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MUNICIPAL WI-FI COST-BENEFIT ANALYSIS FOR THE CITY OF MONONA

PUBLIC AFFAIRS 881: COST-BENEFIT ANALYSIS

FALL 2016

UNIVERCITY BETTER PLACES TOGETHER

MONONA

June 9, 2017

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ACKNOWLEDGMENTS

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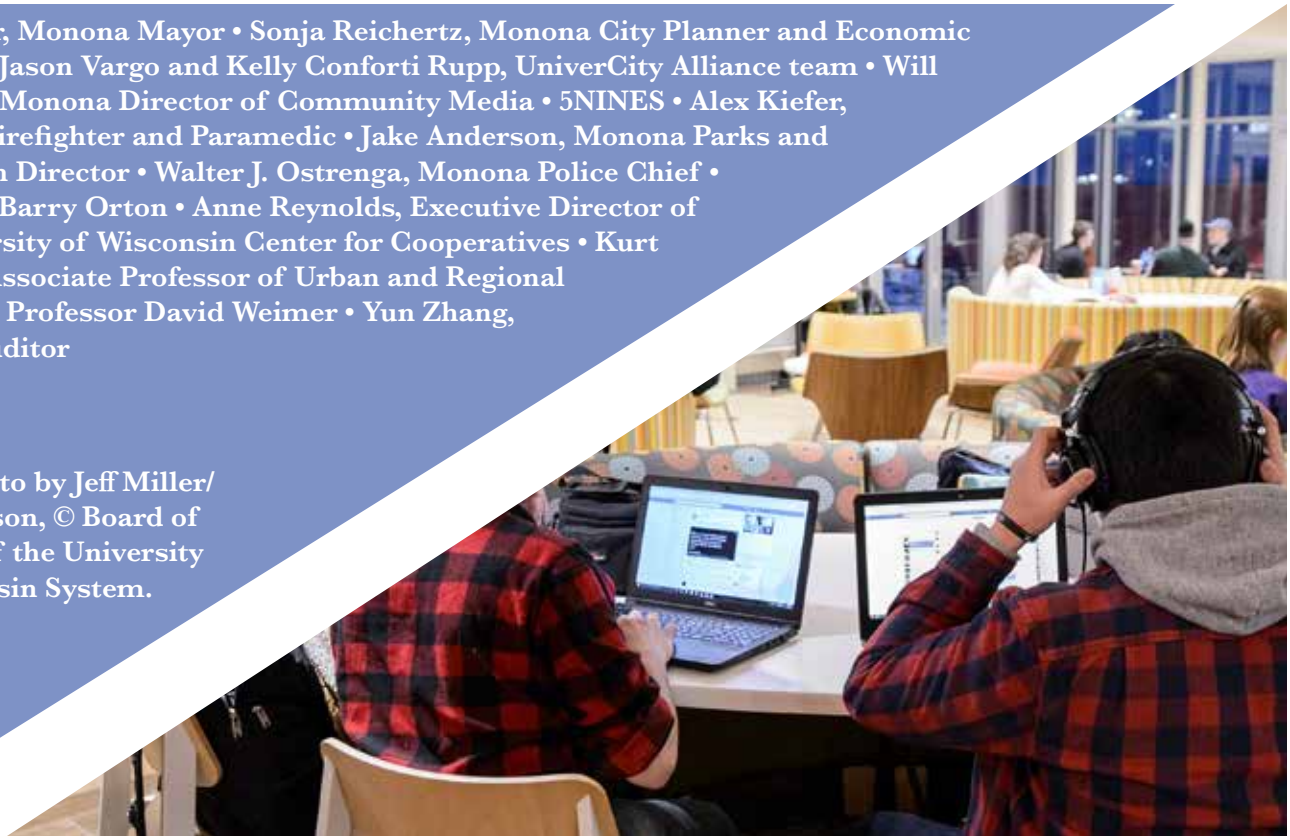

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This report was produced in collaboration with the Public Affairs Department in the College of Letters and Science and the UniverCity Year at UW-Madison.

EXECUTIVE SUMMARY

At the request of the City of Monona, we conducted a cost-benefit analysis regarding a residential in-home municipal Wi-Fi service as well as an outdoor Wi-Fi service. The costs were based on information provided by local internet service provider 5NINES as well as previous analyses conducted on municipal services of this nature. Benefits were assessed from studies related to internet demand and the best information available regarding usage patterns in Monona. The resulting net benefits are positive provided at least 260 residents subscribe. Additionally, a fiber internet option through SupraNet Communications should be explored.

Although our analysis found positive net benefits at the recommended uptake levels, these benefits are not in the form of monetary gains for the city itself. Instead, they are savings residents would experience compared to their current internet service costs. Furthermore, this is only true for the in-home municipal Wi-Fi. Even though an outdoor Wi-Fi service would extend the range of subscribers' internet service, no positive net benefits were found. This infrastructure cost cannot be offset because of the limited time an outdoor service would be utilized in Monona's climate.

Local technology partner 5NINES's presentation of the idea of municipal internet service to the City of Monona is appreciated as it initiated the exploration of this idea; however, a wireless service may not be the most appropriate option for this location. Community feedback that emerged during this indicated that speed and reliability are not always met by current providers in the market. The Wi-Fi proposals analyzed trade off speed for cost, depending on service a resident currently subscribes.

SupraNet reached out to the city while this cost-benefit analysis was already well underway. The fiber based internet service offered by this company should be explored in the future as this type of system can offer increased reliability over Wi-Fi. Additionally, SupraNet is already engaged in a proposal for the neighboring City of Madison which could provide additional benefits and cost savings if the City of Monona engaged in a similar partnership. A faster more reliable service could entice more businesses to uptake a municipal service. We view this analysis as being a first step in evaluating municipal internet service.

"The City of Monona should conduct a survey of interest to find an approximate demand schedule for the in-house service. If the approximate demand and willingness to enter the market exceeds 260 households, then the city should undergo the project."

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INTRODUCTION

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The City of Monona was approached by local internet provider 5NINES regarding a potential partnership to provide a municipal Wi-Fi service for residents. Intrigued by the proposal, the city commissioned our team to engage in a cost-benefit analysis to evaluate the costs and benefits. Through informative discussions with stakeholders, the evaluations of both an in-home residential Wi-Fi service and an outdoor wireless service emerged as the most useful options for exploration.

Municipal internet services address a variety of issues. The most prevalent motivation is to provide service in areas where it does not currently exist. These areas are typically rural and face large infrastructure and service costs that prohibit private sector actors from entering the market.[1] Another motivation and the main impetus for the neighboring City of Madison to engage in internet service provision is equity.[2] The current internet market and relatively homogeneous economic demographics of Monona, neither of these are the main motivation for the creation of this system.[3] However, feedback from a small sample of the local business community indicate there is dissatisfaction with the current internet offerings' speed and reliability.

Despite the different reasons for providing internet access, studies of other municipal internet systems and proposals adequately describe the obstacles that can be encountered. In an era of increasingly restrictive budgets, garnering enough public support to justify utilizing resources for internet service provision as opposed to investing in other local government services are obvious hurdles.[4] These costs are largely dependent on the current infrastructure and difficulty associated with tapping into those resources. Topography and other physical barriers can encumber coverage capabilities.

Additional hurdles faced by proposals in Wisconsin are detailed in the 2003 Wisconsin Act 278. Telecommunication providers were concerned public

1 J.J. Po-An Hsieh, et al., "The Bumpy Road to Universal Access: An Actor-Network Analysis of a U.S. Municipal Broadband Internet Initiative." The Information Society 28, No. 4 (2012): 264-83.
2 Colombia Telecommunications Corporation, "City of Madison Fiber-to-the-Premises Feasibility Analysis." Madison, Wisconsin: CTC, 2016.

3 City of Monona Comprehensive Plan 2016-2036. Monona, WI: City of Monona, 2016. 1-122.
4 Po-An Hsieh, et al., "The Bumpy Road to Universal Access: An Actor-Network Analysis of a U.S. Municipal Broadband Internet Initiative."

providers entering the market would hold an unfair advantage related to acquiring right of way access and infrastructure.[5] The communications companies' lobbying efforts resulted in this act which requires any municipality that does not already provide utility services to hold a public hearing and conduct a cost-benefit analysis of the proposal before providing internet to residents.[6]

Adhering to the aforementioned statutory requirements is essential to the success of the implementation of Wi-Fi. Other necessary investments for implementation related the in-home service include base stations, Metropolitan United Fiber Network (MUFN) fiber splicing, and customer provided equipment (CPE) which will allow residents to connect to the network.[7] The specific one time and ongoing costs associated with these items are detailed later in this report and in Appendixes B and C.

An outdoor wireless internet system would also require base stations and MUFN fiber splicing; however, wireless access points (WAPs) would be installed on locations such as light poles throughout the City.[8] More information regarding WAPs are detailed in Appendix F. Either of these options include a potential tradeoff between speed for a lower cost option. This tradeoff is relative to the resident's current internet access plan. Appendixes D and E detail the cost-benefit analysis.

The subsequent sections of this report detail the specific costs and benefits. The guiding methodology for the analysis is described followed by the assumptions that were necessary to complete the evaluation. Finally, the results are presented followed by summary information and our recommendations.

"However, feedback from a small sample of the local business community indicate there is dissatisfaction with the current internet offerings' speed and reliability."

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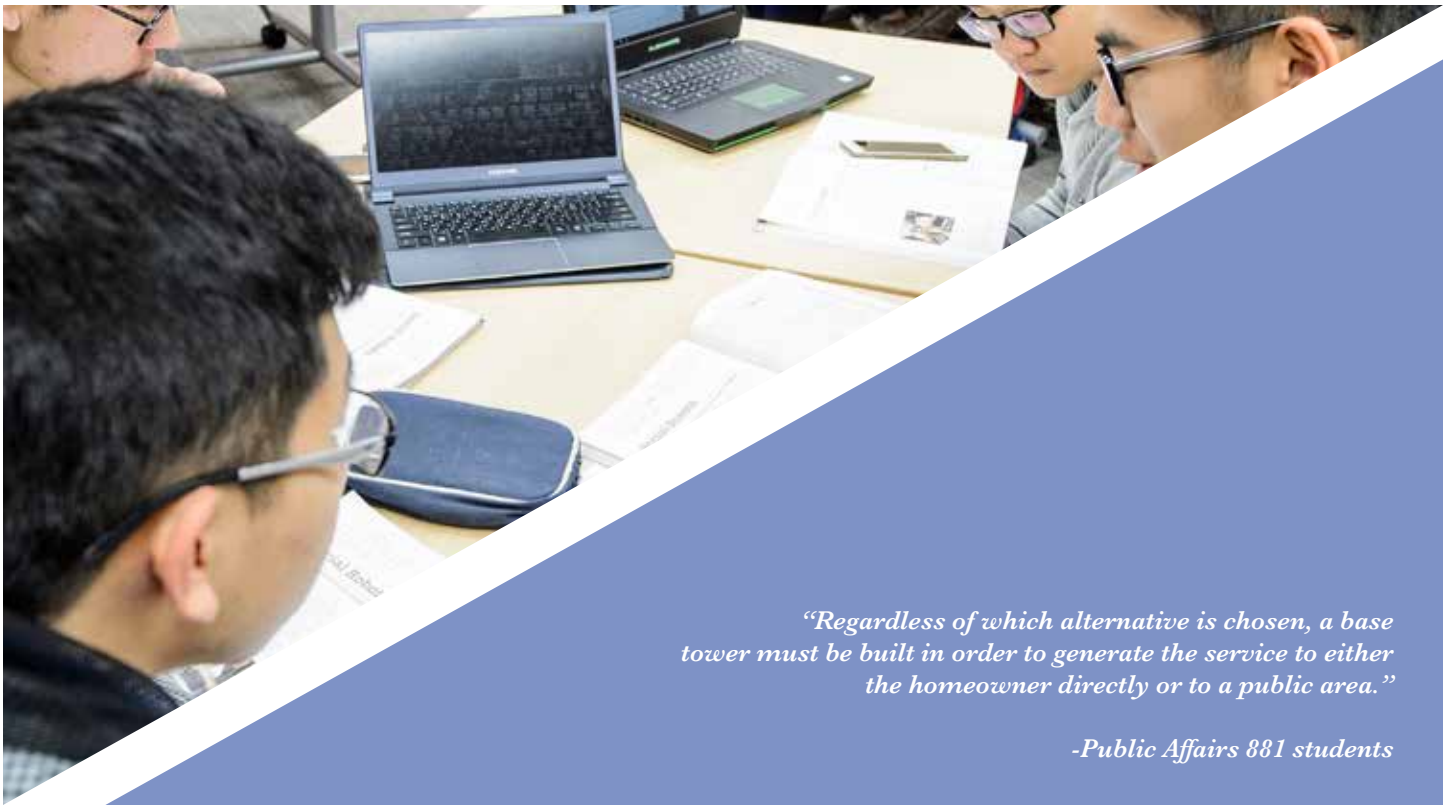
5 Harols Furchtgott-Rott and Arielle Roth, "Answering Four Questions on the Anniversary of the Telecommunications Act of 1996." Federal Communications Law Journal 68, No. 1 (2016): 83-93.
6 "2003 WISCONSIN ACT 278." Wisconsin State Legislature. April 30, 2004.
7 "Standard Terms and Conditions." 5NINES. May 22, 2014.
8 Colombia Telecommunications Corporation, "Wireless Feasibility Study Prepared for the City of Tucson." Tucson, Arizona: CTC, 2007: 95. Web. 8 Oct. 2016. p. 95

