ECE 4450: Computer Network and Telecommunications

NYC Mesh: The Future of Internet Access

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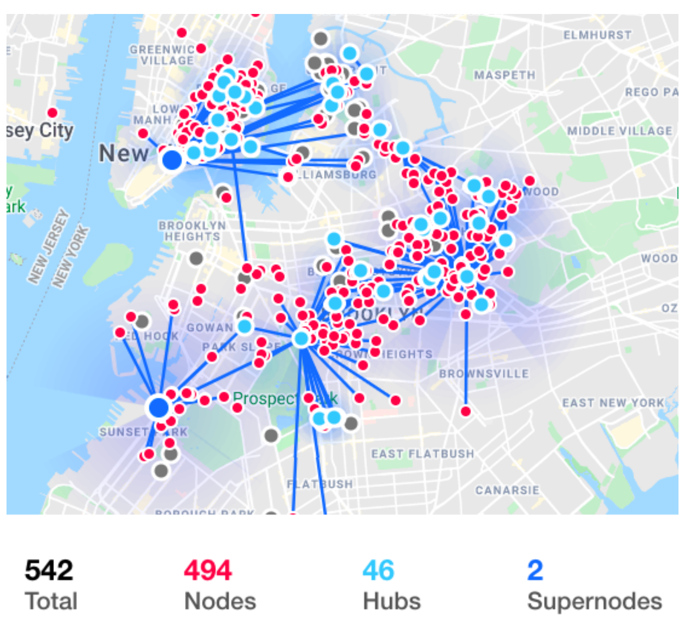
Abstract

This paper will address certain concerns regarding the current broadband usage, like the cost, reliability, net neutrality, as well as user privacy. A proposed solution is NYC Mesh, a non-profit working primarily in Manhattan and Brooklyn. Their goal is to solve these problems by implementing a mesh network to access the Internet, instead of using traditional commercial ISPs. This paper will introduce the technology used in this system, highlight the merits of a using mesh network, discuss some potential problems with a focus on network security, and discuss the future of such technologies.

NYC Mesh

NYC Mesh is a community-driven non-profit network provider that uses mesh networking technology to provide high-speed internet at incredibly low cost with the support of volunteers and donors. “Many of the 50-odd Mesh volunteers are millennials like herself who are concerned about internet affordability, privacy and neutrality”, as said by Ms Leslie Zhu in a Wall Street Journal Interview (Kadet).

The map below is the current spread of the NYC Mesh - it is mostly concentrated in Brooklyn and Lower Manhattan (“Map.”). The network expanded a lot more after the 2017 FCC Repeal of Net Neutrality (Froncek).

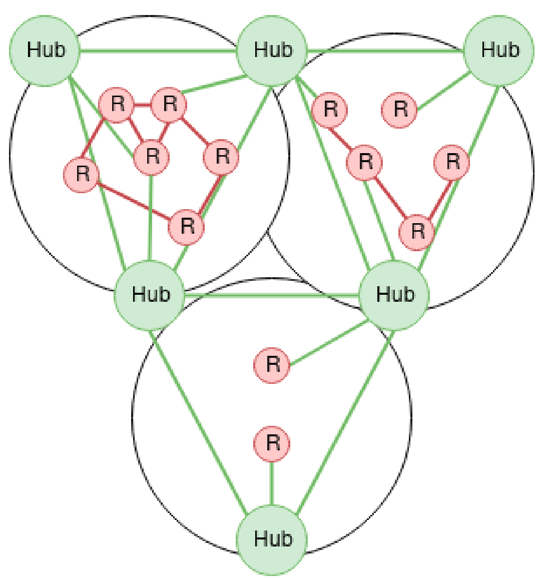


Technology

Network Topology

Traditionally, to access the internet, one would need to use a modem to connect to an ISP (Internet Service Provider), which would then connect the user to the internet. The network in this case is centralised and has a single point of failure. The routing protocol used by these ISPs is BGP.

