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Keywords: Universal access; Information infrastructure; Socio-technical systems;Ubiquity; Interpretive; Theory

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Abstract

'Universal access' (UA) to the Internet and the associated information infrastructure has become an important economic and societal goal. Yet, a comprehensive and systematic understanding of the UA concept is still lacking. In this paper, we apply naturalistic techniques of inquiry to analyze the Philadelphia Wireless initiative, and develop a series of propositions that constitute a proposed new model of UA. The analysis reveals that UA is a multi-dimensional construct that is influenced by different stakeholders with varied and conflicting interests. UA, in the modern era, represents a human-technology alliance that exhibits great diversity across individuals, technologies, and associated social contexts. This departs from the traditional top-down notion of universal access that focused mainly on physical connectivity. The human and technological elements are deeply embedded within institutional dependencies that are essential, yet also alternatively enable or constrain meaningful underlying use of the information infrastructure. The implications of this complexity for achieving universal access and policy making are discussed.

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1. Introduction

Universal access (UA) to the Internet and the associated information infrastructure (II) has become critical for businesses, culture, education, and communities. Yet, a range of obstacles remain. Social and economic inequalities have spilled over into (or even amplified by) the digital world and people who lack access are being relegated into an even more disadvantageous position (DiMaggio et al., 2001). Even when social and economic problems do not form a barrier, there are often geographic or strategic imperatives which determine which regions or individuals get access and which do not.

However, the existing academic understanding of this important concept is relatively weak. Even after years of debate, 'universal access' still remains highly contested among technological, social, and policy making institutions. The challenge has been to identify strategies to provide economical access to technology, engage citizens with the technology, and encourage meaningful use. Justifiably, initial efforts have focused on developing the physical information infrastructure (II). Today, with large portions of the II already built and available, the above approach leaves two critical questions unanswered: Does mere availability of the II lead to universal access? If not, what is universal access?

In this paper, we apply a socio-technical systems lens to systematically deconstruct the meaning of universal access in the context of the II. We show that the concept of UA that was originally developed for utility and information services is problematic when applied to the modern II designed to serve heterogeneous actors using a complex set of technology artifacts. The meaning of UA is examined as it was

conceptualized and negotiated during the development process of the Philadelphia municipal wireless network (MWN). MWNs have been defined as wireless internet access networks that are created with active local government leadership and involvement (Mandviwalla et al., 2008). MWNs are a growing trend today. Communities all over the world are starting ambitious MWN projects to provide affordable high speed Internet access. Typically, the goal of these projects is to provide ubiquitous connectivity and foster innovation and growth. According to industry estimates (Vos, 2006), the overall value of the city Wi-Fi initiatives is estimated to touch approximately $3 billion in the next four years. However, many communities have encountered challenges and have had to either abandon or scale back their projects. The challenges include lack sustainable business models, insufficient adoption, or regulatory constraints. We believe that a more systematic understanding of UA can provide communities and decision makers with tools to better understand and manage the complexity associated with municipal wireless initiatives and other public or private attempts to develop the II. The specific objectives of this study were:

a. Analyze the development of the Philadelphia wireless initiative.
b. Synthesize the results into a proposed theory of UA.

2. Background

Universal access has long been a subject of policy debate in the context of traditional information services such as telegraphy, postal mail, telecommunications, and television, and has traditionally been conceptualized as *accessibility* (geographical ubiquity and physical access) and *affordability* (subsidized services), and was measured through penetration rates (Crandall and Waverman, 2000; Mueller, 1993). Consequently, governments and public policy institutions played an important role in providing

universal and equitable service to the citizenry (Kielbowicz, 2002). This notion of UA was incorporated into the definition of UA provided by the senate committee on science and technology (1994, Pg. 3):

> "*…making available, as far as possible, to all people within USA, access to an affordable, usable and standardized information and communications network capable of enabling users to receive voice, data, graphics and video services. It applies, in principle, to universal access of evolving applications on the Internet*".

While it is tempting to treat the information infrastructure akin to traditional utility such as the telegraph, an information infrastructure represents a much more complex mix of technologies controlled by many different stakeholders.

3. The Information Infrastructure (II)

Hanseth and Lyttinen (2004, p.213) define the II as a "*…shared, evolving, and heterogeneous installed base of IT capabilities among a set of user communities based on open and/or standardized interfaces.*" One important difference of the II with respect to traditional utilities is the heterogeneous collection of different technologies, components and protocols to support varied applications covering large geographical distances. This plurality of technology is further complicated by the content, and the information resources, services and applications that individuals access via this infrastructure (Hanseth and Braa, 2000). Mere access to one form of technology might not necessarily mean universal access. There is so much one can do with this infrastructure that a simple notion of access becomes meaningless. Do users write emails, participate in chats, play games, or access business or health information? Do they access this information through their computers, mobile phones or PDAs? And how does this usage fit into the day to day practices of individuals or organizations? Such heterogeneity in requirements, preferences and diverse operating environments is a challenge if we use just penetration

or connectivity rates to measure universal access. Such simplistic measures hinder our understanding of the influence of individual, communication, and socio-economic forces (Mason and Hacker, 2003).

Further, the II is *enabling*, *shared*, and *socio-technical* in nature (Hanseth and Monteiro, 1998). 'Enabling' is the ability to support a wide range of activities. An infrastructure is shared by the members of a community in the sense that it is the one and the same single object used by all of them (although it may appear differently). In this sense, infrastructures should be seen as irreducible as they cannot be split into separate parts being used by different groups independently. At the same time, an infrastructure is developed and embedded in a wider social-technical context (Star and Ruhdler, 1996). Moreover, the II, especially the Internet, is as much a collection of communities of users as a collection of technologies, and its success is attributable to satisfying the basic community needs (Leiner et al., 1997). As the complexity of system grows, the social and technical elements such as equipment, networks, people, and policies influence, and shape each other, giving rise to new forms and structures. The II, then, no longer remains a physical object that needs to be designed and managed, but a multilayered, contextual and socio-technical phenomenon that is constantly evolving and emerging (Rolland, 2002).

4. Analytical Framework

Previous research treated the development, adoption and diffusion of complex infrastructures separately either at the macro-level (e.g., Hughes, 1987) or at the micro-level in the form of innovation diffusion theories (e.g., Rogers, 1983), technology adoption theories (e.g., Davis, 1989) and user appropriation theories (e.g., DuGay, 1997;

Orlikowski, 1992). The II by default is largely an institutional initiative, i.e., an institution or a set of institutions are needed to build and maintain the II. At the same time, whether or not the users use the information and services available through the II is contingent upon numerous technical, personal and situational factors. To obtain a more holistic understanding, it is important to combine these disparate yet complementary streams of macro and micro thought.

To this end, we adopt the analytical framework proposed by Geels (2004) to systematically guide our data analysis. According to this framework, complex socio-technical systems consist of a cluster of elements including technology, regulations, user practices, cultural manifestations, and the supporting supply networks.