COSTS AND BENEFITS



"Regardless of which alternative is chosen, a base tower must be built in order to generate the service to either the homeowner directly or to a public area."

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Costs

Financial Costs on the City

Regardless of which alternative is chosen, a base tower must be built in order to generate the service to either the homeowner directly or to a public area. Each tower comes at a cost of approximately $10,000. Monona's plan requires two towers for a total cost of $20,000. These costs are outlined in Appendix B.

Monona must also pay a fee in order to access the MUFN fiber optic network that runs under the city. Each base tower must have the MUFN fiber optic network spliced and installed. The costs for one tower is $20,000. We could not obtain a concrete estimate for the second connection but predicted it will be in the range of $2,000 to $10,000. This figure is less than the first tower's costs due to the benefit of existing infrastructure. Finally, there is a structured cost of $4,200 per year in additional service and maintenance costs for the MUFN fiber connection. For a more detailed explanation of the costs of the capital expenditures for the MUFN fiber network see AppendixC.

If the city were to offer the in-house Wi-Fi service to residents or businesses, there would be no additional cost for the city. However, if the city were to create an outdoor Wi-Fi network throughout the city, then the cost estimate would vary based on the number of nodes needed to allow desired access range. For a more detailed explanation of capital expenditures for an outdoor Wi-Fi network see Appendix F.

Financial and Utility Costs for the Consumer

If the city decides to create the Wi-Fi service for residents, the financial costs for each subscriber would be anywhere from $15 to $10 a month depending on how many citizens take up the service. Further, all households would have to spend a $75 to $50 flat fee to purchase the node that produces the Wi-Fi, also dependent on the number of citizens who take up the service. See Appendix B for these figures based on uptake as provided by 5NINES. For all intents and purposes, we will consider the installation costs when estimating demand.

There is also a cost for utility loss depending on what the household had as a prior service. We estimate that there will be a loss of utility for those who have internet that is bundled with another service (phone or TV) but were unable to find any data to capture that utility loss. In addition, we assume another utility loss that is associated with moving from a higher download/upload speed to a slower one. We found that there was approximately a $9 per month loss moving from a higher speed to a lower speed.[9] For a detailed explanation of our estimates of utility loss for very fast to fast internet speed see Appendix D.

Benefits

Financial Benefits

In-Home Benefits

The benefit of the In-Home service largely depends upon resident's current access to the internet. For those without internet, they would gain the ability to access the internet for a relatively affordable price with reliable enough service to use most services (email, streaming, and video-playback). For those who currently have internet service, they will realize cost savings relative to their current plan. Those with AT&T stand to gain the most if they have just internet, saving approximately $30 to $25 per month depending on the final monthly rate from 5NINES. Those with service from Charter will not see as much benefit. This is because Charter's internet offering is equal in terms of dollars per Megabit per second (Mbps) upload speed and is faster, giving it an overall higher net utility. Finally, we won't be able to exactly determine who has their services bundled and to what extent, but we have an approximation of services and benefits rendered from switching. For a more detailed explanation of our benefit estimations and how we apply them to our model see Appendix G.

There may also be a number of businesses that would switch to the 5NINES in-door wireless service. We received responses from local businesses from a survey of their interests and concerns regarding internet service. Several businesses responded that cost was a significant concern, indicating they may be interested in purchasing 5NINES service. However, we only received 9 responses and as such cannot generalize these results. If the city finds significant business interest, assessing their benefits would use the same calculation method utilized for citizens'.

Outdoor Wi-Fi Benefits

If the City of Monona decides to create a city-wide outdoor Wi-Fi network, those citizens who have mobile devices (phones, tablets, and laptops) would have another point to access the internet. This would provide the ability send email, watch videos or look up information all around the city. For phone users, this might result in cost savings if it led them to decrease their data usage. Wi-Fi outside would allow citizens to have free access to the internet when they are within the coverage area of the towers. For a detailed explanation of our calculation of benefits to citizens for an outdoor wireless network see Appendix H.

Social Welfare Benefits

We believe there may be other social benefits to a municipal wireless network. However, these benefits are uncertain and not monetized in this report.

Business Community

Local businesses have the potential to gain more costumers or improved customer interactions if they currently do not have access to Wi-Fi due to the costs of the service. Since the results of the survey conducted from another project focusing on businesses had a small number of respondents, we were unable to use the data in this analysis.

Fire and Police Improvements

The Monona Fire and Police departments both indicated that they have no need for an outdoor wireless service. Both departments already have access to the internet remotely through other means and questioned whether the network would be consistent enough for their use. Thus, we do not calculate any additional benefits provided from offering access to fire and police units within the city.

9 Gregory Rosston, Scott Savage, and Donald Waldman, "Household Demand for Broadband Internet in 2010." B.E. Journal of Economic Analysis & Policy 10, No. 1 (2010).

Parks

The parks in the City of Monona may see higher traffic during the late spring, summer, and early fall due to increased access to the internet. Mobile games like PokemonGo, which utilize geolocation to play, may increase the number of children in particular who visit the parks and other public spaces. However, we are unable to estimate the increase in use of public space due to increased internet access, and so do not monetize this potential benefit.

METHODOLOGY AND DATA

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Methodology

We estimate the net benefits of building two towers and consider the outdoor network and in-home Wi-Fi services as mutually exclusive projects. Regardless of which project is undertaken, both projects must consider the initial costs for building the towers, splicing and rental of the MUFN network, and monthly maintenance costs.

Each project will have additional costs as well. The In-Home service will largely have all additional costs be placed on the consumer for a monthly charge and a one-time fee for their router. The outdoor Wi-Fi network will have additional costs for monthly charges for the service and the infrastructure for the nodes to generate the service.

We estimate the net benefits of either project by taking the difference between the estimated total benefits of either projects and subtracting the projected lifetime fiscal and utility costs for doing either project. We assume total lifetime of the project to be seven years before needing replacements or upgrades. Costs of each of the projects, both one time and annual, are summarized in Table 1.

Table 1. Summary of Costs

One-Time Costs	Annual Costs
Splicing into MUFN Fiber Network	Cost of In-home Service
Base Buildout of the Towers	Tower Maintenance
Building Wireless Access Points	MUFN Maintenance
Installation into Power grid	Wireless Access Points Maintenance
	Power Pole Maintenance

Since many of our estimates for costs and benefits were collected from alternative sources and with multiple different sources giving different estimates, we had to generate a range of potential outcomes for these costs or benefits. Table 2 outlines all the costs that rely on a standard normal distribution showing the 95% Confidence Interval bounds for each variable. Table 3 shows all costs that relied on a uniform distribution and shows the upper and lower bounds for each variable and their unit of measurement.

Data

Our point estimate and Monte Carlo simulation use a variety of data that we have found in previous reports and studies and from contemporary sources like the Census assess the uncertainties of both the likelihood of uptakes and cost of services.

Our point estimate and Monte Carlo simulation will rely heavily on data from previous studies of similar projects in other cities. This data includes uptake rates for services, cost of current private sector plans, willingness to pay for services and utility changes, and estimated capital costs when needed. Our data on access to internet is heavily based off of the Madison Report on implementing public internet. In that report, they display a weighted survey of Madison residents regarding who has internet and under what capacity, which includes crosstabs of a variety of demographic factors. We used this data for our access numbers, because of the close proximity between Madison and Monona which can control for regional access differences. In order to better reflect the Monona population though, we controlled the Madison data with data from the Census so we could create a market that would simulate Monona more accurately.

Table 2. Uncertain Variables under a Normal Distribution

	Lower End (95% Confidence Interval)	Upper End (95% Confidence Interval)
Percent of Residents with Broadband Internet Access	.8371	.8971
Percent of Residents with No Internet Access	.035	.093
Percent of Residents with Only Cell Internet Access	.039	.069
Percent of Residents who take Service with Prior Broadband Access	.02	.06
Percent of Residents who take Service with Prior Cell Phone Access	.02	.06
Percent of Residents who take Service with No Internet	.328	.398
Percent of Residents with AT&T 6 Mb/s Plan	.368	.432
Percent of Residents with Charter Plan	.268	.332
Percent of Residents with AT&T 24 Mb/s Plan	.268	.332

ASSUMPTIONS

We make two assumptions that could alter our results in significant ways. The first is that there are no secondary market effects if Monona were to provide a competitive internet service. In any market where a provider is subsidized by the government, there is a possibility that it can affect private competition. When one firm is given an advantage over others and provides its product at a lower price, as would be the case with 5NINES relative to AT&T and Charter, it is possible that other firms would lower their prices to remain competitive or change some aspect of the service they offer. This has been a concern in other analyses of municipal wireless networks.[10&11] We assume this does not apply in this specific case as Monona's population is small relative to the surrounding area.

The second assumption is that internet service in the coverage areas will be reliable and support consistent speed. Frequent disruptions in the network would alter many of the benefits we calculate for the residents of Monona. We assume both the in-door and outdoor wireless networks are reliable in our benefit calculations.

10 Sean Buckley, "Google Fiber's Presence Continues to Force Broadband Pricing Hand of AT&T, Centurylink and Comcast." FierceTelecom, April 25, 2016.
11 John Barrett and David Tuerk, Municipal Broadband in Concord: An In-Depth Analysis. Boston MA: Beacon Hill Institute. 2004: 4-6.

"The first is that there are no secondary market effects if Monona were to provide a competitive internet service... The second assumption is that internet service in the coverage areas will be reliable and support consistent speed."

