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Wireless Cities: Local Governments' Involvement in the Shaping of Wi-Fi Networks

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This study examines the role of local government in the deployment of municipal Wi-Fi networks from the perspective of path dependency and social shaping of technology. By employing a case study method, the study investigated ways in which municipal networks in three cities in the United States were constructed and operated. The study found that the technology models developed from each city's past experiences in communication technologies played an essential role in the rollout of the current Wi-Fi networks. It also uncovered that social and political factors accounted for the different characteristics of each city's network implementation.

Lately, local governments are increasingly involved in Wi-Fi network deployment, ironically, in the era of deregulation and privatization of public utilities (Bar & Park, 2006). Among the current forms of local governments' deployment of Wi-Fi networks, of most prominence are citywide Wi-Fi networks driven by the local governments' aim of building a wireless city. Taking advantage of the recent development of Wi-Fi technology, local governments proclaimed various goals of the network deployment including: boosting local economies by attracting businesses, improving the effectiveness and efficiency of public service delivery, serving the underserved areas through an alternative network, or generating additional revenues by making use of existing infrastructures as a way of achieving economies of scope. Moreover, in the process of building Wi-Fi networks, local governments played a variety of roles as an infrastructure developer (see Gillett, Lehr, & Osorio, 2004).

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It is not a new phenomenon for local governments to participate in the deployment and operation of telecommunications networks or public utilities in the United States: Local governments' provision of public utilities has more than 100 years' history (Bar & Park, 2006). However, given overall deregulation and privatization, it is obvious that the recent trend of local governments' involvement in Wi-Fi networks will change not only the structure of the broadband Internet service market, but also the ways in which people access the Internet. Despite similar rationale and goals of municipal Wi-Fi networks, implementations and outcomes have not been identical. One question to be addressed is what factors affect the different outcomes from municipal Wi-Fi networks. To answer this question, this study examines the factors that affect local governments' implementation of Wi-Fi networks. The next section discusses theoretical perspectives on local governments' Wi-Fi networks. Then, after a description of the method of study, case studies from three cities are examined.

Theoretical Perspectives on Local Governments' Wi-Fi Networks

To explain the factors that influence the implementation of municipal Wi-Fi networks, this study employs two theoretical perspectives: path dependency and social shaping of technology.

Path dependency is expected to provide a useful explanation of the local governments' implementation of Wi-Fi networks. In explaining the evolution of technology and technical standards, economic historians claim that outcomes would be comprehensible by examining the related sequence of previous historical events, which leads to critical moments or junctures (Arthur, 1994; Rosenberg, 1982). Path dependency also posits that, in the course of technology development, there are four features that individuals and organizations generate (Arthur, 1994): 1) large set-up or fixed costs for a given technology; 2) learning effects by using the technology; 3) coordination effects between the technology and existing technologies or established infrastructures; and 4) users' expectations toward the technology. Integrated with these features, once a technological trajectory is selected foreclosing others, it is hard to reverse the trajectory because of the lock-in effects and social inertia, as evidenced by the development of the ''QWERTY'' keyboard system. Put simply, the main proposition of path dependency is that ''history matters.''

The relevance of path dependency to municipal Wi-Fi networks is the assumption that previous experience of local governments in public utilities or telecommunications networks may provide a cue for the explanation of local governments' involvement in Wi-Fi networks. Early history of local governments' activities in those areas since the dawn of the twentieth century may predict their current activities in Wi-Fi networks. As Nye points out, ''technological change creates new challenges and opportunities for social and political organizations, but the response to those challenges depends on history, culture, institutions, and paths already taken or forgone'' (2002, p. 2).

An important theoretical concept related to path dependency is ''technological paradigm'' (Guthrie & Dutton, 1992), which refers to the widely accepted basis for the solution of the puzzles of technology development. It is assumed that local governments would cope with deploying Wi-Fi networks ''by viewing the project as analogous to existing exemplar technologies with which they were familiar'' (Guthrie & Dutton, 1992, p. 583). In this study, the term ''technology model'' is used instead, which seems to be clearer and more specific, although the meaning of technological paradigm is maintained. Technology model is used as a local government's perspective toward the Internet and information technologies as a good; whether a local government perceives them as either a public utility or a private good.