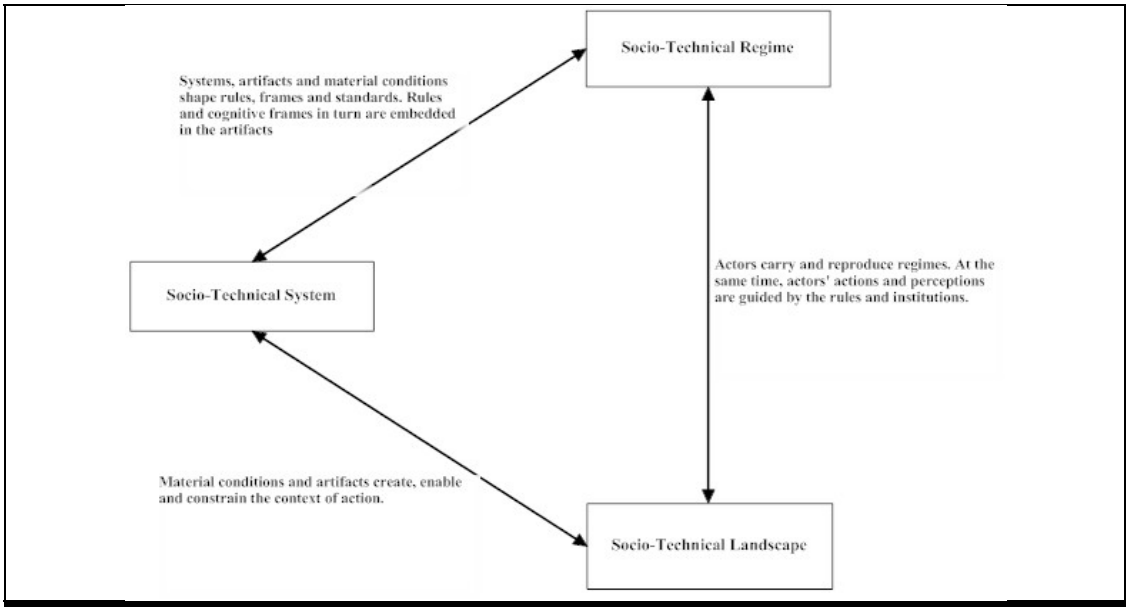

Figure 1: Interrelated elements of socio-technical systems (Source: Geels, 2004: P.903)

Three elements drive the evolution and sustainability of such complex systems (Geels, 2004): 1) Socio-technical systems, 2) socio-technical regime and 3) socio-technical landscape (see Figure 1). In the case of an II, the socio-technical system refers

to the base level IT systems and artifacts, essential IT functionalities, and the fundamental services enabled by them. The socio-technical regime constitutes the cognitive structures that guide and orient the activities of the relevant social groups including the problem agendas, guiding principles, rules of thumb, standards, regulations and institutional representations. The socio-technical landscape refers to the actors and social groups that have definite interests in the infrastructure. These actors and social groups operate in relative autonomy, and at the same time participate in networks of mutual inter-dependency. The elements and their linkages are actively created and sustained by the associated social groups that have vested interests in those systems. Each social group has its own perceptions, values, problems and strategies, thereby making the evolution of the socio-technical system a multi-actor process. However, the autonomy of the social groups is relative in the sense that the material conditions of the socio-technical system create, enable and constrain the context for action. Similarly, the rules and institutional representations are limited to the material possibilities of the technology at hand. At the same time, powerful regimes do not reside just in the heads of the social actors but are eventually embedded in the artifacts and practices. As the complexity of such systems grows, the social and technical elements influence and shape each other, giving rise to new structures of technology and forms of usage (Lamb and Kling, 2003). To analyze this complexity, and its impact on the notion of UA, we apply the analytical framework to examine the development process of the Philadelphia Wireless initiative.

It is important to note two aspects of the analysis in this study. Firstly, our focus is on the relative achievement of UA at the individual level since that was the stated goal of the Philadelphia initiative. At the same time, we apply multi-level analysis (Goldspink

and Kay, 2004; Alexander, 1987) to explicitly delineate the institutional, social, and technical elements, and link them to the factors at the individual level. Secondly, we do not specifically differentiate the concept of digital divide from UA although we apply relevant digital divide concepts; it is likely that the impetus for UA would be less imperative if there was no digital divide. However, the digital divide is an amorphous term that refers to access to computers, computer knowledge, and connectivity and the divide could exist across age, race, gender, geography and socio-economic status. UA as referred to in this paper is centered around connectivity, adoption and usage, and focuses on social, institutional, material, and cognitive factors that impact access for individuals regardless of their classification. It is possible that we could achieve UA without fully addressing the digital divide.

5. Research Approach

This study is based on our analysis of the Philadelphia Wireless Initiative. In 2004, the city invited our research team to assist them in starting the initiative. Our involvement was focused on assessing the business models and analyzing the needs of the stakeholders. The initiative, after a euphoric start, started facing numerous stumbling blocks that eventually slowed down the laying of the network. Further, where the network was made available, the subscriptions were much lower than expected. To better understand the progress, we followed a qualitative approach wherein insights are induced through interpretive means. Interpretative approaches are appropriate when there is no existing theory or model available to study the data and when the goal is to induct a theoretical framework (Klein and Myers, 1999). Table 1 outlines the data which included three different sources (see Appendix I for a detailed breakdown of each data point):

Table 1: Data Types and Sources	
Data Sources	**Number and Period**
200 news articles (both print and electronic media searched through LexisNexis Academic, Google, and Ask.com). An initial reading showed that there were numerous duplications and repetitions in many of reports. We narrowed the list of articles to remove duplication. One part of this data was multi-media interviews of major stakeholders included in the above list were transcribed and also used for the analysis.	79 news items (7/04 to 12/07)
Thirteen focus groups involving various stakeholders were organized involving a total of 120 individuals (Jain, 2006). The discussions were taped and transcribed.	13 (n=120) (9/04 to 10/04)
Formal reports and whitepapers provided by the city to the general public as part of their informational and promotional campaign.	25 (8/04 to 12/07)

6. Methodology and Analysis

The data yielded a total of 232 pages (45,914 words) of textual data. This data was combined in ATLAS.ti, a tool designed to analyze qualitative data. The final data used for the open coding process consisted of a total of 1654 paragraphs of text. For the analysis, we followed the grounded theory approach to data analysis (Miles and Huberman, 1994; Strauss and Corbin, 1990). Through the iterative coding process, we created a set of relationships among the categories and dimensions (Please refer to Appendix II for details of the coding process). The categorization helped us identify the key stakeholders (such as institutions, individuals, technologies) that influenced and socially constructed the notion of universal access. Each final category was assigned dimensions and sub-dimensions, which are discussed next.

7. Results

7.1. Evolution of the 'Philadelphia Wireless' Initiative

The primary objective of the Philadelphia initiative (announced in 2004) was to make the II universally available and affordable to every citizen and business in the city, and to develop an infrastructure that stays current with the current technological developments. At the same time, the city intended to address the apparent digital divide

among the city population and champion the cause of digital inclusion for the economically and socially underprivileged sections of the city. According to the mayor:

> "*Philadelphia hasn't had a first in technology since the Univac. We must prepare our businesses and citizens to face the challenges of the future. Just like roads and transportation were keys to our past, a digital infrastructure based on wireless technology is the key to our future. We are thrilled to expand the city's leadership position in using the wireless technology to meet our people's needs and enhance the services, visitor experience and the business environment*".

Further, internal analyses by the City Government found that Internet awareness and usage among the city residents was much lower than the national averages. Therefore, numerous social/civic service agencies were involved in encouraging the city government to undertake the initiative. As the head of a non-profit organization and an avid supporter of Philadelphia Wireless indicated:

> "*Cities see this as a way to spur economic growth- on one hand to put tools in the hands of the underprivileged and give them a leg up, and on the other to provide incentives to small businesses to locate in these cities and to expand their operations. The vision is to have high-speed broadband affordable and accessible to all. Economic development in our underserved neighborhoods will be achieved by bringing the connectivity up from 58% to 80%. To be a first-class city of the 21st century, we have to have advanced telecommunications. We want the Telecoms to continue to do fiber, but we can't wait till 2015 in Pennsylvania to do that.*"(Cable Digital News, 2005)

In response to this perceived need, the mayor established the Philadelphia wireless committee to explore the feasibility of the MWN initiative. The impetus to this initiative also came from firms such as Intel Corporation, IBM and CISCO who helped launch the 'Intel® Digital Communities program' (Intel, 2005). To ensure a successful adoption of their technologies and applications, these firms have been aggressively courting various communities around the world to adopt wireless 802.11 technologies. From the perspective of key players, the objectives of the initiative can be summed up as follows:

- Provide universal access to the Internet for all individuals and institutions

- Create an entrepreneurial and digitally literate population in the city
- Enhance inclusiveness and cohesion of socially and economically underprivileged segments of the city through technology provision.

