operating Budget (mid)	$750,000	$25,000,000

Demographic	From Range	To Range
Capital Budget per User	$89.29	$2,058.82
Operating Budget per User	$291.67	$4,411.76
Infrastructure Elements	3240	162,010
IT Staff Members	14	540

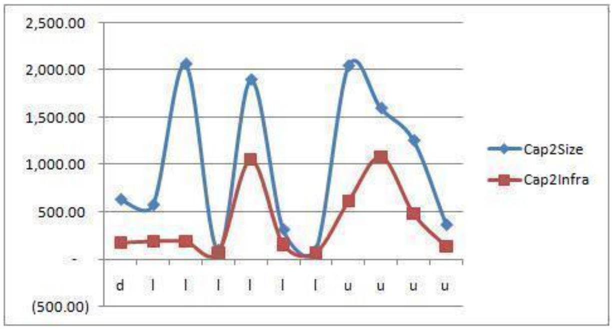
4.2. Financial Outcome

The financial results were categorized into four groups. Each group examined how the technology leader was spending the organization's operating and capital budgets. Budget information was averaged and then was examined for an upward or downward trend, spend per user supported, spend per infrastructure element, and spend per staff member. The purpose of these comparisons was to determine if there were patterns that showed whether or not budgets were trending up or down, or if organizational or infrastructure size had any relationship to the amount of budget being spent per user or infrastructure element.

4.2.1. Spend and Budget Trend

Figure 4.1 shows the relationship between the participant's capital budget per supported user or per supported infrastructure element and the IT department's budget trend. The graph helps to answer the question of whether or not an upward or downward budget trend influenced the capital spend.

Figure 4.1. Budget per supported user.



The x-axis in Figure 4.1 illustrates that most organizational capital funding is either level or on an upward trend. The blue line tells us that when capital spending is compared to the size of the user population or the size of the infrastructure there is no discernable pattern. Healthcare organizations with a level or an upward capital budget trend are spending anywhere between $80 to $2,100 per user or infrastructure element.[1]

Figure 4.2. Budget trends and staffing.

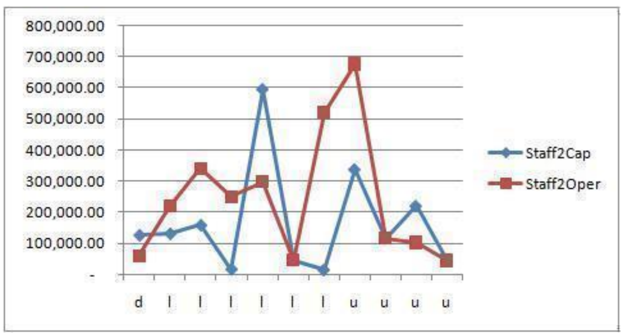
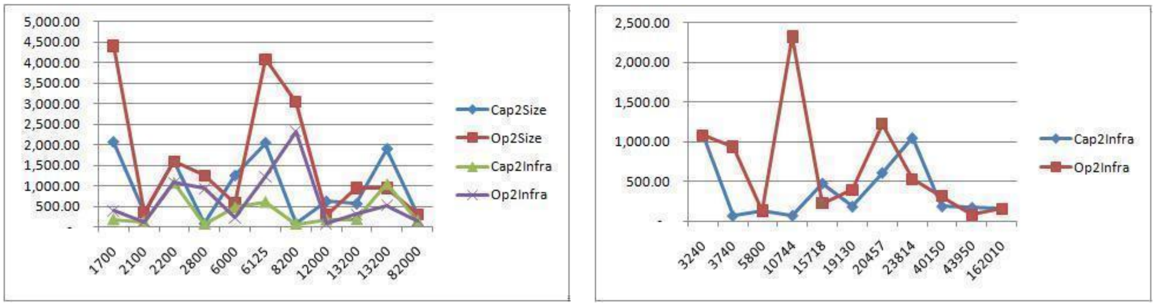


Figure 4.2 shows the relationship between budget trends and spends per staff member. When evaluating the amount of capital or operating spent per staff member, there appeared to be no discernable pattern or relationship between an upward or downward trend in capital or operating and staffing levels.

4.2.2. Spending and Size

Figure 4.3 represents the number of supported users, and the size of the infrastructure respectively. There is no discernable pattern (chart on left) when comparing the amounts of capital spent and organizational size or infrastructure size. However, noticeable peaks exist at 1,700, 6,125, and 8,200 when examining the amount of budget allocated per user. The same pattern holds true and shows moderate peaks at 6,125 and 8,200 users supported (chart on right) when examining the amount of budget allocated for the size of the infrastructure.

Figure 4.3. Budget spent, infrastructure and users supported.



The results tell us that the size of the organization alone shows little relationship to budgeting practices. However, midsized organizations appear to budgeting more than small or large organizations per supported user or per infrastructure element.

Similar to the findings uncovered above, when comparing capital and operating spending to the number of staff on the IT team, there appeared to be more spending among midsized organizations (based on the size of the IT team), when the number of staff is 37 and 42. The capital and operating spend per IT staff member is unquestionably lower for smaller and very large teams.

4.2.3. Flexibility and Budget

The results in Table 4.2 show the relationship between flexibility ratings and the amount of capital and operating budgets. The flexibility scores for each layer of the technology stack were averaged and then the participants below the average were compared to participants above the average. The average flexibility score for those below the midpoint was 2.8. The average flexibility score for those above the midpoint was 4.2.

Table 4.2

Flexibility ratings and budget.

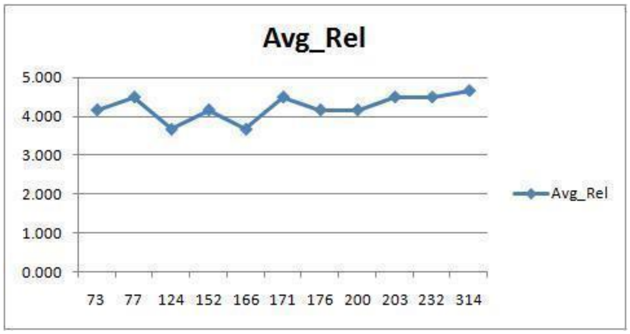
	Flex Score	Capital Budget / Size	Operating Budget / Size	Capital Budget / Infra	Operating Budget / Infra
Below Average	2.8	$810	$790	$442	$484
Above Average	4.2	$1,202	$2,614	$306	$895

Participants that rated their infrastructure's flexibility higher were also budgeting more on average for capital and operating budgets per supported user. They were also budgeting more on average for operating budgets per infrastructure element. Capital budgeting was slightly higher for those organizations below average on the flexibility scale.