A second perspective is the social shaping of technology or social constructivist approach to technology (Bijker, Hughes, & Pinch, 1987; MacKenzie & Wajcman, 1985), which claims that the evolutionary path of a technology is not predetermined by the technology's inner logic, but rather influenced by social, organizational, political, economic, and cultural factors that surround the technology. Emerging in the 1980s as a counter-argument against the then-prevailing technological determinism, the social shaping of technology posits that technologies should not be treated as a given; instead the broader institutional and societal context should be taken into account (Williams & Edge, 1996). However, the perspective is not a simple ''social'' determinism. It emphasizes that social environments shape particular paths of a technology as much as the technology affects society, organizations, and individuals (MacKenzie & Wajcman, 1985). The perspective pays close attention to the role of human beings, not only technology suppliers but also users of a given technology, in the continuous interactions of various social and technical elements. The key question of the perspective then can be how individuals and institutions construct the design and evolution of a technology in question.

Social shaping of technology provides important policy implications (Williams & Edge, 1996). Impacts of government's intervention in the early stages of technological innovation for the purpose of meeting societal goals can lay the groundwork for the routes of technology development. For instance, whether government adopts a proactive policy or a passive stance for a given technology may facilitate or deter the development of the technology. Moreover, policies on technology development are largely dependent upon the retrospective assessments of the costs and benefits of technologies already designed and developed (Williams & Edge, 1996). In this regard, the social shaping of technology is closely related to path dependency.

The perspective comes with some drawbacks. Although it correctly opposed the simple linear process of technology development proposed by technological determinism, the perspective reveals a lack of more sophisticated analytical tools to investigate a wide range of social factors. As a consequence, the perspective sometimes cannot fully explain why certain characters and influences are important while others are not in the shaping of technology implementation. Nevertheless, the perspective is expected to provide a more holistic view for a study of municipal

Wi-Fi networks whose shaping is largely contingent on a broader social context with the interests of the actors at stake.

Since this study focused on local governments' municipal Wi-Fi networks, more emphasis was on political factors—political shaping of technology—assuming that technology design is analogous to political choices (Guthrie & Dutton, 1992). In this sense, ''technology is the outcome of social and political choice'' (Guthrie & Dutton, 1992, p. 575). It should be also noted that technology in this study was not Wi-Fi itself, but municipal Wi-Fi networks whose incarnation could be affected by social factors. In sum, these theoretical perspectives are expected to shed light on the implementation of municipal Wi-Fi networks guiding comparisons and contrasts of the networks.

Method

This study employs a case study method with in-depth interviews with people involved in municipal Wi-Fi networks. First, three cities that deployed a Wi-Fi network—Cerritos, CA, Tempe, AZ, and Hermosa Beach, CA—were selected based upon distinctive characteristics of each network. Cerritos is the first city that constructed a citywide Wi-Fi network, while Tempe had the largest citywide network at the time the study was conducted. Hermosa Beach had a unique political conflict regarding expansion of its hotzone to a citywide network. With respect to demographic background, in Cerritos, the population was 51,488 in 8.9 square miles; Asians constituted the largest ethnic group (58.4%), followed by White 26.9%, Hispanic 10.4%, and African American 6.7% (U.S. Census, 2000). In addition, the median household income was $73,030 (U.S. Census, 2000). Tempe had a population of 158,945 in 40 square miles, among which Whites constituted the largest ethnic group (77.5%), followed by Hispanic 18%, Asian 4.8%, and African American 3.7% (U.S. Census, 2000). The median household income was $42,361 (U.S. Census, 2000). In the case of Hermosa Beach, the population was 18,566 in a 1.3 square mile area, while the majority was White (89.6%), Hispanics constituted 4.8%, Asian 4.4%, and African American 0.8% (U.S. Census, 2000). The median household income was $81,153 (U.S. Census, 2000). These demographics indicate that the three cities compose a diverse set of cities.

After selecting the cities, a key person responsible for each network was identified and contacted. Then, a snowball technique was used in order to expand the interviewee pool by asking each interviewee to identify others who could provide information about the network. With this method, at least four people were interviewed for each city including city government officials, CEOs of companies that were involved in the networks, and network construction managers. The number of interviews was 20, and all conducted from December 2005 to May 2006. Each interview was conducted face-to-face or on telephone for 30 to 80 minutes. All interviews were recorded and transcribed. Interview questions that incorporated the two theories are presented in the Appendix. City documents, internal memos,

and media articles relating to each city's network were also collected to supplement the interviews.