-Public Affairs 881 students

RESULTS

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In-Home Wi-Fi Service

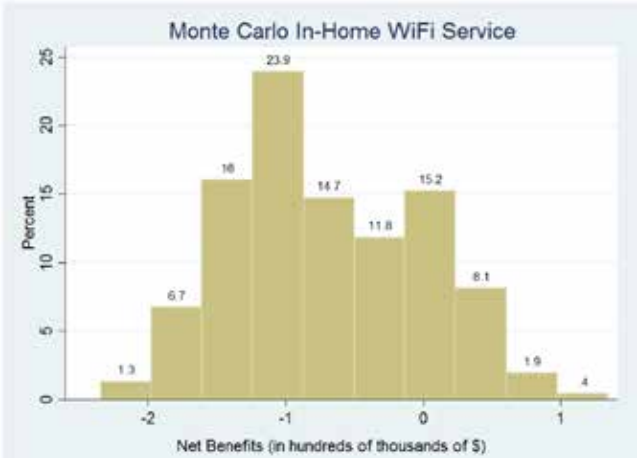
For our point estimate model, we assumed the most likely outcome, for each of the variables to determine, on average, how likely the project will return positive net benefits for the residents of Monona. Through our methodology we estimated the likely net benefits for each service based on uptake from residents, costs levied by the city and users, and changes in the utility from use. We used two estimates for our model, one with expected outcomes and one with more optimistic estimates on uptake. Our model predicts net benefits of approximately negative $39,100 for our likely estimates and $127,050 for our optimistic estimates. The number of people who take up the service was predicted to be 243 for the median expected take up rate and 832 up take in service for our upper bound estimates. Table 2 shows the different uptake rates by demand schedules and overall benefits.

Table 2. Point Estimates of In-Home Service

	Average Estimate	High Estimate
Net Benefits	-$39,100	$127,050
Total Uptake	243	832

In order to handle the great deal of uncertainty with the model, we conducted a Monte Carlo simulation to account for uncertainties. We anticipate an average net cost of $70,300 and with a standard deviation of $69,150. Figure 1 shows the histogram of the Monte Carlo simulation. It is important to note that 802 observations returned negative benefits meaning that there is about an 80 percent chance that the service will return a negative net benefit.

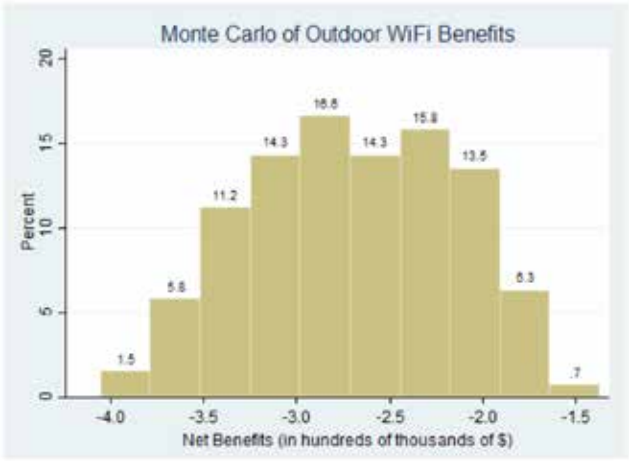
Figure 1.



Outdoor Public Wi-Fi

We utilized a point estimate model and a Monte Carlo simulation much like we did for the In-Home Wi-Fi service to assess the net benefit of Outdoor public Wi-Fi. We used the average estimates for all our variables to determine the point estimation. What we found was that the project would return net costs of $682,500 assuming expected values for our estimated variables. Because of the large amount of uncertainty in our estimates, we conducted a Monte Carlo simulation determine a plausible range of net benefits. Our Monte Carlo simulation of 1000 iterations and found that there was no single event of the simulation that returned a positive net benefit for the project. The mean was negative $269,800 and the standard deviation was $54,700. Figure 2 shows the histogram of the results for this simulation.

Figure 2.



Our results indicate that this project will overall not return benefits that will compensate for the costs of this project. The largest contributing factor to this project seems to be the relatively small area of access coupled with the limited value of the access to consumers, as it depends on sedentary park users during favorable months for park activity.

Sensitivity Analysis

The Monte Carlo simulation for the In-Home Wi-Fi Service generally shows negative results, but the key distinction between a successful project and a failure depends largely upon how many citizens take the service. In order to determine the number of residents it will take in order to return net benefits for this project, we conducted a sensitivity analysis on our Monte Carlo simulation. We looked at the number of residents predicted to uptake the service when there were positive benefits and when there were negative benefits. Table 4 shows the results of our analysis. We found that in order for the project to return positive benefits, at least 252 residents must uptake the service with a mean of 288 residents needed. Though negative benefits can go anywhere from 113 to 335, this is largely based on the utility calculations of residents and which service, if any, they had previously.

Table 4. Uptake of Service Ranges

	Mean	Standard Deviation	Min	Max
Net Benefits < 0	228	34.147	113	335
Net Benefits >= 0	288	22.337	252	379

"Our results indicate that this project will overall not return benefits that will compensate for the costs of this project."

-Public Affairs 881 student

SUMMARY AND RECOMMENDATIONS

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Summary

We performed a cost-benefit analysis of two alternatives for wireless internet access in the City of Monona. Our methodology for the first alternative focused on simulating a market decision made by citizens to select the service based on a variety of parameters. The second alternative focused on citizen participation based upon sedentary park usage with a calculated willingness to pay for the service based on their payment to current service providers. We applied this methodology to the entire City of Monona population drawing on a Madison study on internet accessibility. We found that for the first alternative there are generally positive net benefits provided that the service has a sufficient uptake. We also found that the outdoor service would not be able to provide enough benefits to offset costs needed for the service.

Recommendations

Our recommendations are based on the efficiency of the project and we did not make considerations for equity due to the relative homogeneity of the City of Monona. Further, our analysis assumes that there is not a large amount of distributional costs associated with the implementation of these projects.

Recommendation #1: The City of Monona should conduct a survey of interest to find an approximate demand schedule for the in-house service. If the approximate demand and willingness to enter the market exceeds 260 households, then the city should undergo the project. Otherwise, it should not adopt the project. Largely these benefits depend upon the income, age, and education of the citizens as their market demand for internet is largely based on these demographics.

Recommendation #2: The City of Monona should not consider the outdoor public Wi-Fi project, as our model found no positive returns on investments made. On average the project will produce a net loss of $255,500 with a minimal expected loss of $52,000. We found the high capital costs of implementing this service and the continued maintenance costs coupled with limited coverage would mean low use of the service and thus low benefits gained from its creation.

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APPENDIX

APPENDIX A: WISCONSIN STATE STATUTE REGULATION MUNICIPAL TELECOMMUNICATIONS PROVISION

State of Wisconsin

2003 Senate Bill 272

Date of enactment: **April 16, 2004**
Date of publication*: **April 30, 2004**

2003 WISCONSIN ACT 278

AN ACT *to renumber and amend* 196.204 (5) (a); *to amend* 196.203 (1) and 196.204 (5) (b); and *to create* 66.0419 (3m), 66.0422, 196.204 (5) (ag), 196.204 (5) (ar) 2. and 196.204 (5) (ar) 3. of the statutes; **relating to:** local government telecommunications utilities and public hearings for ordinances and resolutions authorizing local government cable television, telecommunications, and broadband facilities.

The people of the state of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. 66.0419 (3m) of the statutes is created to read:

66.0419 **(3m)** MUNICIPAL CABLE TELEVISION SYSTEM COSTS. (a) Except for costs for any of the following, a municipality that owns and operates a cable television system, or an entity owned or operated, in whole or in part, by such a municipality, may not require nonsubscribers of the cable television system to pay any of the costs of the cable television system:

1. Public, educational, and governmental access channels.

2. Debt service on bonds issued under s. 66.0619 to finance the construction, renovation, or expansion of a cable television system.

3. The provision of broadband service by the cable television system, if the requirements of s. 66.0422 (3d) (a) 1., 2., or 3. are satisfied.

(am) Paragraph (a) does not apply to a municipality that, on March 1, 2004, was providing cable service to the public.

(b) Paragraph (a) does not apply to a municipality if all of the following conditions apply:

1. On November 1, 2003, the public service commission has determined that the municipality is an alternative telecommunications utility under s. 196.203.

2. A majority of the governing board of the municipality votes to submit the question of supporting the operation of a cable television system by the municipality to the electors in an advisory referendum and a majority of the voters in the municipality voting at the advisory referendum vote to support the operation of a cable television system by the municipality.

SECTION 2. 66.0422 of the statutes is created to read:

66.0422 Cable television, telecommunications, and broadband facilities. (1) In this section:

(a) "Cable service" has the meaning given in s. 66.0419 (2) (c).

(b) "Local government" means a city, village, or town.

(c) "Telecommunications service" has the meaning given in s. 196.01 (9m).

(2) Except as provided in subs. (3), (3d), (3m), and (3n), no local government may enact an ordinance or adopt a resolution authorizing the local government to construct, own, or operate any facility for providing cable service, telecommunications service, or broadband service, directly or indirectly, to the public, unless all of the following are satisfied:

* Section 991.11, WISCONSIN STATUTES 2001–02 : Effective date of acts. "Every act and every portion of an act enacted by the legislature over the governor's partial veto which does not expressly prescribe the time when it takes effect shall take effect on the day after its date of publication as designated" by the secretary of state [the date of publication may not be more than 10 working days after the date of enactment].

(a) The local government holds a public hearing on the proposed ordinance or resolution.

(b) Notice of the public hearing is given by publication of a class 3 notice under ch. 985 in the area affected by the proposed ordinance or resolution.

(c) No less than 30 days before the public hearing, the local government prepares and makes available for public inspection a report estimating the total costs of, and revenues derived from, constructing, owning, or operating the facility and including a cost–benefit analysis of the facility for a period of at least 3 years. The costs that are subject to this paragraph include personnel costs and costs of acquiring, installing, maintaining, repairing, or operating any plant or equipment, and include an appropriate allocated portion of costs of personnel, plant, or equipment that are used to provide jointly both telecommunications services and other services.

(3) Subsection (2) does not apply to a local government if all of the following conditions apply:

(a) On November 1, 2003, the public service commission has determined that the local government is an alternative telecommunications utility under s. 196.203.

(b) A majority of the governing board of the local government votes to submit the question of supporting the operation of the facility for providing cable service, telecommunications service, or Internet access service, directly or indirectly to the public, by the local government to the electors in an advisory referendum and a majority of the voters in the local government voting at the advisory referendum vote to support operation of such a facility by the local government.

(3d) (a) Subsection (2) does not apply to a facility for providing broadband service to an area within the boundaries of a local government if any of the following are satisfied:

1. The local government asks, in writing, each person that provides broadband service within the boundaries of the local government whether the person currently provides broadband service to the area or intends to provide broadband service within 9 months to the area and within 60 days after receiving the written request no person responds in writing to the local government that the person currently provides broadband service to the area or intends to provide broadband service to the area within 9 months.

2. The local government determines that a person who responded to a written request under subd. 1. that the person currently provides broadband service to the area did not actually provide broadband service to the area and no other person makes the response to the local government described in subd. 1.

3. The local government determines that a person who responded to a written request under subd. 1. that the person intended to provide broadband service to the area within 9 months did not actually provide broadband service to the area within 9 months and no other person makes the response to the local government described in subd. 1.

(3m) Subsection (2) does not apply to a facility for providing broadband service if all of the following apply:

(a) The municipality offers use of the facility on a nondiscriminatory basis to persons who provide broadband service to end users of the service.

(b) The municipality itself does not use the facility to provide broadband service to end users.

(c) The municipality determines that, at the time that the municipality authorizes the construction, ownership, or operation of the facility, whichever occurs first, the facility does not compete with more than one provider of broadband service.

(3n) Subsection (2) does not apply to a local government that, on March 1, 2004, was providing cable service to the public.

(4) Notwithstanding sub. (2), a local government may enact an ordinance or adopt a resolution authorizing the local government to prepare a report specified in sub. (2) (c).