However, the existing Internet and telecommunication service providers such as Verizon and Comcast strongly opposed the initiative. These firms contended that the city had no right to channel public funds into projects that might not necessarily pay off. In addition, as the CEO of Verizon said, *"[W]e find it unfair that municipalities that regulate us, set our taxes, set our franchise fees… also now want to compete with us, under a different set of rules*." (InternetNews.com, 2004) The firms also argued that universal access to broadband is not a simple concept but, rather, requires a unique marriage between ease and speed of the wireless and ubiquitous coverage of the cellular and wired broadband systems - capabilities which they have built over years of investment. Hence, they are in a better position to ensure universal access rather than the city government. As one official commented:

> "*The city is a steward of its resources. I am not going to tell them how to use them. But in Philadelphia, I think the market did a better job of addressing the issue rather than municipal backed systems*" (Washington post, 2005).

This claim, however, was countered by a city official:

> "*if you ask the local telecom companies, they would say 90% of the city is covered. But if it is at a fee that most people in the city cannot afford, and if they don't have the computers to access the network, then having the network will not help overcome the digital divide*" (Washington Post, 2005).

The legislature also became a stakeholder. A telecommunications regulation bill in the Pennsylvania House of Representatives was brought about to prohibit any municipal government or a related entity from offering broadband services for a fee if there is already an existing private enterprise in that region. However, the bill was modified to include a grandfather clause that allowed those cities that already had

proposed such initiatives to go ahead and finish deployment before a certain deadline. At the same time, the bill eliminated the feasibility of some of the original business plans including a tax payer funded network that would provide free service to the residents of the city. Eventually, the city decided on a hybrid model which was termed the 'cooperative wholesale model'. As per this plan, the city would establish a non-profit organization called 'Wireless Philadelphia'. This non-profit, in turn, will outsource the design, development and maintenance of the network to a private company. Access to the network will be made available to internet service providers (ISPs), telecommunication companies and other institutions, which will eventually provide access to customers.

The final contract for building the network was awarded to EarthLink Inc, a member of the Intel led consortium that also consisted of two equipment providers, Tropos and Motorola. The company agreed to invest the $10 million required to build the network. EarthLink would charge about $20 to regular users and $10 for economically disadvantaged citizens. As a part of the digital inclusion program, EarthLink would provide 3000 free accounts to the city, and also channel 5% of the revenue to provide equipment to low-income households. However, the broader aspects of the digital inclusion program would be taken care of by grants and partnerships with local non-profits, banks and faith based organizations. In return, the city government with its numerous departments would become a subscriber to the network.

7.2. Key Stakeholders in the Philadelphia Wireless Initiative

We identify key stakeholders involved in the initiative and categorize them into three broad dimensions - technical, socio-cultural, and institutional (see Figure 2).

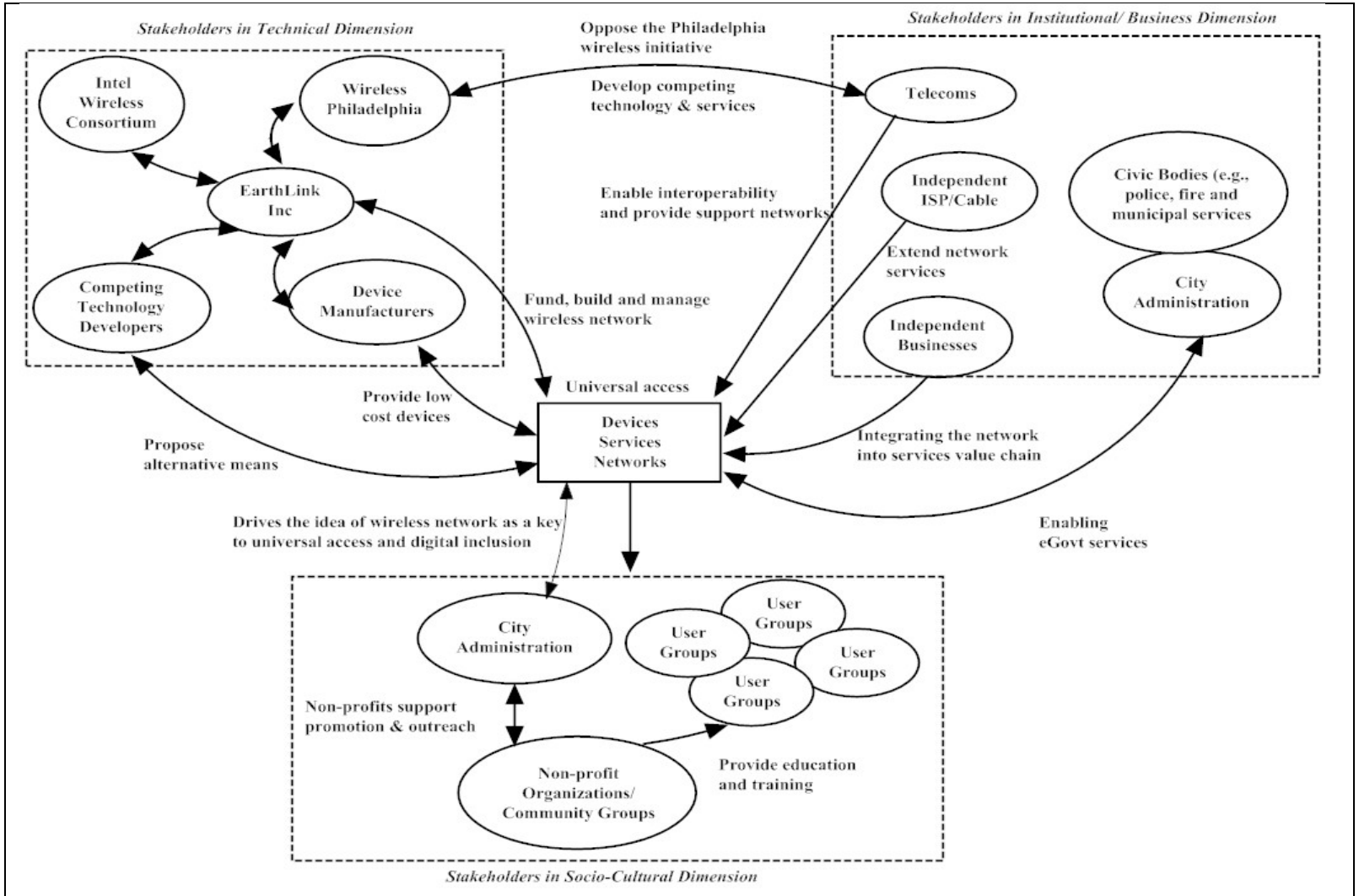

Figure 2: Stakeholders of the Philadelphia Wireless Initiative

It should be noted that these actors do not always fit neatly into a single dimension; they often play varied roles by moving between the dimensions. The current depiction is adopted for its ease of representation. The depiction reflects our analytical framework (see earlier sections) which views complex socio-technical systems as regimes (such as standards, rules, and institutions), landscapes (various actors and social groups), and systems (the artifacts and services).

7.3. Dimensions of UA in Philadelphia Wireless

In this section we further explore how the above stakeholders perceived and reconstructed the notion of UA along the technical, socio-cultural, and institutional/business dimension.