To investigate the role of local governments and its impact on the implementation of Wi-Fi networks, the study focused on two aspects: 1) network coverage; and 2) business model. Network coverage refers to the area a municipal Wi-Fi network covers. First, network coverage includes the number of network nodes in a given area to examine the density of a network. Second, in addition to the network coverage in residential areas, public places such as restaurants, parks, or civic centers were also considered.

The business model of municipal Wi-Fi networks dealt with how the financial resources for the network deployment were provided, how deployment costs were compensated, and how the networks made profits. Bar and Park (2006) classified nine different business models of municipal Wi-Fi networks with two dimensions: 1) who owns? (city, one private actor, or multiple others); and 2) who operates? (city, one private actor, or multiple others). However, these business models have not been solidified; rather they are being developed as demand is growing and the service is expanding. At the same time, it reflects the uncertain future development of Wi-Fi networks.

An examination of these two aspects is of importance with the following implications. First, municipal Wi-Fi networks provide the possibility of a future in which Wi-Fi networks are connected with each other and build an alternative infrastructure with the unwired last mile (Bar & Galperin, 2004). Second, the implementation of municipal Wi-Fi networks would suggest a practical guideline for the debate about whether or not local governments should be allowed to be involved in the provision of broadband Internet access. Third, the proliferation of municipal Wi-Fi networks would make the policymakers reconsider the future spectrum policy in a way that expands the unlicensed portion of spectrum where Wi-Fi networks are operated. Thus, to examine how municipal Wi-Fi networks are actually implemented will help prove the plausibility of those implications.

The Case Studies

Cerritos, CA

The Wi-Fi network in Cerritos was made possible by cooperative efforts between the city government and a private company, Aiirmesh. The city government provided city infrastructures such as rooftops of municipal buildings and intersection signal light structures without charging fees for Aiirmesh to design, deploy, and operate the network.

From late 2003 to early 2004, it was heralded in the nationwide media that Cerritos became the first city in the United States to launch a citywide Wi-Fi network. Before then, however, the city had a long history of no broadband Internet

access. With increasing frustration by the residents, the city government searched for available options for years. In March 2003, a wireless company, then-Aiirnet Wireless, contacted the city government and the company described its plan to start a new wireless broadband service (Hylton, 2005).

Upon Aiirnet's proposal, the city government asked the company to conduct a series of beta tests. The overall performance was acceptable, and together with general satisfaction from the residents, the city government approved the company's deployment of a Wi-Fi network in Cerritos. The most prominent goal of the Wi-Fi network in Cerritos was to provide an alternative broadband service to the residents at a reasonable price.

Network Coverage

About 100 Wi-Fi nodes were installed to allow ubiquitous broadband coverage throughout Cerritos (Esfandiari, 2006). In the downtown area, users were able to freely roam throughout the coverage areas, while Wi-Fi cells seamlessly performed node-to-node handoffs, ensuring users continuously had the most optimal path available (Pronto Networks, 2004). There were more nodes in the downtown area reflecting the fact that Aiirmesh sought more profits in the commercial areas compared to the residential areas (Esfandiari, 2006).

Business Model

As described earlier, the city government allowed Aiirmesh to deploy and operate the citywide network. Aiirmesh funded the entire project and now owns and operates the network, and thus all responsibilities of the network were Aiirmesh's. The city government also functioned as the ''anchor tenant'' of the network (60 subscriptions to the service). The city government agreed to subscribe for its mobile employees, including city maintenance workers and code enforcement officers. However, according to Aiirmesh, the network did not make significant profits with the service to residents to the extent that the deployment costs could be compensated (Esfandiari, 2006). Thus, the company set up fixed wireless for some services and included advertising in its opening website as a way to increase revenues. For Aiirmesh, Cerritos was a testbed city to see whether profits could be made (Esfandiari, 2006).

The business model Aiirmesh adopted can be categorized as that of ''franchise,'' according to Bar and Park's (2006) classification, where one private company owns and operates the network, and sells the service directly to consumers. The city government has a ''hands-off'' policy in the management of the network and, as a consequence, the business model of the network in Cerritos was shaped by Aiirmesh's corporate decision (Hylton, 2005). In addition, the city government allowed other private companies to overbuild a network as long as they were qualified. This means that the local government's perception toward information

technologies played an important role in deciding the business model in Cerritos. The technology model in the city government led to the perception that the Wi-Fi network is a commodity with which the market force would better serve than government.