4.2.4. Reliability and Budget

This section presents the results from comparing the relationship between budgets, staffing, and infrastructure reliability. In these comparisons, the y-axis always reflected the technology leader's rating of their infrastructure reliability. The x-axis was varied eight times to look for relationships between the variables. Only one of the eight comparisons showed a discernable pattern. When reliability ratings were compared to the ratio of IT staff to the number of users supported, the reliability ratings were higher. Figure 4.4 illustrates this trend.

Figure 4.4. Reliability and staffing.



One obvious trend was that the organizations with larger IT teams or larger IT staff to users supported ratios appear to be generally more satisfied with reliability than those with smaller teams. Not all small teams are less satisfied, but the larger teams appear to be more satisfied. All of the charts that compare reliability, budget and staff can be found in Appendix C.

4.3. Dispatch, Reliability and Key Vendors

4.3.1. Reliability Ratings

Survey questions were asked to help this researcher evaluate the relationships between a technology leader's satisfaction with dispatch rates and satisfaction with reliability, then matched up to key vendors used within their infrastructure. Table 4.3 illustrates the relationships between satisfaction with reliability and key hardware manufacturers used in each organization's infrastructure. Each row represents a different element of the technology stack, while each column conveys the average score for the market leader, second place, the number three challenger or a mix. The final column shows the level of agreement or disagreement, conveyed through the standard deviation within the reliability ratings.

Table 4.3

Key vendor and averaged reliability ratings.

Technology	Leader	Second	Challenger	Mix	Standard Deviation
PCs	4.0	3.6-3.7	-	4.0	.23
Printers	4.1	-	4.0	4.0	.07
Servers	4.7	4.3-4.7	-	5.0	.30
LANs	4.8	5	-	-	.14
Storage	4.2	4.0-5.0	-	3.0-4.0	.74
Phones	5.0	4.0	3.0-5.0	3.0-5.0	.93

Personal Computers: The standard deviation for satisfaction with PC reliability, based upon hardware manufacturer, was small at 0.23. All technology leaders reported ‘good’ or very close to it, and the PC manufacturer did not appear to matter. Everyone was running the market leader HP, or the close second Dell, and one runs a mix of those two vendors.

Printers: There was almost no variation in the ratings of printer reliability. Nine of technology leaders have chosen to run HP, the industry print leader. The standard deviation, when printers were grouped by hardware manufacturer, was very small at 0.07.

Servers: Four technology leaders were running servers from the market leader HP as well as the number two Dell. Three were running the leader only, and four were running Dell only. All were running either HP or Dell or both for their server hardware. All technology leaders rated their server reliability high, with a standard deviation of 0.30, when grouped by hardware manufacturer.

LAN: Every healthcare organization runs Cisco for their LAN infrastructure. All rate Cisco high, with a standard deviation of 0.14, which means there is little disagreement in their ratings.

Storage: Storage ratings showed the second most variation in reliability ratings, with a standard deviation of 0.75. Eight of the participants run the market leader EMC; two leaders complimented EMC with another storage manufacturer. Those running a combination of EMC and something else had scores above and below the average. In terms of reliability ratings, EMC as a storage hardware manufacturer landed just above the average score.

Phones: The telephony infrastructure appears to have the greatest variation in satisfaction with key hardware manufacturer reliability. The technology leaders surveyed appear to be evenly divided between Cisco, Nortel and Avaya in their choice of manufacturer. When hardware manufacturers were considered, a standard deviation of 0.93 was calculated in their scores.

4.3.2. Dispatch Ratings

Table 4.4 illustrates the relationships between satisfaction with dispatch rates and key hardware manufacturers used within each organization’s infrastructure. Each row represents a different element of the technology stack, while each column conveys the average score for the market leader, second place, the number three challenger or a mix. The final column shows the level of agreement or disagreement through the measurement of standard deviation within the dispatch ratings.

Table 4.4

Key vendor and averaged dispatch ratings.

Technology	Leader	Second	Challenger	Mix	Standard Deviation
PCs	3.0	3.6-4.0	-	4.0	.47
Printers	3.7	-	3.5-4.0	4.0	.24
Servers	4.7	4.3-4.7	-	5.0	.31
LANs	4.5	4	-	-	.35
Storage	4.4	3.0-5.0	4	5	.80
Phones	5	3.75	3.0-4.5	4.0	.61

Personal Computers: When the technology leaders rated their PC manufacturer and their satisfaction with dispatch, the results showed that those running the PC market leader have the lowest combined satisfaction score. Variation between manufacturers was nearly half a point with a standard deviation of 0.47.

Printers: Similar to the ratings given for satisfaction with PC dispatch, the market leader in the printer category ended up near the bottom of the rating scale, but not by much, because the standard deviation was small at 0.24.

Servers: There was not much variation in satisfaction with dispatch, when server hardware manufacturers were considered, with a standard deviation of 0.31. *LAN:* There was very little disagreement with satisfaction with dispatch when the leader Cisco was considered. Everyone appeared to feel the same about Cisco.

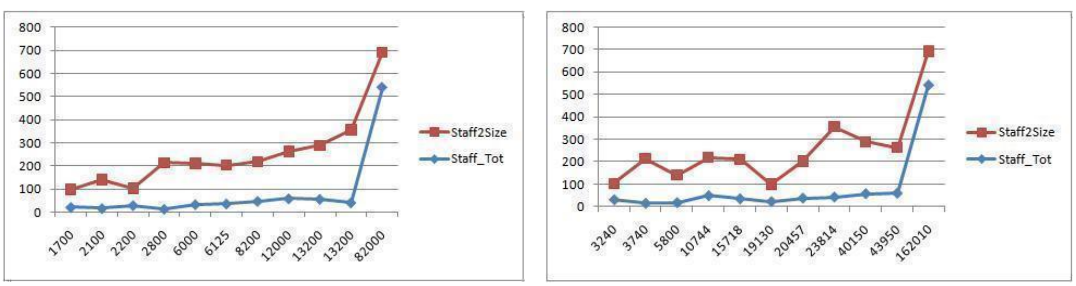
Storage: Ratings of satisfaction with dispatch, when the leader EMC was considered, were generally high, but interestingly enough those with the lowest rating and those with the highest rating all ran EMC storage.

