Project Summary :

NYC Mesh is the largest mesh network in the English-speaking world, a part of a much larger global community that extends from Berlin and Spain to India and Uruguay. With a relatively small amount of money, we can provide wireless broadband access to thousands of people.

We began as a small group of programmers interested in creating a community owned wireless "mesh" network with low barriers to access and independent of the large ISPs. After experimenting with various networking protocols and hardware, we decided to model ourselves after existing successful European mesh networks, most notably Spain's Guifi, a network which already has 30,000 active hotspots, or 'nodes'.We installed our first public node in October, 2014 at d.b.a. bar in Manhattan's East Village. Three more nodes running qMp were installed at a meetup the following November. In 2015, Daniel Grinkevich developed our own firmware (based on qMp) enabling preconfigured routers.

Our project picked up steam with a Vice article and several similar city projects, and by the end of 2015 we had over 40 active installations. In 2016 we concentrated on the logistics of creating our own direct connection to the Internet- a "supernode". The supernode will become our main internet gateway as it is connected directly to backbone fiber at a data center.

Our nodes are currently concentrated in three neighborhoods: the East Village in Manhattan, Bed-Stuy in Brooklyn, and Ridgewood/Bushwick on the Brooklyn/Queens border. All of these locations have line-of-sight to our Data Center. We would like to set-up a network in these three neighborhoods to serve a number of goals.

The first and most obvious benefit is the ability to deliver wireless broadband to areas that have traditionally been underserved by telecommunications networks. For example Bed-Stuy and Bushwick lack access to fiber networks in many places and the coax/cable networks are crowded and unreliable. Also, NYC's proximity to water and current reliance on subterranean infrastructure make existing networks vulnerable, whereas our network design is resilient to inclement weather. After Sandy, large parts of NYC lost power and access to the internet/phone systems--some areas lost phone coverage for weeks. Our network, wirelessly connected rooftops and windows, is flood proof. It is not yet solar powered, but we have begun a relationship with Brooklyn Microgrid (a local solar-power company) to develop self sustaining nodes. We're also building a way to locally distribute creative commons content using a distributed data storage system, allowing people access to educational content, chat applications, and other services without the need for a connection to the world wide web. By targeting three diverse locations -- from the tall buildings of the Lower East Side, to the brownstones of Brooklyn, and the warehouse districts in the Eastern part of the city -- We'll be able to design, deploy, and test the next generation of 5Ghz technology.

We want to build the tools, maps, and designs capable of sustaining a network and making it replicable not only in NYC, but also anywhere in the world. This grant would fund bandwidth, meet-me room access, rooftop antenna space, as well as 50 free access points in areas already served by the network.

Statement of Need (300 words):

More than one in four New Yorkers lack access to broadband internet at home, according to the city comptroller. Race and class dynamics highlight this divide. Black and hispanic households are 23% more likely to be without broadband access, and people who lack formal high school education are 360% as likely to lack broadband as New Yorkers with bachelor's degrees or higher. In the comptroller's own words the "two major causes of Internet inequality in New York City are the high cost and poor quality of broadband compared to other cities" (*Internet Inequality* Stringer, City of New York 2014). Even cities like Seoul, Kansas City, and Chattanooga, Tennessee have gigabit access to the internet for less than $70/month (Cost of Connectivity, Open Technology Institute 2014).

There are two main factors that contribute to the comparative poverty of New York's infrastructure. First are the costs associated with building physical fiber networks. In New York City, it costs $4/foot per month for access to the subterranean infrastructure that houses the cable networks, fiber lines, and telephone system. In concrete terms, this means that it would cost approximately $890 thousand per year in rent to the city to run a cable from our datacenter to my house. That number also assumes that there are no other costs associated with maintaining the network and that the fiber takes a straight path from the data center to my home. Using wireless networking, we can get gigabit-class wireless internet to my block for $2,000, using hardware that lasts 3 to 5 years. And, since it's simply a glorified wi-fi connection, we need no expertise in city planning, construction management, or fiber optic installation. We simply need to understand how wireless networks work in the aggregate -- something we happen to be experts in.