(5) If a local government enacts an ordinance or adopts a resolution that complies with the requirements of sub. (2), the local government must determine the cost incurred in preparing the report specified in sub. (2) (c). As soon as practicable after the local government generates revenue from a facility specified in sub. (2) (intro.), the local government shall use the revenues to reimburse the treasury of the local government for the cost determined under this subsection.

SECTION 3. 196.203 (1) of the statutes is amended to read:

196.203 **(1)** ~~Except as provided in this section, alternative~~ Alternative telecommunications utilities are exempt from all provisions of ch. 201 and this chapter, except as provided in this section and except that an alternative telecommunications utility that is a local government telecommunications utility, as defined in s. 196.204 (5) (ag) 1., is subject to s. 196.204 (5).

SECTION 4g. 196.204 (5) (a) of the statutes is renumbered 196.204 (5) (ar) 1. and amended to read:

196.204 **(5)** (ar) 1. In addition to the other requirements of this section, each telecommunications service, relevant group of services and basic network function offered or used by a telecommunications utility shall be priced to exceed its total service long–run incremental cost. The commission may waive the applicability of this ~~paragraph~~ subdivision to a nongovernmental telecommunications utility's basic local exchange service if the commission determines that a waiver is consistent with the factors under s. 196.03 (6).

SECTION 5. 196.204 (5) (ag) of the statutes is created to read:

196.204 **(5)** (ag) In this subsection:

1. "Local government telecommunications utility" means a municipality that owns, operates, manages, or

controls any plant or equipment, or that wholly owns, operates, manages, or controls any entity that owns, operates, manages, or controls any plant or equipment, used to furnish telecommunications services within the state directly or indirectly to the public.

2. "Nongovernmental telecommunications utility" means a telecommunications utility that is not a local government telecommunications utility.

SECTION 5r. 196.204 (5) (ar) 2. of the statutes is created to read:

196.204 **(5)** (ar) 2. For purposes of subd. 1., the total service long–run incremental cost of a local government telecommunications utility shall take into account, by imputation or allocation, equivalent charges for all taxes, pole rentals, rights–of–way, licenses, and similar costs that are incurred by nongovernmental telecommunications utilities. This subdivision does not apply to a local government telecommunications utility that is subject to the exemption under s. 66.0422 (3m). This subdivision also does not apply to a telecommunications service, relevant group of services, or basic network function if all of the following conditions apply:

a. On November 1, 2003, the commission has determined that the local government telecommunications utility is an alternative telecommunications utility under s. 196.203.

b. A majority of the governing board of the local government telecommunications utility votes to submit the question of supporting the operation of the local government telecommunications utility to the electors in an advisory referendum and a majority of the voters in the local government telecommunications utility voting at the advisory referendum vote to support operation of the local government telecommunications utility.

SECTION 5w. 196.204 (5) (ar) 3. of the statutes is created to read:

196.204 **(5)** (ar) 3. Subdivision 2. does not apply to a telecommunications service, relevant group of services, or basic network function, that is used to provide broadband service and that is offered by a municipal telecommunications utility, if all of the following apply:

a. The municipal telecommunications utility offers the telecommunications service, relevant group of services, or basic network function on a nondiscriminatory basis to persons who provide broadband service to end users.

b. The municipality does not provide to end users the telecommunications service, relevant group of services, or broadband service provided by the basic network function.

c. The municipal utility determines that, at the time that the municipal utility authorizes the provision of the telecommunications service, relevant group of services, or basic network function, the municipal utility's provision of the service, group of services, or function does not compete with more than one provider of broadband service.

SECTION 6. 196.204 (5) (b) of the statutes is amended to read:

196.204 **(5)** (b) Unless ordered by the commission, par. ~~(a)~~ (ar) does not apply to basic local exchange service or to business access line and usage service within a local calling area offered by a nongovernmental telecommunications utility with 150,000 or less access lines in use in this state. If par. ~~(a)~~ (ar) does not apply, the nongovernmental telecommunications utility may not reduce its rates for basic local exchange service below the monthly rate under s. 196.215 (7) or total service long–run incremental cost, whichever is lower, and may not reduce its rates for business access line and usage service within a local calling area below total service long–run incremental cost.

SECTION 7. Initial applicability.

(1) The treatment of section 66.0419 (3m) of the statutes first applies to costs incurred on the effective date of this subsection.

SECTION 8. Effective date.

(1) This act takes effect on the first day of the 3rd month beginning after publication.

APPENDIX B: COST ESTIMATES FROM 5NINES

5NINES' Proposal for Wireless Pilot

City of Monona

Quantity of CPE Purchased	Cost of CPE	One-Time Costs of CPE	Support Cost Per Month Per CPE	Monthly Support
100 or less	$75/ea	$7,500 (at 100 units)	$15	$1,500
150	$65/ea	$9,750	$14	$2,100
200	$60/ea	$12,000	$13	$2,600
250	$55/ea	$13,750	$12	$3,000
300	$50/ea	$15,000	$10	$3,000

*BASE STATION INITIAL COST: $10,000 PER BASE STATION

APPENDIX C: COST OF METROPOLITAN UNIFIED FIBER NETWORK (MUFN)

The MUFN fiber network is a fiber-optic network that unified and augmented existing telecommunications infrastructure in the Madison area to provide high-speed internet. It serves Madison, Middleton, and Monona. Monona plans to connect its two base station towers, one on a city water tower and one on top of City Hall, to the MUFN fiber network. To do this the city would have to pay to splice and install the network into the base towers. There is also a monthly rental fee associated with use of the MUFN fiber network. Our Monona contact provided estimates for these costs.

The estimated cost for splicing and installation of the MUFN fiber network for the water tower base station is $20,000. There are possible additional costs associated with the installation and splicing of the second base station at the City Hall location. City Hall is already connected to the MUFN fiber network, and thus we assume these costs will be lower than those for the water tower. We estimate these costs are between $2,000 and $10,000.

The rental fee for both stations provided by our city contact is $350 a month for each station. We then multiply these numbers by 12 to get an annualized cost. We assume a discount rate of 3.5%

Based on these estimates, the cost of using the MUFN fiber network for the City of Monona is given:

$$Cost\ of\ MUFN\ Fiber = \sum \frac{(MUFN\ Fiber\ Rental)}{1.035^{t-.5}} + MUFN\ Installation$$

Where:

- MUFN Fiber Rental=350*2*12
- MUFN Installation=20,000+(2,000 to 10,000)

APPENDIX D: PERCENT OF MONONA WITH DIFFERENT INTERNET SPEEDS

Several of our benefit and cost calculations required estimates of the percentage of people in Monona with different internet service plans. We estimated how many people in Monona have no internet access, home broadband internet, and smartphone internet only using the Madison feasibility study. We also estimated the percentage of people with fast internet speed and very fast internet speed using the Madison feasibility study. We then used these figures to estimate the number of people subscribed to various Charter and AT&T plans.

Methodology for Calculating Percentage of Residents by Internet Access Category:

To estimate how many people in Monona have internet access, no access, or smartphone only access we drew from the Madison feasibility study's survey resident connectivity. The survey found 89 percent of residents have home broadband internet, 6 percent have smartphone internet only, and 5 percent have no internet access.[12] Adjusted for demographics, we estimate between 83.7 and 89.7 percent of Monona residents have home broadband internet, 3.8 to 6.6 percent have smartphone internet only, and 5 to 7.8 percent have no internet access. We assumed these numbers were representative of Monona, and multiplied them by estimates from the 2010 census for Monona to obtain population estimates. [13]

Methodology for Calculating Percentage of Residents with Each Internet Plan:

The current main internet providers for Monona are Charter and AT&T. The plans they currently offer in the city are:

Provider	Upload Speed	Cost per Month
AT&T	6 Mbps	$40
AT&T	24 Mbps	$50
Charter	40 Mbps	$40

[12] Colombia Telecommunications Corporation, "City of Madison Fiber-to-the-Premises Feasibility Analysis."
[13] "QuickFacts Monona City, Wisconsin." United States Census Bureau. Accessed November 18, 2016. http://www.census.gov/quickfacts/table/PST045215/5553675.

To define what service is considered fast and very fast speed we used definitions found in a study of WTP for internet service. In the study, the authors described low speed as similar to dial-up, fast speed as having much faster uploads and downloads appropriate for music and watching some videos, and very fast as sufficient for gaming and watching high-definition movies.[14] Based on these definitions we defined the 6 Mbps AT&T plan as fast speed, and the 24 Mbps AT&T plan and the Charter plan as very fast speed.

To estimate the percentage of Monona with fast and very fast speed we used the feasibility study conducted for the City of Madison concerning the implementation of a city-wide fiber network. The resident survey asked respondents their self-perceptions of their internet speed on a scale of very slow, slow, medium, fast, or very fast. We used this survey of self-perception as internet providers do not give out information on the number of subscribers to different speed plans, and citizens often are not aware of their internet speed by Mbps.

In the Madison survey 40 percent of residents reported medium speed or lower, and 60 percent reported fast or very fast speed.[15] We assumed these percentages are representative of Monona. We then assumed the 40 percent of residents with slower speed in Monona are subscribed to the AT&T 6 Mbps plan, as it is significantly slower than the other plans provided. We then assumed, due to lack of data and for simplicity, that the 60 percent of residents with fast or very fast speed are split evenly between AT&T's 24 Mbps plan and Charter's plan. The Madison feasibility study had a margin of error of 3.2 percent, which we used to calculate the upper and lower bounds of these estimates.

Given these assumptions the percentage of Monona internet subscribers with each plan is given in the following table:

Internet Service Plan	Percent of Monona Subscribers
AT&T 6 Mbps Plan	36.8-43.2
AT&T 24 Mbps Plan	26.8-33.2
Charter Plan	26.8-33.2

[14] Gregory Rosston, Scott Savage, and Donald Waldman, "Household Demand for Broadband Internet in 2010."
[15] Colombia Telecommunications Corporation, "City of Madison Fiber-to-the-Premises Feasibility Analysis."

APPENDIX E: COST OF HIGH SPEED LOSS

Some residents who switch from their current internet provider to Monona's service will lose speed under their new internet service. Given these residents likely place some value on that higher speed we needed to calculate the value of the reduction in Mbps for this group to offset the cost savings. To calculate this cost we used willingness to pay (WTP) estimates for very fast internet speed.

The estimate we used to calculate WTP for very fast internet speed for those with internet access who switch to Monona's service comes from the national survey outlined in Appendix J.[16] We chose to use this survey as our main source of WTP for very fast internet access as it disaggregates responses by the speed of their current internet service, which is necessary when calculating the cost of switching between very fast and fast speed as would occur in Monona.

The study finds that households with very fast internet speed have an average WTP of $63.32 for very fast speed, and an average WTP of $55.14 for fast speed. We converted these numbers to 2016 dollars to account for inflation, resulting in figures of $70.09 and $61.03. We assumed these numbers were representative of those with very fast speed in Monona. To obtain the cost of switching from very fast to fast speed we subtracted the WTP for fast speed from the WTP for very fast speed, taking the difference as the cost of switching to lower speed, which is $9.06.

To estimate the number of people in Monona with very fast internet speed we took the percentage of Monona with internet access and multiplied it by the percentage of Monona with a plan designated as very fast speed. We assumed 89 percent of Monona has internet access, with a range of 83.7 to 89.7 percent after adjusting for demographics. We then assumed 60 percent of those residents are subscribed to very fast speed plans. For a detailed explanation of these assumptions see Appendix D.

We then assumed that 2 to 20 percent of this population will switch to Monona's service. For a more detailed explanation of this assumption see Appendix J.

We assumed a discount rate of 3.5 percent and multiply the cost by 12 to get an annualized figure.