Phones: Half of the participants ran Cisco and some other manufacturer as their telephony provider. The one organization running only Cisco gave the highest rating of 5. Once again, Cisco seemed to be the only manufacturer that consistently rated high in both LAN and telephony.

4.4. Staffing Capabilities

Figure 4.5 shows staffing levels and their relationship to the total users supported, and the size of the infrastructure supported. The x-axis for the chart on the left represents the total number of users supported. The x-axis for the chart on the right represents the total number of infrastructure elements supported.

Figure 4.5. Staffing and support comparisons.



The chart on the left shows that the number of associates served is approximately 100 per IT staff member at when the number of users supported is at or below 2,200. However, the number of associates served per staff member doubled near 2800, and increased again another 50% when the number of users supported neared 13,200. The number of users supported dramatically increased while the number of total IT staff did not. A similar pattern was found in the second chart. The number of infrastructure elements supported dramatically increased, for larger IT infrastructures, while the number of IT staff did not.

4.5. Satisfaction Indicators

This researcher's desire to examine the relationship between a participant's level of satisfaction with reliability, dispatch and flexibility, against their choices in infrastructure hardware manufacturers prompted the creation of satisfaction indicators. Satisfaction indicators were created from each technology leader's relative ranking in seven categories compared, which was then compared to their choices in hardware manufacturers. Figure 4.6 is divided into 3 sections. The first section showed each of the participant's relative rank in terms of demographics. The second section showed each of the participant's relative rank in terms of satisfaction. The last section showed the number of times each participant chose a market leader, close second, challenger or ran a mix of manufacturer hardware.

Figure 4.6. Demographics/satisfaction rankings versus hardware manufacturer.

	Demographics				Satisfaction			Manufacturer			
Participant	Size	Budget	Staff	Infra	Reliability	Dispatch	Flexibility	Leader	Close	Challenger	Mix
a	1	1	1	1	3	1	3	2	2	0	2
b	2	2	5	4	1	3	3	5	0	0	1
c	3	4	3	3	2	2	2	3	1	0	2
d	4	5	2	2	2	1	3	2	1	1	2
e	5	3	4	8	2	4	2	1	2	3	0
f	6	2	6	5	4	1	2	2	1	1	2
g	7	5	8	7	3	1	2	3	1	2	0
h	8	7	10	10	3	5	3	3	1	2	0
i	9	6	7	11	3	6	4	1	2	2	1
j	10	8	10	9	4	2	3	1	2	2	1
k	11	5	9	6	2	6	1	5	0	1	0

Table 4.5 further summarized the data presented in Figure 4.6 to make the relationships between the satisfaction rankings and manufacturer more visible. The second column of the table represented the number of times the participant's demographic information was ranked within the top three. The third column represented the number of times the participant's satisfaction level was ranked within the top three. The fourth column represented the

participant's tendency to choose a particular hardware manufacturer. A negative number in the demographic or satisfaction column indicates the number of times the participant ranked in the bottom three in demographics or level of satisfaction.

Table 4.5

Satisfaction matrix.

Participant	No. of Top Spot Demographics	No. of Top Spot Satisfaction	Manufacturer Choice
A	4	3	Mix
B	2	3	Leader
C	3	3	Leader
D	2	2	Mix
E	1	2	Challenger
F	1	2	Mix
G	0	3	Leader
H	-2	2	Leader
I	-2	1	Mix
J	-3	2	Mix
K	-2	2	Leader

A participant with a satisfaction level of three (3) was considered highly satisfied. A satisfaction level of two (2) was considered moderately satisfied and a level one (1) was considered a low level of satisfaction with the IT infrastructure. When viewed from the perspective of a hardware manufacturer's market position, the following findings became clear:

Five participants used the market leader in their choice of hardware manufacturer. Three participants who used the market leader were highly satisfied and two of them were moderately satisfied. Five participants had a tendency to use a mix of hardware manufacturers. Of those participants, one was highly satisfied, three were moderately satisfied and one had a low level of satisfaction. One participant had a tendency to use the market challenger and that participant was considered moderately satisfied.

4.6. Freeform Text

Four questions gave the participants an opportunity to provide freeform text-based feedback. Those questions requested feedback on the reasons for dispatch, on how their key hardware vendors impact complexity and scalability, and what could be done to improve infrastructure flexibility.

4.6.1. Reasons for Dispatch

The reasons for service and support dispatch fell into the following six groups: *Refresh or Growth* – Staff was dispatched to replace old equipment, update firmware, or add new hardware. *Break/fix and Patching* – Staff was dispatched to fix hardware failures, to fix environmental problems within closets or data centers, or to update or patch firmware. Many participants also noted that many equipment failures were due to poorly maintained equipment. *Application* – Four participants noted their dispatch reason as to resolve application problems or configuration issues. *Performance* – Four participants noted troubleshooting performance problems as the reason for dispatching support staff. Most involved some sort of investigation of response time complaints. *Malware and Security* – Three participants complained about having to cleanup malware or remove applications that should not have been loaded.

4.6.2. Key Vendor Impact on Complexity and Scalability

Unlike the many reasons for dispatch, participant feedback on how their key vendors can add to or reduce complexity followed two major themes. The two largest groups consisted of the following:

Reduce Complexity – The majority of the feedback in this category included the practice of buying from fewer vendors, which translated into reduced complexity. One participant described an alignment between vendor and technical vision, while another complained of compatibility problems on the motherboard as the product family was updated.

Standardization – Much of the feedback on reducing complexity was a requirement for standardization. One reported “fewer vendors support standardization.” A participant described it as “many have same technologies that cross-over from a strategic aspect; drivers and protocols do not always match up; standardizing with a few major hardware manufacturers does ease the complexity at times when trouble-shooting issues and helps with economies from a budget aspect.”

Feedback around how an organization’s key hardware vendors can impact scalability varied significantly, but it tended to follow two major themes:

Roadmap – Understanding the importance of a vendor having a long term roadmap was vital to scalability. One participant referred to the roadmap as “lifecycle planning integrated into all of a vendor’s products.” Another participant reported “the reason we choose Cisco was due to their ability to scale to meet the growing demands of this organization, and they have been very willing to work with us directly.”

