CAN A CITY MANAGE BROADBAND INFRASTRUCTURE?
AN ORGANIZATIONAL LEARNING PERSPECTIVE

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ABSTRACT

This research examines the organizational learning process in the context of municipalities learning to build and operate broadband wireless networks. We apply the concept of absorptive capacity to understand the link between prior experience, knowledge activities and performance improvement. We use comparative exploratory case studies, Chaska, Minnesota and Hermosa Beach, California to illustrate our points. This study contributes new knowledge to the absorptive capacity literature by providing a better understanding of how public organizations learn to acquire new knowledge and the influence of absorptive capacity on performance improvement. We also extend the absorptive capacity model by introducing constructs that influence absorptive capacity and performance supported by the qualitative data from interviews with key personnel and archival data. These constructs include the dynamic of technology development, partnership commitments, the roles of external knowledge and learning-by-doing, and politics. From a practical perspective, the study provides insights and learning lessons for cities that are in the process of planning and deployment. It also offers more realistic expectations around Wi-Fi deployment taking into consideration that the technology is not a plug and play technology and that considerable efforts are needed to integrate the technology with other solutions to deliver broadband Internet services as well as to configure the system according to topologies, street conditions, buildings, density of trees, among others.

Keywords: organizational learning, absorptive capacity, digital community, broadband, Wi-Fi, public organization

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INTRODUCTION

The United States historically has depended on the private sector, to a large extent, for its delivery of telecommunications services (Crew and Kleindorfer, 1996; Eisenach, 2001). As the 21st Century opens, a new technological revolution is transforming the market for telecommunications services, blurring previously clear distinctions between products such as local and long distance telephony, or telephony and cable television. With the arrival of the Internet, communications services generally are converging into a single marketplace of digital bits (Gillett et al., 2004). The focus of this new marketplace is on broadband services – high-speed, 'always-on' connections that combine Internet access and other data applications (Voice-over-Internet Protocol for instance) (Firth and Mellor, 2005; Graham and Ure, 2005).

Entry in this telecommunications marketplace is coming from many directions, including cable companies (e.g. Time Warner Telecom), wireless Internet Service Providers (e.g. Google and EarthLink) and electric utilities like Texas Utilities (owner of local phone service provider TXU Energy) for instance (Lehr and McKnight, 2003; Lenard, 2004). It is believed that when such entry is initiated by private companies, it contributes to the development of competition and ultimately reduces government regulation. Indeed, this is the vision of the Telecommunications Act of 1996 and the intent of the policies pursued by the FCC under the Act (Telecomm Act of 1996, 2006).

Simultaneously, this convergence is contributing directly to deregulation and luring government entities like municipal electric utilities, municipally owned cable television systems, and municipal-owned wireless broadband networks into telecommunications markets (Allen, 1985; American Public Power Association, 2005; Bar and Park, 2006). The pace of government entry into telecommunications and Internet services markets is rapid and increasing (Lenard, 2004). Government-owned entities already offer virtually every type of telecommunications and Internet-related service, from cable TV and local dial tone to ISP service and broadband networking. Furthermore, government entrants into these businesses are increasingly adding wireless broadband to their delivery package.

In recent years, approximately 400 U.S. municipalities have designed, developed or deployed some form of a citywide broadband networks. Although some cities have prior successful experience in building and managing physical infrastructure such as water, sewer and road systems, and some limited telecommunications networks, providing of telecommunications services through broadband information networks are new to local government and might be considered outside their competencies (Daggett, 2007; Wireless Internet Institute, 2003). From an organizational learning perspective, a city faces significant challenges in several ways. First, it has to learn the new and rapidly evolving broadband technologies, their strengths and weaknesses, implementation details, and associated costs. Second, it has to do so in a relatively short period of time. Third, it has to apply the knowledge learned from other cities and industry to achieve its own goals.

Research Questions

This research examines how a city assimilates, transforms, and exploits knowledge to deploy and manage a citywide broadband network. We are particularly interested in those cities that own and operate their infrastructure. The specific research questions are:

. • How does a municipality learn to develop and manage a citywide broadband infrastructure?
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. • What is a learning process to handle unanticipated challenges that arise during the course of network operation and how the learning, in turn, influences performance?
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. • What are the barriers to citywide management of these networks?

THE SETTING: THE GROWTH OF MUNICIPAL-SUPPORTED WIRELESS BROADBAND NETWORKS

Although wired fiber optic cables are a far more secure broadband network medium, they are not cost effective, require a significant amount of labor to set up, and are disruptive to build and maintain (Gillett and Lehr, 1999; Gillet et al., 2004). Recently, cost-saving wireless technologies have become an alternative to wired technologies. The recent Federal Communications Commission (FCC) report shows that wireless accounts for 18% of all high speed connections of 200 Kbps or higher (including DSL, cable modems, fiber optic, and satellite) in June 2006, a 17% increase from the same month in 2005 (FCC, 2007). As the demand increases and more users join the wireless community, wireless technologies become faster, more robust, and cheaper (Lehr and Sirbu, 2004).

These new wireless technologies, particularly Wi-Fi (wireless fidelity or IEEE 802.11a/b/g/n), enable broadband Internet access without requiring a spectrum license from the FCC, such as is required for cellular telephone service providers. According to Bar and Galperin (2004), the proliferation and adoption of wireless technology has been successful for three reasons. First, the FCC did not require a license for the 2.4 GHz and 5 GHz spectrum; the airwave spectrum in which Wi-Fi works. Second, standardization as specified by the Wi-Fi Alliance and the IEEE organization led to an interoperability standard. Third, the large scale production of Wi-Fi chipsets resulted in low unit costs for Wi-Fi equipment, fueling the technology's integration as standard equipment in laptop computers and allowing widespread diffusion of Wi-Fi access points for private and public use (Bar and Galperin, 2004; Bar and Park, 2006).

Recently, high speed information networks have been increasingly viewed as essential infrastructure similar to road systems, sewer, and water (Crandall et al., 2007). However, the current market for U.S. broadband is primarily dominated by one cable company and one phone company. It was estimated that some ten percent of households do not even have access to broadband from any provider. The lack of competition does not provide incentives for private operators to expand coverage to rural areas, lower prices, and upgrade the speeds (Daggett, 2007). As a result, many cities in the U.S. have considered deploying wireless broadband Internet networks on their own. According to muniwireless.com, as of August 2007, there were 415 U.S. counties and cities, a significant 240% growth from 122 in July 2005, who are in the deployment or planning stage of Wi-Fi broadband networks. Table 1 provides a summary of the number of U.S. cities and counties with Wi-Fi from 2005 to 2007. Municipalities have decided to enter the telecommunications realm because of the cost savings opportunities that new Wi-Fi technologies offer. In addition, these municipalities are making claims that Wi-Fi networks would enhance economic development, provide for additional tourism, support city services and personnel, and perhaps decrease the digital divide. Given existing municipal assets such as buildings, rights of way and structures that can house wireless antennas, municipalities may enjoy lower cost of broadband infrastructure deployment.

