BRIDGING THE GAP: UNIFYING REMOTE WORK AND IOT INTEGRATION WITH ZERO TIER FOR BETTER CONNECTIVITY AND SECURITY.

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Abstract

Integrating various cross-platform devices under the same network (logically/virtually) is possible using ZeroTier. ZeroTier is an open-source SDN technology that uses a modified version of SDN with Virtual Private Network (VPN) principles to virtually have all the devicesconnected to the same network, regardless of the physical location of the devices. Although the data is transmitted through the Internet, communication between devices is end-to-end encrypted which is an added layer of security. A Prototype network created using the ZeroCentral portal. Various Devices running operating systems like Android, Windows and Linux are connected to this network to check the capabilites and efficiency of the technology. A few protocols (Flow Rules) are added to restrict the types of data packets entering the network.

Keywords: Software Defined Networking, Global Ethernet Switch, Virtual Private Network, ZeroTier

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Introduction

In modern network era, Enterprise Networks are constructed to serve the need of a business or any government agency. This connects multiple devices, server, data centres and applications together, to establish communication, data sharing and collaboration within the organization. Typically, enterprise networks are built using a combination of various hardware and software technologies. These technologies include, but not limited to, routers, network switches, firewalls (physical as well as software)and protocols such as TCP/IP, DNS, DHCP, etc,.

The enterprise network is commonly organized/split into multiple sub-networks to better manage network traffic and enhance security. The primary objective of an enterprise network is to provide reliable and secure connection between different devices and applications within the organization while providing an easier centralized management and control over that network. This allows employees and users with authority to access the network from different locations, devices and platforms and to share information among themselves and collaborate on projects more effectively. Although many advancements are made for connecting various locations such as MPLS, VPN, Lease lines and satellite connections, these methods have their own disadvantages.

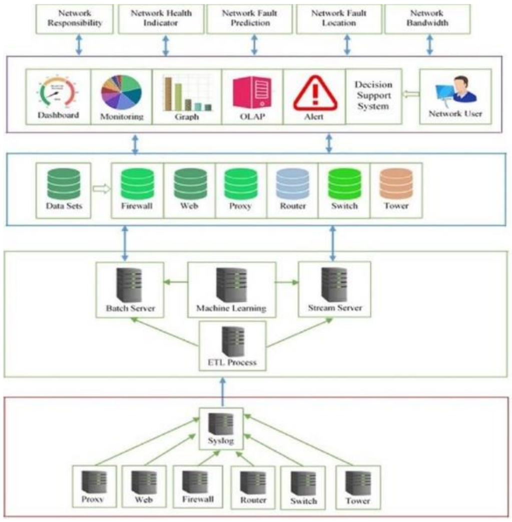


Figure 1. Basic architecture of an enterprise network; Palanivel (2019).

Starting with MPLS [Multiprotocol Label Switching], it is a routing technique that allows various locations to be connected via a private network. It does provide a high level of performance and reliability for transferring data, but the downside being, way to expensive compared to other options, and it also requires specialized experts to implement and maintain. This cannot be utilized by smaller businesses. VPN provides greater security in connecting remote devices but can be slower that other connections due to encryption overheads. Also large scale VPN connections cause increase in complexity and thus can end up being a vulnerability. Leased Lines are also really expensive, When the requirement increases and the business require high bandwidth connections. They may also not be available in all locations. Slow to install, less flexible and many more disadvantages follow. Satellite communication also stands in the same way with may disadvantages over the advantages.

This is where ZeroTier comes into play. Compared to all the methods used in enterprise network, which as been around for quite a few decades, ZeroTier is a relatively newer technology and has the prospect to be a game- changer in enterprise networks' future. ZeroTier has many advantages over existing enterprise network solutions, particularly where multiple connections or remote works are required to be connected.

ZeroTier is easy to setup and configure which saves time and resources compared to MPLS where new devices and experts are required to setup and maintain the technology.

ZeroTier provides a global virtual network that can connect devices and users from anywhere in the world, in a mesh-like fashion but virtually, which is ideal for remote workers and to connect multiple locations. It also provides end-to-end encryption which ensure secure connectivity at all times, even over unsecure networks as encrypted data cannot be deciphered. Additionally, granular access controls also allowadministrators to control the accessibility of resources and applications. The scalability of ZeroTier very high, which allows enterprises to easily add new and, in some cases,, remove, devices and locations as per requirement. This makes it a cost-effective and flexible solution compared to traditional enterprise network.