[16] Rooston, Gregory, Scott Savage, and Donald Waldman. "Household Demand for Broadband Internet in 2010." B.E. Journal of Economic Analysis & Policy 10, no. 1 (2010): Table 9.

Given these assumptions the cost of losing very fast internet speed to Monona subscribers is given:

$$Cost\ of\ High\ Speed\ Loss = \frac{(THH)(\%\ HHI)(WTPFVS - WTPFS)(Uptake)(12)}{1.035^{t-.5}}$$

Where:

- THH=Total Monona Households= 4,088
- % HHI= Percent of Households with Broadband Internet= .837 to .897
- WTPFVS= WTP for Very Fast Speed= $70.09
- WTPFS= WTP for Fast Speed= $61.03
- Uptake= Percent of Monona Households that Subscribe to the New Service= .02 to .2

APPENDIX F: COST OF WIRELESS ACCESS POINTS

If Monona is to implement an outdoor wireless network it will have to install wireless access points (WAP) throughout the intended coverage area. WAPs serve as a go-between for resident's Wi-Fi devices and the network base stations. Residents would be able to connect their devices to the WAPs, which then transfer the data to the larger base stations of the wireless network for a more reliable connection. If the City is to pay for this infrastructure, it will have to purchase the hardware, install the WAPs, pay monthly rental fees for the structures on which they are installed, and pay for the maintenance costs. To estimate these costs we have used WAP costs from several companies, expected costs determined for other municipal wireless programs, and the 5NINES cost estimates.

Methodology for Estimating the Number of Wireless Access Points:

To estimate the number of WAPs Monona would need we used a variety of municipal wireless plans and took into account the coverage area of Monona's base towers. The Tucson municipal wireless plan estimated between 20-40 WAPs per square mile would be needed.[17] The Palo Alto municipal wireless plan estimated a need for between 35-40 WAPs per square mile.[18] Monona's network is expected to have lower traffic than either of these networks, so we assume 20 WAPs is a reasonable lower bound with 40 as an upper bound. To obtain an overall estimate of needed WAPs we then multiplied these numbers by the square miles of the coverage area of Monona's base towers, which is estimated to be between 1.84 and 2.16 square miles. For a detailed explanation of our coverage estimate see Appendix I.

Methodology for Estimating the Cost of Wireless Access Points:

To estimate the costs of the WAP hardware we investigated companies that have provided municipal wireless services to other cities and looked at the projected costs of other municipal wireless plans. We looked at the products of two companies, Tropos and Meraki, that have provided hardware for networks in Chaska Minnesota[19], Oklahoma City[20], Prestonburg Kentucky[21], and others. The price for the Meraki lower-end outdoor WAPs is $699[22] and the price for the lower-end Tropos WAP is $749.[23] We converted

[17] Colombia Telecommunications Corporation, "Wireless Feasibility Study Prepared for the City of Tucson." Tucson, Arizona: CTC, 2007: 95. Web. 8 Oct. 2016. p. 95
[18] CTC Technology and Energy, "Findings and Recommendations for Wireless Network Plan." Kensington, MD: CTC, 2015. p. 54
[19] Esme Vos, "Chaska, Minnesota citywide wireless mesh broadband network." *Muniwireless*, May 25, 2004.
[20] "Oklahoma City Now Operational With World's Largest Municipal Wi-Fi Mesh Network." *Business Wire* (New York), June 3, 2008.
[21] Merrill Douglas, "Mesh Network Creates Low-Cost Muni Wi-Fi For Kentucky Town." *Government Technology*, July 16, 2008.
[22] "MS220-8." Cisco Meraki. Accessed December 04, 2016. https://meraki.cisco.com/buy/cost-calculator.
[23] "New Tropos 1410 Cost-Effectively Delivers Secure Field Area Networks for Smart Grid and Other Industrial Applications." *Business Wire* (New York), January 18, 2012.

these numbers to 2016 dollars to account for inflation, giving us figures of $699 and $787.36. However, it should be noted that municipal wireless plans for other cities priced WAPs much higher. A plan for the city of Palo Alto estimated costs of $2,100 per WAP[24] and a plan for the city of Tucson estimated $2,800 per WAP[25]. These cities likely expect a larger user base and thus need more expensive routers to service a higher number of customers. We assume Monona will be able to purchase lower-end WAPs for its needs, and put our estimates between $699 and $787.36 per WAP.

Methodology for Estimating the Installation Costs of Wireless Access Points:

To estimate installation costs, we looked at the cost estimates from the city of Tucson's municipal wireless cost estimation. Tucson's wireless plan estimates it would cost $300 to install each WAP,[26] which includes both installing the device and connecting it to a power source. We convert this figure to 2016 dollars to account for inflation, giving us a figure of $349.27. We assume these numbers are representative of the costs to Monona.

Methodology for Estimating Pole Rental Costs:

To estimate monthly fees associated with rental of telephone poles and traffic lights for placement of WAP we again used cost estimates from Tucson's municipal wireless cost estimation. The fees for pole attachment for a WAP are between $10.30 and $15.34 per pole per year.[27] We convert these numbers to 2016 dollars to account for inflation, giving us figures of $11.99 to $17.86. As Monona does not own the utility poles, we assume these numbers are representative of the costs to the city.

Methodology for Estimating Maintenance Costs:

To estimate maintenance costs, we used both fiscal estimates from other municipal wireless plans and 5NINES maintenance estimates for its in-door wireless service. The Palo Alto municipal wireless cost estimates put maintenance of the WAPs at $10,000 a year for a plan of 30 WAPs.[28] This is equal to $333 dollars per WAP per year. We used a maintenance cost range of $300-$366 per WAP per year. We converted these numbers to 2016 dollars to account for inflation, giving us a range of $306 to $372. We then multiplied this number by the estimated number of WAPs to establish our maintenance costs.

[24] CTC Technology and Energy, "Findings and Recommendations for Wireless Network Plan." p. 68
[25] Colombia Telecommunications Corporation, "Wireless Feasibility Study Prepared for the City of Tucson." p. 105
[26] Ibid. p. 105
[27] Ibid. p. 90
[28] CTC Technology and Energy, "Findings and Recommendations for Wireless Network Plan." p. 66

We also use the figures from the 5NINES maintenance cost estimates outlined in Appendix B for the in-door wireless service to see if they reasonably fall within the Palo Alto cost estimates. The 5NINES cost plan estimates $1,500 dollars a month of monthly support costs when servicing less than 100 customers. We equated the number of customers to the number of WAPs, assuming maintenance needed for an outdoor wireless network is similar to that of an in-door wireless service. The estimated number of WAPs falls below 100, and thus we assumed a $1,500 dollar a month maintenance fee for the city. We then multiplied this number by 12 to obtain an annual cost estimate of $18,000, which falls between our estimates derived from the Palo Alto study. This gives us confidence in using the range provided by the Palo Alto cost estimates.

We assume a 3.5 percent discount rate on annual costs.

Costs:

One-time cost of WAPs for the city of Monona:

$$One\ Year\ Cost = (\#WAP)(SqMi)(WAP\ Cost) + (WAPIN)(\#WAP)(SqMi)$$

Where:

- #WAP= Number of Wireless Access Points per Square Mile= 20 to 40
- SqMi= Square Miles of Network Coverage= 1.84 to 2.16
- WAP Cost= Cost of Purchasing each WAP= $699 to $787.36
- WAPIN= Cost of Wireless Access Point Installation= $349.27

The annual cost of WAPs for the city of Monona:

$$Annual\ Cost = \frac{(PR)(\#WAP)(SqMi) + (\#WAP)(SqMi)(Maintenance)}{1.035^{t-.5}}$$

Where:

- PR=Yearly Utility Pole Rental Fee= $11.99 to $17.86
- #WAP= Number of Wireless Access Points per Square Mile= 20 to 40
- SqMi= Square Miles of Network Coverage= 1.87 to 2.13
- Maintenance= Yearly Cost of Maintenance per Wireless Access Point= $306 to $372

The total cost under these assumptions:

$$Total\ Cost = Annual\ Cost + One\ Time\ Cost$$

APPENDIX G: BENEFITS OF MONONA'S IN-HOME MUNICIPAL WIRELESS

We measured the benefits to citizens who switch to Monona's in-home wireless service by calculating the difference in cost between their current plan and the price of Monona's service. These benefits differ from customer to customer depending on their current internet service. To capture these varying benefits, we have calculated benefits differently for those who currently have no internet connection, those switching from AT&T's $40 a month plan, those switching from Charter's $40 a month plan, and those switching from AT&T's $50 a month plans.

Methodology for Those Without Internet Access:

To estimate WTP for broadband for those who do not currently have access to internet and subscribe to Monona's service we used a WTP survey[29]. It surveyed 15,802 heads of household from seven different states who had not adopted broadband internet service. To obtain WTP, the authors used stated preference methods, asking if households would subscribe to broadband at a price they considered acceptable and if so what monthly price for broadband would they consider "too expensive to consider." The study attempts to correct for bias from over and underreporting of WTP estimates to obtain valid values of WTP.[30] We have chosen to use this study as our main source of WTP for those without broadband because it is the most recent large scale survey of its kind, which is important in a fast changing service like broadband internet.

The survey found 37.3 percent of broadband non-adopters would subscribe to a service if the price were acceptable and had cost as their greatest motivator for not purchasing internet service.[31] The study had a margin of error of 2.67 percent, so we estimate an uptake range of 34.6 to 40.0 percent. We assume this estimate is representative of an average household without internet in Monona.

The survey found the average WTP of all survey respondents was $19.96[32], above Monona's projected cost of $15 to $10 a month. We converted this number to 2016 dollars to account for inflation, giving us a figure of $20.33. We assumed this estimate was representative of an average value of household WTP for those without internet access in Monona.

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[29] Octavian Carare, et al., "The Willingness to Pay for Broadband of Non-adopters in the U.S.: Estimates from a Multi-state Survey." *Information Economics and Policy* 30 (2015): 19-35.
[30] Ibid. p. 24
[31] Ibid. p. 23
[32] Ibid. p. 27

We estimated between 5 and 7.8 percent of households in Monona have no internet access. For a detailed explanation of this estimate see Appendix D. We assumed this number is representative of Monona. We then multiplied this by the total households as outlined in the 2010 census to obtain an estimate of the number of households without internet access.

We assumed a discount rate of 3.5 percent.

The benefits of Monona's service to those without internet:

$$Benefit\ No\ Internet: \sum \frac{(Total\ HH)(\%\ HH\ Without\ Internet)(Uptake\ \%)(WTP)(12)}{1.035^{t-.5}}$$

Where:

- Total HH= Total Households in Monona= 4,088
- % HH Without Internet= Percent of Monona Households Without Internet= .05 to .078
- Uptake %= Percent of Households Without Internet Who Subscribe to the Service= .373
- WTP= Willingness to Pay for Internet for Residents Currently Without Access= $20.33

Methodology for Those with Broadband Internet:

To estimate the benefits for those with internet access we calculated the difference in price between resident's current internet service and Monona's service. We estimated three separate benefits based on the three internet service plans offered in Monona.

We assumed between 83.7 and 89.7 percent of Monona residents have broadband internet service. For a detailed explanation of these estimates see Appendix D. We then multiplied these estimates by the total households as outlined in the 2010 census to obtain an estimate of the number of households with broadband internet access. We assumed these numbers are representative of Monona.

To get an estimate of the number of residents with each service we assumed between 36.8 and 43.2 percent are subscribed to AT&T's $40 a month plan, between 26.8 and 33.2 percent are subscribed to Charter's $40 a month plan, and between 26.8 and 33.2 percent are subscribed to AT&T's $50 a month plan. For a detailed explanation of these estimates see Appendix D. We assumed these estimates are representative of Monona.