Table 1. Cities and Counties Using Wi-Fi Networks

TYPE OF NETWORK	JULY 2005	JUNE 2006	AUGUST 2007
Region or citywide	38	68	92
City hotzones	22	32	68
Municipal or public safety use only	28	35	40
Planned deployment	34	121	215
Total	**122**	**247**	**415**

Source: www.muniwireless.com

As municipal wireless broadband deployments have become more high profile in the past several years, private sector providers and others have expressed a number of concerns. Private providers understandably express concern that cities providing wireless broadband service have an unlimited base from which to raise capital, act as a regulator for local rights of way and tower permitting, own public infrastructure necessary for network deployments including street lights, and are tax-exempt organizations. Several reasons have been discussed for dissuading municipalities from developing and deploying broadband networks. First, it has been argued that these broadband networks may cost more than the cities anticipate, resulting in money and attention being diverted away from other public interests. Second, it is fear that if these networks were allowed to flourish, the municipality would have unfair regulatory and economic advantages (Lenard, 2004). In addition to concerns from private broadband operators, others also express uncertainties and doubts on municipal wireless networks. Some of them include a city's overestimation of demand (Feiss, 2007), lack of market discipline and technology capability (Feiss, 2007), the overlook of major elements in the operation costs including maintenance and replacement and network operations center costs (McClure, 2005), and a lack of resources to maintain the network (Cox, 2004).

Next, we discuss business models that municipals use in their Wi-Fi deployment.

Municipal Wi-Fi Business Models

Since social, political and economic situation is unique to each municipality, one might argue that there are 400 unique business models among approximately 400 municipalities deploying wireless broadband networks in some form. However, for analytical purposes, we can group these models into four main types, each with certain strengths and weaknesses. Each of these four business models possess different foci, funding, and objectives. They include: *community network model*, *cooperative wholesale model*, *private consortium model*, and *public utility model*.

The first two business models, community network and public utility models, tend to be owned and managed by the city itself. The private consortium and cooperative wholesale models tend to be owned and managed by private organizations or non-profits, sub-contracted with the municipality to provide service.

We have chosen to focus our research on the first two types as we are interested in the extent of learning and changes brought to the city organization based on their full entrance into the telecommunications market as a provider.

Community Network Model

The community network model is focused on providing free or low cost wireless broadband service. Two hybrid sub-models have emerged from cities using this model, but both share similar characteristics: free Wi-Fi access. This model most often supports wireless hot zones or citywide networks. The first sub-model involves the city or a non-profit organization (NPO) receiving funding from taxpayer funds, foundation grants, donations from citizens and businesses, and then builds and gets advertising revenue from a splash page. The second sub-model involves a non-profit community group or government entity that acquires funding to educate business owners about the benefits of deploying a Wi-Fi hotspot. The non-profit NPO (or government agency) acts as a catalyst, gets funds, educates and encourages the organic build-out of a Wi-Fi network in downtown areas. Since the city or non-profit organization is not funding the network deployment, the need to use city funds is substantially lower (Tapia et al., 2005; 2006a; 2006b). The advantages of the community network model are free access to broadband Internet, targeting certain areas for revitalization by attracting people to downtown areas. Since the network is most often provided as an amenity, little focus is given to building a universally available, secure, and reliable network. Therefore, the city government usually chooses not to use the network to support mobile applications for public safety and public works functions (Tapia et al., 2005; 2006a; 2006b). Hermosa Beach, California is an example of this form of business model.

Public Utility Model

The public utility model requires a local government to establish a new community department or combine with existing water, gas, and/or electric utilities departments to deploy, operate and manage broadband service for the local citizenry. The broadband utility's capital cost is funded through the use of taxpayer dollars, revenue bonds, and private donation. The public utility installs the network, markets the service, and provides customer support and billing. In addition, the local government may choose to provide both fixed and mobile broadband to its agencies. This model is most often used when private providers choose not to offer broadband service in a city for financial reasons. (Tapia et al., 2005).

The public utility model affords local governments the ability to control a number of factors involving broadband service. Since governments have easier access to capital through tax dollars, bonds, and other revenue sources, municipalities do not always face the same capital scarcity that private sector providers do. With a clear funding strategy, public utility networks can be built quickly by a city interested in providing broadband service to its citizens. Cities are also able to control the price of broadband access to the end user through this model, or even subsidizing enterprise fund losses with general fund monies (Tapia et al., 2005; 2006a; 2006b). Chaska, Minnesota is an example of this form of business model.

THEORETICAL BACKGROUND

This study seeks to extend the research on absorptive capacity (Cohen and Levinthal, 1990; Lane et al., 2001; Zahra and George, 2002) to understand the assimilation and exploitation of new knowledge in public organizations with particular emphasis on studying the role of absorptive capacity in U.S. cities' attempt to develop a broadband wireless infrastructure and associated services. Absorptive capacity is an organizational learning theory that focuses on learning from the external environment through various mean including acquisitions and other inter-organizational activities, among others.

According to Cohen and Levinthal (1990), absorptive capacity refers to an organization's ability to learn and apply new knowledge to improve performance. Zahra and George (2002), in their extension of the original theory proposed by Cohen and Levinthal (1990), suggests that absorptive capacity consists of four components: (1) the ability to recognize the value of new knowledge, (2) the ability to assimilate knowledge, (3) the ability to transform knowledge, and (4) the ability to exploit knowledge.

We apply the conceptualized model of Zahra and George (2002) to explore the temporal development of the three components of absorptive capabilities in the context of municipalities learning to build and operate broadband wireless networks. Although research on learning suggests that an organization's ability to recognize the value of new external knowledge is critical for the survival of organizations in dynamic environment (Todorova and Durisin, 2007) as evidenced in numerous examples of firm failures (e.g., failure of Polaroid to shift from analog to digital imaging) in the face of radical environmental and technology change, we chose not to include the ability to recognize and acquire external new knowledge in our study. This is because we consider a city's Wi-Fi deployment as a given event that is determined a prior by a city. In other words, a city is required to seek new knowledge to help with planning, deployment, operation, and maintenance of the Wi-Fi infrastructure and broadband services.

Figure 1 illustrates the main features of Zahra and George (2002)'s model that we will highlight in this study. The constructs and their definitions in the context of a city broadband deployment is presented in Table 2. Next, we provide a brief overview of the constructs in the model.