7.3.1. Technical Dimension

The technical issues were categorized as *Performance*, *Interoperability,* and *Availability* (see Table 2).

Table 2: Technical dimension

Category	Sub-categories
Performance	• Speed and reliability • Standards • Quality of Service
Interoperability	• Connectivity through existing mobile platforms • Connectivity to existing services
Availability	• Indoor vs. outdoor connections • Work vs. home connectivity • Access devices • Ubiquity vs. security

Performance refers to the speed and reliability of the network, the quality of the equipment, and the quality of the service provided (the network by itself as well as in comparison to the existing wired and mobile communication infrastructures). However, achieving these performance attributes is complicated and requires sustained investment and negotiation of tradeoffs. As one technology expert commented:

"*building the network is easy, maintaining it is tough. Cities have to also fund the operations of the network. That's the piece most people overlook in such initiatives. If an access point goes out, who will go out at 2 am to climb a pole and fix it? How much extensive support can you provide to the users? And at the same time maintain the costs?"* (News.Com, 2005)

Similarly, selection of the *IEEE* 802.11b standard also ran into challenges. This standard is generally considered advantageous for two reasons: It operates in an unlicensed spectrum and provides relative cost advantage as opposed to other wireless standards; reasons that very well suited the initial objectives of the city. According to the CIO of Philadelphia, Diana Neff:

"*the city decided on the 802.11b wireless standard since it was cheap and relatively easy to install, especially if you are working with a municipality, and have access to public infrastructure such as street lamps, power etc. It fits into our overall goal of digital inclusion by allowing easy access and lower costs*" (Interview with Etopiamedia, 2005).

However, one business owner argued the opposite:

"*this standard is just a workable solution for today, and will seem less and less attractive with other wireless technologies currently being offered. For example, the EV-DO standard being rolled out by Verizon is much more powerful, faster, and works over larger distances. What is the guarantee that people won't shift to it?"*(Hitech/Early startup companies focus group).

Experts also pointed out challenges regarding the reliability and fidelity of Wi-Fi. Since wireless networks run on unregulated spectrum; devices such as microwave ovens, hand-held phones, garage door openers, home wireless networks, and Bluetooth all use the same frequency and can cause interference leading to higher error rates and router overload. According to a technology expert:

"*the 2.4MHz spectrum is already very crowded. When you have a large deployment such as Philadelphia also using that spectrum there's a lot of potential for overcrowding and interference*" (CNET News, 2006).

Further, a majority of the stakeholders agreed that if the network performance is poor as compared to the already established communication channels such as mobile phones, it will create an expectation paradox which could be detrimental in the long run. To overcome the

current debate of performance and interference, some experts suggested that the city should instrument a set of common standards for developing these networks and that this standardization has to involve a national debate. A tourism industry representative remarked: "*…the network is going to affect not only the residents but also travelers visiting the city. This requires common standards and capabilities*." (Focus group with tourism professionals) The above discussion indicates that despite the novelty of the new infrastructure, users tend to compare the new technology with existing standards and communication infrastructures. It also shows that relative performance is an enduring issue; improvements in technology will likely always present users with "better" alternatives and they will always compare the alternatives to whatever they may already have. Overall, the above discussion about speed, reliability, standards, usability, and overall quality of service lead to the following proposition:

P1: Increasing performance will enhance UA.

Related to the issue of performance is 'interoperability'. Switching between different forms of communication channels coupled with myriad types of devices used for each network limits the value one network can provide to the users. One participant in a focus group commented:

> "*…if the expectation is ubiquitous connectivity, then various entities in the communication infrastructure must be integrated. Integrate with cell phone providers- otherwise citizens might find it hard to use/ not enough access devices.*" (Hitech/Early startup companies focus group).

The users did not see the new infrastructure as a standalone system. Rather, it has to fit with the installed base. Therefore, we propose:

P2: Increasing interoperability will enhance UA.

The third aspect of the technical dimension was availability, including where the network will be accessed, and how it will be accessed. There was considerable debate about indoor vs.

outdoor access. The value of an outdoor only network was seen as limited. However, even with outdoor access, there were proponents who envisioned fantastic opportunities:

> "*Think of all the business transactions that can take place on something as simple as a park bench. Being outdoors is not as bad as you think*" (Wirelessphiladelphia.org, 2005).

David McClure, president of the U.S. Internet Industry Association commented:

> "*It's too risky to build the new public networks when the market is so difficult to predict. Wi-Fi is a great technology in the confines of a limited space. We're somehow dreaming that we can extend it in a wide mesh to cover 138 square miles, in the case of Philadelphia. What happens when the city has invested millions of dollars of taxpayer money to build a network and then all of those private Wi-Fi networks that everyone put in their homes and businesses just trash the network?*" (Cable Digital News, 2005)

Another aspect of availability is access devices. Although it seems trivial in the larger context of an exciting infrastructure, the data suggested that access devices were a major concern for many stakeholders. The main issue was the high cost and rapid rate of obsolescence of access devices. For instance, one city resident observed that "*the cost of ownership of a personal computer is much higher than other major electronic media such as a television or mobile phone"* (African-American chamber of commerce). The rate of technological change makes it difficult to only adopt one form of technology to access the II. The availability of the infrastructure becomes a multidimensional construct with both spatial (geographical) and technical (access devices) elements:

P3: Increasing availability will enhance UA.

7.3.2. Socio-Cultural Dimension

We categorized three issues with respect to the socio-cultural dimension: *Individual capacity*, *Relevance* and *Interconnectedness* (see Table 3).

Table 3: Categories and sub-categories for socio-cultural dimension

Category	Sub-Categories
Individual capacity	• Experience with the technology • Usage context • Appropriation of the technology artifact

Relevance	• Uniqueness/Justification for use and investment • Information/communication/entertainment needs
Interconnectedness	• Existing social and business relationships • Access to social networks • Cultural sensitivity

The primary category related to socio-cultural dimension is individual capacity. Individual capacity refers to the experience, interest, anxiety and attractiveness of the new technology and is determined by the physical properties of the technology, personal factors (literacy, innovativeness and social intelligence), and social/situational context (nature of work, location, culture and technical means). Consistent with previous research in digital divide (Cronin and Davenport, 1993; VanDijk, 1998), and user appropriation of technology (Orlikowski, 1992), our data suggests that individual capacity is an enabler as well an immediate barrier to universal access. Consider the following statement from a member of African-American chamber of commerce: "*what are people accessing the network for? We need to understand what people need and then promote the network based on use*". A city resident noted, "*Technology should be intuitive, similar to familiar systems. People have to feel comfortable with their own surroundings to use technology*". Another resident echoed similar sentiments: "*Enable people to enable themselves. Don't force usage on everyone.*" (Focus group of civic/community groups). Further, the positive or negative outcomes from the use of an artifact arise if it enables appropriable activities. To be appropriable, usage has to connect to some well established personal knowledge of those involved in the activity. It has to make sense in the larger social setting, and has to be personally meaningful (Papert, 1980).

Related to individual capacity is the notion of relevance. The technology artifact, to be relevant, should be embedded in the existing social and cultural contexts of the user. Reflecting these ideas, some city residents actually needed a justification for the whole initiative. As one resident remarked:

"*Immediate barrier is trying to justify the expense. Why wasn't the 10 million (the budget for the initiative) spent on schools, or flu shots? Wireless is still a luxury and there are many unmet basic needs. In this state of affairs, I am not sure how many will embrace this initiative*" (Focus group of Hispanic chamber of Commerce).