To obtain the benefits of the service we take the current prices residents are paying for their internet service and subtract the cost of Monona's service, taking the difference between them as the benefit of the new service. We estimated the cost of Monona's service is between $15 and $10, as provided by 5NINES in Appendix B.

We also must estimate a cost of the loss of high-speed internet for those who would lose speed when switching to Monona's service. We assumed the cost of high-speed loss is $8.18. For a detailed explanation of this estimate see Appendix E. We subtracted this estimate from the benefits for those with the $40 a month Charter plan and those with the $50 a month AT&T Plan, as these plans have higher Mbps than Monona's plan.

We assumed between 2 and 20 percent of residents with each type of internet will subscribe to the new service. For a detailed explanation of this estimate see Appendix J.

We then multiplied all benefits by 12 to get an annualized benefit and assumed a discount rate of 3.5 percent.

Under these assumptions the benefits of Monona's service to those with broadband internet access is given:

Benefit for those with AT&T $40 a Month Plan:

$$Benefit\ AT\&T\$40 = \frac{(Total\ HH)(\%\ HH\ Internet)(\%\ HH\ AT\&T\ \$40)(PrPl - 5NINESPr)(\%\ Uptake)(12)}{1.035^{t-.5}}$$

Where:

- Total HH= Total Households in Monona= 4,088
- % HH Internet= Percent of Households with Broadband Internet= .837 to .897
- % HH AT&T $40= Percent of Broadband Households with AT&T $40 a Month Plan= .368 to .432
- PrPl= Price of Plan= $40
- 5NINESPr= Price of Subscription to 5NINES Plan= $15 to $10
- % Uptake= Percent of Households with Internet Who Subscribe to 5NINES Plan= .02 to .2

Benefit for those with AT&T $50 a Month Plan:

$$Benefit\ AT\&T\$50 = \frac{(Total\ HH)(\%\ HH\ Internet)(\%\ HH\ AT\&T\ \$50)(PrPl - 5NINESPr - HSL)(\%\ Uptake)(12)}{1.035^{t-.5}}$$

Where:

- Total HH= Total Households in Monona= 4,088
- % HH Internet= Percent of Households with Broadband= .837 to .897
- % HH AT&T $50= Percent of Broadband Households with AT&T $50 a Month Plan= .268 to .332
- PrPl= Price of Plan= $50
- 5NINESPr= Price of Subscription to 5NINES Plan= $15 to $10
- HSL= Cost of High Speed Loss= $9.06
- % Uptake= Percent of Households with Internet Who Subscribe to 5NINES Plan= .02 to .2

Benefit for those with Charter $40 a Month Plan:

$$Benefit\ Charter = \frac{(Total\ HH)(\%\ HH\ Internet)(\%\ HH\ Charter)(PrPl - 5NINES\ Price - HSL)(\%\ Uptake)(12)}{1.035^{t-.5}}$$

Where:

- Total HH= Total Monona Households= 4,088
- % HH Internet= Percent of Households with Broadband= .837 to .897
- % HH FS= Percent of Broadband Households with Fast Speed= .268 to .332
- PrPl= Price of Plan= $40
- 5NINES Price= Price of Subscription to 5NINES plan= $15 to $10
- HSL= Cost of High Speed Loss= $9.06
- % Uptake= Percent of Broadband Households Who Subscribe to 5NINES Plan= .02 to .2

Methodology for Those with Smartphone Internet Only:

To estimate benefits for those with smartphones only we used a national online WTP survey conducted between December 2009 and January 2010.[33] It surveyed 5,799 experienced internet users and 472 inexperienced users. To obtain WTP, the survey asked respondents to choose repeatedly between two hypothetical internet services that differed by cost, speed, reliability, and several other features. We utilized this study as it is the only large-scale study to include smartphone WTP responses.

The study found that households with smartphone internet access only have an average WTP for fast speed of $46.99.[34] We converted this number to 2016 dollars to account for inflation, giving us a figure of $52.01. We assumed these numbers are representative of the WTP of those with internet access in Monona. To obtain the true benefits received, we took these WTP numbers and subtracted the cost of Monona's service, assessed the difference between them as the benefit of that service. We estimated the cost of Monona's service is between $15 to $10, as provided by 5NINES in Appendix B.

We assumed between 3.8 and 6.6 percent of Monona residents have smartphone internet access only. For a detailed explanation of these estimates see Appendix D. We then multiplied these estimates by the total households as outlined in the 2010 census to obtain an estimate of the number of households with smartphone internet access only. We assumed these numbers are representative of Monona.

We assumed between 2 and 20 percent of residents with smartphone internet will subscribe to the new service. For a detailed explanation of this estimate see Appendix J.

We then multiplied all benefits by 12 to get an annualized benefit and assumed a discount rate of 3.5 percent.

Benefits for those with only smartphones:

$$Benefit\ SPO = \frac{(Total\ HH)(\%\ HH\ SPO)(WTPSPO - 5NINESP)(\%\ Uptake)(12)}{1.035^{t-.5}}$$

[33] Gregory Rosston, Scott Savage, and Donald Waldman. "Household Demand for Broadband Internet in 2010." *B.E. Journal of Economic Analysis & Policy* 10, no. 1 (2010): p. 2

[34] Ibid. Table 9

Where:

- Total HH= Total Monona Households= 4,088
- % HH SPO= Percent of Households with Smartphones Only= .038 to .066
- %WTPSPO= Willingness to Pay for Households with Smartphones Only= $52.01
- 5NINESP= Price of Subscription to 5NINES plan= $15 to $10
- % Uptake= Percent of Broadband Households Who Subscribe to 5NINES Plan= .02 to .2

Given these benefits the total benefit of Monona's in-door wireless plan is given:

$$Total\ Benefit = Benefit\ No\ Internet + Benefit\ AT\&T\$40 + Benefit\ AT\&T\$50 + Benefit\ Charter + Benefit\ SPO$$

APPENDIX H: BENEFITS OF OUTDOOR WIRELESS

We measured the benefit to Monona citizens who use Monona's outdoor wireless internet through willingness to pay (WTP) estimates. The WTP estimate varies based on current internet connection. We estimated customer uptake through surveys of outdoor park usage.

Methodology for Estimating WTP for Outdoor Wireless:

The WTP survey we used asked 522 people in Canada and the United States how much people would be willing to pay for wireless access outside their home. They found on average WTP for wireless access outside the home was 9.5 percent more than their current internet service.[35] As Monona offers several services, this WTP is different for each customer. We assumed this WTP is representative of Monona residents.

There are three different internet service plans offered in Monona. We assume between 36.8 and 43.2 percent of broadband households have AT&T's $40 a month plan, between 26.8 and 33.2 percent of broadband households have AT&T's $50 a month plan, and between 26.8 and 33.2 percent of broadband households have Charter's $50 a month plan. For a more detailed explanation of these estimates see Appendix D.

We then multiplied the costs of these plans by.095 WTP to obtain the benefit to residents of an outdoor network. The benefit for those with AT&T's 6 Mbps plan is $3.8, the benefit for those with Charter's plan is $3.8, and the benefit to those with AT&T's 24 Mbps plan is $4.75.

Methodology for Estimating the Number of Network Users:

To estimate the number of people who would benefit, we used a national survey of park usage. The survey asked 1,250 people about their use and value of parks. It found for those living in cities with population under 10,000, 62 percent said they use parks occasionally or frequently.[36] We assumed this is representative of park use in Monona. We further assumed due to lack of data on general public space usage that this is the fraction of people using all public spaces where Monona's outdoor wireless internet would be in place.

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[35] Amdocs Market Insight & Strategy, "The Digital Consumer: Global Views on the Pay TV Experience, Cable Analytics and Cable Wi-Fi." INTX. 2015.

[36] Andrew J. Mowen, et al., "American's Use and Perceptions of Local Recreation and Park Services: A Nationwide Reassessment." *National Recreation and Park Association.* 2016. Accessed December 4, 2016. p. 27

To estimate how many of the 62 percent of residents who use outdoor space would take advantage of the wireless network we used headcount surveys of park usage from other cities that measure the number of active and sedentary park users. We assumed only sedentary users of outdoor space would take advantage of the network. Three different headcount surveys found the percent of sedentary park users to be 68,[37] 66,[38] and 52.7 percent,[39] respectively. We assumed this 52.7 to 68 percent is the representative range of percentage of users of outdoor space who would take advantage of the outdoor network.

We then estimated the percentage of Monona's population that owns wireless devices necessary to use the outdoor wireless network. We used a national Pew research study to estimate this number. The study found that 85 percent of people own at least one of a smartphone, laptop, or tablet.[40] We assumed this is representative of device ownership in Monona. The study had a margin of error of 2.6 percent, which we used as the range for this figure, giving estimates of 82.4 to 87.6 percent.

Methodology for Estimating Number of Months for Benefits:

We also assumed Monona will not receive this benefit for some time in the winter. We had email contact with a representative of the Parks Department who said the majority of their reservations for park space occur between the months of April and September. We assumed this is representative of the months that citizens will receive the benefit, so multiply our figures by 6 to obtain the annual benefits. We then assumed a 3.5 percent discount rate.

Under these assumptions the benefits of Monona's outdoor Wi-Fi service is given:

Benefit for Households with AT&T 6 Mbps Plan:

$$Benefit\ 6MBPS$$

$$= \frac{(Total\ Pop)(\%\ Pop\ 6\ MBPS)(WTP * 6MBPS\ Price)(\%\ Device)(\%\ Park\ Use)(\%\ Sedentary)(6)}{1.035^{t-.5}}$$

[37] Deborah Cohen et al., "Parks and physical activity: Why are some parks used more than others?" *Preventative Medicine* 50. (2010). Pg. S10
[38] Deborah Cohen et al., "Contribution of Public Parks to Physical Activity." *American Journal of Public Health* 97, no.3 (2007). Pg. 511
[39] Gina M. Besenyi et al., "Demographic variations in observed energy expenditure across park activity areas." *Preventative Medicine* 56, no. 1 (2013). Pg. 80
[40] Monica Anderson, "Technology Device Ownership: 2015." Pew Research Center. October 29, 2015.

Where:

- Total Pop= Total Population of Monona
- % Pop 6 Mbps= Percent of Population with AT&T 6 Mbps Plan= .368 to .432
- WTP= Willingness to Pay for Outdoor Wireless= .095
- 6Mbps Price= Price of AT&T 6 Mbps Plan= $40
- % Device= Percent of Individuals with at Least One Wireless Device= .824 to .876
- % Park Use= Percent of Individuals Who Use Parks= .62
- % Sedentary= Percentage of Park Users who are Sedentary= .527 to .66

Benefit to Households with AT&T 24Mbps Plan:

$$Benefit\ 24MBPS$$

$$= \frac{(Total\ Pop)(\%\ Pop\ 24\ MBPS)(WTP * 24MBPS\ Price)(\%\ Device)(\%\ Park\ Use)(\%\ Sedentary)(6)}{1.035^{t-.5}}$$

Where:

- Total Pop= Total Population of Monona
- % Pop 24 Mbps= Percent of Population with AT&T 24 Mbps Plan= .268 to .332
- WTP= Willingness to Pay for Outdoor Wireless= .095
- 24Mbps Price= Price of AT&T 24 Mbps Plan= $50
- % Device= Percent of Individuals with at Least One Wireless Device= .824 to .876
- % Park Use= Percent of Individuals Who Use Parks= .62
- % Sedentary= Percentage of Park Users who are Sedentary= .527 to .66

Benefit to Households with Charter Plan:

$$Benefit\ Charter$$

$$= \frac{(Total\ Pop)(\%\ Pop\ Charter)(WTP * Charter\ Price)(\%\ Device)(\%\ Park\ Use)(\%\ Sedentary)(6)}{1.035^{t-.5}}$$

Where:

- Total Pop= Total Population of Monona
- % Pop Charter = Percent of Population with Charter Plan= .268 to .332
- WTP= Willingness to Pay for Outdoor Wireless= .095
- Charter Price= Price of Charter Plan= $40
- % Device= Percent of Individuals with at Least One Wireless Device= .824 to .876
- % Park Use= Percent of Individuals Who Use Parks= .62
- % Sedentary= Percentage of Park Users who are Sedentary= .527 to .66

Given these benefits the total benefits of Monona's outdoor wireless network is given:

$$Benefit\ 6MBPS + Benefit\ 24MBPS + Benefit\ Charter$$

APPENDIX I: MONONA CITY COVERAGE

The coverage map provided to us was incompatible with GIS software. To estimate city coverage, we printed out the coverage map. We then drew a 10 by 10 grid over the city limits of Monona. We found 54 squares that contained some of the Monona city limits. We then estimated the percentage of each square that contained the land area of the city, adding them up to find a total number of squares equal to the city limits. We then estimated the percentage of the land area in each square that was in the green coverage zone and divided the total squares of green coverage area by the total squares of the city limit. This gave us a coverage area of 61.4 percent, which is 2 square miles of the city. Due to the inaccuracies inherent in our method we have given our estimate a range of 1.837 to 2.16 square miles, or between 56.35 to 66.35 percent land area coverage.

