LIBRARY OF THINGS (LoT) - AN URBAN SYSTEM MODEL FOR RECONCEPTUALIZING THE ROLE AND SPATIALIZATION OF PUBLIC LIBRARIES IN THE DIGITAL AGE

by

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ABSTRACT

ALEXANDRA CHRISTINE NELSON. Library of Things (L.o.T.) - An Urban System Model for Reconceptualizing the Role + Spatialization of Public Libraries in the Digital Age. (Under the direction of CHRIS BEORKREM)

As the public library system struggles to find support in the age Google and Amazon, their impact through crucial resources and personalized support from library staff prove their undeniable value in cities -- especially for those without internet access or devices in their home. As smart cities begin to integrate the Internet of Things (I.o.T.) into urban infrastructure, the public library has a great opportunity to use this model as a method for extending access to those who need it most. The *"*Library of Things*"* (L.o.T.) model, a play on "I.o.T.", aims to reconceptualize the public library's role in cities by using data-driven design, analysis, and optimization to help libraries justify their disbursement of resources, while also significantly reducing their expenses. These library access points are mobile, small-scale public computing and learning spaces that act as extensions of existing libraries but can grow and move responsively to usage analysis. The L.o.T. model can allow libraries to make the most effective use of their funding while also ensure that they are meeting the needs of the public in an effort to democratize the access of information and opportunity for all.

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LAP	Library Access Point

SECTION 1: INTRODUCTION

As the rise of Smart Cities and IoT devices suggests the current interest of data-driven design processes, one wonders how this might be translated into ways to better serve the needs of the community, especially for those who are underserved. These new trends offer great potential applications for the distribution of library resources and services. Instead of the traditional brick and mortar buildings, which often come with an enormous expense, planners can challenge the distribution of resources to increase access in areas of the community that have the greatest need, while also significantly reducing their expenses. The use of small-scale public computing spaces might offer the public library a way to reconceptualize their role in the community, by expanding the democratic access to information and to provide the basis for promoting digital inclusion and upward mobility.

With the abundant amount of data that cities already have access to, such as census data and data from service providers, the need for access to resources can be mostly quantified. Through locational analysis, average income per household can be used to calculate areas in cities where residents are likely to have broadband internet and those that might not. Once this has been evaluated, it can be applied to the population density in each census block so that an understanding of the total need for access can be found. An overlay of the existing libraries can then be displayed to show the city's current impact and response to the need as well as to show a heat map for locating new service areas. The design of the physical structure and ways in which

it responds to social thresholds and dynamics are crucial variables for the success of this decentralized library model. Through sensor integration, design and resources can be continually monitored and updated so that they are responsive to the dynamic forces that are found in cities.

This utilization of smart city infrastructure to better democratize the access of information to all can begin to speak to many institutions in cities so that they might work together to spread useful data that aims to help them achieve their goals of large scale impact in the community. This paper will outline the research and logic behind the Library of Things (LoT) model which aims to give libraries a new way to imagine their role and spatialization in the digital age.

SECTION 2: BACKGROUND

2.1 Libraries in the Digital Age

"Everywhere one turns these days, commentators are predicting the death of the library and lambasting Google, Amazon and others for...'stealing' the rightful role of the library." (Miller, 2006) These tech giants, among many others, have provided essential platforms for easily accessing and storing the expanse of digital information that can be found online. The strength of these platforms have led many to question whether we actually even need public libraries in the digital age. "The Internet has exposed the limitations of a service available at a physical building, with limited opening hours. More fundamentally, Internet users simply expect to be able to access any information they want, from anywhere in the world, at any time." (Chad, 2005) For many, however, the public library is their most reliable and welcoming option for access to the internet, resources, personalized support, and shelter during the day. It also provides a unique place for community engagement and interaction.

Figure 1: Public Library Resources

2.2 The Need for Internet Access

In this era of smartphones and smart devices, users can connect to a limitless

expanse of information at their fingerprints. Each day, the digital library of information and resources continues to grow exponentially, with endless amounts of ways to gather and explore digital information. With this innovation, the world's institutions have quickly transformed their workflow to this paperless, high-speed medium that can be reached by the vast community online. For many, these systems have made life much easier, but for those without access to internet, this evolution has only led to "new inequalities, of power and wealth, reinforcing deeper divisions between the information rich and the information poor." (Norris, 2001) "The Digital Divide" which was coined in 1995, just a few years after the creation of the World Wide Web, shows severe racial, economic, and location based gaps in access to the internet. The Obama Administration worked with cities and broadband companies across the country to map the income levels and percentage of households who have access to internet throughout every region in the United States. The maps that followed, showed clear links between income and the access to internet -- the less income, the less likely one is to have home broadband. (The White House, 2015)

2.3 The Need for Shelter and "Something to Do"

With an estimated 610,042 people in the United States currently experiencing homelessness (Urban Ministry Center, 2017), state and localized efforts have played a critical role in providing and sustaining shelters and other facilities for this population. However, even for guests of shelters, many are forced to wander the streets during the day due to the hours of operation at shelters. Some individuals also find it hard to maintain a life at shelters due to addiction problems and other mental

health issues. As a result, public libraries have become a common destination "for people who have nowhere else to go" and are in search of daytime activities and shelter.

"Staff at public libraries interact with almost as many homeless individuals as staff at shelters do." (ALA, 2016). Meeting the needs of this population has become increasingly more integrated into the operational protocols for public libraries across the country. Due to complaints and other issues, libraries across the country have responded to those experiencing homelessness by developing policies that often restrict these patrons from using the library. However, many groups have worked over the years to represent this population in order to ensure that the rules set in place at libraries are fair and comfortable for all people in the community, so that the library remains a space that is welcoming, as it is intended to be.

2.4 The Need for Personalized Support

Librarians have always been an integral part of the library, but as digital age has brought about new devices and technologies, it has only amplified the need for personalized support and teaching for online services. Also, library staff work hard to deliver job help, housing, and educational support tools and assistance.

2.5 Barriers to Access

A Community Toolbox, which looked at the barriers to access public services, was developed by the University of Kansas. This report broke down these barriers into three main categories, one of which is "Institutional". The Institutional barriers

are often based on factors of Location, Accessibility, Administrative Issues, Poor Communication, and Lack of Cultural Sensitivity. For designers and planners, location and accessibility are two major factors that are within their grasp.

Of all American workers in 2015, 51 percent made less than $30,000 a year and 38 percent made less than $20,000 a year (Washington's Blog, 2017). At these income levels, amenities, like the internet, are often cut out of the budget, for healthcare or food. These low income individuals often do not live within convenient location to a library which is often the only place where they have access to the internet.