The artifact should also be relevant to the day to day practices of users. A doctor commented:

"*most of our work is definitely not time sensitive. For our profession, the benefits of instant communication are not important. Also, why would I transmit confidential medical information over a public network when I have secure digital lines for those purposes?*" (Focus group with Health Care professionals)

The needs also vary in terms of information, communication and even entertainment. For example, one resident of the city commented:

"*for me, it is entertainment and the excitement of meeting new friends using the new technology, and broaden my knowledge through it.*"

Individual capacity and relevance may operate directly on UA but as discussed above and reflective of our data, they are highly interdependent with the technical, economic, social, and environmental context. Therefore, we propose that:

P4a: Individual capacity positively moderates the extent to which performance, availability, inter-operability, and affordability[1] enhance UA.

P4b: Relevance positively moderates the extent to which performance, availability, inter-operability, and affordability enhance UA.

The above statements echo the tension that is reflected in our analytical framework which views complex socio-technical systems as a series of relationships among regimes (such as standards, rules, and institutions), landscapes (various actors and social groups), and systems (the artifacts and services). Further, the above statements also integrate the macro and micro units of analysis that have been traditionally discussed separately in extant research in areas such as innovation diffusion, cognitive psychology and user acceptance.

[1] The concept of affordability is developed in the next section.

An interesting issue that emerged in our analysis is the concept of interconnectedness[2]. When looking at technology as a resource, access becomes more than a question of ownership of the artifact. Rather, it has to be defined in terms of the ability of technology to maximize the utility for pursuit of various goals. The II is essentially a medium through which an individual achieves certain social and instrumental goals. To this end, one needs to have access to various forms of social, economic, and cultural capital/networks. This requirement is illustrated by a small business owner:

> "*to afford and acquire access, one needs money, but to use to it appropriately and meaningfully, one must have access to social and business networks*".

Another city resident echoed similar sentiments:

> "*what will I do accessing the wireless if I do not have people to contact on the internet?*" (Focus group with African-American chamber of commerce)

Every setting involves social relationships and cultural materials. It consists of the interactions that individuals have with one another as well with the materials in the environment. Interconnectedness in such a setting denotes interdependence, in the sense that the artifact allows a person to explore new potentials freely, while at the same time connects the person back to people and the environment. The true potential of the artifact is realized only in such conditions. Therefore, we propose that:

P5: Interconnectedness positively moderates the extent to which performance, availability, interoperability, and affordability enhance UA.

7.3.3. Institutional dimension

The technical and socio-cultural dimensions of UA are inherently interlinked with the institutional forces driving the infrastructure. Our analysis identified three issues: *Resource mobilization, Affordability* and *Local involvement* (see Table 4).

[2] We use the term interconnectedness to denote social connections while the term interoperability refers to technical issues.

Table 4: Institutional dimension	
Category	**Sub-categories**
Resource Mobilization	• Funding mechanism (business models) • Cost reduction and investment
Affordability	• Subsidization • Relative cost of access and devices
Local involvement	• Promotion and outreach • Education and training • Civic ownership

One of the initial efforts by the city officials was to look for a realistic business model that sustains affordable broadband access. The actual cost of access is in addition to the issues such as lack of access devices, and enough opportunities to use the Internet that were seen as a major road block in the path to achieve UA. Considering these issues, resource mobilization becomes an important aspect especially in projects that involve socially desirable goals, since such projects are not a core competency of public agencies, and create significant funding and management risk and challenges. Complicating factors include dealing with arbitrary and inflexible budgetary, regulatory, social, ideological, and political constraints such as 'the project must be completed at zero cost to the taxpayers' (Jain et al., 2007). Yet, our data analysis shows that most stakeholders think that UA can only be achieved by public-private partnerships and the involvement of multiple parties. The initial business model in the case of the Philadelphia wireless initiative was to fund the initiative through tax payers' money, and provide free service to the residents, and at a nominal fee to the businesses. One city official commented:

> "*the city could provide the service for free but it will be unlikely to find funding. Alternatively, it could offer the service through a consortium that could sell to the public at a certain price*" (PCWorld, 2005).

The final business model reflected the above challenges and resultant compromises. In an effort to increase the long term resource availability and create economies of scale, the final contract mandated EarthLink to grant other ISPs access to the infrastructure. According to EarthLink:

> *"any ISP that is willing to sell this service will, for a fee, be able access our network. This will generate scales and foster competition, eventually driving down rates"* (Network World, 2005).

However, the wholesale business model was not without its own problems:

> *"the network needs to be solid enough for other service providers to rely on it. Since this wireless is relatively inexpensive to install, as some point, it will become more attractive for the ISPs to build their own Wi-Fi networks and charge on their own basis. Once the technology is standardized, the only differentiating factor will be the personalized services provided by the ISPs. This again becomes a typical economic model."* (Small Business Association focus group)

The above discussion suggests that beyond the obvious need of capital to build and maintain the UA, there is a more subtle requirement that resources need to be mobilized from multiple sources. Further, the type of resource required may change and mobilization of one resource (e.g., creating a way in which others can sell services through the network) may lead to mobilization of additional resources. It is unlikely that one entity will ever have the capital or political will to fully sustain UA.

P6: Increase in resource mobilization enhances UA.

Affordability refers to the cost of the access devices, internet access and complementary services. Complementary players such as device manufacturers drive network externalities, and contribute to low prices of access devices. The role of complementary players also becomes critical in enabling UA. A city official commented:

> *"we have to build partnerships with hardware manufacturers. Otherwise the price of the equipment becomes unaffordable"* (Silicon.com, 2005).

Similarly, according to a member of local chamber of commerce:

> *"the city should invite sponsorships that help cut costs. You are investing in future of Philadelphia. So let the businesses invest in, and sustain this initiative and drive low costs*".

Affordability, as used here, is a relative concept; we propose that any relative decrease in price and overall cost will enhance UA[3]. Note also that in some cases (such as cell phones), it is possible even today to receive free devices, but still those devices are not completely affordable; some may require additional components such as memory cards, accessories such as headsets, and more importantly expensive contracts. To the individual, the overall affordability of a cell phone is still quite low. We therefore propose that the affordability remains an important determinant of UA.

P7: Increase in affordability enhances UA.

Many residents felt a need for intervention from existing providers. Surprisingly, this is in contrast to the initial view that telecommunication firms were competitors and barriers to the initiative rather than assets. As one participant suggested:

> "*use the private companies who do this. For example bundle Microsoft and Philadelphia wireless together-schools will benefit. Involve Verizon and Comcast. They have experts and the infrastructure to help*." (Focus group with small business group)

Given that personal communication devices such as cell phones are a major medium of access to the Internet and other information sources, it is consistent that incumbent firms such as Comcast and Verizon were considered important to ensure interoperability and affordability. Further, these institutions provide information and services that are the primary goods exchanged over the information infrastructure. They also drive down the costs of access devices by generating economies of scale.

P8a: Increased involvement by existing service providers will increase interoperability.

P8b: Increased involvement by existing service providers will increase affordability.

[3] There are marketing and economic theories of optimal pricing – those issues are beyond the scope of the discussion here – our focus is relative overall affordability.

To help communities actually leverage the given technology base, beyond just generic resources, local resources have to be mobilized. For instance community leaders can play an important role in promotion and outreach, as one resident opined:

> "*How are they going to pay for it? If the city promotes it, that will cost the city money. Churches can drive it. We don't need a sweet marketing contract for $10 million when the preachers can do it for free*." (Focus group with African-American business owners)

One student commented:

> "*Community centers will help the neighborhoods, organizations to help donate computers. This could help lessen the digital divide. This effort would create more of a demand /pressure to have groups to address the digital divide. Offer the needed training.*" (Focus group with local students)

These comments are consistent with the literature on development, where it has long been established that local communities and civic groups play a powerful role in actualizing the use of resources for development (Kretzmann and McKnight, 1993). These entities are the vehicles through which community assets can be identified and connected to one another in ways that multiply their power and effectiveness. Since technology adoption by communities is closely connected with the available resources and local uses, these community groups can play a major role due to their familiarity with the local conditions and problems. Based on this discussion, we propose that:

P9: Increase in community and grassroots involvement enhances individual capacity.