Figure 1: Coverage Map of Monona with 2 Base Towers

APPENDIX J: NETWORK UPTAKE RATES FOR MONONA CITIZENS

To estimate the benefits and costs of Monona's In-door Wi-Fi network and how many people would switch to the new internet service, we have separated uptake rates into two different groups, those without internet who would be new subscribers and those who currently have broadband internet who would switch plans.

Methodology of Uptake for Those Without Internet Access:

To estimate the uptake rate of those without internet access we used a survey of willingness to pay (WTP) for broadband for those who do not have access to internet.[41] It surveyed 15,802 heads of household who had not adopted broadband internet service from seven different states. The survey asked households if they would subscribe to broadband at a price they considered acceptable and if so what monthly price for broadband would they consider "too expensive to consider." We used this survey as it is the most recent large scale survey of its kind, and in a fast changing market like internet service having a recent survey is valuable.

The authors found 62.7 percent of households would not purchase broadband internet at any price, citing barriers other than cost to their adoption. The remaining 37.3 percent who would adopt broadband if the price were acceptable had cost as their greatest motivator for not purchasing internet service.[42] The study had a margin of error of 2.67 percent, which is the range we assume for uptake of citizens without internet. With these assumptions, the uptake rate of an average household without internet in Monona is between 34.6 to 40.0 percent.

Methodology of Uptake for Those with Internet Access:

To estimate the uptake rate for those with internet we used a range of uptake rates from other cities. Chaska, Minnesota had one of the highest uptake rates at a peak of about 20 percent,[43] while Philadelphia had one of the lowest uptake rates at between 1 and 2 percent.[44] However, the Chaska wireless network was originally funded due to low internet penetration by private companies in the area, which may have boosted its uptake numbers and is not a problem that Monona faces. Chaska's uptake also declined to 13 percent in 2014 and the network was ultimately shut down. Other municipal wireless cities have had uptakes in-between these estimates, with Minneapolis having an uptake rate of around 6 percent[45] and Lompoc CA having an uptake rate around 10 percent.[46] We weight this estimate toward the lower end of the 2 to 20 percent, centering it at 5

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[41] Octavian Carare, et al., ""The Willingness to Pay for Broadband of Non-adopters in the U.S.: Estimates from a Multi-state Survey."
[42] Ibid. p. 23
[43] Susan Feyder, "Chaska powers down as internet provider." *Star Tribune,* December 16, 2014.
[44] Harold Dyck and Montgomery Van Wart, "A More Realistic Approach to Citywide Municipal Wireless Networks: The Anchor Tenant Model?" *International Journal of Organization Theory* 13 no.3 (2010).
[45] Steve Alexander, "1-gigabit Internet service available for 4,000 Mpls. homes." *Star Tribune,* April 23, 2014.
[46] CTC Technology and Energy. *Findings and Recommendations for Wireless Network Plan.* p. 6

percent. We assumed these estimates are representative of the uptake rate of Monona residents who currently have access to internet.

APPENDIX K: LIFETIME OF THE PROJECT

Wireless internet is a fast evolving technology, so it is important to take into consideration how long it may be before infrastructure for a project like this would have to be updated. To estimate the lifetime of this project we examined several other municipal wireless programs and proposed plans for other cities.

Proposals for Tucson[47] and Meridian[48] wireless projects assumed 5 year timelines. Similarly, a proposal for Palo Alto estimated the technology would need to be updated between 5 to 7 years in the future.[49] Other networks shut down after around the 10 year mark, and needed maintenance in the intervening years. These included wireless networks in Chaska, MN[50] and Seattle.[51] Both networks shut down due to increased costs of updating the existing technology and because of less benefit to citizens due to increased use of smart phones and greater internet penetration by private companies. We assumed an outdoor wireless network in Monona would have similar timelines to other projects, and will need to update its infrastructure after 7 years. We assumed the same timeline for the in-door wireless network.

[47] CTC Communications and Engineering & Analysis for the Public Interest, *Tucson Wireless Feasibility Study*. Columbia MD: Colombia Telecommunications Corporation, 2007. p. 130
[48] Dustin Odom and Seungjae Shin, "Wireless Meridian: Strategy & Analysis for Municipal Wireless Project" *Business Studies Journal* 4, no. 1 (2012). pp. 30-31.
[49] CTC Technology and Energy, "Findings and Recommendations for Wireless Network Plan." p. 66
[50] Susan Feyder, "Chaska powers down as internet provider."
[51] Brian Heaton, "Free Community Wi-Fi Coming to an End in Seattle." *Government Technology,* April 27, 2012.

APPENDIX L: MADISON ACCESS WITH MONONA DEMOGRAPHICS CONTROL NUMBERS

To obtain an accurate estimate of internet access in Monona we adjusted the Madison feasibility study figures by Monona demographics. The following tables present the demographically adjusted percentage and number of Monona citizens with no internet access, internet through smartphones only, and broadband and smartphone internet. We used these numbers when estimating our uptake ranges for each benefit type.

Percentage of Population:

City	Monona No Access %	Cellphone Only %	Broadband and Cell %
Men	5	6	70
Women	6	5	73
White	5	5	72
POC	7	6	66
18 to 34	3	4	77
35 to 44	1	7	86
45 to 54	3	4	76
55 to 64	7	7	67
65 +	20	7	36
HS	19	9	47
Two-Year/Tech School	6	6	67

Four-Year	3	4	76
Graduate	4	6	74
> 25,000	24	6	36
25,000 to 49,999	6	7	65
50,000 to 74,999	5	5	68
75,000 to 99,999	3	7	77
100,000 to 149,999	3	3	83
<= 150,000	2	5	82
Children	7	6	82
No Children	1	3	68
Total House of 1	13	6	59
Of 2	3	5	73
Of 3	4	8	67
Of 4 or more	1	2	89
Own Residence	5	4	76
Rent Residence	7	7	63
Year at current address < 1 year	6	5	72

1 to 2 years	5	2	77
3 to 4 years	1	8	73
5 or more years	7	6	68

Number of Individuals:

City	Monona No Access	Cellphone Only	Both Broadband and Cell
Men	191	229	3395
Women	234	195	3467
White	363	363	6524
POC	23	20	289
18 to 34	119	34	3800
35 to 44	9	60	785
45 to 54	36	47	1100
55 to 64	87	87	1071
65 +	306	107	1116
HS	252	119	955
Two-Year/Tech School	125	125	1837

Four-Year	51	101	1533
Graduate	43	64	914
> 25,000	216	54	628
25,000 to 49,999	61	71	885
50,000 to 74,999	37	37	666
75,000 to 99,999	18	42	537
100,000 to 149,999	12	12	370
<= 150,000	7	16	303
Children	7%	6%	
No Children	1%	3%	
Total House of 1	13%	6%	
Of 2	3%	5%	
Of 3	4%	8%	
Of 4 or more	1%	2%	
Own Residence	5%	4%	107
Rent Residence	7%	7%	128
Year at current address < 1 year	6%	5%	