2.6 Library Deserts

A "Library Desert", like a Food Desert, is a region that is deprived of an essential resource, in this case it's the access to a public library and the essential free resources and amenities it provides. These areas are located in neighborhoods with low income levels resulting in a lack of internet access in the household, and also located more than a one-mile distance (20-minute walk) to a public library. To respond to the propensity of Info Deserts across American Cities, and to the new-found desire for cities to invest in smart city infrastructure, we propose the development of L.o.T (Library of Things) Pods and Kiosks — digitally connected small-scale libraries with a virtual, personal computing (PC) interface for individualized and distributed access to resources, information, and other services typically provided at public libraries, in the digital age.

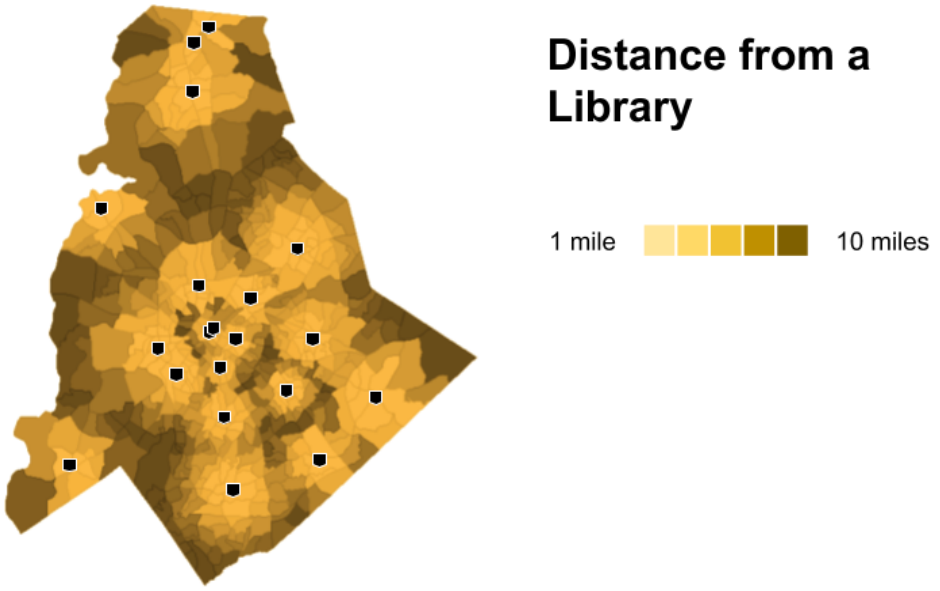

Figure 2: Heat Map showing Distance from a Library in Mecklenburg County, NC

2.7 The Price of Distribution

Public services, like the library, have grown and distributed their services by building more and more brick and mortar institutions. This growth has come with a great expense along the way. Brick and mortar libraries cost millions of dollars and take up a majority of the library's budget, which would otherwise we used to extend the staffing and services they offer. This expense has been for a valid effort though, to decentralize and democratize the access of information to all. But is it really accomplishing this? In Mecklenburg County, many neighborhoods are still as far at 10 miles from the closest library. Patrons who are in critical need of library resources are often those who can't afford to have those resources in their home, like home broadband

internet. For these patrons, the cost of transportation is often a limiting factor. When the current state of library distribution is not yet providing easy access for all those in the community and it's using a majority of its funds to provide access, it becomes clear that the method of distribution is nowhere near where it need to be.

SECTION 3: LITERATURE REVIEW

3.1 “Abundance for All”

In Peter H Diamandis and Steven Kotler’s book “Abundance”, the two stated their belief that “We will soon have the ability to meet and exceed the basic needs of every man, woman, and child on the planet... Abundance for all is within our grasp.” This idea defines abundance as ‘to have met or exceed the basic needs of every living being.’ It discusses abundance not being an issue of scarcity, but rather an issue of accessibility. Accessibility, being the ability to access a resource, both locationally and physically through a design that considers all user types. This idea of accessibility has become the primary focus for the decentralized library model, which suggests taking the library to people rather than make them come to you. This concept combined with the affordability of sensors to extract usage data at every LAP can lead to a more efficient use and distribution of the available resources that libraries have to offer.

3.2 The Internet of Things

As sensors and microcontrollers are becoming a fraction of the price they once were, their application and integration with everyday devices is growing rapidly. Once these devices are connected to an online network, their ability to speak to this larger system of interconnected devices has become known as the “Internet of Things” (IoT). As Diamandis and Kotler explained, with the growth of IoT devices “the Planet has grown a central nervous system” that can allow for endless amounts

of data to be collected and analyzed for major improvements in efficiency and optimization throughout the world. For public institutions who often rely on limited budgets, this ability to improve efficiency and expand their budgets more effectively has the potential to make a huge impact.

3.3 Smart Cities

Mecklenburg County, NC is currently in the process of looking for funding to help develop its "North End Smart District" to grow what they envision as an "Applied Innovation Corridor" to spur business development and growth along a new mass transit route. This same neighborhood is home to shelters, interim housing options, services, and soup kitchens for those experiencing homelessness. These county services are vital to this population, but as the city looks to the smart city plans as a way to grow that area, there is fear that this growth could have long term gentrification effects. These new technologies, however, have the potential to bridge the gap between the communities if they are used to provide resources for not just the incoming businesses but also for those currently in the neighborhood.

3.4 Smart Distribution

Smart city applications are focusing a lot on the efficiency of power grids, since they have an enormous impact on the environment. A "smart distribution system" has been one major approach for tackling this issue because they use sensors to monitors and calculate current distribution in order to regulate and control the flow of power to each feeder line and redistribute it for grid optimization. Their aim is "to

leverage more value from their current distribution infrastructure, preventing additional investment and need for new generation, transmission and distribution assets." These methods are the exact type of smart city techniques that can supply our communities with more efficient use of our current resources and begin to offer abundance in a way like we haven't been able to do before (Smart Distribution, 2013). For public libraries that often have limited budgets, planners can use similar logics to monitor and optimize the distribution of LAPs and their resources. Rather than spending a bulk of their budgets on brick and mortar library construction and renovation, libraries can increase access in areas of the community which are often overlooked or underserved.

3.5 Precedents

Urban kiosks are one of the more popular ways to distribute information in cities. The LinkNYC is unique in that it also aims to provide free wireless access throughout New York City's 5 boroughs, with the eventual goal of installing 7,500 kiosks. LinkNYC allows for users to make free phone calls, charge their phone, as well as access internet and city information. Two 55" digital displays are also provided on each Link and display advertising which funds the upkeep of the kiosks and provides additional income for the city. So far, some of the major criticism residents have had are through fear of losing privacy by somehow giving out their personal information while using the Link or being seen by the cameras at each of their locations. Another issue has been the gathering of many in the city that are experiencing homelessness around these kiosks, which could lead to stigmatization.