Figure 1. An absorptive capacity model of organizational learning in citywide broadband infrastructure projects

Table 2. Definition of Research Constructs

COMPONENT	DEFINITION	REFERENCES
Experience	City's prior related knowledge that is relevant to its broadband deployment.	• Cohen and Levinthal (1990)
Ability to assimilate knowledge	City's processes and routines to interpret and understand the new external knowledge.	• Kim (1998) • Szulanski (1996)
Ability to transform knowledge	City's ability to absorb the new knowledge into the existing knowledge.	• Fichman and Kemerer (1999) • Kim (1998)
Ability to exploit knowledge	City's capability to incorporate transformed knowledge into its operations to increase the performance of its broadband deployment.	• Cohen and Levinthal (1990) • Szulanski (1996)
Activation triggers	Internal or external events that triggers a city to learn new knowledge.	• Huber (1991) • Haunschild and Ree (2004)
Performance improvement	Outcomes from new knowledge learning and integration	• Lyles and Salk (1996) • Tsai (2001)

Organizational learning and dynamic capabilities research suggest that knowledge is a critical source of competitive advantage, and therefore absorptive capacity as knowledge learning and utilization processes is also important to increase innovation, enhance performance, and gaining or sustaining competitive advantage. Tsai (2001) reported that organizational units in the petrochemical and food manufacturing industries produced more innovations and had better performance when they had higher levels of absorptive capacity. Lyles and Salk (1996), in their study of international joint ventures, found a positive relationship between knowledge acquisition and several performance measures including market share, profits, and improved management skills. In dynamic capabilities research, Kusunoki et al. (1998) found that organizational capabilities viewed as multilayered knowledge influence product development performance of Japanese manufacturing firms. We next look at the three components of absorptive capacity and the role of experience and activation triggers.

Knowledge assimilation refers to routines and processes that allow an organization to interpret and understand new ideas learned from external sources (Zahra and George, 2002). An organization faces several challenges in comprehending knowledge acquired from external sources. For example, external knowledge may have heuristics that depart from those used by an organization (Leonard-Barton, 1995). The tacitness, specificity, and complexity of external knowledge can generate causal ambiguity between knowledge and outcomes which can prevents others from replication (Reed and DeFillippi, 1990). In addition, interorganizaitonal learning reearch also suggests that the ability to assimilate new external knowledge is greater when the two firms share similar systems for processing knowledge measured by similarity in organizational structures, compensation policies, among others (Lane and Lubatkin, 1998).

Once an organization interprets and understands new knowledge, the next challenge it faces is how to absorb the new knowledge into the existing knowledge system. Knowledge transformation involves an organization's capability to develop routines to combine new knowledge with the existing knowledge (Zahra and George, 2002). Internal organization mechanisms that enable knowledge sharing across organization members is necessary for the new knowledge to be integrated into an organization (Cohen and Levinthal, 1990). This statement is supported by findings from Jansen et al. (2005) in their study of financial services firms. Their results suggest that coordination capabilities (e.g., job rotation, participation in decision making), systems capabilities (formalization and routinization), and socialization capabilities (connectedness among members, and socialization tactics) enhance knowledge transformation. In addition, research on interorganizational learning also suggests that tailoring knowledge to fit the specific needs of a recipient organization, active management involvement and training and development of an organization's staff are important for learning (Nonaka, 1994; Lane et al., 2001).

Cohen and Levinthal (1990) emphasizes that the new absorbed knowledge has to be applied for an organization to achieve competitive benefits. Knowledge exploitation refers to an organization's capability to extend its competencies, enhance performance, or increase innovation by incorporating transformed knowledge into operations (Zahra and George, 2002). Some of the outcomes of exploitation processes are new competencies, products, processes, or organizational forms. Cohen and Levinthal (1990) suggests that the ease of knowledge utilization depends on the extent to which an outside knowledge is targeted to the needs and concerns of a recipient firm. The experiences in which two organizations share in solving similar types of problems make it easier for a recipient organization to find applications of the new knowledge, the results supported by Lane and Lubatkin (1998)'s study of alliances between pharmaceutical firms and biotechnology firms.

The ability of an organization to absorb new external knowledge depends on its level of prior related knowledge. This suggests that the development of absorptive capacity is a path-dependent process. Existing capabilities to absorb new knowledge is influenced by past experiences. (Cohen and Levinthal, 1990). Customer interactions, alliances with other firms, and learning-by-doing are some of the ways an organization can gain its experiences (Nonaka and Takeuchi, 1995; Lane and Lubatkin, 1998). Pennings and Harianto (1992) found that experiences with information technology and linkages with other firms influence a firm's decision to adopt video banking.

Then, the interesting question is what forces an organization to develop new knowledge. The answer lies in activation triggers which are events mostly negative ones or even crisis that encourage an organization to learn new knowledge and develop actions to in response to those threats (Zahra and George, 2002). Examples of internal triggers are performance failure, redefinition of an organization's strategy, as well as other forms of organizational crises. External triggers are those events that emerge as changes in an organization's environment including technological shifts, radical innovations, and changes in government policy. For example, Haunschild and Ni Sullivan (2002), in their study of airlines' learning, reported that prior accidents and incidents provoked airlines to learn by finding out the causes of these problems and in turn improving their performance over time through the reduction of subsequent errors. Haunschild and Rhee (2004) evaluated the question of whether firms learn better in response to internal or external triggers in the U.S. automotive industry. In particular, they compared the extent of learning from voluntary recalls as internal triggers and government mandated recalls as external triggers. Their results suggested that voluntary recalls lead to fewer future errors than involuntary recalls partly because automotive companies were likely to engage in shallow learning by developing defensive responses when they involved in mandated recalls.

Despite a growing body of research that examines absorptive capacity in organizational learning and dynamic capabilities literatures, most studies focused on the competitive outcomes of absorptive capacity (Jansen et al., 2005). As a result, little is known about the components of absorptive capacities and the related processes and routines that an organization uses to acquire, assimilate, and apply new knowledge. In addition, previous studies examined absorptive capacity in firms across a number of private industries including the manufacturing industry (Cohen and Levinthal, 1990), the financial industry (Jansen et al., 2005), the pharmaceutical and biotechnology industries (Lane and Lubatkin, 1998), the electronics and IT industry (Malhotra et al., 2005), and the publishing industry (Van den Bosch et al., 1999), among others. Limited research has looked at the role of absorptive capacity in the process that public organizations use to acquire, integrate and apply knowledge in their services.

This paper seeks to address these theoretical and empirical limitations. We apply the model of absorptive capacity to case studies in the context of municipalities learning to build and operate broadband wireless networks. As Eisenhardt and Martin (2000) suggested that although the organizational processes underlying absorptive capacity have some commonalities across various organizations, there are still certain idiosyncrasies in the ways organizations develop and use their absorptive capacities. Our research highlighted processes and issues that a city has to resolve through learning and applying new knowledge in various phases of their deployment.

METHODS AND DATA COLLECTION

Exploratory Case Study Method

We chose two sites as case studies for this work, Chaska, Minnesota and Hermosa Beach, California primarily because they maintain some form of ownership over their wireless broadband network and the provision of service. In addition, these two cities were also interesting in that their networks have been in operation longer than almost any other city in the USA and have some relatively long term data.

The case study method is a research method used for the purposes of capturing holistic detail in natural settings. Yin (2003, p. 13) defined case study research as “A case study is an empirical inquiry that investigates a contemporary phenomenon within a real-life context, especially when the boundaries between phenomenon and context are not clearly evident.” Case studies are considered to be appropriate for theory development and extension, and even falsification (Benbasat et al., 1987; Flyvbjerg, 2006).

The selection of case study as a methodology for conducting this research is appropriate for three reasons. First, case studies have been identified as an appropriate and important tool for the study of information and communications technologies in organizational contexts (Darke et al., 1998). Second, the case study is viable method for studying areas that are underdeveloped in the literature (Benbasat et al., 1987). Third, the case study method is particularly well suited for studying phenomena that cannot easily be distinguished from its context.