1 to 2 years	5%	2%	
3 to 4 years	1%	8%	
5 or more years	7%	6%	

APPENDIX M: STATA CODE FOR MONTE CARLO

This Appendix contains all the do-files for each part of the analysis we have conducted within the statistical software package, Stata. The first do-file handles the point estimate for the In-home service. The do-file has two parts, the first uses the mean estimates for our uncertain variables. The second part of this do-file does the point estimate for the in-home service under our most optimistic numbers. The second do-file handles the Monte Carlo Simulation for the in-home service, the code will execute 1000 draws and each draw will handle our uncertain variables through either a normal or uniform random distribution draw. The third do-file handles our point estimate for the Outdoor Service under our mean predictions for our uncertain variables. The final do-file handles our Monte Carlo simulation for the Outdoor service, the code will execute 1000 draws and like the previous Monte Carlo, uncertain variables are handled through either a random uniform or normal distribution.

```
//Start of Do-File
drop _all
set obs 1000
//Point Estimates of In-Home Service
//Initialize base case parameters
gen MUFNSplice = 20000
gen BaseBuild = 20000
gen MUFNAnnualCost = 350*2*12
gen totalpop = 4000
gen Utilityloss = 70.09-61.03
gen WTPBroadbandVeryFast = (50-Utilityloss)*12
gen WTPBroadbandVeryFast2 = (40-Utilityloss) * 12
gen WTPBroadbandMedium = 40 * 12
gen WTPCell = 52.01 * 12
gen WTPNoInternet = 20.33 * 12
//Point Estimate Low
gen SpliceRepair = 2000
gen InternetAccess = totalpop * .8671
gen NoInternetAccess = totalpop * .064
gen CellOnly = totalpop * .054
gen ATT6 = InternetAccess * .4
gen ATT24 = InternetAccess *.3
```

```
gen Charter = InternetAccess * .3
gen UptakeInternet = InternetAccess * .04
gen UptakeCell = CellOnly * .04
gen UptakeNoInternet = NoInternetAccess * .373
gen uptakeCount = UptakeInternet + UptakeCell + UptakeNoInternet
gen MonthlyCost = 15 * 12
gen CPECost = 75
gen MUFNMaintenanceCost = 1500 * 12
gen Costs = MUFNSplice + BaseBuild + MUFNAnnualCost + MUFNMaintenanceCost +
SpliceRepair
gen Benefits = (UptakeInternet *.3)*(WTPBroadbandVeryFast - (MonthlyCost + CPECost))+
(UptakeInternet *.3)*(WTPBroadbandVeryFast2 - (MonthlyCost + CPECost)) +
UptakeCell*(WTPCell - (MonthlyCost + CPECost))+ (UptakeInternet *
.4)*(WTPBroadbandMedium - (MonthlyCost + CPECost))+UptakeNoInternet*(WTPNoInternet -
(MonthlyCost + CPECost))
gen CB = Benefits - Costs
display CB
display uptakeCount
//Point Estimate High
replace SpliceRepair = 10000
replace UptakeInternet = InternetAccess * .2
replace UptakeCell = CellOnly * .2
replace uptakeCount = UptakeInternet + UptakeCell + UptakeNoInternet
replace MonthlyCost = 10 * 12
replace CPECost = 50
replace MUFNMaintenanceCost = 3000 * 12
replace Costs = MUFNSplice + BaseBuild + MUFNAnnualCost + MUFNMaintenanceCost +
SpliceRepair
replace Benefits = (UptakeInternet *.3)*(WTPBroadbandVeryFast - (MonthlyCost + CPECost))+
(UptakeInternet *.3)*(WTPBroadbandVeryFast2 - (MonthlyCost + CPECost)) +
UptakeCell*(WTPCell - (MonthlyCost + CPECost))+ (UptakeInternet *
.4)*(WTPBroadbandMedium - (MonthlyCost + CPECost))+UptakeNoInternet*(WTPNoInternet -
(MonthlyCost + CPECost))
replace CB = Benefits - Costs
display CB
display uptakeCount
//End of Do-File

//Start of Do-File
drop _all
//Monte Carlo In-Home
set obs 1000
set seed 123456
//Establish Fixed Costs and Willingness to Pay
gen MUFNSplice = 20000
gen BaseBuild = 20000
gen MUFNAnnualCost = 350*2*12
gen totalpop = 4000
gen Utilityloss = 70.09-61.03
```

```
gen WTPBroadbandVeryFast = (40-Utilityloss)*12
gen WTPBroadbandVeryFast2 = (50-Utilityloss)*12
gen WTPBroadbandMedium = 40 * 12
gen WTPCell = 52.01 * 12
gen WTPNoInternet = 20.33 * 12
gen discountrate = .035
//Establish Uncertain Variables
gen MonthlyCost =.
gen CPECost =.
gen FIVENINESMaintenanceCost =.
gen InternetAccess =.
gen NoInternetAccess =.
gen CellOnly =.
gen ATT6 =.
gen ATT24 =.
gen Charter =.
gen UptakeInternet =.
gen UptakeCell =.
gen UptakeNoInternet =.
gen uptakeCount =.
gen Benefits =.
gen Costs =.
gen NetBenefits =.
gen DiscountCB =.
gen SpliceRepair =.
gen CaptialCosts = MUFNSplice + BaseBuild

//Monte Carlo Simulation
forval i = 1/1000{
        replace InternetAccess = totalpop * rnormal(.8671,.015)
        replace NoInternetAccess = totalpop * rnormal(.064,.0145)
        replace CellOnly = totalpop * rnormal(.054,.0075)
        replace SpliceRepair = runiform((.10*MUFNSplice),(.50*MUFNSplice))
        replace ATT6 = InternetAccess * .4
        replace ATT24 = InternetAccess *.3
        replace Charter = InternetAccess * .3
        replace UptakeInternet = InternetAccess * rnormal(.04,.01)
        replace UptakeCell = CellOnly * rnormal(.04,.01)
        replace UptakeNoInternet = NoInternetAccess * rnormal(.363,.0175)
        replace uptakeCount = UptakeInternet + UptakeCell + UptakeNoInternet

        replace MonthlyCost = (15 * 12) if uptakeCount <= 100
        replace CPECost = 75 if uptakeCount <= 100
        replace FIVENINESMaintenanceCost = (1500 * 12) if uptakeCount <= 100

        replace MonthlyCost = (14 * 12) if uptakeCount > 100 & uptakeCount <= 150
        replace CPECost = 65 if uptakeCount > 100 & uptakeCount <=150
        replace FIVENINESMaintenanceCost = 2100 * 12 if uptakeCount > 100 & uptakeCount
<= 150
```

```
        replace MonthlyCost = (13 * 12) if uptakeCount > 150 & uptakeCount <= 200
        replace CPECost = 60 if uptakeCount > 150 & uptakeCount <=200
        replace FIVENINESMaintenanceCost = 2600 * 12 if uptakeCount > 150 & uptakeCount
<= 200

        replace MonthlyCost = (12 * 12) if uptakeCount > 200 & uptakeCount <= 250
        replace CPECost = 55 if uptakeCount > 200 & uptakeCount <=250
        replace FIVENINESMaintenanceCost = 3000 * 12 if uptakeCount > 200 & uptakeCount
<= 250

        replace MonthlyCost = (10 * 12) if uptakeCount > 250 & uptakeCount <= 300
        replace CPECost = 50 if uptakeCount > 250 & uptakeCount <=300
        replace FIVENINESMaintenanceCost = 3000 * 12 if uptakeCount > 250 & uptakeCount
<= 300

        replace Costs = MUFNAnnualCost + FIVENINESMaintenanceCost + SpliceRepair
        replace Benefits = (UptakeInternet *.3)*(WTPBroadbandVeryFast - (MonthlyCost +
CPECost))+ (UptakeInternet *.3)*(WTPBroadbandVeryFast2 - (MonthlyCost + CPECost)) +
UptakeCell*(WTPCell - (MonthlyCost + CPECost))+ (UptakeInternet *
.4)*(WTPBroadbandMedium - (MonthlyCost + CPECost))+ UptakeNoInternet*(WTPNoInternet -
(MonthlyCost + CPECost))
        replace NetBenefits = Benefits - Costs
        replace DiscountCB = ((NetBenefits/((discountrate + 1)^.5)) + (NetBenefits/((discountrate
+ 1)^1.5))+(NetBenefits/((discountrate + 1)^2.5))+(NetBenefits/((discountrate +
1)^3.5))+(NetBenefits/((discountrate + 1)^4.5))+(NetBenefits/((discountrate +
1)^5.5))+(NetBenefits/((discountrate + 1)^6.5))) - CaptialCosts
        display DiscountCB
        display uptakeCount
}
//Histogram of Results
histogram DiscountCB, bin(10) percent addlabel
//End of Do-File

//Start of Do-File
drop _all
set obs 1000
//Point Estimates
//Initialize base case parameters
gen MUFNSplice = 20000
gen BaseBuild = 20000
gen MUFNAnnualCost = 350*2*12
gen totalpop = 7111
gen Utilityloss = 70.09-61.03
gen sedentary = .6223
gen ParkUse = .62
gen CoverageArea = 2
gen CostperWAP = 12.82
gen WAPBuildNumber = 30
```

```
gen ATT6Plan = 40*6
gen ATT24Plan = 50*6
gen CharterPlan = 40*6
gen InternetAccess = totalpop * .95
gen WiFiDevice = InternetAccess * .85
gen WTP = .095
gen WAPPrice = 745
gen Cost = 349.27
gen AnnualWAPCost = 14.93
gen AnnualCost = 339
gen discountrate = .035
gen SpliceRepair = MUFNSplice * .3
//Point Estimate of Outdoor Service
gen OneTimeCost = (WAPPrice * WAPBuildNumber * CoverageArea) + (Cost *
WAPBuildNumber * CoverageArea)
gen AnnualCosts = (AnnualWAPCost*WAPBuildNumber*CoverageArea) + (AnnualCost *
WAPBuildNumber * CoverageArea)
gen Costs = OneTimeCost + AnnualCost + MUFNSplice + BaseBuild + MUFNAnnualCost +
SpliceRepair
gen ATT6Benefits = (WiFiDevice * .4) * (ATT6Plan * WTP)
gen CharterBenefits = (WiFiDevice * .3) * (CharterPlan * WTP)
gen ATT24Benefits = (WiFiDevice * .3) * (ATT24Plan * WTP)
gen Benefits = (sedentary * ParkUse * ATT6Benefits) + (sedentary * ParkUse * ATT24Benefits) +
(sedentary * ParkUse * CharterBenefits)
gen NetBenefits = AnnualCosts - Costs
gen DiscountCB = ((NetBenefits/((discountrate + 1)^(1-.5))) + (NetBenefits/((discountrate + 1)^(2-
.5)))+(NetBenefits/((discountrate + 1)^(3-.5)))+(NetBenefits/((discountrate + 1)^(4-
.5)))+(NetBenefits/((discountrate + 1)^(5-.5)))+(NetBenefits/((discountrate + 1)^(6-
.5)))+(NetBenefits/((discountrate + 1)^(7-.5)))) - OneTimeCost
display DiscountCB
//End of Do-File

//Start of Do-File
drop _all
//Monte Carlo Outdoor
set obs 1000
set seed 123456
//Establish Fixed Costs
gen MUFNSplice = 20000
gen BaseBuild = 20000
gen MUFNAnnualCost = 350*2*12
//Establish Population Parameters
gen totalpop = 7111
//Establish Plan Variety
gen Utilityloss = 70.09-61.03
gen ATT6Plan = 40*6
gen ATT24Plan = 50*6
gen CharterPlan = 40*6
//Intialize Uncertain Variables
```

```
gen sedentary =.
gen ParkUse =.
gen CoverageArea =.
gen CostperWAP =.
gen WAPBuildNumber =.
gen InternetAccess =.
gen WiFiDevice =.
gen WTP =.
gen WAPPrice =.
gen OneTimeCost =.
gen PoleCost =.
gen AnnualCosts =.
gen InstallationCost =.
gen MaintenanceCost =.
gen Costs =.
gen ATT6Benefits =.
gen CharterBenefits =.
gen ATT24Benefits =.
gen Benefits =.
gen DiscountCB=.
gen discountrate = .035
gen NetBenefits =.
gen CapitalCosts =.
gen SpliceRepair =.
//Monte Carlo
forvalues i = 1/1000{
replace sedentary = .6223
replace ParkUse = .62
replace CoverageArea = runiform(1.837,2.16)
replace CostperWAP = 12.82
replace WAPBuildNumber = runiform(20,40)
replace SpliceRepair = runiform((.10*MUFNSplice),(.50*MUFNSplice))
replace InternetAccess = totalpop * .95
replace WiFiDevice = InternetAccess * .85
replace WTP = .095
replace WAPPrice = runiform(699,787.36)
replace InstallationCost = 349.27
replace PoleCost = runiform(11.99,17.86)
replace MaintenanceCost = runiform(306,372)
//Monte Carlo
replace OneTimeCost = (WAPPrice * WAPBuildNumber) + (InstallationCost * WAPBuildNumber)
replace AnnualCosts = (MaintenanceCost*WAPBuildNumber) + (PoleCost * WAPBuildNumber)
replace Costs = OneTimeCost + AnnualCosts + MUFNSplice + BaseBuild + MUFNAnnualCost +
SpliceRepair
replace ATT6Benefits = (WiFiDevice * (rnormal(.4,.016))) * (ATT6Plan * WTP)
replace CharterBenefits = (WiFiDevice * (rnormal(.3,.016))) * (CharterPlan * WTP)
replace ATT24Benefits = (WiFiDevice * (rnormal(.3,.016))) * (ATT24Plan * WTP)
replace Benefits = (sedentary * ParkUse * ATT6Benefits) + (sedentary * ParkUse *
ATT24Benefits) + (sedentary * ParkUse * CharterBenefits)
```

```
replace NetBenefits = Benefits - Costs
replace DiscountCB = (NetBenefits/((discountrate + 1)^.5)) + (NetBenefits/((discountrate +
1)^1.5))+(NetBenefits/((discountrate + 1)^2.5))+(NetBenefits/((discountrate +
1)^3.5))+(NetBenefits/((discountrate + 1)^4.5))+(NetBenefits/((discountrate +
1)^5.5))+(NetBenefits/((discountrate + 1)^6.5))
display DiscountCB
}
//Display Histogram of Results
histogram DiscountCB, bin(10) percent addlabel
//End of Do-file
```

ABOUT THE UNIVERCITY YEAR

UniverCity Year is a year-long partnership between UW-Madison and one community in Wisconsin. The community partner identifies sustainability and livability projects that would benefit from UW-Madison expertise. Faculty from across the university incorporate these projects into their courses with graduate students and upper-level undergraduate students. UniverCity Year staff provide administrative support to faculty, students and the partner community to ensure the collaboration's success. The result is on-the-ground impact and momentum for a community working toward a more sustainable and livable future.

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