Related to the business model, it is necessary to examine the price of the service as a comparison with that of cable modem or DSL service. In the case of the residential service, the price is $49.99 per month at the downlink speed of 768K (Aiirmesh Company Website, 2008). It should be noted that Aiirmesh significantly raised the price of the residential service from the price offered when the company started the business, which was $29.99 per month.

Analysis

The Wi-Fi network in Cerritos is a case that shows cooperation and partnership between local government and the private sector. The incarnation of the network was made possible by both the effort of the city government that intended to provide an alternative broadband Internet access to residents and the pursuit of a private company that tried to test the possibility of making profits with Wi-Fi technology.

It is necessary to examine the local government's technology model. At the beginning, the effort of the city government to search for a viable broadband service made Aiirmesh propose the deployment of an alternative Wi-Fi network. However, the city government perceived Internet access as a commodity provided by the market, but not as an essential public utility for the lives of residents. Moreover, the city government did not have any experience in provision of other public utilities. Thus, for the city government, it was logical to believe that broadband Internet services should be offered by private companies, because they perceived that it would be hard for a small government to grasp information technologies due to their rapid development. After all, although the city government achieved its goal of providing an alternative broadband access to its residents, it came with an unexpected high price.

In addition, since Aiirmesh deployed the network, the activities of the city government were limited. Because the primary purpose of the city government was simply to provide an alternative broadband service, the city government thought that its role was not to actively engage itself in the details of operation. Once Aiirmesh finished the network deployment in most of the residential areas, the company clearly focused on making profits. The company raised the price of the residential services and installed more network nodes in the public places where Internet traffic was heavy. In fact, it is hard to find any other benefits from the network except for its existence and an available service for residents.

An economic factor noted in shaping the Cerritos network was residents' economic status. Since the overall level of income was relatively high (median household income was $73,030 as of 1999 compared to $41,994 of U.S. average [U.S. Census, 2000]), it was possible for Aiirmesh to charge a relatively high price. The

CEO of the company also claimed that the price of $49.99 was not a serious issue for the residents of Cerritos (Esfandiari, 2006).

In sum, local government played a critical role in shaping the Wi-Fi network in Cerritos. The minimal role played by the city government in operation and its consequences illustrate that the role of local governments still matters in the age of deregulation and privatization. By remaining as a facilitator of the network, the city government achieved only half of its goals; provision of a broadband service. However, it witnessed a price rise in residential services, contrary to most of municipal Wi-Fi networks' expectation of providing an alternative broadband service at a lower price.

Tempe, AZ

The Wi-Fi network in Tempe was constructed by a private company, NeoReach, with partnership and cooperation with the city government and Arizona State University (ASU). The city government conceived a Wi-Fi project in January 2004 with approval from the City Council. Until July 2004, a series of feasibility tests were conducted with collaboration between the Information Technology Department of the city and the Information Technology Division of ASU. Then, the city and ASU offered free Wi-Fi access in a five-block area of the downtown in October 2004. At the end of February 2006, the company completed the deployment of the network covering approximately 95% of the city.

The goals of the Wi-Fi network in Tempe are manifold. First, it aims to provide affordable, high quality broadband service for residents and businesses in Tempe, promoting competition with the existing cable modem or DSL (City of Tempe, 2005). A second goal is to offer free Wi-Fi access in Tempe's downtown areas. A third is to promote economic development of Tempe and to enhance the image of the city and of ASU (City of Tempe, 2005). In particular, the city government tried to portray Tempe as a city of technology, at the same time promoting ASU as a technology center (McKee, 2006), together with promoting usage of the Tempe city website and e-government applications (Heck, 2006).

Network Coverage

The network in Tempe covers the city with approximately 600 access points at roughly every 1,500 feet (Rockwell, 2006). There were five phases to cover the city, and the deployment was conducted in 180 days. The first phase started in the downtown area and then expanded to other areas with more nodes. Unlike the network in Cerritos, the number of access points in the downtown area is fewer than that of other areas in Tempe. It is largely because wireless access in the downtown area is offered for free, making NeoReach focus on other areas to generate more profits.