An interesting point that surfaced in the data analysis was the issue of social control. Residents seem to demand civic ownership of the network since they consider it a social initiative. As the representative of a Wi-Fi consulting firm suggested:

> "*the city needs to have some skin in the game. Someone needs to take ownership of the project to make sure it happens and is done right. There needs to be accountability. And this means that the city either needs to put up some money upfront or actually use the network to deliver some kind of mission critical application or service*".

A city resident concurred:

"the city has to initiate the program, not businesses. They will take too much advantage of grants and empowerment zone; Comcast reaped heavy benefits at the city's expense. Citizens should have 51% at all times. Make sure that citizens have a significant amount of input" (Focus group with Educators).

This suggests that large "public works" type of projects automatically take on some civic ownership regardless of the source of funding:

P10: Increase in civic control increases UA.

The series of dimensions and their relationships are depicted in Figure 3.

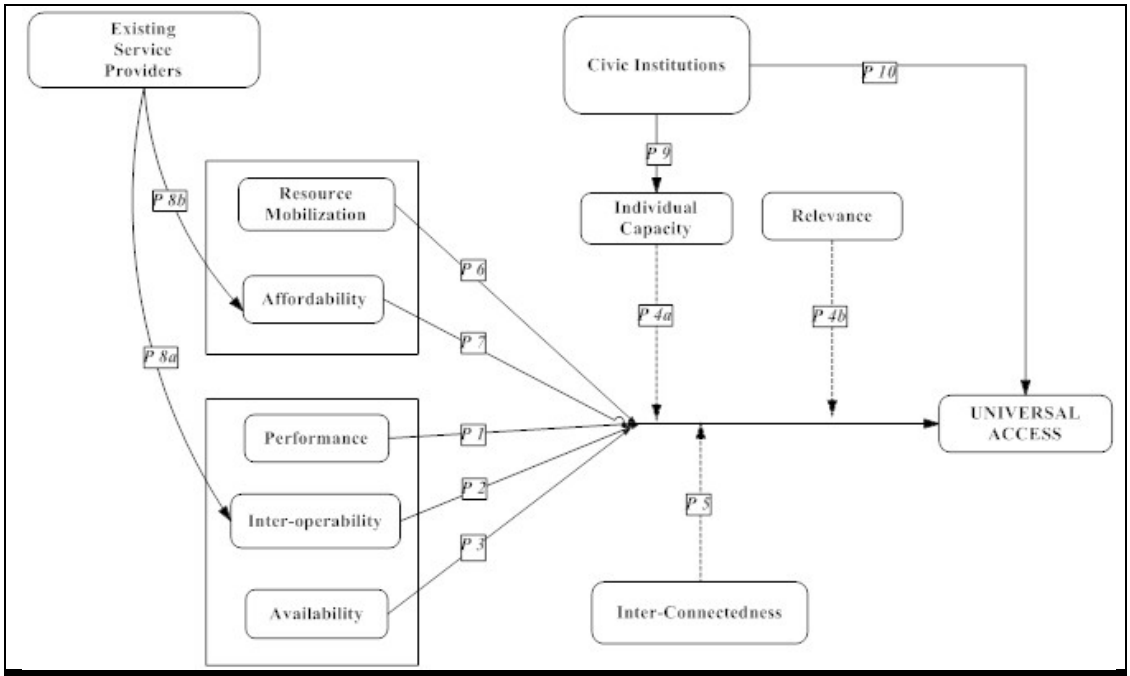

Figure 3: Proposed model of Universal Access

8. Discussion and Definition of UA

The data analysis enabled us to identify categories of stakeholders and issues that impact UA. The technology under study, no longer remained a simple artifact, but rather, a complex and heterogeneous system. We consequently define UA as:

"a human-technology interaction that is influenced by the interplay of a range of technologies, individuals and their social context. At the same time, the human and technological elements are deeply embedded in institutional dependencies that are essential, yet sometimes constrain access and use of the information infrastructure."

We discuss below how the proposed model and definition increase understanding of UA.

UA is a non-linear concept: The major stakeholders of the Philadelphia initiative as well as the general discussion surrounding UA assume a linear relationship between the availability of the II and developmental opportunities such as quality of life, community well being, and poverty reduction. UA is typically articulated as a need that has to be fulfilled or a problem that has to be resolved. This determines the interpretation of the infrastructure as well as of its constituent technology components. For instance, the most powerful stakeholders see UA as a problem of economic disparities, and consequently, Wi-Fi technology was adopted to enable cheap and easy access. However, the base technical components themselves are sometimes not directly conducive to enable ubiquitous or even equitable access. As we elaborated in our analysis of the technical dimension, some of the technology choices in the case of the Philadelphia Wireless initiative can even become barriers to UA if they do not fit well into the installed base or if they have reliability problems.

The UA concept is constantly evolving: The data analysis suggests that the notion of UA is in constant flux, and is predicated upon the shifting relationships among the stakeholders as well the evolution of the underlying technologies. New technologies with better usability and functions as well as better economic models emerge; these new technologies can fundamentally alter the dynamics among the actors in all the dimensions, resulting in a changed meaning of UA. In the current case, wireless standards are still under development and this area is seeing unprecedented innovation. When new standards emerge, private enterprises are generally well placed to manage the cycles of creative destruction. Governments are not used to handle such cycles of change. Similarly, due to the lack of common standards wireless technologies are still controlled by vendors owning proprietary technologies. This creates a situation where success is

overly interlinked with particular vendors. It is not only the technology, but also the business models or other institutional motivations/agendas that add to the constantly and dynamically changing meaning of UA. For instance, several initiatives in the USA were stalled due to the decision of EarthLink to exit the municipal wireless business. The proposed model in this paper tries to take into account the dynamic inter-relationships of the technical, social and economic dimensions of UA.

The Macro-Micro linkage: The proposed model and definition also bridges the gap between the macro and micro units of analysis that have been traditionally discussed separately in extant research on technology adoption. A logical connection between the two units of analysis is that diffusion of innovative systems, and eventually their adoption by individuals (and communities) is the primary requirement for UA. Rightly so, theories that shaped our understanding of design, development and usage of technology have taken many forms such as innovation diffusion (Rogers, 1983) and cognitive psychology and user acceptance studies (Davis, 1989), and prevail in multiple contexts such as organizations, communities and nations (Selwyn, 2004). Technology diffusion studies consider diffusion as a function of time and environmental factors, whereas technology acceptance theories look at individual cognitive and affective properties that determine whether a technology is eventually accepted. In addition, research on digital divide has considered either binary measures (access or no access) or spatial measures (number of places in which the media is used) as indicators of UA (e.g., Nie and Ebring, 2000). The above stream of research has overlooked the influence of institutional structures and social environment on technology adoption and usage. On the other hand, structuration theory (Orlikowski, 1992) recognized the complexity of design and usage in social settings, but has been quite ambiguous about the mutual influences of technology and agency. Our analysis illustrates that UA is

interwoven with the power relationships among the institutional elements that determine the trajectory of the technology development and use, as well as the elements of action at the grassroots level of the social system. In other words, while the demand for or diffusion of the II is driven by the need for information and social interaction at the local level, it is also determined or diminished by functional transformations at the systemic level. This inherent macro-micro dualism presents interesting challenges for the policy making realm and for future research on measuring success. For instance, one of the major challenges in the Philadelphia Wireless initiative is sustainability. For this to happen, it is not sufficient that the individual members of the population adopt the system but there has to be a larger demand and involvement from government, local businesses, and education. However, these entities have existing infrastructures that are either better in terms of performance, or not complementary to the proposed technology.