We have arranged through in-kind donations to get the long-range, point-to-point antennas we require to pipe our datacenter access to these neighborhoods, able to provide 500-800Mb/s connections. If we allocated bandwidth like a telecom company (where a real 1Mb connection serves up to 4 people), then we could serve 2-3 thousand people across these three point to point connections. In Manhattan, that might be a block or two radius. In Bed-Stuy, it will be about twice as wide. In Bushwick, given the lower population density, it would be an even bigger radius. The point-to-point antennas would distribute high-level internet access to a neighborhood, while the smaller, cheaper devices would distribute that connection to a block and building on rooftops and inside homes. We need a one-time investment that will fund our data center access for one year and give us enough hardware stock to extend the mesh in the most sustainable way possible.

Solution

After 4 years of building, testing, and strategizing, we found a fiscal sponsor (ISOC-NY), negotiated a contract with the datacenter, and secured organizational and local support, we are ready to expand. Our growth model thus far has relied on individuals buying and maintaining their own hardware, using software maintained by the collective (and the much larger, global mesh community). However, the cost of joining the network is not insignificant. In our most common scenario, someone wishing to join the network must purchase an $85 Ubiquiti Nanostation, a $50 TP-link WRT router, $20-30 ethernet cable, and a $25 mount for the antenna. The Ubiquiti router acts like a conventional ISP modem, being used as the Wide-area-access device that connects different mesh 'nodes' together. The TP-link distributes that received internet to the household, because it's the same as a home router. The only difference is it runs software that is designed to 'mesh' and share the problem of routing traffic to the www. The mounts secure everything to reduce the need for service calls. The Ubiquiti devices are rated for outdoor use, meaning that they can be placed on the rooftop for maximum range. A standard set-up costs $180.

This cost could be reduced by using cheaper ethernet cable, moving the Ubiquiti indoors, dropping the separate indoor router, and using velcro instead of a purpose-built mount. All of this drops the cost of the install to about $100. In either case, the cost remains prohibitive is for the majority of families we would like to serve. By subsidizing the cost of bandwidth and the initial cost of hardware, we can ensure that our access is affordable or free. Most people already **interested** in the network *can* afford the hardware, so, by having some extra on-hand, we can sell the hardware (with a small software installation fee) in order to generate revenue for the hardware fund, so that that those who truly cannot afford the hardware nevertheless have access to the service. This will give us plenty of time to secure monthly subscriptions (at $20/month/household) and move our focus from platform development, to serving the community at large. At $20/month, the mesh could provide access comparable to that offered by cable networks, at ⅓ of the price. Each rooftop broadcasts a public wireless network, usable at street-level by anyone while providing a wireless backbone for the household network.

Goals and Objectives

Our goals with this grant are to get internet access and open-source software into the hands of people who have been purposefully excluded by the large telecommunications companies. We intend not only to install 50 nodes around three neighborhoods to extend cheap or free access to 50 more buildings (and at least two households per building). This will not only provide free, street-level access to anywhere between ½ a block and several blocks depending on building height, topography, and density, but will also make the marginal cost much lower for neighbors who don't get the free hardware. If a roof-top node serves ½ block, then each additional small router (the tp-link or equivalent) can extend that coverage to reliably cover an additional household. Because our routing software doesn't care about what the network looks like, the added network density actually *improves* our total throughput creating, multiple, resilient transit lanes as well as allowing for many gateways to the internet. In cases where we can run ethernet cable, the marginal cost of access is just that ethernet cable (provided somebody has an extra router of any type).