Business Model

Similar to the network in Cerritos, the city government allowed NeoReach to design, deploy, and operate the citywide Wi-Fi network, and provided city infrastructures without charging fees. Yet, NeoReach provided other costs of installation and operation, and the network is owned and operated by the company. Thus, the business model is that of ''franchise.'' One different characteristic from the Cerritos network is that selection of a business model resulted from the mutual agreement between the local government and NeoReach. The city government outlined the business model, which would not involve any spending from the government budget. Then, NeoReach configured a slight variation of the business model following the city government's initial guideline. By accepting NeoReach's revision, the city government approved the company's future plan of the business model in the form of a ''proposed contract'' (Heck, 2006).

At the time the business model was determined, the issue regarding the appropriateness of local governments' involvement in municipal Wi-Fi projects at the cost of taxpayers' dollars was debated vehemently in the national scene, and many critics opposed local governments' actions of providing an alternative service. Thus, in order for the Tempe city government to avoid criticism for using tax dollars for the Wi-Fi network, it was a better choice to select a business model that did not require expenditure of city budget or tax dollars (Heck, 2006).

With respect to pricing schemes, NeoReach provides residential services at $24.95 (at the downlink/upload speed of 1.5M) and $29.95 (2M) per month (WAZTempe Website, 2008), which are much cheaper than that of the network in Cerritos. In addition, the network in Tempe allows enhanced competition with the existing broadband services as the city government aimed.

Analysis

The Wi-Fi network in Tempe is a prototype of a public-private partnership where a well-prepared local government initiative delineates the shaping of a Wi-Fi network. A few factors should be mentioned to explain the network implementation.

First, the local government's technology model played a crucial role: the city government's experience managing information technologies for decades. It had Cisco construct a gigabit network infrastructure and owned the fiber optic and point-to-point wireless metro backbone. Moreover, the city government provided e-government applications as a vehicle to enhance the residents' welfare. Thus, it was logical for the city government to perceive information technologies as a kind of public utility rather than commodity (Kleeman, 2006). Further, the city government perceives itself as a ''digital cowboy'' (Heck, 2006), and it consequently made it a government aim to provide an affordable broadband service and promote economic development of the city with the Wi-Fi network. This technology model resulted in

smooth and rapid deployment of the Wi-Fi network in Tempe with the proactive role of the city government.

To examine the general activities of the city government in the process of network implementation, it is necessary to divide the process into two phases: the pre-deployment phase, and the deployment and operation phase. The pre-deployment phase should be emphasized for the city government's activities. The city government conceived a Wi-Fi network earlier than other cities at the end of 2003 when most cities did not envision citywide Wi-Fi networks (Kleeman, 2006). In particular, the Information Technology Department of the city persuaded other departments and the City Council about the benefits of Wi-Fi technology and conducted a few feasibility studies. The department deployed a ''proof-of-concept'' wireless network in the downtown corridor prior to release of the RFI (Request For Information) in September 2004, and offered free wireless access in the downtown in October 2004 (Heck, 2006). Based on these experiences, the city government prepared a well-designed RFP (Request For Proposal) where network coverage, business model, terms and conditions about deployment, and even service price range were clearly specified. In addition, the city government could receive 2,000 free accounts as compensation for providing city infrastructures. From the perspective of the city government, the goals they envisioned were successfully achieved (Heck, 2006). The role played by the city government affected almost all aspects of the network deployment and operation turning the vision of Wi-Fi networks into a reality. Rather than remain on the sideline of the network implementation, the city government actively participated in the overall process, which in turn made NeoReach follow the general direction under the supervision of the city government.

From the social shaping of technology perspective, one unique aspect in the rollout of the Tempe network is the role of, and contributions from, ASU. Unlike other cities, the local university played a significant role in the deployment of the network. Before the city government planned a Wi-Fi network, ASU already had its own free Wi-Fi network on campus. With the experience of operating the network, ASU claimed that the citywide Wi-Fi network should offer free access in the downtown area so that buzz of ''word-of-mouth'' from users could facilitate early adoption of the network, and the university's interest of free service was reflected in the RFP. For ASU, free service could be a facilitator not only to make the citywide network and its own network seamless but also to recruit more students to the university who become technology-savvy. As a result, ASU could receive 1,000 free accounts for staff and 50% discounted rate for students. As a stakeholder, ASU's goal was to take advantage of the network in the city as much as possible in a way to promote the university's image as a technology hub, based on the good relationship with the city government and its expertise in the technology sector.