The importance of institutions: The discussion on macro-level structures brings forth the role of local institutions such as government, community, and civic groups as well as service providers in enabling UA. The involvement of civic bodies in technology initiatives has been subject to extensive scrutiny and criticism either due to economic or political reasons. However, Catinat and Videl (2000; p.184), in the context of European *e*Democracy project, suggest, "*The market place is always not the best mechanism to ensure the basic values associated with the notion of digital democracy (such as freedom of communication and equal access to information infrastructure)*". From the user's perspective, using the new infrastructure requires access to devices, and skills to use and obtain information and services from the II. To facilitate such use requires computer literacy, education and training, assistance from friends, colleagues, and from civic bodies and local community groups. Further, as we show in our analysis, there is a general

perception that cities and other public institutions should take ownership of the projects and integrate the technology into the basic civic services such as emergency response centers. The very usage of the II by these entities as well as the extent of services they provide enhances the legitimacy and usability of the II among the grass root levels of the community. A new technology is as much a social commodity as it is a technology artifact. The ways in which public institutions represent the technology has a definite influence on individual adoption. The proposed model conceptualizes the dynamic role of local institutions rather than simply depicting them as sources of inertia and stability.

The socio-cultural aspect of UA: The focus of UA initiatives has been on the access part, and less on the content and usage. However, our data shows that problems of access are not only related to adopting a new technology or having access to technology and content, but also about having limited possibilities to communicate and share information. It is important not to consider lack of usage as a characteristic of only a few sections of the population. The usage gap exists due to limited abilities or opportunities of certain social groups to systematically use and benefit from the II. These groups exist at every strata of the society. While there are macro level factors that determine the need for or access to technology, it is individual capacity that determines whether people are actually able to put UA into some meaningful use. This individual capacity is a combination of individual characteristics such as relevance, literacy, intelligence, and innovativeness, and situational factors such as location, cultural associations and social networks. Therefore, access to the II cannot be seen as an end by itself. It is only an enabler of further activities that can only be partially specified beforehand, and are determined by the socio-cultural characteristics of the target populations. Recognizing this diversity and heterogeneity of

users and uses is an important first step in realizing the vision of digital inclusion, participative citizenship, and the dream of UA.

9. Conclusion

We deconstruct the meaning of universal access in the context of the modern information infrastructure. There is rapid growth in deployment of these infrastructures to support widening social, economic, educational and even political activities. However, to realize the promise of these technologies, it is important to rethink the traditional notions of access. In this paper we show that UA is not a singular concept, but rather multi-dimensional and highly contextual. Each dimension and the specific propositions in our model are influenced by multiple actors. The II involves a wide range of technical, business and social networks. The key to the success of initiatives such as 'Philadelphia wireless' is to understand this complexity, and provide sufficient resources to the user to activate, and reconfigure these networks according to his/her needs.

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APPENDIX I

DATA COLLECTION DETAILS BY SOURCE

I) NEWS ITEMS (N= 79)

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II) FOCUS GROUPS (N=13; Participants= 120)

- African American Chamber of Commerce – African American owned businesses (2)
- Asian American Chamber of Commerce – Asian owned businesses
- Community Network – organized by the Institute of Civic Values, this group was comprised of civic outreach organizations and social service agencies (2)
- Greater Philadelphia Tourism Marketing Corporation – Tourism business sector
- Health Care Group of doctors and medical professionals
- Higher Education – Administrators and faculty from various area universities
- Higher Education – Students from various local universities
- Hispanic Chamber of Commerce – Hispanic owned businesses
- Innovation Philadelphia – High Tech, Early Start-up Companies
- Philadelphia Chamber of Commerce – Small business group
- Universal Community Homes, a private corporation building low income house and providing education to underserved areas in Philadelphia

III) REPORTS & WHITEPAPERS (N= 25)

WIRELESSPHILADELPHIA.ORG DOCUMENTS

- 501c3 Determination Letter
- BCO Certificate of Registration
- Annual Plan for Fiscal Year 2007-8
- Status of the Initiative - 5/21/07

HISTORIC DOCUMENTS

- Original Business Plan 2/9/2005
- Summary of Citywide Wireless RFP 4/4/2005
- Non-Profit Summary 4/4/2005
- Wireless Fact Sheet 4/6/2005
- Press Release 4/7/2005
- Business Plan Summary 4/7/2005
- City Wi-Fi Pilot Areas 2005

OPEN RFPs (Request for Proposals)

- RFP for Evaluation Services for Wireless Philadelphia

CONTRACT DOCUMENTS AND CLOSED RFPs

- RFP for Counsel and Legal Services
- RFP for Grant Writing and Grant Management Services
- RFP for Website Design and Hosting 8/17/2006
- FAQ for Website Design and Hosting RFP
- RFP for Community Websites
- RFP for Financial Services
- Network Agreement
- Network Agreement Exhibits
- RFP for Citywide Wireless Network 4/5/2005
- RFP for Citywide Wireless Network - Appendix A
- RFP for Citywide Wireless Network - Appendix D

APPENDIX II

METHODOLOGY & CODING PROCEDURE

First, we cleaned the news items and the city reports of headings, subheadings and any other identifiable information that can lead to the nature or source of data. The objective was to reduce source bias on the coders' interpretation. Similarly, the recordings of the focus group sessions were transcribed verbatim by a transcription specialist. The focus group conductors further revised this data based on their notes taken during the sessions. The entire data yielded a total of 232 pages (45,914 words) of textual data. This data was entered into ATLAS.ti (ATLAS.ti Scientific Software Development GmbH., 2006), a tool designed to analyze qualitative data using the concept of nodes and cases. The ATLASti format yielded approximately 2556 paragraphs of data that was content analyzed in the final analysis phase. In the initial coding, various paragraphs were combined due to their similarity and orientation. The final data used for the open coding process consisted of a total of 1654 paragraphs of text.

For the analysis, we followed the grounded theory approach to data analysis (Miles and Huberman, 1994; Strauss and Corbin, 1990). The analysis involved three interpretive and hermeneutic coding methods referred to as open, axial and selective coding respectively (Strauss and Corbin, 1990). During the open coding we examined, compared and categorized the data by coding each paragraph or groups of paragraphs with specific codes. The preliminary examination of the data helped us to fracture and generate codes from the textual data. The open coding process yielded approximately 74 open codes. These codes were used to further categorize the data, and identify potential dimensions and sub-dimensions of each category. As the open coding proceeded, certain plausible concepts emerged, which were coded in relation to each other using the axial coding procedure. During the axial coding process, data was sought depending on its ability to suggest relationships among a category and its sub-categories, or its ability to support or falsify plausible relationships between categories. Once a set of categories were identified, we conducted the selective coding process to link the different categories to the core category using the analytical framework (consisting of conditions, context, and consequences; see previous section). For instance, we identified numerous codes related to the technical issues of the wireless network (Please refer to the codes and the coding procedure in appendix I). Some of them include '*Devices/users*', '*Integrating services with cell phone providers*', '*Privacy/ Security issues*', and '*Create uniform standards*', etc. As we reread these codes, it was apparent that they belonged to the technical aspects of the network. However, these codes also linked other categories and dimensions. The code "integrating services with cell phone providers" linked two categories- "inter-

operability" of the technical dimension and "complementary services" of the business/institutional dimension. Based on the analytical framework, we interpret this linkage as follows: the wireless network, even though a presumably radical technology innovation (socio-technical system) is inherently interlinked with the existing institutional arrangement (socio-technical regime). This linkage might not be technical but is viewed thus by the existing social actors who will eventually use the system. Therefore, the success of either entity is predicated on a mutually beneficial coexistence. Through the iterative coding process, we created a set of relationships among the categories and dimensions.