Standard Configurations and Design – One participant reported “single vendor configurations allow an organization to deploy or scale infrastructure quickly.” Another, "battling through procurement is considered half the battle and using multiuse products reduced the requirement to bring in unique equipment for special needs." Another reported that each vendor tried to provide solutions, which allowed for consolidation and eased the management burden. Knowing the design limits of vendors before buying was emphasized as important information. Only one participant stated that a design based on virtualization was the key to scalability.

4.6.3. Flexibility

When asked what could be done to improve flexibility, answers seemed to be less about hardware and more about people, process and procurement of certain technologies. Their feedback included:

Capacity on Demand – One participant insisted upon investment in technologies that supported capacity on demand at nearly every layer of the technology stack.

More Resources – Multiple participants reported that more budgets, more staff and more training would allow them to be more flexible. Many complained about having to run a very lean and aging IT infrastructure.

Virtualization – Two participants noted that virtualization was the key to a flexible infrastructure.

4.7. Summary

Thirty-eight different relationships were examined among 73 different data elements. This survey has revealed the following:

- There was no relationship between spending on infrastructure and an organization's budget trending up or down.

- Moderate sized organizations tended to budget a bit more per supported user or supported infrastructure element.
- A positive relationship between higher flexibility and higher budget existed on a per supported user basis.
- There was a higher level of satisfaction with reliability for larger IT staffs or where the IT to user ratio is higher.
- Most participants ran hardware manufactured by the market leader or a mix of the leader and second place.
- Cisco and HP clearly pulled up the ratings on satisfaction with reliability and dispatch for the market leaders. The higher ratings by these two manufacturers alone improved the average for all layers of the technology stack.
- PCs and printers showed little relationship between manufacturer and satisfaction with reliability or dispatch.
- Most healthcare organizations ran EMC hardware, the storage leader, but satisfaction with reliability and dispatch varied greatly.
- IT shops with a higher staff to supported user ratio appeared to be able to support a much higher number of infrastructure elements.
- The market leading manufacturers appeared have more satisfied participants. When a mix of manufacturers was used, the participants were moderately satisfied.

The implications of these findings are discussed in the next chapter.

Chapter 5 - Discussion and Conclusions

Each chapter of this research builds upon the premise that today's healthcare infrastructure technology leader is facing unprecedented challenges that complicate their ability to deliver an effective IT infrastructure. The challenges include financial constraints, unprecedented demand, and a drive toward operational excellence. The pressures they face come from government, internal and external sources simultaneously. Ranking these challenges in order of importance is not useful because they all must be tackled simultaneously. None of them may be omitted or forgotten and financial constraints are common throughout all of them.

It was this researcher's intention to provide information to healthcare technology leaders that can be applied to IT infrastructure design and buying decisions. Exploring the role that market leading hardware manufacturers play in strategic and tactical decision making, defined the purpose of this research. Validating the role of the market leading manufacturers against organizational benefits completed the picture.

Chapter 4 presented the results of an online survey built to evaluate healthcare technology leader feedback about the health of their infrastructure. Ten major themes were summarized. Those themes have been further consolidated in this discussion to focus on a few key concepts to make the information more useful. This chapter examines the implications of the three consolidated themes of financial impact, vendor impact, and IT staffing impact upon the IT infrastructure. Impact is then expressed in terms of whether or not an organizational benefit was realized.

5.1. Financial Impact

Two major financial patterns were discovered within the results. Unexpectedly, the data showed that moderate sized organizations were budgeting more for both capital and operational expenses per user and infrastructure element than either large or small organizations. This does not mean that moderate sized organizations had the biggest budget; in fact the big budgets belonged to the bigger organizations. This finding does not appear to correlate with any other finding except satisfaction with flexibility.

The second financial trend follows the first in that when there is more spending per supported user and there tends to be a higher level of satisfaction with their infrastructure's ability to flex and meet changing business demands. The transitive nature of these two findings appears to show moderate sized organizations are more satisfied with their infrastructure's ability to flex because they have more budget per supported user. If flexibility is supported by a modular, standardized and connected infrastructure, it appears as though large or small organizations are less able to achieve these goals. Moderate sized organizations appear to have found the sweet spot between too little or too much budget. Larger organizations often struggle to standardize when they are faced with overwhelming growth. Smaller organizations are too often unable to take advantage of economies of scale.

There should be no doubt that a tighter budget leads to a tighter run ship. A technology leader with too much budget often fails to ensure that the organization is getting the most value out of their IT infrastructure. On the flip side, the technology leader with too little budget struggles to keep his or her head above water. Prior research showed that it is not a good strategy to rely upon budget slack to fund innovation or ensure flexibility. Some budget slack ensures there is room to flex with the organization's dynamic needs, but it is not necessary to build slack into one's budget. Throughout the fiscal year, products and projects will come and go. A technology leader focused upon efficiency and eliminating waste will look for opportunities to cut expenses. As known expenses are cut, budget is routinely created for those unexpected projects. Taking shortcuts in infrastructure builds, to increase budget slack, has been shown to have diminishing returns and lead to poor innovation performance.

5.2. Key Vendor Impact

Six major patterns were noticeable, that defined the relationship between market leading hardware manufacturers and IT infrastructure. The six patterns highlighted where the market leading manufacturers were being used by technology leadership and where they were not.

5.2.1. Role of the Market Leaders

Without exception, when it comes to data networks, servers, and storage, all healthcare technology leaders were building with the market leader, the owner of second place, or a mix of the two. The research showed that a higher level of satisfaction with reliability, rate of dispatch, and flexibility can be achieved when building data networks and servers using industry leading manufacturers. Nearly every technology leader had market leading EMC storage installed; although, their satisfaction scores did not reflect the same higher level of satisfaction. That fact will be explored later in this section. Healthcare technology leaders cannot afford to take chances with mission-critical patient care delivery systems and are building their IT infrastructures with market leading hardware manufacturers for those components where reliability matters most.