Figure 3: LinkNYC by CitiBridge

Smart furniture is another growing product, where sensors are often integrated to measure and offer data back to the city while offering a place for the community to sit and charge their phone or device. Soofa developed a smart bench called the Soofa Bench (Figure 4), which is now in over 100 cities, that incorporates their "Sensor Pro" kit that measures how traffic around the bench through recognizing cell phones signals. Once a cell phone signal is recognize, Soofa can use this to detect where else that same signal is detected, which allows them to show how people move throughout the city. The Soofa Bench uses a solar panel for power and a battery for energy storage for hours of use when the sun in not out.

Figure 4 : Soofa Bench by Soofa

Project Loon is an effort by Google to supply the world with internet access. They have designed a network of balloons that can travel at the edge of space to supply the globe with internet. This effort could help many communities, like rural and remote areas that struggle to gain access. This project is not the only effort to bridge the digital divide, there are others working toward this grand challenge. This brings interesting questions to mind about what would the libraries future look like if everyone had access to internet in there home. Offering free access to devices that can connect to the internet as well as learning spaces and personalized support are still needed in this scenario.

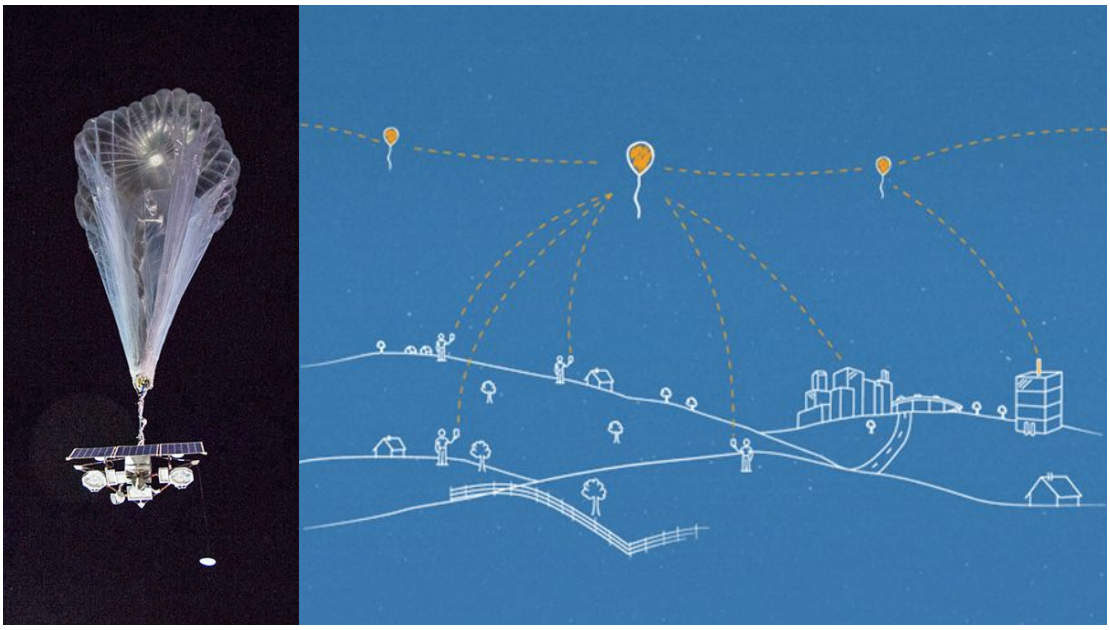

Figure 5 : Project Loon by Google

SECTION 4: METHODS

4.1 Ethnography

To better understand how patrons view the libraries services, it was crucial for me to get a first hand perspective through observation and interactions at different library locations. I visited 7 different libraries, all of which are in different parts of the county. to better Over 90% of my time, however, was spent at the Main Library branch, which is located closest to services for those experiencing homelessness and is located in a prime location for public transit users and those who live in or around the dense urban center.

Many of the patrons I saw at the Main library, I noticed again on other visits. I didn't pick up on this as much at any of the other libraries. This made me believe that the Main library maybe has more frequent regular users than other branches. This could be due to its close proximity to the homeless shelters and transit line. The Main Library also has a very large Job Help Center on the first floor allows which allows extended (3 hr) computer usage, rather than the typical 2 hr limit. This location, however, filters out and restricts access of distracting websites, such as Facebook. The area is meant for those who need to focus. Another interesting feature of the Main Lirbary is their Idea Box which contained MakerBots, laser cutters, a classroom, and more. Public parking, however, was non existent at the Main Library. This difficulty and expense for finding parking Uptown made me feel less inclined to use their services.

At the Scaleybark branch, one thing I found interesting was that they had two standing workstations with computers just for finding a book. This seemed like a waste of computers, since you actually had to still login to browse the books. This process felt unnecessary and like a challenge that sits between a patron and their access to the physical materials offered at the library. Also, this method wastes a patron's computer usage time, which as I mentioned before is limited to 2 hours for every cardholder. These observations had the biggest takeaways for me. It really began to show me how resources are not currently being used efficiently or affectively. It also brought to my attention the challenges to access, both locationally and physically.

4.2 Data Collection + Analysis

Currently, the Charlotte Mecklenburg Library breaks down their cardholders into cluster groups by primary use of their resources(Figure 6). This data helps them keep track of the type of use each individual library is getting, so that they can better organize and distribute their services in each region. Since each library card holder gives their birthdate and home address when applying for a library card, the library can directly connect how their resources are being consumed by different census blocks. This study showed that an astonishing 45% of cardholders are primarily physical material borrowers and users. This is in contrast with what many people have feared is the "death of printed material" in public libraries. In the county, 15%

of cardholders are borrowing children's material, while only 2% are borrowing teen material. How this is dispersed throughout different regions and 25% of cardholders are strictly digital material users, 9% of which were heavy users of the library's computers and 7% stayed for long periods of time and used the library's wifi. Also, 9% are considered "transitional" as they use both digital and printed materials. As many as 21% of cardholders rarely, if ever, use the libraries resources. Some takeaways from this data show that many are still interested in going to the library for printed material. in need of As many as 21% of cardholders are rarely, if ever, using their services.