The conducting and comparing of multiple case studies is also a preferred technique for increasing the validity and generalizability of the findings as well as theory development and testing (Benbasat et al., 1987; Yin, 2003, p. 46). Inductively generalizing from a single case study is epistemologically problematic and runs the risk of being easily falsified by a single counterexample (Benbasat et al., 1987). However, this risk can be partially overcome by conducting multiple case studies of similar case studies to identify recurring patterns and make general propositions.

Data Collection

For each case study we collected evidence from multiple sources. These sources included city documentation, archival records, and interviews. Documentary data will serve to build the “picture” of the state of the city network under observation, the changes it has gone through, and provide possible pointers to other sources of evidence and questions to ask. Interviewing was used to follow-up on questions arising from the archival, documentary, and observational data. For each of our two case studies we interviewed two or three city officials. We also examined press releases and public discussion of the network.

CHASKA WI-FI DEPLOYMENT

Chaska is located 20 miles southwest of downtown Minneapolis in Minnesota. According to the metropolitan council estimates, Chaska's population was 22,467 with 8,194 households in 2005. The estimated per capital income was $44,137. About 3.4% of families and 4.7% of the population were below the poverty line. The city's area is approximately 14.5 square miles.

Chaska's Broadband Experience

Prior to its Wi-Fi broadband deployment, Chaska began its broadband service project referred to as Chaska.net (www.chaska.net) in 2000 as part of a partnership between the city and the Chaska school district. The mission of Chaska.net is:

"*Through use of existing fiber optic and wireless technology, develop a high quality, low cost, high speed Internet service for Chaska's public, business, and residential entities, thereby enhancing Chaska's vision of being a connected community.*"

The school district entered into an agreement with the city in which they paid all the costs associated with the construction and ongoing maintenance of the system with the condition that the city owns the fiber lines. The agreement was beneficial for the school district because it allowed them to pay lower costs for their broadband access than they were paying to the private operator. Around the same time, the city also partnered with KMC (now CenturyTel) by granting KMC the right to utilize the city's right-of-way in their fiber optic installation with the agreement that KMC would construct a public fiber network to serve five city facilities including the city hall, community center, fire station, municipal services building, and the Carver county courthouse. The city received a grant from 3COM to purchase equipment to bring Chaska.net online and the city assumed its new role as an internet service provider to the school district.

Later in 2001, the city began expanding their high speed fiber network service to Chaska businesses. By the end of the year, the city had seven private businesses signed up for the service. The small number of business customers was due to the high costs of $500 to $800 a month. In 2002, the city decided to expand to more affordable broadband services through a line of sight 2.4 GHz point-to-multipoint wireless network. This new technology allowed the city to charge business customers less, between $125 to $365 per month. The antennas were installed at the city hall, community center, and the water tower. In 2003, the service was expanded to other cities nearby including Victoria, Waconia, Norwood, Young America, and Shakopee.

The third phase of Chaska.net is its Wi-Fi mesh network to provide broadband access to residential customers. According to Mr. David Pokorney, Chaska's city manager stated, "We were getting a fair number of residential customers saying we would be interested in getting the service" In addition, Mr. Noel Graczyck, Chaska's administrative services director added "This third step follows one of the missions of Chaska.net to provide a low cost residential Internet service that will provide a greater access for the community by either reducing price point or providing speeds that were improved and faster than basic dial-up services."

The Beginning of Wireless Residential Services

In early 2004, the city information systems manager at that time, Mr. Bradley Mayer, began exploring and evaluating suitable technologies for wireless access to residential users. In particular, he narrowed his choices down to three products: Metricom/Richochet system, Motorola canopy, and Tropos Wi-Fi mesh. The city chose Tropos Wi-Fi mesh system over the other two alternatives because Tropos system is an open system while Metricom/Richochet system had slower speed of 250 Kbps and was considered a dead technology and Motorola canopy was a proprietary technology. The equipment and software investment was projected at $535,000 with the assumptions that (1) the city will bill customers for the service through their utility billing system, (2) the city will provide modems to customers at no cost, and (3) the city will provide customer service support through hiring an additional staff person.

In April 2004, the city council approved the network with 230 Tropos 5110 routers installed on city-owned assets predominantly street lights through out the 14 square miles of the city. Backhaul was installed at 36 locations around the city using the existing city's infrastructure including the point-to-multipoint wireless links and fiber network. The installation was completed in June 2004. Table 3 summarizes the annual subscriber base and other key information of Chaska.net services.

Table 3. Chaska.net Subscribers and Services

• **SUBSCRIBERS**		
YEAR	**NUMBER OF SUBSCRIBERS**	
2004	1,853	
2005	1,889	
2006	2,051	
2007	2,289	
• **SERVICES**		
Residential service	$16.99 per month	Speed up to 1.2 Mbps
Business service	$24.99 per month	Speed up to 1.5 Mbps

Through out the course of the operation of the system, there have been several events that triggered the city to acquire new knowledge to allow them to address those issues or to improve the overall performance of the system. We highlighted those events in the following discussion.

Testing Period

During the system built out, the city did some testing to make sure that the system worked well. “We are fairly confident it is going to work pretty well. I can sit in my office and log in to an access point a quarter of a mile away pretty reliably, and that is through a brick wall, trees, another building and I am still getting about 1.5 Mbps” said Mr. Bradley as reported in Blackwell (2004). The test period lasted for five months from July to November 2004 with 1,200 customers signed up for free access to test the service. Throughout the test period, the city, particularly Mr. Mayer and his two other staff members in the information systems department, had to address several issues to get the system to work. Mr. Graczyck explained, “We were not just deploying Tropos products. We had to figure out how to backhaul from gateways through fiber resources. We also had to ensure that we had some wireless backhaul in the area that we did not have fiber access. We had to work out some issues that we had in terms of inconsistent coverage. During that time, we were getting a lot calls from people saying that this does not work.” Mr. Pokorney concluded in his interview reported in Hughlett (2007) that “In hindsight, that was a mistake. That is because 1,000 households made for too big of a test sample, considering the new network still had bugs. A lot of Chaskans peppered the city with complaints. A smaller sample size would have been easier.”

Helpdesk and customer service

The city employed two to three temporary staff members to provide phone support to subscribers. As the number of subscribers grew, Chaska realized that the city did not have the resources to fully support customer calls. One of the early customers of Chaska.net, Mr. Ben Palmby said “No one ever answered the phone. Their customer service was horrible. At first, Chaska.net was pretty reliable. Then after about six months, the service began slowing down, pages would take 20 minutes to load and sometimes did not work at all.” Mr. Pokorney explained, “We originally thought that we could operate the helpdesk and be open 8 hours a day and we found that customers wanted it to be available more time than that. We were not open during the right hours. We would get certain peak times like 5:00 p.m. or 6:00 p.m. we would get overwhelmed with calls. But as we looked back, we should’ve realized that were not going to be good at customer service.”