Healthcare organizations are dependent upon their information and biomedical systems like never before. Nearly every aspect of the patient care continuum requires the use of some type of technology. For example, in today’s modern hospital it would be difficult to call a film librarian to request that x-rays be brought up and displayed on light boxes in the radiology department. Those x-rays are most likely digital and no longer printed. A few short years ago, the technology would have forced a radiology technician to pull the films, walk them to the radiology department and get them mounted on the light boxes; most likely taking 30 minutes to carry out the workflow. A radiologist living in the digital age expects a newly captured image, with the patient's prior studies, to be available on multiple displays within seconds. The introduction of digital imaging is one example of how new technology has raised the bar for the delivery of patient care. New opportunities to save patient lives using information technology are now commonplace and expected. A fast, stable infrastructure is required to deliver the digital images to today's healthcare worker. This is further motivation for the healthcare technology leader to purchase from industry leading manufacturers, where they must eliminate single points of failure.

One more example of healthcare's dependence upon information technology is illustrated in the fact that a nurse can no longer pull a patient's paper chart off of a rack at a nursing station if the computer system was to go down. For years, computerized medical records were simply a convenient reference. Electronic records at the time were rarely considered the legal medical record. The legal record was still on paper. Much of the electronic medical record of the past was printed and included in the patient's file. Today, it is no longer possible to pull a chart off the rack if the computer system fails. The delivery of patient care is severely crippled if the hospital's electronic medical record system were to fail. Everyone from hospital administrators to nurses on the floor expect highly available information systems. IT professionals are reminded often that patient lives are at stake when information systems become unavailable. Today's technology leader has no choice but to provide the highest performing, most reliable, and flexible infrastructure that can respond to the needs of the organization. The data showed that building critical components of an IT infrastructure with market leading hardware manufacturers gives the technology leader that opportunity.

5.2.2. The Importance of Cisco and HP

More than any other manufacturers, Cisco and HP are responsible for the higher combined market leader ratings within the results of this research. The market leaders in the personal computer, printer, storage and telephony technology layers are much more dispersed. The data offered in the freeform text provides some insight into why. Three examples of participant feedback, that reported using these industry leaders, were: 1) delivering solutions that fit into the enterprise architecture is something that industry leading hardware manufacturers have mastered; 2) eliminating redundancy, creating a roadmap for integration, and adapting to change is required of your hardware manufacturer and is called out in the IT architecture; and 3) creating enterprise architecture is a crucial step, in conjunction with the purchase of enterprise-capable hardware, to be completed to build an enterprise-class infrastructure.

Delivering solutions that fit into the enterprise architecture is something that the industry leading hardware manufacturers appear to have mastered. Eliminating single points of failure, creating a roadmap for integration, and adapting to change is required of a hardware manufacturer that plays a role in the enterprise architecture. Creating enterprise architecture is a crucial step, in conjunction with the purchase of enterprise-capable hardware, to build an enterprise-class infrastructure. The data showed that when building with Cisco and HP, technology leaders appeared to be aligned with many of the concepts, previously identified in this research, that make infrastructure valuable to the organization.

Anywhere a single point of failure can be found, healthcare technology leaders appeared to be driven toward the industry leading hardware manufacturers. This section began by highlighting the fact that the industry leading manufacturers were being chosen for data networks, servers and storage. Each of these layers of the technology stack can be built redundantly, but typically are not. Servers can be clustered, but for the most part only the most critical servers are afforded that configuration. Data networks can be built redundantly, but often only the core is built in that way. Storage arrays can be duplicated within the data center, but it is rarely practiced.

Market leading EMC storage was deployed in every participant's infrastructure, but the level of satisfaction was not as consistently as high as the ratings for Cisco (networks) and HP (servers). The lower ratings may have been due to the fact that a second storage manufacturer was included by online survey participants in many of the lower rated infrastructures. The wider range of satisfaction scores may be due to poorer performance of either primary or secondary manufacturer. A similar phenomenon was observed in the telephony data. Cisco alone was rated high, but when combined with Nortel or Avaya, the ratings were lower. The research data was inconclusive.

5.2.3. Satisfaction with Market Leaders

Overall satisfaction ratings, for those technology leaders running market leading manufacturers, were slightly higher than satisfaction ratings for those running a mix of manufacturers. The number of times a survey participant captured one of the top three rankings in reliability, dispatch or flexibility was higher when they were running an industry leading hardware manufacturer.

Thus far this discussion has been primarily focused on reliability, but dispatch and flexibility also appeared to play a big role in overall IT infrastructure satisfaction. Direct feedback (freeform text) from the online survey participants showed that satisfaction with dispatch and flexibility appeared to have less to do with hardware and more to do with people, process, and procurement. The underestimated costs outlined by Huang in Chapter 2 were also more about people, process and procurement. Many IT leaders appear to fail to pay attention to the strategies and processes within their infrastructure that drive up their costs or drive down their level of satisfaction. The data in this research showed that the market leading manufacturers contribute to solving the people, process and procurement problems.

5.2.4. When Market Leadership Has No Impact

When technology leaders are faced with buying a mission critical hardware components they appear to be driven to use market leading manufacturers. Conversely, the data showed that when technology leaders choose infrastructure hardware that is deployed in large numbers, they appeared to be satisfied with the manufacturer in the first, second or third position, or a mix of hardware manufacturers. This fact was observed in the data pertaining to PCs and printers. The highest PC and printer satisfaction levels came from technology leaders who were deploying manufacturer's hardware ranked second, third, and at times lower in the market. If technology leaders are being pushed to market leaders for mission critical components, they appear to feel less pressured when deploying PCs and printers for the reasons stated above.

5.3. Staffing Impact

The most interesting trend to come out of the data gathered around staffing was that when the ratio of users to IT infrastructure staff was higher, the level of satisfaction was higher. Furthermore, the same ratios showed that each IT infrastructure staff member was able to support more infrastructure elements. This trend was most obvious as the IT infrastructure teams, of medium-sized organizations, approached 50 members. Some special combination of budget, workload, and management has made those teams much more efficient than their counterparts in smaller and larger organizations.

The demands upon the IT infrastructure teams and the competition for capital, on a wide variety of hospital projects, has made it important to get the technology implementation right the first time. Most technology teams scarcely have time and money to implement the required technology once, let alone having to do it again because it was not done right the first time. Most infrastructure teams work at a near burn-out level. When the capital dollars and human resources are available, it is mandatory that the organization get the most out of their investment. The importance of this detail to the technology leader underscores the value of providing a roadmap for buying infrastructure hardware. Insight into the benefits of industry leading hardware manufactures helps the technology leader choose the right technology the first time.