Cluster	Primary Use	Percentage of Cardholders
Digitarians	Download eBooks and eAudiobooks through library website	4%
Transitionals	Borrow adult print materials and eBooks	9%
Staying Connected	Use library computers	9%
Bedtime Stories	Borrow children materials or attend programs for children	15%
Bright Future	Borrow teen materials	2%
Dependables	Borrow adult print and A/V materials	11%
Page Turners	Borrow adult print materials	17%
Audiophiles	Borrow audiobooks	4%
Double Feature	Borrow DVDs and music CDs	1%
Dining In	Study or work, read print materials, or use free Wi-Fi at the library	7%
Occasionals	Infrequently borrow adult print materials	21%

Figure 6 : Aggregate Customer Data Set by the Charlotte Mecklenburg County Library

4.3 Mapping

For Mapping was first used to understand where libraries are currently located throughout Mecklenburg County, NC and then and In order to quantify the need for access to library resources throughout the county, a mapping was done to locate "Library Deserts", where there is likely to be less of an ability to access public

libraries based on data that looks at distance from each census block group to a public library location. Since there is access to a great deal of data for each census block, including the population density, we can better understand how many people are more than a mile away from a public library and of those people how many of them are below poverty level. Since people experiencing poverty are much less likely to have the money in their budget to afford access to internet in their home as well as the Their mapping then determines the need for these mobile, decentralized library locations. These info desert regions are then divided up into a square mile grid. By taking the population density of that region and mapping it overtop, you are able to grab square mile areas and get data based on their average population density. For example, if there were 1,500 people per square mile and you know from the data that 30% of people in that region have no access to internet, then you would understand that 450 people in that zone are without access to information. In locations that were categorized as “Info Deserts”, there would be a ratio of 1 small-scale library pod per 10 people without access, which would give us a need of 45 library pod in that particular region. (Figure 7) Once the amount of library pods has been established, you then need to locate infrastructure in that region that falls under any of the three categories: parks, transit stops, and shelters. Library pods will be placed in these public areas due to their public nature and the fact that these spaces are already maintained by the city.

SECTION 5: LIBRARY OF THINGS MODEL

5.1 Reconceptualizing the Role and Spatialization of Public Libraries

The services and support provided by libraries is continually evolving to better suit its patrons as well as its willingness to embrace, perhaps, its most critical role — as a daytime shelter and internet access point for many who are without. While efforts are in place to respond to this need, a physical reconceptualization of the role of public libraries' in the city must take place, to respond in kind. In this proposal, "library access points", small scale public computing spaces, can be designed spaces as an extension of brick and mortar libraries. With digital innovation, there are now methods for accomplishing most of the activities, that would typically be done in public libraries, online. (Figure 7)

Figure 7 : LoT Activities Chart

LAPs can offer a more affordable method for distribution as well as the ability to adapt to urban growth and change through their mobility. By developing an urban system model that uses data as a means for justifying the distribution of LAPs and the resources they provide, this system uses the affordances of the digital age (ie. embedded sensors, IoT models, and optimization logics) as an aim for extending the access of information and opportunity for all.

5.2 LoT System Model

Urban system models were developed before the affordances of the digital age and they weren't developed with theory of abundance. The theory of abundance really aims at using digital innovation as a means for providing everyone with the resources they need. As we know, many people experience different challenges that heighten their specific need for certain resources. The LoT System Model enables you to more democratically distribute the libraries resources as well as explore the potential benefits that the digital age offers public libraries. (Figure 8)

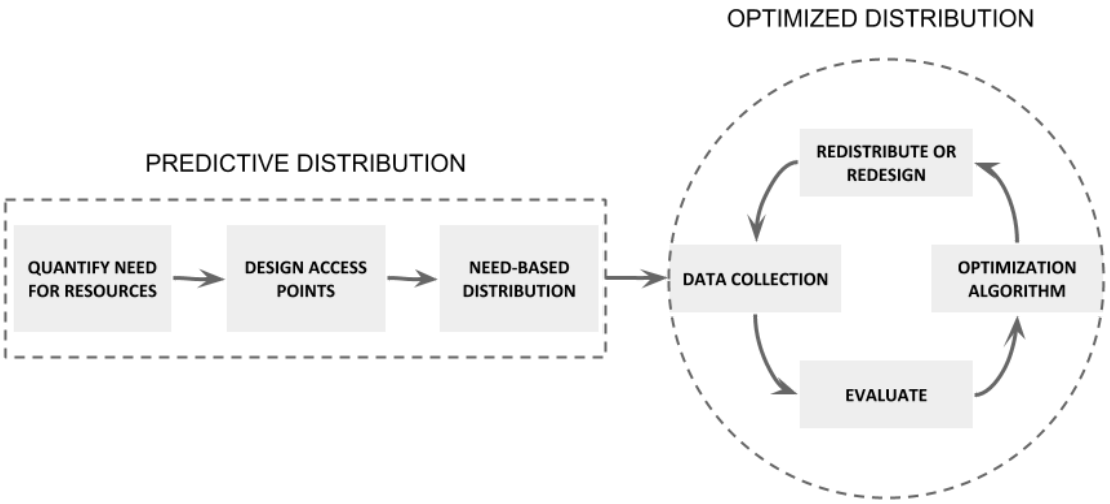

Figure 8 : LoT System Model

The system logic first addresses predictive distribution by quantifying need, designing access points to respond to this need, and then deploying these access points through need-based distribution. Once the access points are distributed, data is continually collected for the purpose of optimizing distribution. Once the data is collected, it will be evaluated to ensure that there are no outliers that can affect the optimization, such as unusual high traffic due to an event nearby or due to severe climate conditions that make the space less desirable. Once the data has been evaluated, the relevant data will be sent through an optimization algorithm for which it can be compared to prior analysis so that it can indicate positive or negative changes as the design of the space evolves to better suit the neighborhood. The use of resources is also examined as a way of better understanding how to utilize the resources available.

5.3 Contextualizing the System

In order to appropriately organize the flow of data and how it serves to enhance the system model, it was necessary to first contextualize the system. Since public services are almost always distributed and funded through their counties, the highest level of the system is the county scale. The next level of the system is the neighborhood scale. The neighborhood scale is used to measure the how and understand how use varies from one region to another. In an effort to democratize use of services, further analysis can be done to estimate why this is the case. The location scale is looking at the immediate site where the library access point was located. This scale is important as it works to negotiate the flow of traffic and use of resources at

each site. If locations are low in use, this use data can be compared to it's site conditions to better understand what features negatively or positively impact use. Lastly, the user scale is examined as a way of knowing how each individual user/patron uses resources more specifically and what library locations they visit. A key element of understanding how effective this model is will be evaluated through the user data. Does the user come back? How long are they staying? What resources are they using? Is the library's website fulfilling the needs and interests of the user? These kinds of questions and analysis of the user can help to provide a better understanding of how well the system is functioning.