We want to use this opportunity of rapid network expansion to measure, model, and map network performance in the three neighborhood types mentioned. Using an open-source development board (i.e.: raspberry pi 3), a gps module, and 2 wi-fi dongles, we can map the wireless networks around a given site. This will provide us with noise levels that we can use to calibrate our radios, determine angles of connection, and map the coverage zone. So far, we have relied on simple procedures that vastly under-estimate our coverage areas. The will also define a worst-case scenario for wireless networking given that NYC has millions of wifi capable devices all locked-down, and with only 16 available wi-fi channels. By getting real data, we'll be contributing to the academic discussion of radio frequency modelling and wireless network planning in urban spaces. We will develop the tools and data to make our network resilient to outages and an ever-increasing number of competing devices. Most of these tools already exist as open-source software, and (as per the timeline) will be stable/usable for this project.

Additionally, we can use the opportunity to document extensively. We will develop materials for outreach and determine what kinds of outreach activities effectively get people involved as developers, users, or organizational partners. We will release all of our data, maps, and analysis on our website and on github available under GPL3. Because of the particular challenges of propagating wi-fi frequencies through NYC’s urban jungle, we will also develop a model that is portable to anywhere else in the world.

Budget

~$15k for datacenter

$570/month for meet-me room and equipment room.

570*12 = 6840

$560/month for 2 x Antenna mounts

560*12 = 6720

$425/year Insurance for 3 installers and no sub-contractors, general property/medical/accident liability

6720+6840+425 = **$13985/year for 1Gb/s internet for 3 neighborhoods**

~15k for hardware/outreach

50	NSM5	$84.99	$4249.5
Educational and Outreach Materials (printing only)	Donated design costs		$2000
100	Dual band routers	$50	$5000
5000 ft	ethernet cable	$250/1000 feet	$1250
4	Raspberry pi starter kits	$59.99	$239.96
4	GPS modules	$49.99	$239.96
4	Network install kits	$149.99	$1220.62
2	PoE injectors/batteries	$600	$1200
			$14979.38

$13985 for Hardware

+$14979.38 for Datacenter Access

+$1000 petty cash (broken equipment, more ethernet cable, tape, etc)

= $29964.38/ 1 year of access for 100+ households with marginal access available to neighbors at an additional $50 of hardware (1 time cost). In cases where we can run ethernet cable, marginal access is a trivial cost.

Timeline

Fall -Winter 2016:

Finish prototyping mapping rig, using raspberry pi3, gps, and wireless cards. Make it so that data translates to heatmap hosted on NYCmesh.net. Finish testing and gathering content for outernet/wikipedia creative commons library. Distribute free and creative commons content over network using a distributed protocol like .torrent or ipfs. We will also deploy a network monitoring package for use on each ‘island’ independently using donated hardware.

January -February 2017:

We will meet with neighbors, community leaders, small-business owners and others to discuss how/when we are going to install. We will gather devices, install software, and configure for each ‘island’ of the network. This can be done in conjunction with interested community parties so that each part of the technology becomes less and less of a black box. Closing the digital divide will require much more than internet access in itself. The only way to close it is by making the technology open and accessible. We will build and develop our curriculum.

Spring 2017:

Continue as above.

We will complete site surveys, display mapping data, and publish results on our website. We will take the raspberry pi devices to the areas in question. If we do one neighborhood per weekend, this will take at most a month. I have also been in contact with friends who are taxi drivers and bicycle delivery people who can toss the device in the their bag or trunk to get a much wider map of the spectrum in NYC. This data will be published as a map and a raw export on our website and on our repository.

In addition, we will coordinate with the Open Technology Institute’s Resilient Community’s program that is itself targeting under-served areas to develop a curriculum that teaches the necessary network management skills without getting bogged down in technical details and jargon. We can use the map data to show our predictive network designs, introduce new neighbors to the network, and map the installs.

We might do some installs here, but given the cool, wet weather of an NYC Spring, we will likely not have much suitable weather until May anyway.