This section reminds us that being good stewards of the organization's constrained resources is non-negotiable. A technology leader cannot escape the requirement to build a fast and reliable infrastructure to support the organization's growing dependence upon technology. Finally, when the funding and resources become available it is important that the technology leader gets it implemented right the first time.

5.4. Limitations

Although the research has shown a correlation between market leading hardware manufacturers and higher satisfaction, reflected in key IT infrastructure metrics, there were several limitations to the study. The first limitation was related to the size of the sample set. Nineteen technology leaders participated in the study. Eight were eliminated due to the fact that their online surveys were incomplete, which left 11 usable studies. A second limitation was due to the fact that the research was constructed as a qualitative study instead of a quantitative study. The qualitative approach captured mostly ratings and opinions rather than hard data about an organization's IT infrastructure. Therefore, the results and discussion offer this researcher's observations about the relationships and benefits between market leading manufacturers and organizational benefits, instead of empirical evidence. A larger sample set and a quantitative study could offer the hard evidence that would further validate the assertions made in this research.

Another limitation included the fact that some of the terms used in the online survey were not defined. Including definitions at the beginning of the study would have ensured that all participants had the same baseline understanding of the meaning of the questions. For example, defining the meaning of dispatch or flexibility would have reduced any uncertainty about the variation in the answers to the questions which used those terms. Asking for *hardware standards* (e.g. server, storage, PBX) instead of *key vendors* may have produced the technology leader's truer choice of hardware manufacturers versus what was installed.

Similar to the need to ensure a baseline understanding of key terminology, each question about the budget should have emphasized the need to report only the IT infrastructure budget. The budget reported of one of the online survey participants was significantly different than the data reported by all of the other participants. It was ignored and not considered in Chapter 5.

The above limitations injected minor uncertainty about the validity of the study. A larger sample set, hard evidence, and terminology definitions in the online survey would have helped to eliminate any doubt about the strength of the research.

5.5. Recommendations for Future Research

This study was designed to fill a gap in the IT infrastructure literature, namely to explore the relationship between infrastructure buying decisions and benefits to the organization. The literature could benefit from studies that include a larger sample set and more hard data about the health and performance of each organization's IT infrastructure. Obtaining the measured data may require paying the survey participants to spend more time communicating facts about their infrastructure and/or the implementation of software tools in the infrastructure to gather critical health and performance data.

Another area of future research could focus on where technology leaders are spending their IT infrastructure budgets. The amount of budget spent per associate or per infrastructure element varied significantly. The data showed that the healthcare technology leaders surveyed were all using the top one or two market leading manufacturers for critical components of their infrastructure. That leads one to wonder: where are those budgets being spent? A more detailed breakdown of how the IT infrastructure budgets are being spent could reveal further insight into why satisfaction with the same hardware manufacturers varies. Best practice around research and development, vendor negotiations, or how each leader manages the soft costs mentioned earlier in this research could be uncovered.

In addition, multiple online survey participants mentioned virtualization in freeform text fields. A study of cloud computing and virtualization technologies and how they impact reliability, complexity and level of satisfaction could provide more insight into how some technology leaders are able to achieve more results with the same hardware.

Often hardware manufacturers leapfrog one another in market share as new innovations are released. For those IT departments building their infrastructure with multiple hardware manufacturers, further research into which manufacturer a healthcare organization is moving toward would provide more insight into each leader's choice of hardware manufacturers.

Two final ideas for further research would tackle what projects are not getting completed. Freeform text feedback revealed that resource and budget shortfalls are common among all participants. A study of what is not getting funded, combined with a study of the impact of the resource shortages, could add further meaning to the results of this study. The missing infrastructure capabilities may influence the technology leader's ratings and opinions about reliability, complexity and flexibility.

5.6. Conclusion

Three major conclusions can be made from this study. The first states that when technology leaders are faced with choosing a hardware manufacturer, to fill a critical component of their infrastructure, they are choosing to build using one of the top two hardware manufacturers in the market. This fact clarifies that any definition of market leading must include the top two manufacturers instead of only the manufacturer on top. The reasons why a technology leader chooses to build using the market leaders vary. The data showed higher levels of satisfaction with reliability, staff problem dispatch rates and flexibility when they do. Choosing market leading manufacturers translates into improved availability, fewer interruptions to end users, and faster response to organizational needs. Anywhere a technology leader faces a potential single point of failure; they are filling those critical components of the architecture with industry leading hardware. Due to the mission-critical nature of their life saving technologies, healthcare IT leadership cannot afford to take chances where it counts most.

Through freeform text, online survey participants shared how their key hardware manufacturers impact their IT infrastructure. The manufacturer's ability to effect enterprise architecture through a roadmap was repeated several times. It has been previously argued that enterprise architecture creates order from chaos, and allows an organization to accept new technologies with less effort. Therefore, technology leaders are relying upon industry leading hardware manufacturers to help them complete the enterprise picture.

A second conclusion reveals that when hardware components are widely deployed, and multiple components are available within a limited physical space, choosing to build with the market leaders are less of a concern. This fact is clearly observable when evaluating the deployment of PCs, printers and phones. The market leaders failed to dominate the *key vendor* feedback, for PCs, printers and phones, of the participants in the online survey. The reasons why were not clear in the study. Speculation about why this buying behavior occurs is based upon the fact that these components are not mission-critical. The technology leader's behavior is in fact the opposite of their behavior when it comes to buying network, server and storage components. Due to the fact that PCs, printers, and phones are often just a few feet apart from one another in the hospital setting allows the technology leader to buy hardware that may not be as reliable. These components have also become commodity devices driven toward rock-bottom pricing. They do not require the engineering or high-availability of their data center counterparts.

A third conclusion is that flexibility is more a function of the available budget and infrastructure strategy than it is hardware manufacturer. Research prior to this study argued that flexibility is defined by the infrastructure's ability to respond to organizational change. That ability is then supported by an agenda or plan, which is shared with the organization. This study expanded upon that foundation with data that connects flexibility with budget ratio per user and infrastructure element. Technology leaders appeared more satisfied with their infrastructure's ability to flex with organizational change when their budget ratios are higher. Furthermore, through freeform text feedback, online survey participants shared that technologies like *capacity on demand* and virtualization are examples of technologies that allowed them to build a flexible infrastructure. When viewed in their entirety, the arguments for greater flexibility made the case that flexibility required a strategy that defined where the budget was spent and how the infrastructure was built (enterprise architecture) versus a choice in hardware manufacturer.