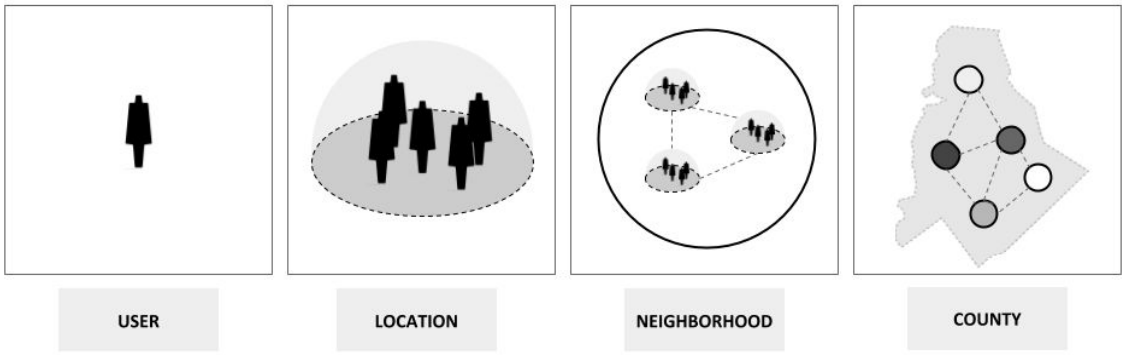

Figure 9 : LoT System Context Diagram

5.4 Quantify Need for Resources

In order to quantify the need for resources, a mapping was first done to locate census block groups that are more than a 1 mile walk from an existing library. Once this was found, Census Data was used to estimate the total number of people whose income in these areas is below poverty level. These two values were used together to find a severity rating for absolute need for access to library resources. The distance from each census block group was divided by the max distance, which was set at 10

miles, and then multiplied by the number of people experiencing poverty in those regions. This equation resulted in a total of 15, 271 people in critical need of an LAP in Mecklenburg County, NC.

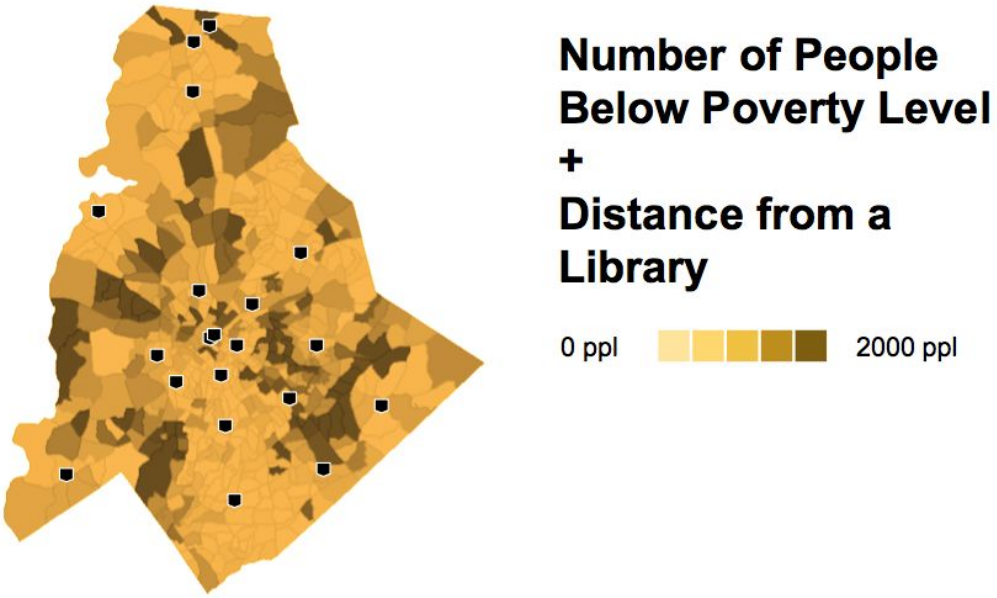

Figure 10 : Heat Map Showing Severity of Need

5.5 Design Access Points

The design of a network of digitally-connected, small-scale, mobile library access points(LAPs) could help libraries extend access to their resources in a more affordable and flexible way. The design focuses around finding the right scale, that extends beyond an individual pc experience, but is also smaller than brick and mortar libraries that carry with them a heavy expense. This design will also be constrained to a built form that is portable, so that as usage and need changes, so can the location and growth of the LAP.

LAPs would be designed at three different scales to allow for flexibility as it develops in various locations. The largest scale LAP is the Enclosed Pod (Figure 8), which could range from $50,000 to $100,000, but would provide shelter from the elements and offer desks for people to spend longer periods of time. This LAP as well as the others would require a library card or library login number to access. The enclosed pod would best be situated into a public park, where there are nice views and a quiet setting. The next scale of LAP would be the “PC Redbox”, which similar to a Redbox, allows users to rent a laptop or tablet for a period of time. (Figure 9) This would be great for users who do not own a device or simply don’t have theirs with them. These machines range from $14,000 to $30,000. Lastly, an Urban Furniture LAP could be designed as a way for users to quickly grab information they need while they are on the go. (Figure 10) This LAP would cost $2,500-$5,000 and would include an interface, wifi, and charging.

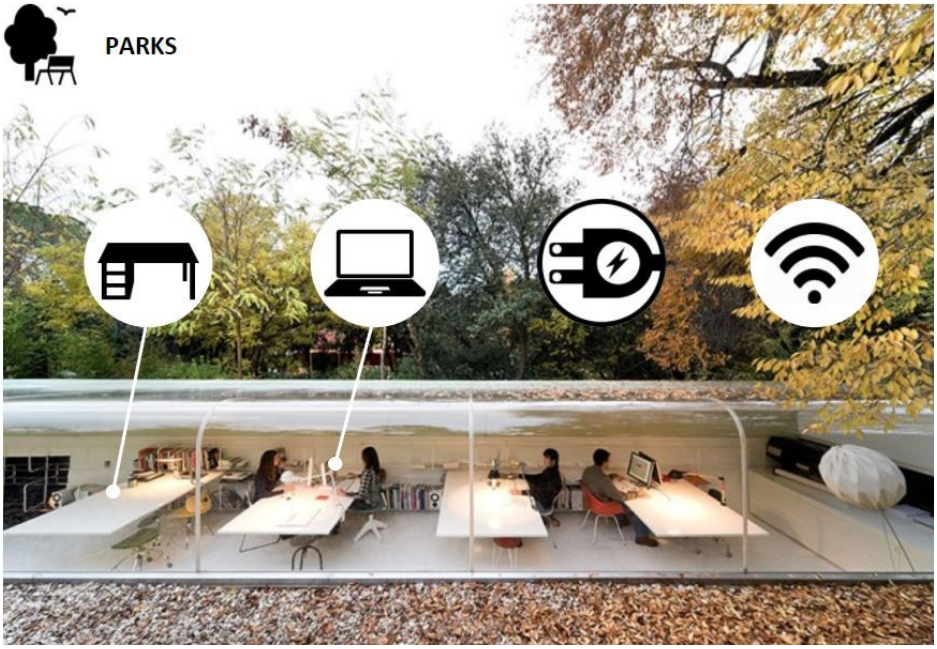

Figure 11. Enclosed Pod

Figure 12. PC “Redbox”