Summer 2017:

We will do the installs. With 100 installs and a 16-weeks between May and September, we would need to install about 6 nodes per week. Given that we will have configured the devices already, we would only need to plug them in, do network range tests (using the mapping rigs again), and compile the data. Since the installs will be within a few blocks, a couple volunteers can easily knock out a dozen in a day.

End summer-fall 2017:

Synthesize our new map data into a city-wide spectrum map that illustrates the noise (other networks) and the coverage (our network). We can use this data to build predictive mapping tools that will take gps input, a noise figure, and the locations of existing nodes to output a map that illustrates how to get the most network out of every dollar spent. If New York City is actually a worst case scenario, then this data will allow any other mesh to easily design and deploy a network that is more resilient than any in NYC.

Project Constraints and Risks:

The biggest constraint to the project is getting access to the buildings that others own. Since NYC has incredibly high rent, paying for this privilege is an unsustainable way to start. However, we've spent years building networks in-place, growing word-of-mouth name-recognition, and persuading neighbors to join. For individuals who own their homes, we'd need a few dollars of power a year and less than 1 square foot of window/rooftop space to extend free network access to their block and to their building. By working in and with the communities in which we live, we maximize our ability to do effective outreach and reach the people who really need it. By working with a variety of institutional, residential, and business interests, we can grow our donation base while ensuring that those who cannot afford access still have the it.

Another constraint is long-term support. While we have 100 volunteers ranging from network engineers to front-end web designers and activists to organizers, we lack a paid support network. This means that these installs will be conducted by volunteers, that the support number will be staffed by volunteers, and that the back-end will be built by volunteers. However, since we've been at it 4 years under the same model, I don't expect our volunteers to dry up because our network is suddenly expanding and accomplishing its goals. Additionally, building a large coverage zone and connecting it the internet provides a value-added benefit to those who seek an alternative to the over-priced cable/fiber networks that they use currently, creating a consumer base that can (hopefully) sustain itself.

Guifi.net, the world's largest such network (at 30,000 nodes), sustains itself through a patchwork of public investment, small monthly subscriptions, grants, volunteer labor, and paid support personnel. As we build network density and a larger user/installer/developer base, our offline and online usability will grow proportionally. By design, our capacity will increase along with our reach and scale.

As with any telecommunications system, there is a non-zero risk that something bad happens. Our design requires rooftops, and NYC has unpredictable and gusty winds. However, these devices are being used as designed--perfectly capable of standing up to even hurricane-force winds. Part of the budget also goes to insurance so that everyone from workers, principals, and even passers-by are covered on the off-chance of a catastrophe. While slight, the risk of injury to person or property is covered and insured.

I'd also like to note the number of similar projects in NYC. The New York Public Library (NYPL) has a program where they lend 4G access points to low-income families. The biggest problem with that system is that the basic infrastructure for 4G networks does not exist in low-income areas. Sprint happily sold these devices to the NYPL, but nobody at that organization was aware of the coverage maps. Alphabet Inc. has a program to replace all the payphones in the city with wifi kiosks, which have been criticized for attracting homeless people and others who traditionally lack access. Yesterday, they decided to remove the browsers from the kiosks, making the wifi access points accessible only to those who already own wi-fi capable devices. Additionally, because these programs are owned by corporations known to mine, sell, and exploit user data, these public programs serve the interests of the corporations rather than those of the users. None of these heavily funded projects actually intend to close the digital divide. Whereas these other programs focus on providing opportunities for passive consumption, our mesh program not only provides access, but trains people on what the internet is, where it 'lives,' and how to reproduce it.

The last risk is software bugs. However, in the modern software development cycle, there are always bugs. While we have eliminated (seemingly) any major issues over the last 4 years, nobody ever knows how these things scale. However, given our huge volunteer team, decades of combined experience, and excitement for equitable access, scale is the only way to test, identify, and repair bugs. As we can see from Spain's mesh project, Guifi, flexible and localized deployments will be the key to long-term success and scale.