Flexibility is an important component of an infrastructure's value to an organization. A poorly constructed infrastructure will not accept changes easily because at its root it fails to easily adopt new components. Building with open source software is an example of how one would build infrastructure less expensively. However, when an organization chooses to build their infrastructure by means of open source software, they are choosing to build using the software architectures of tens if not hundreds of designers. Multiple software designers unknowingly create software that is difficult to integrate or interoperate. These difficulties reduce flexibility and the organization's ability to adopt new technologies. In contrast, software products from a single source, built around a single architecture, are much easier to fit together and add to an existing infrastructure.

The stress caused by rapidly changing technologies and fixed or declining IT budgets can force the technology leader to walk a tight rope daily. As demand to adopt new technologies and to integrate with external partners becomes more important, it will be crucial that the technology leader choose their hardware manufacturing partners wisely. Each and every infrastructure initiative must be connected to the business initiative it supports with a vision of where their road is taking them and how to get there. This research will help the technology leader understand when it is important to build using the industry leaders and when it is not important.

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Footnotes

[1]Personal computers, printers and phones each counted as one infrastructure element, but servers and network components were weighted to ensure their relative impact within an IT infrastructure was reflected. Each terabyte of storage was counted as one infrastructure element.

Appendix A

Sample Emails Requesting Participation

From: Biondolillo, Frank
Sent: Saturday, January 30, 2010 12:51 PM
To: <name>@exempla.org
Subject: Master's Thesis

<name>,

I am working through the final semester of my master’s program. In fact, my master’s thesis is due in early June and I am gathering research data at this time. I received your contact information through my relationship with Jeff Pelot. In early February I plan to send out a short online and anonymous survey, about infrastructure spend/build patterns, to my healthcare technology peers like you. It should take you under 10 minutes to complete. Are you willing to help me out?

Additionally, do you mind replying with contact information for two of your peers that I may add to my survey distribution list? I’d like to expand the size of my survey. I could really use your help in getting through my master’s thesis. Someone should have warned me about how much fun this part of the program would be. Thank you in advance.

Frank Biondolillo
Vice President/CTO | Acting Security Director
Centura Health, Information Technology
303-643-4143
mailto:frankbiondolillo@centura.org
http://www.centura.org

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This communication is for the use of the intended recipient only. It may contain information that is privileged and confidential. If you are not the intended recipient of this communication, any disclosure, copying, further distribution or use thereof is prohibited. If you have received this communication in error, please advise me by return e-mail or by telephone and delete/destroy it.
****

From: Biondolillo, Frank
Sent: Sunday, February 07, 2010 4:41 PM
To: Biondolillo, Frank
Subject: Master's Thesis Survey

Dear Colleagues,

You are being invited to participate in my Master's Thesis survey. In this survey, 12 technology leaders will be asked to complete a survey that asks questions, which will help me better understand what makes your infrastructure strong. It will take approximately 10 minutes to complete the questionnaire.

Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for me to learn your opinions.

Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. I do not ask for any information that can tie your answers to your organization. If you have questions at any time about the survey or the procedures, you may contact me at 303-229-3511 or by email at the email address specified below.

Thank you very much for your time and support. Please start the survey now by clicking on the following URL.

http://infrastructure-survey.questionpro.com

Frank Biondolillo
Vice President/CTO | Acting Security Director
Centura Health, Information Technology
303-643-4143
mailto:frankbiondolillo@centura.org
http://www.centura.org

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This communication is for the use of the intended recipient only. It may contain information that is privileged and confidential. If you are not the intended recipient of this communication, any disclosure, copying, further distribution or use thereof is prohibited. If you have received this communication in error, please advise me by return e-mail or by telephone and delete/destroy it.
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Appendix B

QuestionPro Online Survey Questions

Infrastructure Reliability, Complexity and Availability Survey

Dear Colleagues,

You are being invited to participate in my Master's Thesis survey. In this survey, 12 technology leaders will be asked to complete a survey that asks questions, which will help me better understand what makes your infrastructure strong. It will take approximately 10 minutes to complete the questionnaire. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for me to learn your opinions. Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. I do not ask for any information that can tie your answers to your organization. If you have questions at any time about the survey or the procedures, you may contact me at 303-229-3511 or by email at frankbiondolillo@centura.org.Thank you very much for your time and support.

1. Size of healthcare organization:
Approximately how many employees are supported by your IT department?

Approximately how many physicians are supported by your IT department and part of your IT infrastructure?

2. Capital budget:

What is your capital budget in the current year?

1. Less than $500,000
2. Between $500,000 and $1,000,000
3. Between $1,000,000 and $5,000,000
4. Between $5,000,000 and $10,000,000
5. Between $10,000,000 and $15,000,000
6. Between $15,000,000 and $20,000,000
7. Between $20,000,000 and $25,000,000
8. Over $25,000,000
9. Other ____________________

Infrastructure Reliability, Complexity and Availability Survey

What was your capital budget last year?

1. Less than $500,000
2. Between $500,000 and $1,000,000
3. Between $1,000,000 and $5,000,000
4. Between $5,000,000 and $10,000,000
5. Between $10,000,000 and $15,000,000
6. Between $15,000,000 and $20,000,000
7. Between $20,000,000 and $25,000,000
8. Over $25,000,000
9. Other ____________________

What was your capital budget two years ago?

1. Less than $500,000
2. Between $500,000 and $1,000,000
3. Between $1,000,000 and $5,000,000
4. Between $5,000,000 and $10,000,000
5. Between $10,000,000 and $15,000,000
6. Between $15,000,000 and $20,000,000
7. Between $20,000,000 and $25,000,000
8. Over $25,000,000
9. Other ____________________

3. Operating budget:

What is your operating budget in the current year?

1. Less than $500,000
2. Between $500,000 and $1,000,000
3. Between $1,000,000 and $5,000,000
4. Between $5,000,000 and $10,000,000
5. Between $10,000,000 and $15,000,000
6. Between $15,000,000 and $20,000,000
7. Between $20,000,000 and $25,000,000
8. Over $25,000,000
9. Other ____________________

What was your operating budget last year?