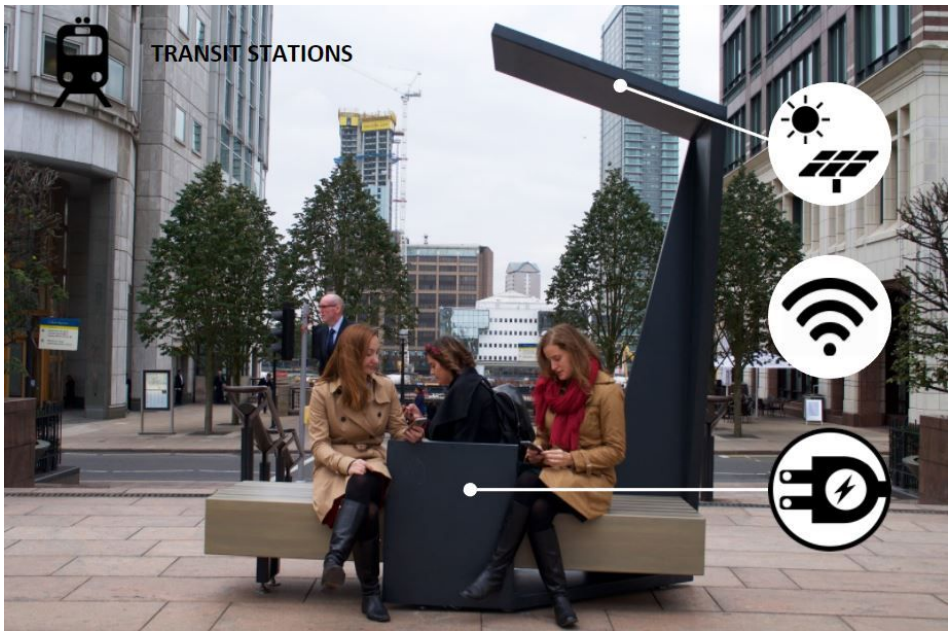

Figure 13. Urban Furniture

5.6 Need Based Distribution

The goal of the need-based distribution is to first locate the areas in need of access to resources. Once need is found, prioritization can be placed on regions with the greatest severity of need. For mapping need, there was an importance in understanding the distance people are from a library as well as if they are experiencing poverty. In addition to this, focus should be given to prioritize distribution based on need. The following chart helps to illustrate how this might be done. For example, community members below poverty level have the highest priority. Those that are also unemployed have potentially the greatest need because they are available during the daytime to use the libraries resources and also are actively looking for work, which the library provides services for.

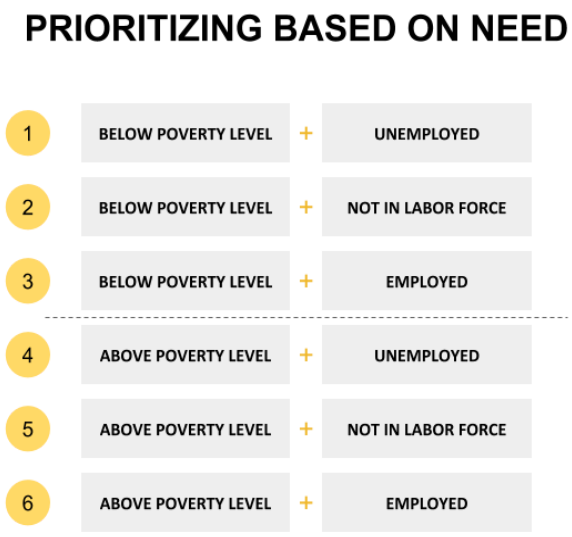

Figure 14 : LoT Prioritization Diagram

5.7 Data Collection

There are three main types of data that will be collected at each LAP: Usage Data, Comfort Data, and Feedback Data. The Usage Data will be measured by embedding pressure sensors into each chair in order to know what workstations are receiving the highest level of use. Usage Data will also be measures with a sensor that detects cell phones of the people that pass by, this count can help to quantify how many people pass by the location at a given time. Lastly, the consumption of wifi, charging, and computer use will be measured. All of this data will be associated with a time and can allow for the system to be better informed about how it's being used.

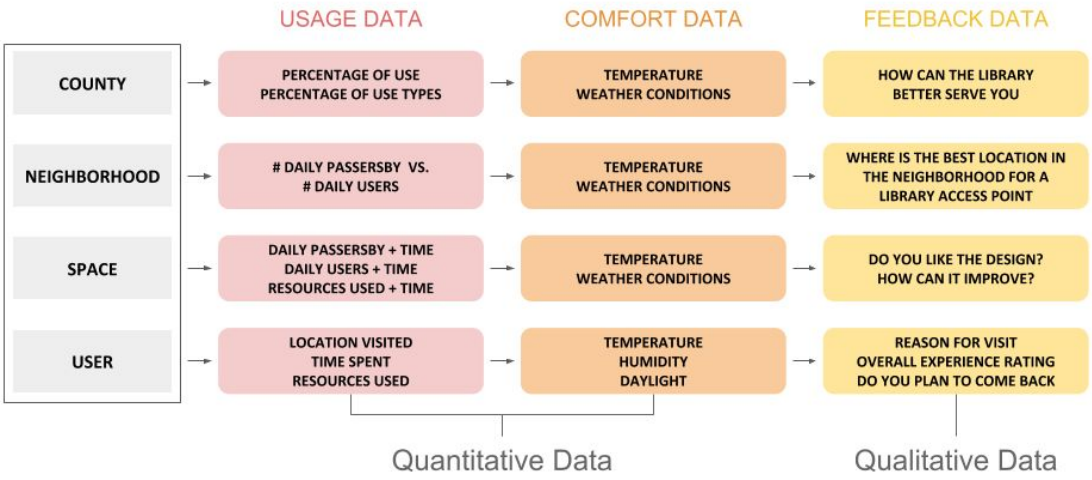

Figure 15 : LoT Data Collection Chart

Comfort Data will be used as a way of eliminating and calculating how usage data is affected by the environmental conditions. This data will be gathered by by temperature, humidity, and daylight sensors that can be combined to give an overall comfort level for the location. If the condition of the location is currently outside of

the comfort range, then that can help to better gage why the usage might be low at that specific moment. Comfort data can also be used to better inform design decisions in an effort to provide a space that experiences the most days possible that are within that comfort range.

Lastly, feedback data can be taken online through quick surveys or questionnaires for measuring how individual users feel about the LAP they visited. There can also be questions that ask for suggestions, such as “How can the library better serve you?” or “How can the design of this space improve?”. Feedback can allow the library to better understand how people feel about the way their resources are distributed and can offer consensus for how some neighborhoods might feel about the location and design chosen for their neighborhood versus another, so that improvements can be made.