In contrast to the role of the city government and ASU, NeoReach played the major role in the phase of deployment and operation of the network. For the initial shape of the network, NeoReach followed the city government's direction; yet once the company finished the deployment, it was able to obtain more autonomy in operation. For instance, NeoReach installed more access points in the residential

areas and further tried to invite other retail ISPs to maximize profits with their network. In addition, the company set the prices at a competitive level with those of DSL or cable modem. The public/private partnership between the city government and NeoReach was a win-win strategy where the city government was able to receive free accounts as well as provide an alternative broadband service to its residents, while NeoReach utilized the city's infrastructures and compete with the existing ISPs. After all, the active role of the city government in the initial stage not only enabled NeoReach to meet the needs of the city but also led both parties to anticipate expected outcomes, although the network's performance remains to be evaluated further down the road.

Hermosa Beach, CA

The Wi-Fi network in Hermosa Beach was built mostly by the effort of one of the city council members who had the experience of using a small Wi-Fi hotspot in his local business. It was July 2003 when the Wi-Fi project was publicly discussed in the city. Since then, the deployment plan was discussed in succeeding council meetings, and finally, the city decided in February 2004 to build a Wi-Fi network covering approximately 35% of the city, initially centered around the downtown area and the City Hall. Upon this decision, the city launched a network in August 2004 and has provided free wireless service to the city's residents, outside workers, and visitors.

After the initial phase of the network deployment, the city intended to expand the network to cover the entire city. However, in a council meeting where the decision about whether or not the city should expand the coverage of the network was made, the opinion of council members was split and the plan was postponed until the issue could be revisited.

The goal of the Wi-Fi network in Hermosa Beach was to provide free Internet access to residents in the downtown area. According to the city council member who initiated the deployment of the network, the vision of the city was to provide Internet access to residents in the way that other basic services are offered, as a public amenity and convenience (Keegan, 2006). Although Hermosa Beach had cable modem and DSL services, the city envisioned that free Wi-Fi access would make the city a more convenient and communication-rich place.

Network Coverage

The network in Hermosa Beach covered the downtown area with 10 access nodes attached to tall buildings and streetlight pole arms. In the test phase, no more than 12 nodes were expected to be installed. This area of coverage served as a test area for signal strength and the related backhaul equipment before proceeding to other areas of the city.

Business Model

The network was built by the city government's discretionary fund which came from residents' tax dollars. The city council approved in February 2004 the phase 1 project budget of $35,000. After the approval, the city government conducted a typical RFP process and selected a private company, LA Unplugged, as the system builder. However, the network was owned by the city government because the city funded the project. Currently, network operation is managed largely by the city council member who initiated the project since LA Unplugged went out of business. Thus, the business model of the Wi-Fi network in Hermosa Beach is that of ''public utility'' in which the city owns and operates a network.

The city government employed an advertising-support model as a way to cover operating costs. By directing users to the initial webpage of the network where local advertisers or sponsors provide classified ads, the city government is covering the ongoing monthly costs of $2,500. However, the amount of advertising revenue per month from the webpage operation has been approximately $1,600 through the sponsorships at about $250 from each advertiser or donation (Keegan, 2006), which is quite short of the monthly costs.[1]

Analysis

The Wi-Fi network in Hermosa Beach is an interesting case in that a political conflict made expansion of the network impossible. It is an exemplar that illustrates that the trajectory of technology development is shaped by social factors rather than technology itself.

The technology model in Hermosa Beach has been a mixed bag. For some council members, broadband Internet access was perceived as a public utility like water and electricity, while for other members, it was perceived as a private sector like other commodities. After the deployment of the test area, the city council had a meeting in November 2004 for decision about expansion of the network. Although the city administration was ready to spend its budget for the network expansion, it could not be fulfilled because of the conflict between the council members.

Faced with this uncoordinated perception toward the Internet and information technologies, the city administration was on the sideline without taking any position. In addition, the city government has not had any experience on other public utilities or information technologies. Thus, virtually no experience and expertise in the area of information technologies made the city government not only treat the Wi-Fi network as they have conducted other city works but also be ineffective confronted with the political obstacle.

Related with the city government's activities, it is necessary to investigate why the city council impeded expansion of the network. It can be explained with existence of other broadband services and the use of taxpayers' money. Since there were cable modem and DSL services in the town, there was no compelling rationale for

the city council to support a citywide network at the expense of the city's funds. In the case of the Wi-Fi network in Cerritos, there was no other available broadband service for a decade, and thus, the city council was very supportive to invite a Wi-Fi network. By contrast, in Hermosa Beach, the mediocre performance of the network together with failure to entice sufficient advertisers for operation caused the city council to rethink continued use of the city budget. Since the launch of the network, the number of users dwindled to approximately 150 people per day from about 400 people at the beginning (Burrell, 2006) due to insufficient signal strength. In addition, the network became a venue for some wireless ''techies'' rather than serving the residents in general (Edgerton, 2006), which made some council members uncomfortable with spending more money for operation and maintenance.