In the case of a Mesh Network, the routers are the "nodes" interconnected to each other in a decentralised network. While a pure mesh network will have all the nodes connected to each other, it is not feasible to achieve this in a densely populated place like New York City. The NYC Mesh network is designed to have a three level hierarchy of nodes - Nodes, Hubs, and Supernodes. The Supernodes and Hubs are connected to all the routers in a given neighborhood, like a local mesh. These Supernodes and Hubs are then interconnected to each other. Therefore, instead of a pure mesh approach, NYC Mesh implements multiple mesh networks that are interconnected to each other as shown in the figure below ("Mesh Design.").



This approach is a happy medium between the traditional centralised ISP approach as well as the pure mesh approach. This hierarchical mesh approach supports scalability to a greater extent than a simple mesh network. An administrator can easily make changes (eg. protocols) to a local mesh network as opposed since there is a limit to the number of nodes that would need updating. Additionally, this approach is more secure than the traditional, centralised, approach using an ISP as there is no single point of failure.

Routing Protocol

The network in NYC Mesh uses the OSPF routing algorithm in between nodes of an area ("OSPF."). OSPF is a link-state protocol that creates a topographical map of the Autonomous System and computes the least-cost path using Dijkstra's Algorithm (Kurose 443). To help with scalability, OSPF also supports hierarchical routing, where each area runs OSPF using the local topographical map of the nodes, which all communicate to a Hub or Supernode. NYC Mesh implements OSPF for the Nodes with the community in mind. The dependence of the mesh on the community demands a need to simplify the setup process. As the number of nodes increase, more users would require training to set up and maintain the network Not all the users are able to set up a protocol and maintain the network, and using OSPF alleviates this problem.

The Hubs and Supernodes use BGP as a routing protocol, much like the traditional Internet setup. BGP is considered to be more scalable, as proven by its use for the entire internet. Here, there is no need for a simplified, autonomous protocol as only a small number of users, who have access to these Hubs and Supernodes, would need training to configure the BGP protocol.

Advantages

Cost

Tom Geoghegan's BBC article highlights the disparity between the cost and quality of American Internet Service Providers compared to other countries as of 2013. Seven years later, negligible changes have been made. After a glance at the list of the Internet service providers in

New York City in 2019 provided by the Mayor's office (Appendix A), one can notice that the only affordable (under 20$ per month) traditional ISP plan is Spectrum Assist, which is a special program for low-income families ("Spectrum Internet® Assist."). NYC Mesh aims to provide free internet, with a recommended donation of 20$ a month. There are no requirements besides the purchase and installation of a modem and a regular power supply ("NYC Mesh Community Network Rate Card."). NYC Mesh thus proves to be the most affordable service plan in New York City.

Reliability

Mesh networks have proven to be resilient to natural disasters, when traditional ISPs fail. During Hurricane Sandy, "residents and government workers [of Red Hook, Brooklyn] could log on to the mesh to quickly find out where to pick up supplies or find government officials" (Cohen). As mentioned earlier, the mesh-like approach to networking prevents a single point of failure. As a result of the interconnected structure, the network can still function if a few nodes get shut down. This is better than the traditional approach of accessing the internet using a single ISP as it allows for greater flexibility in routing. Mesh networks will prove to be reliable during severe weather or unexpected power outages in certain parts of the locale.

Net neutrality

As said by an NYC Mesh volunteer Brian Hall, "People are so used to ISPs that they think that's the only way to access the internet" (Greenemeier). Using NYC Mesh will reduce the demand of traditional commercial ISP providers. With a decreasing number of consumers using traditional ISPs, the power and monopoly of these ISPs will also diminish. The constant debate of Net Neutrality will be resolved as NYC Mesh is powered by a community and not a for-profit company. By adopting this mesh-networking strategy, the threat towards Net Neutrality will thus be mitigated.