5.8 Evaluate + Optimize

Once data is collected each day, the data has to be evaluated based on whether it’s data has anything else as a factor for its outcome. As discussed before, the comfort data can be used to measure whether the condition of the space was inside or outside of the comfort zone. If it was outside the comfort zone, then it can be stored as “Uncomfortable”. If it is inside the comfort zone, it can then be compared with the average totals of that week. If the usage is unusually high or low, then it can be stored as “Unexpected”, so that it can be further evaluated to see if there was an event or occurrence that might have attributed to that unusually high value. If the usage values are pretty typical, then they can be gathered with all other typical days to run totals

and an evaluation for each month. If the value is higher than the previous month, then the changes that have been made since that last period could be defined as positive influences on the system. On the opposite side, when the values have decreased they can be considered negative influences on the system. These key indicator can be values that are interpreted by an optimization algorithm for further analysis and results to see how the system might work to redistribute or redesign the space and resources it provides.

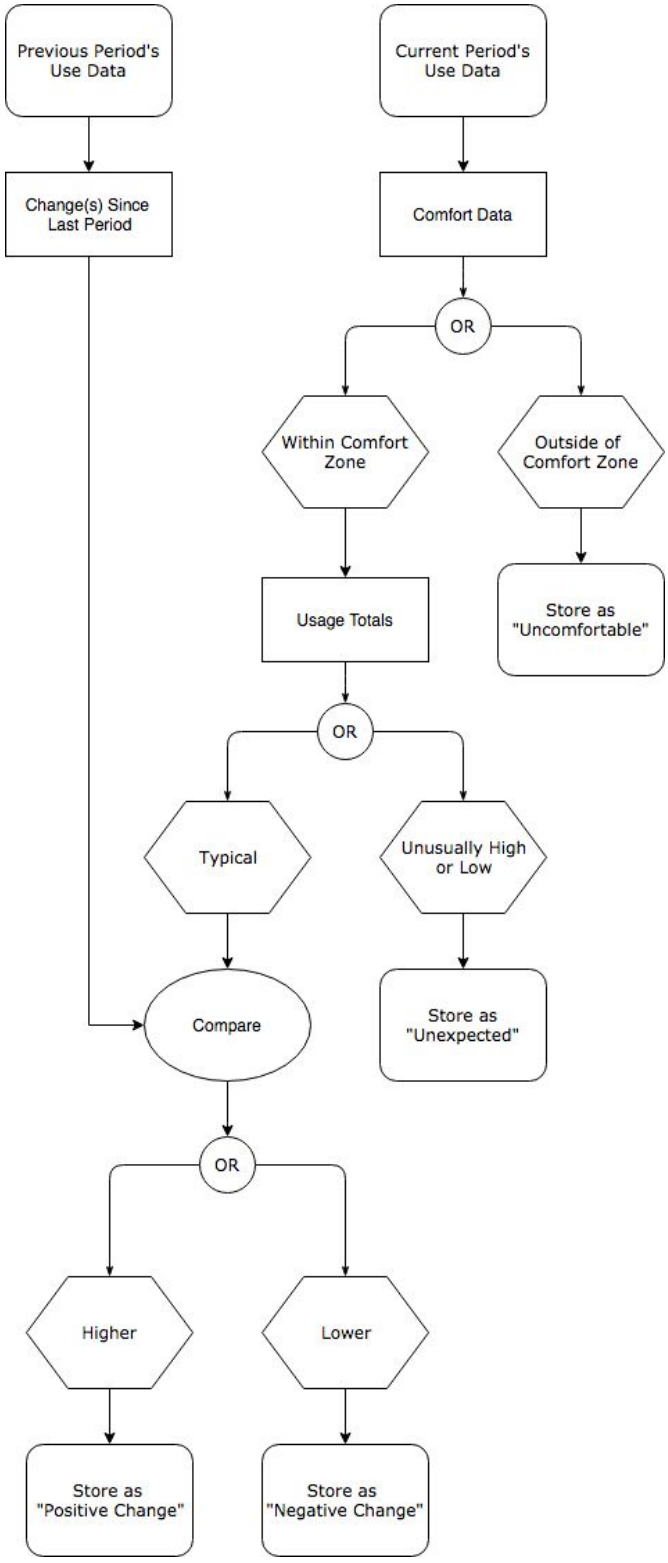

Figure 16. LoT Data Flow Diagram

5.9 Redistribute or Redesign

Once the system has processed the data, it will output a set of solutions for updating each system location. The system can work through a set of calendar updates. For example, every 3 months, the system may aim to redesign the space to increase use. This redesign will be assessed on the feedback and usage data that is collected at each location. The layout and resources offered as well as aesthetic choices can be updated in response to this analysis. Every 6 months, the LAPs could be analyzed to make the network of resources used more efficiently. For example, if the usage is high in some areas and low in others, resources could begin to be shifted to respond to this need.

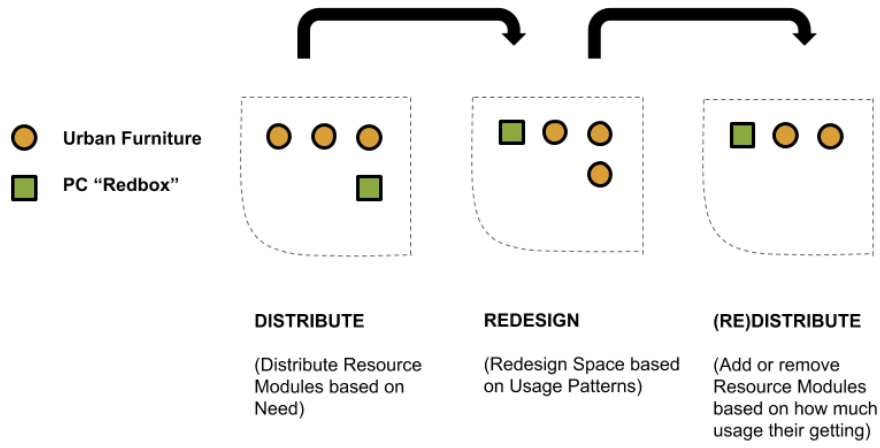

Figure 17 : LoT Resource Optimization Diagram

In order to redesign or redistribute each location, it's resources, and/or it's design, an evaluation for the data collected must be made. For the location itself, it is

important to calculate the average ratio of passersby to actual users at each location. If the passersby count is low and the usage is low, then that location doesn't seem to be the best site for LAP. If passersby total is low but the usage is high, then it would be worthwhile to add an additional location somewhere else in the neighborhood where more people would pass by. If the passersby total is high, but the usage total is low, this means the design of the LAP, whether it be the layout or the design features, is not effective in that location so it must be redesigned. Lastly, if the passersby total is high and the usage total is as well, then no change is needed. One concern of this evaluation system would be the fact that denser areas might have way more passersby than others. This issue can be handled by simply changing the range at each location to match the density of that area.