According to Hughlett (2007), Chaska had 1,100 residents signed up to use the service in 2005 but 800 of those left.

Rapid Change of Technology

Throughout its deployment of Wi-Fi mesh technology, Chaska has faced a number of challenges with the system. First, the city realized that Wi-Fi mesh is not a plug-and-play technology. It requires significant fine-tuning according to the city's various topologies, buildings, street conditions, and dense tree neighborhoods. The city started out with 230 routers in early 2004. In August 2007, the city has 378 routers, with 148 routers added or a 64% increase from the original installation. Mr. Mayer admitted in his interview reported by Hughlett (2007) that "It took about a year and a half before we felt we really had a good handle on the network. There were a lot of preconceived notions that you could just blast Wi-Fi signals through walls and trees and everything. We discovered that wet, leafy trees absorb radio signals. Wi-Fi signals don't pass through stucco like they did wooden walls." The city also found that if the number of hops grows beyond 3 or 4 hops to a gateway, the speed significantly drops down to dial-up grade service or even worse. This has become a problem in neighborhoods that are a long way from where gateways are located. In summer 2005, the city replaced the routers in one neighborhood with the newer 5210 Tropos routers. According to Mr. Graczyck, that neighborhood experienced improvement in the quality of signal coverage because the 5210 technology works at different frequencies and it supports greater distance. Second, the technology was new at the time the city begun its deployment. "We are being one of the first or even the first to do a complete city Wi-Fi. There were still bugs that need to be worked out. We had a number of issues that hardware suppliers and software suppliers had not really thought about." said Mr. Pokorney. During the first year of operation, Chaska learned that "to get good residential service, the original standard that Tropos had was every 5th or 6th router needed to be connected via gateway. We found that it probably needed to be closer to every 4th radio." Finally, Wi-Fi mesh technology had been improving at a rapid rate between 2004 and 2005. Only in one and a half year into its operation, the city replaced all of its Tropos 5110 routers with the newer 5210 ones. Mr. Graczyck explained, "Tropos created resolutions for some of the problems that we initially saw on 5110. We would be working on a problem and then we called Tropos and they said that the problem had been resolved in 5210 model, or that is not available in 5110 but it is on 5210. There is a bit of frustration on our part. We were only into this for a year and a half, the new features that we help identify and we need were not going to be available in 5110." Since then, "Tropos has a new product called 5320 that we continue to evaluate." said Mr. Chad Palm, the current IS manager and Internet service manager.

Departure of Key Personnel

Brad Mayer was the lead personnel through the city's testing and deployment periods. He left Chaska in March 2006 to join EarthLink in Atlanta. Dave Pokorney stated, "It was a big deal and it was probably one of our ongoing challenges. There are limited number of people who understand how Wi-Fi system works." Later around July or August 2006, Chaska also lost another employee, Mr. John Gammons, to EarthLink. Mr. Gammons worked closely with Mr. Mayer and became knowledgeable with Tropos products, backhaul products and the servers that support the operation center. Mr. Chad Palm was hired in late 2006 after Mr. Gammons left and in order to get him up to speed with Wi-Fi mesh technology, the city sent him to a training course with Tropos. According to Mr. Palm, "It was a very good week of exploration of equipment, how to configure 5210, how to perform installation of 5210, and what optimal deployment looks like from a geographical standpoint." At present, Chaska's information system department has four full-time staff with Mr. Palm as the IS manager for the city and Internet service manager for Chaska.net and three other support staff. Around February 2006, the city also partnered with Siemens for take care of the network operation center and customer support.

Some Unexpected Technology Solution Needed

Chaska also found out after deployment that a small number of users who consume a lot of bandwidth through some applications such as peer to peer file sharing system can downgrade the quality of the entire network by consuming a lot of bandwidth. To address this issue, the city has to employ a solution from Ellacoya networks that allows the city to perform bandwidth shaping and control bandwidth usage of the users on the system. "This is one of the things that we did not know that we needed and it was not part of the things that we initially included." said Mr. Graczyck.

Solution integration Challenges

Chaska needed to integrate solutions from multiple partners to provide Internet service through their Wi-Fi mesh system. At present, Chaska.net has at least nine partners in their Wi-Fi mesh system including Tropos, Pronto, CenturyTel, First Mile Wireless, PepLink, Creature Works Labs, Residential Computer Solutions, Ellacoya Networks, Siemens, and Time Warner Telecom. To understand the intricacies of the implementation of Tropos products, Chaska has hired outside consultant Jay Gustafson, President and CEO of First Mile Wireless (an authorized reseller of Tropos) who is an expert in wireless technology and Tropos products. With Tropos at the core of the entire system, the city had to integrate solutions from various vendors. Mr. Graczyck stated "We not only had to deal with finding an authentication product, we had to find one that could handle the scale of customers that we were anticipating but could also allow us to put up the portal page that we considered an electronic gathering. We also had trouble with the authentication system so we had to take it down and we left the system open while we worked with Pronto to bring the authentication controller back on again. We also were doing a lot of things to get different pieces in place including an e-mail server, web servers. We had to get the customer premise equipment (CPE) programmed and make sure that they could connect to the mesh and they could connect with the authentication product."

HERMOSA BEACH WI-FI DEPLOYMENT

Hermosa Beach is a city in Los Angeles County, California, United States. The population was 19,435 according to 2006 census data estimates. The city is located in the South Bay region of the greater Los Angeles area and is one of the three Beach Cities. It is bordered by Manhattan Beach to the North, and Redondo Beach to its East and South. The city's area is approximately 5.9 square miles.

As of the 2000 census, Hermosa's population was 18,566. There were 9,476 households, and 3,553 families residing in the city. The per capita income for the city was $54,244. About 1.7% of families and 4.6% of the population were below the poverty line. According to the City Manager, Hermosa Beach is a very high income area. "Everyone has broadband internet here. There is no digital divide."

Why Building a City-Owned Wireless Network?

The current city manager of Hermosa Beach, Steven Burell, stated, "We did not build this network out of necessity. We build it because we could. For us there was no necessity. There was no passion. There was no public outcry. The public did not demand we build this network."He went on to say that the citizens of Hermosa Beach had both a lot of choices for broadband internet service and the household income to support the monthly costs.

The original idea for the city to build and manage the network came from one of the city council members who also happened to be an owner of a local bakery. Mr. Keegan had two years experience with a Wi-Fi hotspot in his own local bakery and café. In interviewing Mr. Keegan, who is now the Mayor of Hermosa Beach, he concurred and stated, "Yeah, it was my idea. There was this engineer guy who got laid off and hung around my bakery. We built a hot spot for the bakery and then we got thinking we should build one for the city." Mayor Keegan gave two principal reasons for building the network. He stated, "When we first came up with the idea for a citywide network we did it because there were only two choices, Cable and DSL. Both provided poor service, especially video and were really expensive. We knew we could do it better and cheaper." The second reason he gave is that he felt strongly that broadband Internet should be treated as a public service or utility and offered by the city, paid for by city tax dollars. He stated, "I likened it to library use. It is another service or amenity, like a library or park, gives to the public to make your town a little better." In an earlier statement he said, "I find it interesting that it is ok for our local library to loan out books, commercial movies, and many other informational items for free, yet Barnes and Noble and Blockbuster are not trying to stop that program. Under this bad for business argument, we should close the libraries and buy all our books from Amazon.com and Barnes and Noble." Later Mr. Keegan stated, "The vision is to provide the Internet to the city like other basic services, as a public amenity and convenience… I think the people want the access to information and want it at the lowest possible cost. Government is in the unique position to do that best. Access to information is critical to homeowners and businesses, this is just another service that local government can provide to improve the daily lives of their constituents."