1. Less than $500,000
2. Between $500,000 and $1,000,000
3. Between $1,000,000 and $5,000,000
4. Between $5,000,000 and $10,000,000
5. Between $10,000,000 and $15,000,000
6. Between $15,000,000 and $20,000,000
7. Between $20,000,000 and $25,000,000
8. Over $25,000,000
9. Other ____________________

Infrastructure Reliability, Complexity and Availability Survey

What was your operating budget two years ago?

1. Less than $500,000
2. Between $500,000 and $1,000,000
3. Between $1,000,000 and $5,000,000
4. Between $5,000,000 and $10,000,000
5. Between $10,000,000 and $15,000,000
6. Between $15,000,000 and $20,000,000
7. Between $20,000,000 and $25,000,000
8. Over $25,000,000
9. Other ____________________

4. Who are your key hardware manufacturers?

Workstations (PCs, laptops):

Printers:

Servers:

Network (LANs):

Storage:

Infrastructure Reliability, Complexity and Availability Survey

Phones:

5. Infrastructure scalability and flexibility:

How do your key hardware manufacturers affect infrastructure complexity?

How do your key hardware manufacturers affect infrastructure scalability?

6. Approximate size of your infrastructure (number of):

Workstations (PCs and laptops):

Printers:

Servers:

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Network (routers and switches):

Storage (TB of spinning disk):

Phones:

7. How would you rate the reliability of your:

	Poor	Below Average	Average	Good	Excellent
Workstations:	❑	❑	❑	❑	❑
Printers:	❑	❑	❑	❑	❑
Servers:	❑	❑	❑	❑	❑
Network:	❑	❑	❑	❑	❑
Storage:	❑	❑	❑	❑	❑
Phones:	❑	❑	❑	❑	❑

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8. How satisfied are you with your support teams dispatch rate for:

	Very Dissatisfied	Not Satisfied	Neutral	Satisfied	Very Satisfied
Workstations:	❑	❑	❑	❑	❑
Printers:	❑	❑	❑	❑	❑
Servers:	❑	❑	❑	❑	❑
Network:	❑	❑	❑	❑	❑
Storage:	❑	❑	❑	❑	❑
Phones:	❑	❑	❑	❑	❑

What would you say is the main reason for dispatching each infrastructure team?

Workstations:

Printers:

Servers:

Network:

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Storage:

Phones:

9. Approximately how many staff do you have on each infrastructure team?

Workstations:

Printers:

Servers:

Network:

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Storage:

Phones:

What is the average number of training classes per infrastructure team member per year?

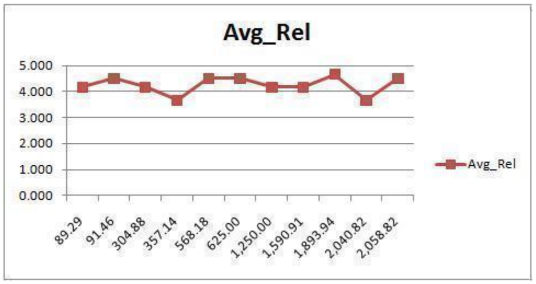
10. How satisfied are you with your infrastructure's ability to flex and respond to changing business needs:
1. Very Dissatisfied
2. Not Satisfied
3. Neutral
4. Satisfied
5. Very Satisfied

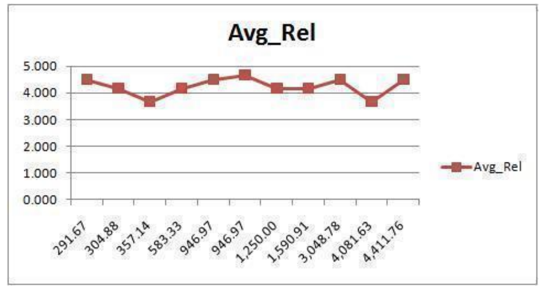
What would improve your infrastructures ability to flex and respond to business needs?

Appendix C

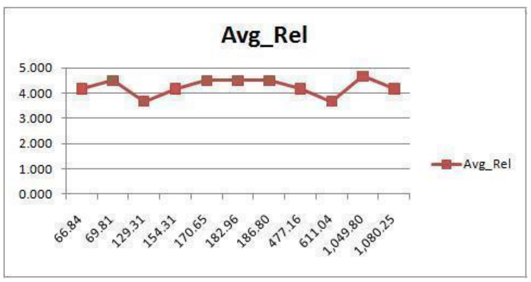
Reliability Charts

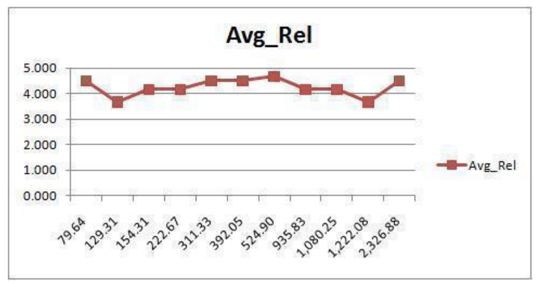
Capital and Operating Budget Spent on Users Supported vs. Reliability Rating



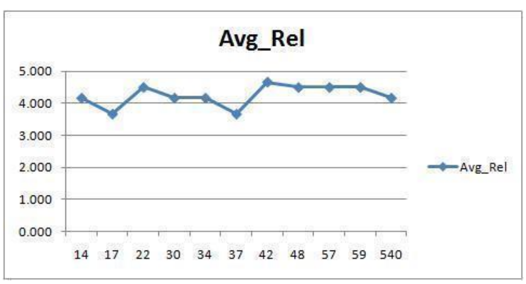


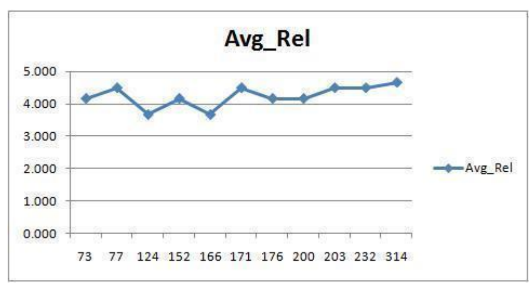
Capital and Operating Budget Spent per Infrastructure Element vs. Reliability Rating





IT Staff Size and IT Staffing Ratio to Users Supported vs. Reliability Rating





Capital and Operating Spending per IT Staff vs. Reliability Rating