In the case of Tempe, the city council supported the citywide Wi-Fi network even though there were other broadband services. The difference between Tempe and Hermosa Beach is reflected in the activities taken by the city administrations. The city administration in Tempe was very enthusiastic about and well prepared for the citywide network, whereas that of Hermosa Beach was lukewarm in persuading the city council and encouraging use of the network, thereby operation of the network was mediocre at best. In fact, the city administration never encouraged users to rely on the Wi-Fi network (Burrell, 2006). Although the city administration was willing to spend its fund for network expansion before the plan was rejected, almost no active participation from and cooperation within the city departments was made.

From the perspective of the social shaping of technology, the political factor was thus most prominent in the case of Hermosa Beach. For some council members who opposed the citywide network with more tax money, other technologies such as WiMax would make the network out of date in the future, and therefore, further investment for the Wi-Fi network would waste government resources. Based on this argument, they preferred the market players to take the role of the service provider. Further, telephone and cable companies that served the city lobbied against expansion of the network for fear of losing profits due to the planned citywide Wi-Fi network. A local newspaper also published a negative editorial regarding expansion of the network because the telephone and cable companies in the city were big advertisers in the newspaper (Keegan, 2006). In fact, the local telephone and cable companies combined their efforts to prevent the Wi-Fi network from materializing in a larger scale, and their endeavor was explicitly represented in the council meeting for the network expansion.

From the aspect of economic factors in the shaping of the Wi-Fi network in Hermosa Beach, residents' economic status needs to be mentioned. Residents' relatively high average income ($81,153 as of 1999 [U.S. Census, 2000]) affected the network expansion negatively. For the people who could pay for commercial services, there was no compelling reason to embrace the Wi-Fi network (Burrell, 2006).

In sum, in Hermosa Beach, the interests at stake coupled with the role of local government delineated the trajectory of the Wi-Fi network development in a way

that further expansion of the network was blocked. The finding is consistent with the political shaping of technology (Guthrie & Dutton, 1992), which claims that political actions and interactions between the players construct the design and evolution of a technology in question.

Discussion and Conclusion

A growing number of local governments are constructing Wi-Fi networks with a variety of goals. Such networks, however, have produced different outcomes with respect to their network coverage, the business model, and price ranges. This study investigated the ways in which Wi-Fi networks in three cities were implemented. The three cities presented significantly different characteristics regarding the shaping of the networks.

The findings in this study support the propositions of path dependency and technology model. As illustrated, previous experience and knowledge about information technologies of the city government of Tempe positively affected the implementation of the network, whereas little experience and comprehension from the city government of Cerritos resulted in less than optimal success. These contrasting findings demonstrate that the existing technology structure and problem solutions influenced the local governments' policy decisions, accompanying practices, and consequently the implementation of the networks. Prior knowledge and experience contributed to establishing dominant technology models, and further helped the cities hold a particular perspective on information technologies when they encountered a new technology, Wi-Fi. Obviously, these different technology models played an essential role in the shaping of municipal Wi-Fi networks. In general, the proactive local government that perceived the Internet and information technologies as a public utility produced more positive outcomes, while the passive or opportunistic government with respect to utilizing information technologies brought about mediocre performance.

Upon these findings, one might argue that it is natural to generate better outcomes and performance if a city government is more active and puts more effort and resources into its Wi-Fi network. However, these findings provide an important policy implication. As Bar and Galperin (2004) claim, the deployment of a wireless Internet infrastructure in general and the construction of municipal Wi-Fi networks in particular, stands at a critical juncture, given that such networks provide a possibility of establishing an alternative Internet infrastructure that could compete with the legacy networks. Pool (1983) posited that new advances in the technology of communications challenge a status quo. Clearly, Wi-Fi technology and municipal Wi-Fi networks have a potential to disturb the current broadband Internet market. Thus, in order for local governments to truly serve their constituents with municipal Wi-Fi networks, they need to be more proactive in the design and deployment and properly oversee the operation of the networks.