Getting It Built

Both the City Manager and the Mayor see themselves as having been the driving force in the construction of the network. While Mr. Keegan had the hotspot experience and the idea for the network, Mr. Burrell has been a co-implementor since before the first Request for Proposals (RFP) was written. Perhaps most interestingly, both men stated that they have no training in information technology issues and have no technological skills that have not been self taught. The City Manager stated, "No, I have no technological background. I'm a manager. I'm a generalist." Mr. Keegan said, "I'm a business owner, a manager. I just like technology." Both men stated strongly that building and maintaining the network had been very easy. Mr. Burrell said, "The city just did this on the fly. We didn't hire any consultants. We just did it."

In 2003 the city of Hermosa Beach put out a Request for Proposals (RFP) to build their wireless network. Both the City Manager and the Mayor stressed the fact that there were no models "out there" for them to emulate concerning city-sponsored wireless programs. They stated that they did all of the fact finding, writing of the RFP, evaluating the bids, and making a decision without training, experience or consultants. Mr. Burrell stated, "Michael and I went to two conferences on municipal wireless about 5 years ago, one locally and one in Santa Clara. We came home and wrote our own. We circulated it around the city employees, including the IT staff, and then we put it out there…Our RFP was only for building the network, not running it. We got 7 bids ranging from $35,000 to $200,000." Mr. Keegan agreed and stated, "There was no RFP model. No other cities were doing this at the time. There was nothing to follow. I got a copy of one RFP from a university professor who had written and RFP for a wireless dormitory project. I used some of that language, but for the most part, I just wrote the RPF myself."

The city evaluated proposals from system integrators who wanted to use Wi-Fi systems from several vendors including Strix Systems, Tropos, BelAir, Cisco, among others. The City eventually chose the lowest bid from the company LA Unplugged. The City Manager stated, "We eventually went with a company called LA unplugged. They were just the lowest price. They bought the equipment from Strix Systems (http://www.strixsystems.com) and assembled the boxes and the network. After that they provided one year of operational maintenance. I think the company folded since then."

The Network

On August 11th 2004 Hermosa Beach, California launched the first phase of what was to be a free citywide Wi-Fi service (http://www.wifihermosabeach.com). Phase I of the citywide plan was expected to cover approximately 35% of the City, providing free wireless Internet service to the downtown, city hall, and adjacent neighborhoods. In Phase I of the Hermosa Beach Internet signal deployment, 9 access point/nodes were placed along Pier Avenue with coverage planned to extend to 35% of the land area in the city. Those outside this initial area could have tapped into the signal if they had line of sight to the city hall.

Hermosa is covering the costs of running the network via advertising from merchants on the splash screen. Mr. Keegan stated, "We put in a system that cost $35,000 which contained a one year maintenance agreement. We have sold over $1,500 per month in local icon advertising on our forced homepage. Our city is getting rid of two T1 lines that currently are in use at City Hall at a cost of $1,900 per month. The Wi-Fi project is buying bandwidth wholesale from a local ISP and receiving 6 Mbps for $600 wirelessly. Currently we are saving $1300 per month on bandwidth charges and pocketing $1500 a month from our advertising model."

The project uses a multi-radio technology from Strix Systems. The radios are based on 802.11g standard with speeds up to 54 Mbps. At the time of Hermosa Beach's deployment, Strix Systems did not have outdoor nodes available so the city had to adapt the indoor nodes for outdoor use.

According to both the mayor and the city manager, phase one of the city's wireless project was the only completed phase of the project. Currently phase one is operational, but at a reduced capacity. Mr. Burrell stated, "The network is about 4 years old. It is a mesh system. Now it covers about 20% of the whole city. It mostly covers a mile strip right along the beach and a small residential development. It's a roof-top system. We have only three towers. We knew the limitations of the equipment." He also characterized the network in the following manner, "Our network is really just intended for recreational use. It's not made for business use. It's made for tourists and people sitting in cafes and on the beach. The network doesn't compete with FIOS or any other services. It's just really a big hotspot." Mr. Keegan characterized the network as, "We have about 100-200 users each day. We cover 3,000-4,000 households. However, we really only cover about 25% of the city…The network really serves the city hall."

Organizational Changes and Learning

Mr. Burrell and Mr. Keegan felt that Hermosa Beach had significant advantages providing for the success of phase one of the network. Mr. Burrell stated, "Our advantages were that we were small, nimble and could innovate quickly." Both felt very strongly that creating and deploying the network was very simple.

One year after the maintenance contract with LA Unplugged, the city ended the contract and did not renew it, nor seek additional maintenance contractors. The Mayor said that he had done all the maintenance himself for about two and a half years. Mr. Keegan stated, "We have no maintenance contract. We have gone for two and a half years without a contract. We have some guys come by every 6 months. There is no maintenance. It's like running a router from your home. How much maintenance is that?"

While the city manager expressed the same lack of contractor for maintenance, he also expressed that the city had suffered under the lack of proper maintenance. Mr. Burrell stated, "After the maintenance contract with LA Unplugged ended, we figured we could do without a maintenance contract. We'd just do it ourselves. That was not a good idea. It was just a manpower issue. Fixing the network and the boxes was simple and just called for easy solutions. We just had no help. Since then we've hired an on-call contractor to manage the maintenance on the network. They don't do much, but we're glad we aren't getting the calls on that anymore."

Both the mayor and the city manager stated that in the last year that had hired a maintenance contractor who was on-call for network hardware problems. Mr. Burrell expressed relief that this contract alleviated some of the support burden the city had been carrying. Mr. Keegan expressed that the contractor did very little and was hardly needed.

In terms of technical support to the users of the network, the city offered little. The city asked its employees at the time, two office assistants and two IT employees to "answer the phone" if there were any calls about how to use the network. Mr. Keegan stated, "We had a couple of local computer guys that volunteered their help. Secretaries pitched in to handle some calls. We trained them." Mr. Burrell stated, "The city has only two permanent IT employees. These have changed over the years, there has been some turnover. These IT people helped by reading the RFPs and sorting through the eventual bids."

Mr. Keegan stated that since the network was free, the city would be depending on the users to volunteer in many ways to support the network and other users. The city has a support forum (http://www.wifihermosabeach.com/support/index.php) for users to post questions and others can answer them. He said that a lot of the technical support burden was shifted to the users themselves. Mr. Keegan stated, "It was not a "full-service" network. Each user had to learn how to connect themselves. The class taught people to install cards and passive antennas. Gave training on it and put it on local cable access. We were going to get volunteers to teach classes. There were lots of volunteers . We had no shortage of instructors. People had to have a little gumption. Interested parties had to figure it out." Mr. Burrell stated, "We really didn't offer much in the way of technical support. Out IT guys took all the calls initially. This was just around 20 calls a week at first. Since then it has really tapered off. We offered some classes too. These were really well attended."