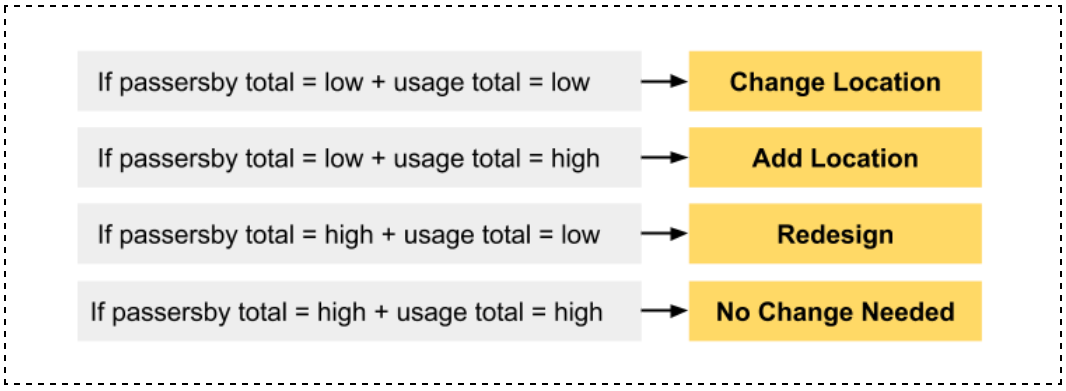

Figure 18 : LoT Location Evaluation

The resources offered in each LAP location also needs to be evaluated so that efficient use of these resources can be maintained. As mentioned before, the seats at each location will have pressure sensors to measure the use of each workspace. The use of wifi, charging, and computers will also be measured. Of these resources, an

evaluation will be done for each resource type to measure what percentage of the time all of that resource type were fully occupied. For instance, if there were 3 computers at a specific location, then a measure would be done to see how often those 3 computers were being used at the same time. This allows for the system to understand what locations have limited resources. If the percentage of time that all resources are occupied exceeds 25%, then a resource of that type needs to be added. If this percentage fell between 5% and 25%, then no change would be needed. If the percentage fell below 5%, then a resource could be removed and sent to another location that in need of added resources. These percentage values are currently an estimate, but through analytics, they can be optimized by reviewing expectations versus the actual outcomes of the system.

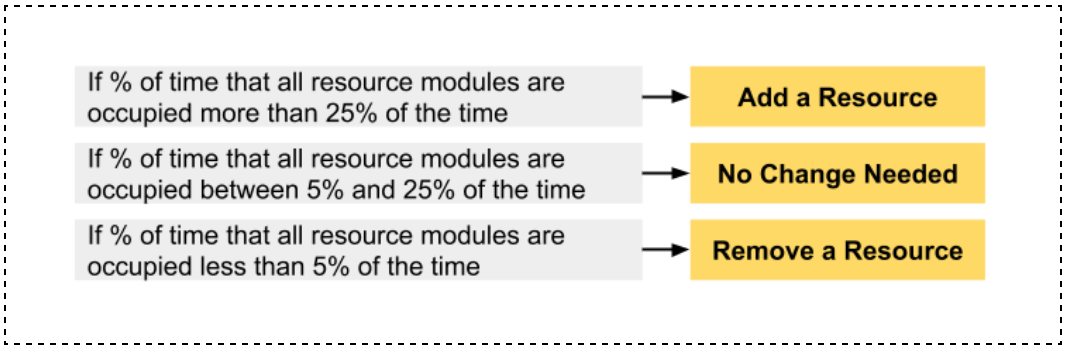

Figure 19 : LoT Resource Evaluation

As discussed before, surveys can be taken after each session. This request for feedback will have a location that requests ideas for improving the design. Through this collected feedback, automation can be used to locate specific design features and whether or not the feedback was negative or positive. Once this is found, a

spreadsheet could output all the features whose response was mostly negative. For these negative design features, a redesign would be necessary. The suggestions offered alongside an analysis of usage patterns could be used to help with the redesign. As this project progresses, the ability to add layers evaluation for the design can be met through measuring important aspects like social capital, diversity, time spent, as well as other attributes that pertain to how the design encourages or affects the use of the space. Social capital could be tallied through counting how often seats that are next to each other are used at the same time. There is a lot of potential for future evaluations like this.

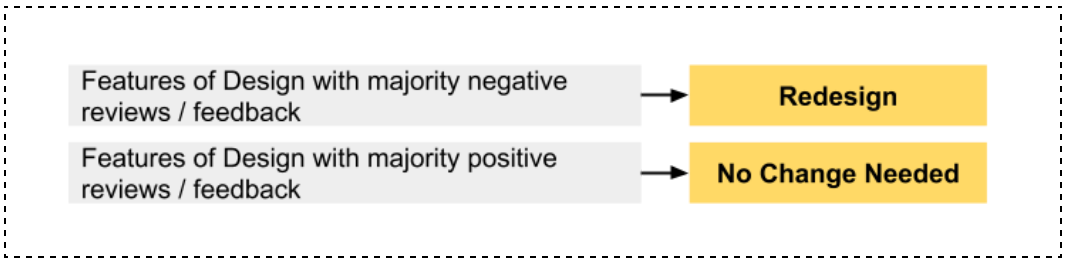

Figure 20 : LoT Design Evaluation

SECTION 6: RESULTS

The ease of access and cost effective distribution of LAPs could offer a great influence on communities and could help to reimagine the role and spatialization of the public library in the 21st century. In Mecklenburg County, where I focused my research, their was over 15,271 people in critical need of the library's resources. If 103 LAPs were distributed throughout the county, over 95% of those in need could be provided access. Even at the most expensive scale of LAPs, which are the enclosed pods that could cost up to $100,000, this distribution would only cost $1.3 million dollars. This might seem like a great deal of money, but when compared to the cost of the recent brick and mortar library that the county has planned costing an upward of $93 million, this cost really seems to be worth it.

Figure 21 : LoT LAP Locations

SECTION 7: CONCLUSION

As more and more cities take on smart city concepts to integrate technology and wireless internet access throughout community spaces, the public library must grab hold of its opportunity to extend its resources to this broader audience; and in so doing, libraries will become a leading force in the efforts to democratize the access of digital information to all. When looking at the costs associated with brick and mortar libraries, one becomes confident that extending the library beyond its walls is both critical to communities and simply practical, when looking at the development of infrastructure and resources available as cities begin to implement smart city concepts. The L.o.T. system model can allow libraries a method for distributing LAPs and to make the most effective use of their funding, while also ensure that they are meeting the needs of the public.

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