The history of local governments' involvement in telecommunications projects shows that their endeavors were not successful in the past (see Carlson, 1999). If one can learn a lesson from history, it is that local governments should not make municipal Wi-Fi networks a waste of their resources or another one-time venture with the current opportunity. In so doing, Guthrie and Dutton's (1992) claim could be empirically proved, which states that technological paradigms—technology models in this study—are not simply an independent variable that affect the implementation of new technologies, but also a dependent variable affected by continuous experiences and practices with technological changes.

The current study uncovered that the making of municipal Wi-Fi networks in the three cities was not a technologically driven event. Rather, in parallel with the claims of the social shaping of technology, a series of choices, negotiations, and interplays among a variety of actors and environments shaped the architecture of the networks. However, social or political factors did not equally affect the implementation of the networks across the three cities. For instance, the political factor was most prominent in Hermosa Beach, while the organizational factor played an important role in the Tempe network (i.e., interaction and cooperation between the city government and ASU). In the case of Cerritos, the absence of broadband Internet service in residential areas heavily affected the configuration of the network in the city. After all, in the process of shaping the networks in these cities, the capabilities of municipal Wi-Fi networks (e.g., network coverage, price ranges, downloading/uploading speed, etc.) were determined by ''choices by people about what they do, with whom they do it, when they do it, and how they do it'' (Dutton, Gillett, McKnight, & Peltu, 2004, p. 29).

This study was limited in some ways. First, although the present study compared two cities where one company has provided Wi-Fi services as a franchise (Cerritos and Tempe) for the purpose of comparison, inclusion of a more diverse set of networks (e.g., Austin, TX, where two service providers exist) would have provided another perspective on the study of municipal Wi-Fi networks. Second, the current study could not include user experiences from Wi-Fi services since the study was conducted at the beginning stages of the network implementation, focusing mainly on the role of local governments. Future studies are strongly encouraged to examine the level of user adoption and experiences in order to paint a complete picture of the success or failure of the networks.

In conclusion, this study highlights the role of local governments in the shaping of municipal Wi-Fi networks from the theoretical lenses of path dependency and social shaping of technology. Although a general convention is that the role and influence of government are diminishing in the era of deregulation and privatization, especially in the information and communication sector, those of local governments still matter in the local level where Wi-Fi networks are deployed and operated. Whether or not the networks could develop to provide a public information utility and to be an alternative to incumbent networks, however, depends on local governments' willingness to achieve the goals with the networks they initially set forth.

Appendix

Interview Questions (Cerritos, CA)

1. What were the driving forces that made you decide to build a Wi-Fi network in Cerritos?
2. What are the goals of the network in Cerritos?
3. What has been your role as a government department in the process of deployment and operation of the network? In other words, how have you affected the deployment and operation of the network?
4. How could you select Aiirmesh as the service provider?
5. When you selected Aiirmesh as your partner, was there any opposition from your local government?
6. Aiirmesh deployed the network with mesh architecture. Was there any reason for the architecture from the perspective of city government?
7. If there were other city departments which participated in the decision about the network, who were they and how did they affect the decision?
8. Could you explain the bureaucratic structure and rulemaking procedure of your local government?
9. How do your departments or agencies interact with each other in terms of decision making?
10. If there was any entity such as citizen groups or business interests in your city which affected your decision about the Wi-Fi network, who were they, and how did they affect your decision? If any, how did you respond to those groups?
11. Is there any feedback system for residents' opinions or suggestions about local government's policymaking and implementation?
12. Have you owned or invested on other information technologies? If so, what are they and how are they different from the Wi-Fi network?
13. Have you involved in the provision of other public utilities such as power, water, or gas?
14. Is there any local policy for city infrastructures such as licensing of rights of way, cable franchise, utility pole attachment, or zoning or antenna siting policy?
15. What is your citizens' expectation toward local government in terms of the Wi-Fi network, or any other local government's policymaking and implementation?
16. Can you tell me about the residents in Cerritos in terms of political culture, economic status, and political activism?
17. How has been the performance of the Wi-Fi network in Cerritos so far? If you set up some goals with the network, do you think those goals have been successfully achieved?
18. Do you have any future plan for the Wi-Fi network in Cerritos?

*The interview questions for other cities were modified accordingly.

Note

[1]A council member who supports the network argued that operation of the webpage has been profitable. However, the City Manager disagreed and said the council member used a different measure for profit calculation.

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