Political Issues

The city of Hermosa Beach only completed phase one of their city-sponsored wireless project. The network covers somewhere between 20% and 35% of the city. This is the result of a vote made by the city council that decided not to support or fund the second phase of the wireless project for the citywide deployment.

The city manager stated that initially when the project was first proposed there was an even split between those council members supporting the project and those opposing the project. One council member withdrew because he worked for the local cable company and felt there would be a conflict of interest in his participation in the deliberations and subsequent vote. This allowed the phase one measure to pass by a slim margin. Mr. Burrell stated, "There have been some political issues. At first the council was split 2-2 on whether we should have our own network. With some heavy negotiating we were able to convince one member and it went 3-1. We went forward with stage one. That's what we've got now, just stage one, the 20% coverage."

After stage one was implemented the city manager and mayor went back to the council to request support and funding for stage two, complete city coverage. Stage two proposal was not supported. Mr. Burrell stated, "We then had to go back to the council and they said no this time. So we never got to expand the network. The cable company was opposed but the phone company was not." Mr. Keegan described the situation in which the telecommunication incumbents lobbied the city council members and eventually convinced them that phase two was a poor investment of the City's money and effort. Mr. Keegan said, "We had a pretty good deal with one of our initial vendors. They were going to offer us all of the radios for free. The cable companies got involved. Some independent wireless people got involved. They sent emails to our council people and got them to turn against us. They said the technology was inferior and obsolete. I had a real battle with another councilman. He claimed that it's a horse and buggy technology. I tried to expand the network throughout our town, but the Telco and Cable industry got to one of my fellow council members and got him to go over to the dark side."

In speaking of the future of the network, both Mr. Burrell and Mr. Keegan believed there would never be a full rollout of a complete citywide network. From Mr. Keegan's point of view, since the last council election, more of the present council members were in favor of the network, but it was no longer needed. He explained that with so many new options for broadband Internet in Hermosa Beach, such as Verizon's FIOS fiber system, that the need for city-sponsored wireless was disappearing. Mr. Burrell agreed and stated, "Verizon just laid fiber throughout the city. The speeds are incredible and with the bundling it is not even that expensive."

DISCUSSION

The cities of Chaska and Hermosa Beach began their Wi-Fi planning in 2003 and deployed the system in late 2004. Over the course of their deployment, the two cities have gone through different growth and development paths and had to overcome various expected and unexpected issues. Table 4 provides a summary of the key features of both projects.

Table 4. City of Chaska and City of Hermosa Beach Wi-Fi Deployment

FEATURES	CHASKA	HERMOSA BEACH
Network technology	Wi-Fi mesh from Tropos	Wi-Fi mesh from Strix Systems
Backhaul	Combination of fiber and wireless connections	Wireless connections
Scale	Citywide network with 378 routers covering 14 square miles	Hotspot with 9 routers covering downtown, city hall, and selected neighborhoods
Services	Paid services at $16.99 a month for residential grade service	Free service
Financial model	Supported by subscriber fees	Supported by advertising revenues
Growth	Ongoing growth of subscribers and has potential for network expansion	The network has been considered completed with no future growth
Partnerships	Tropos, First Mile Wireless, and Siemens are the key partners with several other partners providing related solutions for Internet services.	LA Unplugged was the only key partner
City players	IS department has the key role with the support from city manager and administrative services manager	IS department has little involvement. The mayor and city manager play the key role in the project
Prior experience	The city had six year experience being and internet service provider to local school district and other businesses	The mayor had two years experience in providing a hotspot in his own business. Neither of the two key personnel had any previous IT network experience.

Although Chaska and Hermosa Beach cases confirm the absorptive capacity model and the relationships between prior experience, learning, and performance improvement, our case study data indicate several areas where the model might be extended to enhance the understanding of the complexity of learning process involved in city broadband projects. We added five constructs to the model illustrated in the revised model in Figure 2: *dynamic of technology development*, *partnership commitments*, *external knowledge*, *learning- by- doing*, and *politics*.

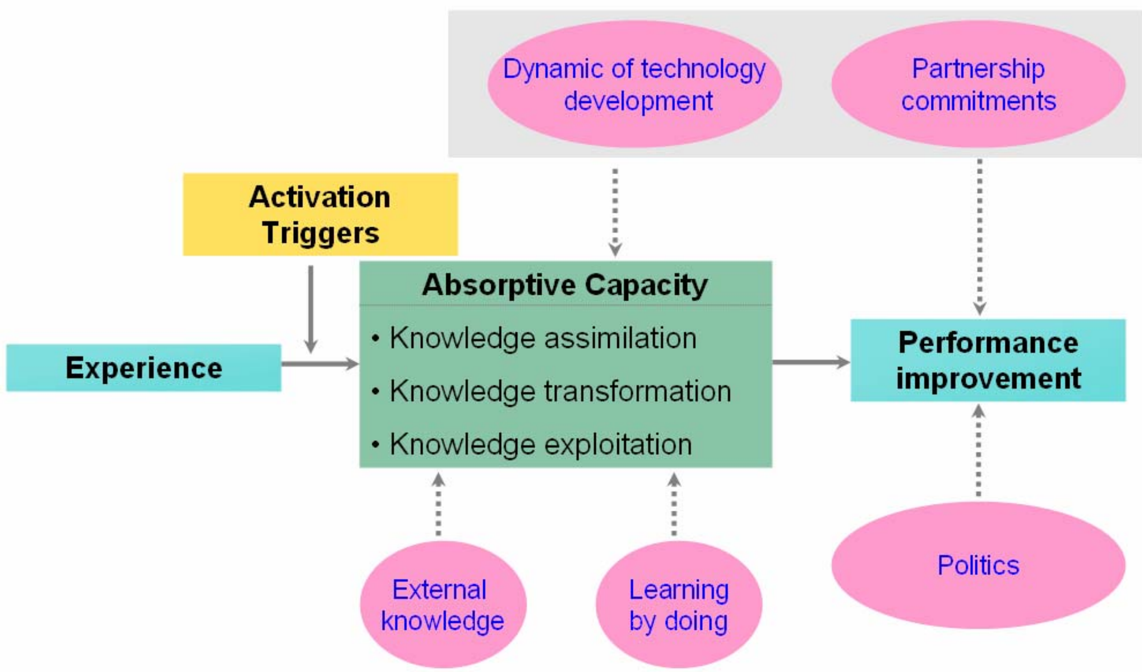

Figure 2. An updated absorptive capacity model of organizational learning in citywide broadband infrastructure projects

Dynamic of Technology Development

In 2004, Chaska and Hermosa Beach were considered pioneers in using Wi-Fi mesh technology for citywide broadband networks. Most of the technologies were still under development. There were a few industry players who offered Wi-Fi mesh products at the time. In addition, vendors had limited or in some cases no experiences in deploying Wi-Fi mesh in a large geographical area. In Chaska's case, Tropos had previously performed Wi-Fi mesh deployment in selected applications including public safety, police, and fire usage. Similarly, Hermosa Beach had to adapt routers from Strix Systems that were originally designed for indoor use for their outdoor project. Later on in December 2004, Strix Systems introduced weatherized rugged routers with better coverage and improved power transmission specifically designed for outdoor use. If the second phase of Hermosa Beach Wi-Fi project were to be approved by the city council, the city would have had to go through replacing some of the existing routers for the newer and better models. Chaska went through the upgrade like this when Tropos came up with its 5210 routers (801.11g) which are far better than 5110 model (802.11b) in terms of capacity and enhanced multi-use network capabilities in April 2005. Chaska evaluated the performance of Tropos 5210 by employing a small number of these routers in a topological challenged area. Finally, the city decided to upgrade more than 200 of its Tropos 5110 routers with a better Tropos 5210 within only one and a half year into deployment.