Evaluation:

In order to succeed in a cost-effective manner, we will have to beat the price-point of the local cable providers. A single family can get a minimal level of broadband service for about $60/month. If we spend $30,000 over 12 months to build a network, we will invest $2500/month. When that serves more than 42 people, we will have under-cut the cable companies with a community-based program designed to educate and not exploit.

We expect to serve 5-10 times that figure. First, the grant covers 50 roof-top grade access points and 50 indoor access points. Conservatively, each the rooftop (or window) access point serves 1 family and the street outside while the indoor-grade access point serves another entire family. In the right circumstances, we might be able to double even that kind of coverage. Assuming that the average NYC apartment houses 4 people, our model can provide cheap or free access to 400 people--no wires attached. If each of those people can afford even $5/month, then the mesh will be sustainable. Additionally, once we have a roof-top installation on a given building, adding a user is as simple as plugging in a router pre-configured with our software.

A lot of things are possible, but what is certain is that we will give free access to every street where a node is installed, every family that cannot afford access on that block, and any small business or individual willing to subsidize the growth of the network. While this grant would ensure we have a proper stock, our volunteer base loves to tinker and buy additional hardware for us. We also have a few leads on bulk, donated routers, meaning that we will likely serve many dozens of people more than this grant provides for.

In a year, we hope to have gotten more community interest, trained a variety of people from the targeted neighborhoods, and created a localized support infrastructure that promotes a model in which neighbors help neighbors instead of one in which expertise seems so far removed.

Chapter Visibility:

ISOC-NY, as our fiscal sponsor, will be prominently featured on our network splash page, the front-page of the NYC Mesh website, and on any and all promotional materials (including interviews with the press). This will encourage active participation in both and give already-existing ISOC members an avenue through which to actually extend access to free and open connectivity technologies. The fiscal sponsorship with ISOC also provides NYC Mesh a way to sign contracts, raise tax-deductible funds, and get liability coverage. Donor and email information will be shared with the local chapter as per our fiscal sponsorship agreement, allowing our efforts to extend and amplify the efforts of ISOC (both locally and internationally). In ISOC's document, "A Policy Framework for enabling Internet Access," outlines the three interrelated policy areas of expanding infrastructure, fostering skills and entrepreneurship, and supportive governance. NYC Mesh (and ISOC-NY) propose a system in which individuals can directly connect to and IXP to expand the backbone of the internet, in which trainings and skill shares provide new skills for the job market, and a non-profit structure to ensure that the network only serves the interests of its users.

Project Promotion:

There are many ways in which we will share the gathered information:

1. We will develop and open curriculum with Open Technology Institute that translates our networking expertise into easily-digestible lesson plans, worksheets, and graphics.
2. We will publish this material as well as our install procedures on our website (nycmesh.net), on our wiki (wiki.mesh when connected to the mesh), and on our github (github.com/nycmeshnet).
3. We will synthesize map data, make computerized models of network coverage, and use this data to build predictive mapping tools that take the engineering out of network design.
4. We will attach a sticker to each device with our web-link and our support number.
5. We will spend time in each community, training locals to maintain the network. We will encourage people to donate for support calls and on-site hardware maintenance as a way to incentivize these trainings and make it sustainable.
6. We take the course materials, training policies, support network, and map data to publish a peer-reviewed technical article so that the mathematics and modelling of 5GHz networks is more widely known.
7. We will cross-promote with ISOC-NY to expand the reach of their organization through web-links, emails, and physical infrastructure
    a. We will work with other ISOC Chapters who are also working on wireless community networks to combine our expertise. It would be great to translate all materials into all the languages used where these networks are needed.
    b. We will integrate and cross-link course materials with other relevant materials produced by ISOC such as the IXP Toolkit. The end goal will be to develop an open source DIY stack for all components of an open telecom infrastructure.