Privacy

NYC Mesh is as secure as any other commercial ISP, where unencrypted data can be viewed en route (“Security.”). The privacy policy of NYC Mesh also mentions, “NYC Mesh does not collect, store, or log any user data content that passes through our network. During required network maintenance and troubleshooting, network packets, including content, may be monitored to ensure successful network functionality” (“Privacy Policy.”).

Concerns

Bandwidth

There is naturally a question of reliability. NYC Mesh provides a best effort service, but the “typical speeds [of the network] are 80 to 110 megabits a second” (D’Souza). While this is a fast enough speed for most users, it is not guaranteed and there might be slowdowns in times of severe weather conditions. As the number of Nodes, Hubs, and Supernodes grow, the network will prove to be stronger and faster.

Security

There are a number of vulnerabilities in the network of NYC Mesh that could lead to potential problems. For instance, the mesh-like topology of this network allows for multiple points of attack. Additionally, there could be issues with the routing protocol used. As mentioned earlier, OSPF is used as the inter-node routing protocol to simplify the setup process for the owners of these nodes. A big vulnerability of using this protocol is that it is open and trusts blindly without any form of authentication. This might lead to false nodes entering the network and accessing and/or deleting private data.

A whitepaper by the SANS Institute highlights common Mesh Networking threats as summarised and analysed below (Gerkis 13,14):

- **Routing Errors**
  - Black-Hole: A false node becoming a part of a network and dropping any packets sent to it. As explained earlier, this is possible in NYC Mesh due to the trusting nature of OSPF.

- ➢ Grey-Hole: A false node becoming a part of a network and choosing to drop, inspect, or reroute packets sent to it. This is also likely to happen in NYC Mesh for the same reason as above.
- ➢ Worm-Hole: Disrupting the routing by relaying a packet from one node to another. This would greatly affect the transmission rate of the network and ultimately cause severe communication issues.
- ➢ Route Error Injection: Breaking healthy links in the network by sending falsified route error messages. If NYC Mesh expands further, this threat might have limited effects due to a higher number of alternative routes.

- ❖ **Network Problems**
  - ➢ Spoofing: A lack of authentication allows for false nodes acting maliciously. As mentioned earlier, this is a threat in the case of NYC Mesh as well.
  - ➢ Denial of Service: An attacker tries to block the usage of the network by constantly disrupting the services (eg. IP flooding). This might be a problem in NYC Mesh as it is a community network and users could unknowingly consume the entire bandwidth.
  - ➢ Theft of Service: An attacker steals the credentials of another user to access the network. If NYC Mesh expands enough for everyone to have free access to the Internet, this threat of “freeloading” would not make a lot of sense.

- ❖ **Physical Problems**
  - ➢ Outdoor Device: Since the modems of NYC Mesh are located on rooftops of buildings, there is a chance of theft or tampering. It is difficult to constantly keep watch due to the sheer number of nodes present. Setting up a notification system to allow for timely replacements might help preserve the network strength, but might be a financial burden.
  - ➢ Wired Connections: There might be a need to have a wired connection in between some nodes. This could lead to possible interception of information and risk the privacy of the users.

Future Growth

Numerous locales have implemented mesh networking strategies to solve various problems related to traditional ISP providers.

Guifi.net is a mesh network that was started in a small Catalan village due to a lack of traditional broadband access. The network has been growing rapidly, “linking more than 46,000 premises and 33,700 connection points or nodes. It is adding nodes at the rate of more than 100 a week and is developing quickly in Catalonia and Valencia.” (Tieman). The Financial Time article also affirmed that the network will soon grow big enough to be a valid competitor to the country’s leading 5G network.

Another mesh network that was mentioned earlier is the one in Red Hook that helped communications during Hurricane Sandy as well as train and employ residents to become “digital stewards” (Cohen). Not only did the creation of this mesh network assist in an emergency situation, it is also playing a role in the upliftment of the community.