The continuing development of Wi-Fi and other related wireless technology has implications on learning and performance. First, cities have had to keep pace with technological development and have had to learn and evaluate new technologies that might offer better features or solve some of the current issues the cities experience. In addition, as early adopters of the new technology, cities also involved in co-learning with their partners to identify problems with the current technology with the intention that the vendor partner will resolve these issues in the next technology generation. As a result, cities might not get the optimum performance that the technology has to offer in its current generation.

Partnership Commitments

Chaska and Hermosa Beach pursued different strategies in deployment, management, and ongoing maintenance of the networks. Chaska chose to work closely with Tropos and their staff to implement the Wi-Fi mesh network and integrate other solutions to deliver Internet services. All three Chaska key personnel whom we interviewed shared similar views of the strong partnership from Tropos. Mr. Graczyck summarizes Tropos's commitment as follows: "The thing that I have to give Tropos a lot of credits is they really step up and provided us access to a lot of their systems engineers and some of their key field people to help us with the deployment at the time it was certainly one of the largest deployment that they had done and also the largest deployment of varying topologies."

In addition to a partnership with Tropos, Chaska also enjoyed a long, ongoing relationship with First Mile Wireless, who has partnered with the city on a prior line of sight wireless service for businesses. First Mile Wireless CEO, Jay Gustafson, is very knowledgeable in wireless technology and he has provided extensive assistance to help the city understand Tropos technology and how to transform the knowledge into practice including frequency allocations, effective coverage of routers in the field, and adaptation to topologies and challenges in the implementation environment.

Hermosa Beach used a hands-off approach in their Wi-Fi mesh deployment. The city outsourced the entire system integration activities to LA Unplugged. LA Unplugged committed to Hermosa Beach through a written contract agreement. Since the city implemented only nine routers, the project did not appear to experience any major issues during installation and deployment.

Strong partnerships offer partners the opportunity to learn from and about each other. The notion of partnership commitment in our research relates to trust in strategic alliances and joint venture research (Koza and Lewin, 1998; Lane et al., 2001). Kumar (1996) defined trust as dependability by the partners and each partner is interested in the welfare of each other. Successful alliances and joint ventures exhibit trust between partners. Trust is also important to absorptive capacity because it stimulates open sharing of valuable information and tacit knowledge (Inkpen and Beamish, 1997).

Roles of External Knowledge and Learning-by-doing

The rapid change of Wi-Fi mesh technology and the limited experience in Wi-Fi deployment in the industry requires a city to try out knowledge learned from the industry, evaluate the performance, and readjust their knowledge based on feedback from actual experience. The implementation of Tropos routers in Chaska illustrates this point. Chaska learned from Tropos that every 5^{th} or 6^{th} routers needs to be connected via a gateway to backhaul connection. However, after implementing routers according to this standard rule, the city experienced problems in signal strength and unacceptable speeds leading to unreliable and low quality Internet services. This is because some areas in Chaska had dense tree lines and green vegetation, while other areas had no gateways close by. In addition, some materials used to build houses can also block out signals. The city worked closely with Tropos to resolve the issues by limiting the number of hops to 3 to 4 hops, adding gateways, and revising frequency plans. Chaska went through a process of iterative knowledge discovery and had to adjust knowledge previously learned according to various idiosyncrasy conditions of the city.

Mr. Graczyck described Chaska's learning experience as, "A lot of knowledge that we have obtained has been through our efforts of trying something, see how it is performed, looking at alternative solutions, trying these alternative solutions and working to create what is the best combination to meet the needs of a particular area… The first two years we continue to make a lot of … discoveries. We know that it is not just drawing a circle and positioning these radios but we also have to take into account the topology."

The knowledge discovery process not only benefits Chaska but it also significantly benefits Tropos. Mr. Ron Sege, president and CEO of Tropos, in his comment article on muniwirless.com said "The lessons learned in deploying Chaska spawned many mesh software innovations and a new class of analysis tools that will dramatically decrease the time needed to optimize networks in the future."

The relationship between Tropos and Chaska and the mutual benefits that they share in new knowledge creation relates to the collaborator supply chain relationships in Malhotra et al. (2005). In their exploratory study of RosettaNet consortium in the IT industry, they found that firms that engage in collaborator type partnerships achieved high knowledge creation by exchanging privileged information and engaging in joint decision making.

Politics

Politics appeared to be the central problem that prevented Hermosa Beach from achieving its goal to have a citywide Wi-Fi network. Different viewpoints have been expressed on the question "Should a city deploy its own broadband network?" Proponents of the idea would argue that broadband infrastructure has become one of the basic infrastructures like water, electricity, sewer and should be operated by a local government to protect public interest. Some other supporting reasons include enhancing business development, improving economic development, closing the digital divide, and building stronger community. Strong opponents of the idea are from telecommunications and other incumbent firms who are concerned about the unfair competition from local government.

Since city Wi-Fi network projects have to go through extensive scrutiny from multiple constituents and get approval from the city council, politics can lead to inevitable outcomes like in the case of Hermosa Beach in that the network is now considered complete with only 20% coverage of the city.

CONCLUSION

This study applies absorptive capacity theory in the context of municipal deployment of Wi-Fi networks. We used an exploratory case study approach and chose the city of Chaska, MN and Hermosa Beach, CA, pioneers in city Wi-Fi deployment using Wi-Fi mesh technology.

This study adds new knowledge to the absorptive capacity research by providing a better understanding of how public organizations learn to acquire new knowledge and the influence of absorptive capacity on performance improvement. We also extend the absorptive capacity model by introducing constructs that influence absorptive capacity and performance supported by the qualitative data from interviews with key personnel and archival data. These constructs include the dynamic of technology development, partnership commitments, the roles of external knowledge and learning-by-doing, and politics.

The study also provides insights and learning lessons for cities that are in the process of planning and deployment. It also offers more realistic expectations around Wi-Fi deployment taking into consideration that the technology is not a plug and play technology and that considerable efforts are needed to integrate the technology with other solutions to deliver broadband Internet services as well as to configure the system according to topologies, street conditions, buildings, density of trees, among others.

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