Table 5: Open codes generated and the number of paragraphs grounded on each code

OPEN CODES	**PARAGRAPHS**
Community control	43
Community empowerment	11
Community identification	34
Community participation	16
Developing adoption networks	12
Communication needs	47
Critical awareness (current self/ common image)	14
Digital divide	69
Distributive justice	26
Education & training (impacts community participation)	31
Build community partnerships	33
Contradiction between universal access and effective use (e.g. what are they accessing? Promote the uses of the system based on use. Find out what people need.)	22
Don't lose personal touch	6
Individual/ organizational needs	56
Entertainment needs,	21
Information needs	49
Transaction needs and communication needs	12
Public & private partnerships	29
Opinion leaders	8
Organization driven innovation/complementary players	24
Mechanisms to foster participation	8
Bridging digital divide	34
Resistance to change	5
Social divide	42
Targeting differential	27

Universal access	17
User fit	3
Wireless enables partnerships with peers	7
Establish norms	15
prioritization of city funds (lowers targeting differential)	31
Promotion of the network	9
Alternative to existing services	63
Argument for public good vs. argument for profitability	37
Benefits to complementary players	26
Competition/ backlash from existing service providers/ stakeholders	39
Customer relationship management	1
Funding sources (funding through complementary players such as equipment manufacturers)	23
Increased market reach for businesses	18
Integrated value chain	1
Integrating services	1
Location based targeting of existing services	22
What's new syndrome? (negative impact on perceived additional value)	18
Perceived additional value- individual / organizational (Positive impact on funding and adoption)	16
Mechanisms to foster participation of community stakeholders	11
Image/ branding (wireless Philly image- positive impact)	19
Major funding needed	25
Privacy/ Security issues (apprehension about privacy in public networks a possible negative fallout)	17
Development of standards / Create uniform standards	8
Devices/users	38
Ease of use	23
Complexity	2
Ensure regulation of places to use	20
Establishing regulations	20
Citizen control	12
Incumbent TelComs	27
Performance of the network	32
Service support	16
usage patterns & behavior	45
network performance	31
Infrastructure- complementary	13
Interoperability	22
Ubiquitous information	43
Governmental intervention	39
External players such as Intel, IBM.	24

Measures of success	28
Information overload	4
Organizational adoption	14
Possible inefficiency of the network	36
Potential tourist attraction	15
What are the revenue sources?	19
Skepticism	12
Existing social context	26
Who will provide the access devices?	19

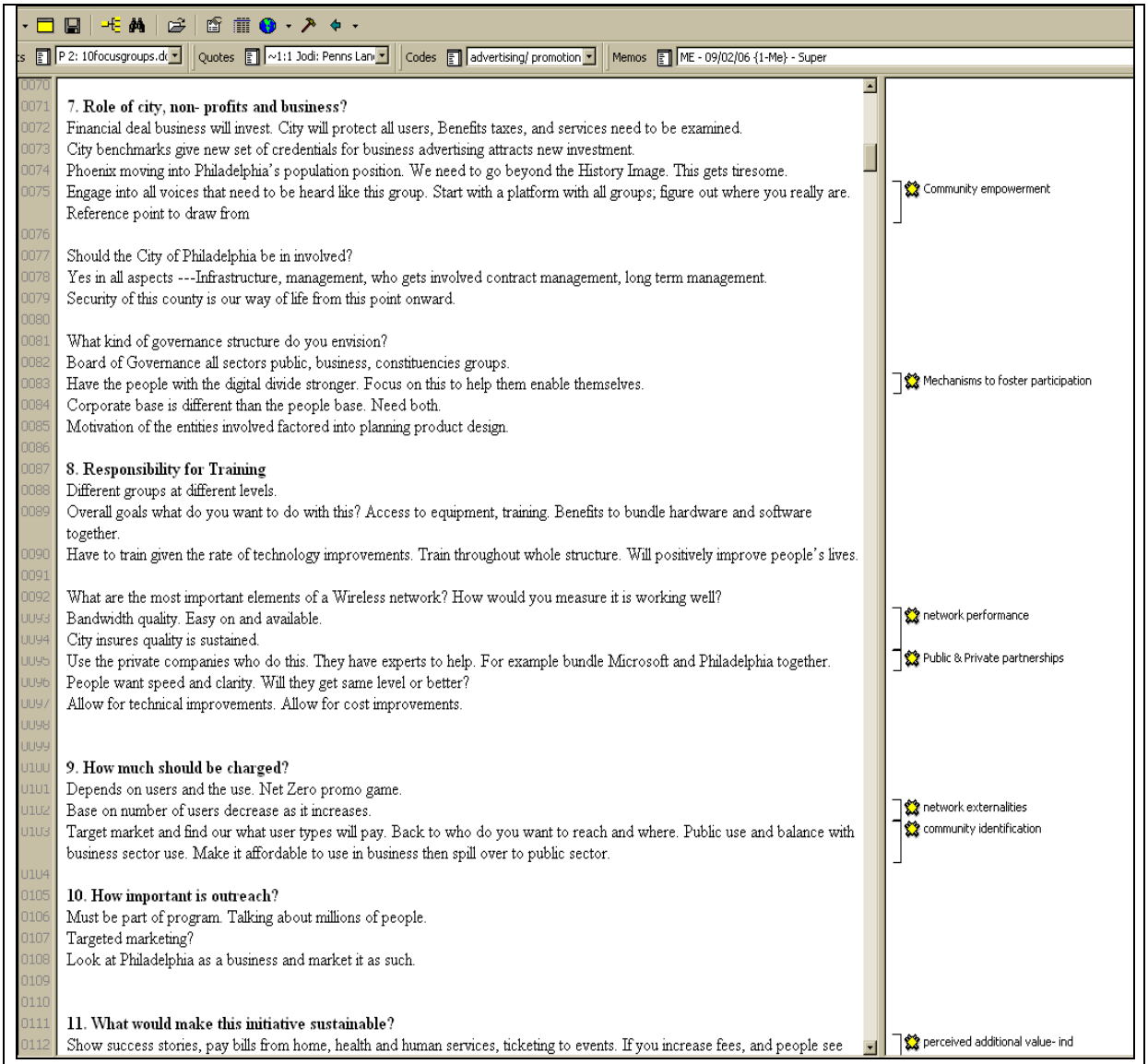

Figure 4: Example of the coding scheme in Atlas.ti analytical software

Table 6: Coding scheme and sample codes generated

UA Dimension	Paragraph from Transcript	Sample Coding
Technical	Bandwidth quality is my major problem. People want speed and clarity. Will they get same level or better? Easy to log in and available all the time Allow for technical improvements. Allow for cost improvements. Indoors we have access already. The ability to get work done outside would be the big advantage.	Speed of the network is one major aspect of having access to II Ease of use Scalability and efficiency are important requirements Ubiquitous connectivity: indoor vs. outdoor
Social	Aren't they ignoring more important investment issues like the devastated areas of the city that could be improved? There are more important issues to address. Get the money that comes from the payback of investment and improve the city in other ways. Doctors have little patience for new things. If system does not work, they will scrap it. They have a short tolerance for failure.	Ways to justify the initiative - important to convince people to participate User group specific qualities: Need to identify user specific diversity
Institutional	From an affordability point of view, there are actually more opportunities for those who can get ahead, there is already a divide- a whole culture will be left behind. Chamber of Commerce, Tourism Board, Some public business groups. Comcast, Verizon should get involved.	Affordability of the equipment is a major factor-worsens digital divide The importance of complementary players and even competitors

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