The Mayor of NYC, Bill de Blasio, has also expressed a need for free public wifi available to all, as implied by his New York City Internet Master Plan. This plan projects a $142 billion boost in the Gross City Product, 165,000 new jobs, and a $49 billion increase in personal income (“The NYC Internet Master Plan”). There lies enormous economic growth in having free internet access, in addition to the resolvance of Net Neutrality, Privacy, and Affordability concerns. NYC Mesh has incredible potential for growth if it is successful in garnering the support of the Mayor. With this network expansion and the government stimulus, significant improvements in the bandwidth and network security could be implemented.

Appendix: A list of Internet Service Providers ("The NYC Internet Master Plan")

INTERNET SERVICE PROVIDER	PRODUCT NAME	DOWNLOAD SPEEDS / UPLOAD SPEEDS (IF SPECIFIED) - UP TO OR HIGHER	MONTHLY RATE	MONTHLY WI-FI FEE	MONTHLY EQUIP. CHARGE	EST. TOTAL MONTHLY COST	OFFER TERMS	% OF CITY W/ SERVICE AVAIL.
ALTICE (OPTIMUM)	Advantage Internet	30 Mbps	$14.99	$0	$10	$24.99	For eligible customers	32%
	Optimum 200	200 Mbps	$44.99	$0	$10	$54.99	1 - Year	
	Optimum 300	300 Mbps	$54.99	$0	$10	$64.99	1 - Year	
	Optimum 400	400 Mbps	$64.99	$0	$10	$74.99	1 - Year	
BKFIBER	Basic	20 Mbps/10 Mbps	$75.00	Not Listed	Not Listed	$75.00	Monthly	<1%
	Speed	30 Mbps/20 Mbps	$100.00	Not Listed	Not Listed	$100.00	Monthly	
	Pro	50 Mbps/25 Mbps	$215.00	Not Listed	Not Listed	$215.00	Monthly	
CHARTER (SPECTRUM)	Spectrum Internet Assist 30/4	30 Mbps/4 Mbps	$14.99	$5	$0	$19.99	Monthly - For eligible customers	66%
	Spectrum Internet 200/10	200 Mbps/10 Mbps	$65.99	$5	$0	$70.99	Monthly	
	Spectrum Internet Ultra 400/20	400 Mbps/20 Mbps	$90.99	$0	$0	$90.99	Monthly	
	Spectrum Internet Gig	940 Mbps/35 Mbps	$125.99	$0	$0	$125.99	Monthly	
HONEST		980 Mbps	$50.00	Not Listed	$5	$55.00	Monthly	No data
NYC MESH	Mesh Internet	Speeds vary. NYC Mesh uses best efforts for speed and support.	$20-50 *sliding scale*	Not Listed	$0	$0.00	Monthly	No data
RCN	High Speed Internet	25 Mbps/4 Kbps	$82.00	$5.50	$10.50	$98.00	Monthly	14%
	High Speed Internet	50 Mbps/10 Mbps	$99.99	$5.50	$10.50	$115.99	Monthly	
	High Speed Internet	Downloads 75 Mbps/110 Mbps/155 Mbps Upload 15 Mbps	$149.99	$5.50	$10.50	$165.99	Monthly	
	High Speed Internet	330 Mbps/20 Mbps	$249.99	$5.50	$10.50	$265.99	Monthly	
	500 Mbps	500 Mbps	$89.99	$5.50	$10.50	$105.99	Monthly	
	1 Gig	1 Gig	$149.99	$5.50	$15	$170.49	Monthly	
STARRY		200 Mbps	$50	$0	$0	$50.00	Monthly	No data
VERIZON (FIOS)	200 Mbps	200 Mbps/200 Mbps	$39.99	Not Listed	$12	$51.99	1 - Year	74%
	400 Mbps	400 Mbps/400 Mbps	$59.99	Not Listed	$12	$71.99	1 - Year	
	FiOS Gigabit Connection	940 Mbps/880 Mbps	$79.99	Not Listed	$0	$79.99	1 - Year	

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