Replicability

Since each part of the project is designed with scaling in mind and all intellectual property freely available, the project will be incredibly replicable. There are 490 buildings around the world that house high-level internet connections, called Internet Exchange Points (IXP). If we can make access to one of these IXPs sustainable, then we can apply this model to any major city in the world. We are already in touch with groups from Germany to Spain and India to Uruguay. In all cases except for Spain, the local networks are small, largely ad-hoc, and largely dependent upon traditional ISPs. By hopping over the traditional telecommunications structure and going directly the the source, we can build community networks that are sustainable and encourage participation and growth.

The other long-term concern is paying the support staff. Luckily, we have a few tricks up our sleeves. Most importantly, we have a dedicated team of 100 volunteers, many of whom have spent years working in the telecom industry--if something goes wrong, we can fix it. As we grow from an experimental network into one ready to serve consumers and grow a support network, we need to generate revenue. Luckily, as modern life moves online, it is easier and easier to sell digital services. From our data center, we can sell value-added services like server space, virtual private computers, website hosting, content streaming, and archival services to corporate and organizational clients generating revenue for our support technicians and data center engineers. Volunteers, though valuable, are not very sustainable.

We would work along ISOC to build an open telecom toolkit. Our end-goal is to build the tools, documentation, and funding models such that anyone with access to an IXP can build networks for their communities. That’s 500 cities and regions around the world that will have access to free and open wireless technology. By building and testing in a city notoriously unsuited for wireless networks, we can build a model that works anywhere and everywhere.

Sustainability

Sustainability is our biggest goal. We recognize that communication is a human right. We don’t see why digital technology should be excluded from that category when libraries, radio, and television broadcast are free. We will make this project sustainable by ensuring that the hardware, the software, and the support staff keep working. To that end, we have partnered with several organizations.

For hardware, we are building ways to source locally, reduce e-waste, and power the network with solar energy. We've reached out to the Lower East Side Ecology Center, and, depending what they have in stock at any given moment, we could get household routers for as cheap as $10, allowing us to reach five or ten times the number of people we've budgeted for. We've also solicited hardware and received donations from a US-based manufacturer called LigoWave that specializes in delivering wireless broadband. Netflix has offered to give us a caching server. Wikimedia-NYC would like to partner and help distribute all of their creative commons content on the mesh. We've also received hardware donations for our data center from people who work in data-center industry capable of connecting our customers to the backbone of the internet--to one of the few buildings globally connected to the undersea fiber optic cables that comprise the internet. Cruzio, a wireless internet provider in Santa Cruz has offered to send us "a crate" of routers capable of serving internet to an entire building. Brooklyn Microgrid has installed our nodes along with their solar panels to both monitor the panels and offer public wireless. With this grant and these hardware donations, we will be able to serve many thousands of people.

Our software is maintained as part of a much larger community of developers with active support bases in Berlin, New York, Barcelona, and Slovenia. Because our software is open-sourced there are no recurring costs. This also means that our technicians will have the ability to fix any problem that occurs. By building software that's transparent and teaching people to read it, we can close the digital divide. With support from ISOC, Cruzio, LigoWave, Wikipedia, and Netflix this is actually possible. If only one-third of users pay $20 a month, the network will sustain itself.

We create opportunities to expand digital literacy while training people in a growth industry. We are building an open infrastructure on which communities can become digital. We will offer web hosting, virtual servers, and other data services to sustain our staff. We imagine a host of local ISPs, maintained by a neighborhood, and connected wirelessly. We imagine business districts with public wifi and parks permeated with educational content. We'd like to partner with organizations that already buy bandwidth (businesses, libraries, etc.) and provide them an opportunity to donate their unused access. Libraries close down for the day right about when children need to do their homework. So, by building a resilient mesh, we can ensure those children always have access. That is sustainable. What isn't sustainable is investing in companies that created the digital divide. High rates and low quality aren't sustainable. Off-grid, community-owned wireless networks are. In a year, we will be able to grow ourselves, but, right now, we could use a little push.