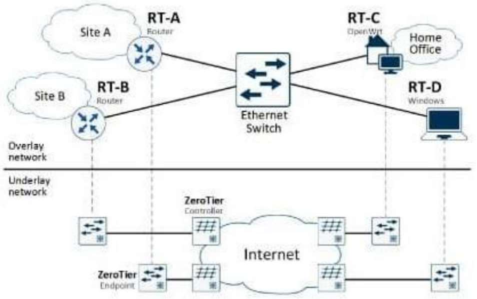


Figure 2. Various clients connect through the ZeroTier(virtual) Switch; (Source:

OpenSourceForU blog).

Furthermore, ZeroTier Rules engine allow network administrators to control the network and set custom policies for the network, which is done using the web-based management portal for ZeroTier networks called ZeroTier Central. Utilizing the rules engine, administrators can allow or block data transmission based on diverse categories such as IP address, protocols, ports, time of day, etc,. They can also be used to limit bandwidth and segment networks into smaller subnetworks

Proposed Work

Figure 2 depicts the architecture of how ZeroTier connects with various clients through it's global ethernet switch concept. Using this architecture as base, a prototype is designed. The Zero-Central portal is used to create a new network. For research purposes, we have utilized the free version of the open-source ZeroTier controller for the prototype. In the ZeroTier Central website, create a network using the "Create Network" option. After creating the network, additional setting such as IP (Internet Protocol) range, IP version to be used for all the devices connected can be set/modified. We're going with the default settings. This ZeroTier Central is the admin control which is used to manage the network. All settings and changes pertaining to the network is handled here.

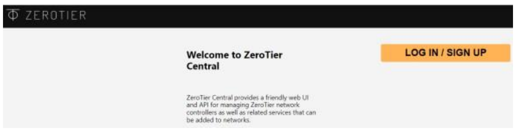
After creating the network, devices need to be connected to the network. There are two methods to go about this – Network ID and Node ID. Network ID is the identification given to the created network, which can be used by the nodes (endpoint devices) to connect to the network. Node ID is the identification number given the devices which have the ZeroTier application installed in them. Admin(s) can enter the Node ID of devices to manually add them to the network. To access the ZeroTier network, The device in question must be installed with the ZeroTier application. The app is available for many platforms such as Windows, MacOS, Android, iOS and Linux. Even IOT devices can be installed with this app and be connected to the ZeroTier network. The network is not limited to the default settings and security features, additional conditions can be added using

Design and Implementation.

The proposed work can be split into three major parts. The following sub sections explain in detail about each block.

Creating the network.

ZeroTier Central is the web-based portal used to create a network, and has the Administrator controls. An account is required in order to start the process. Once logged in, we can create our own network (Figure 3).

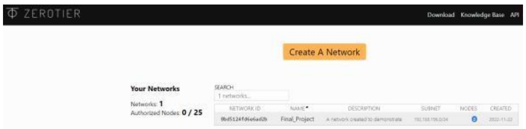


Welcome to ZeroTier Central

ZeroTier Central provides a friendly web UI and API for managing ZeroTier network controllers as well as related services that can be added to networks.

Figure 3. ZeroTier Central: The web-based portal to oversee ZeroTier networks.

After logging in to the ZeroTier central portal we have the option to create our network, show in Figure 4.



Your Networks

Networks: 1

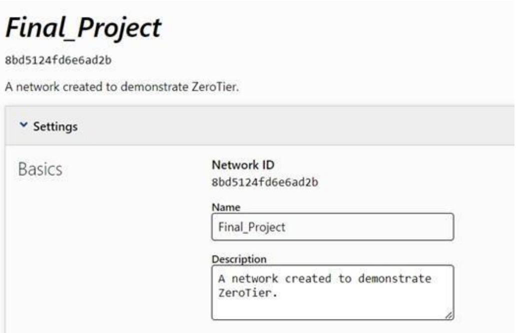
Authorized Nodes: 0 / 25

1 networks...

NETWORK ID	NAME*	DESCRIPTION	SUBNET	NODES	CREATED
8bd5124fd6e6ad2b	Final_Project	A network created to demonstrate	192.168.196.0/24	0	2022-11-22

Figure 4. A ZeroTier Network created using ZeroTier central portal

Thus a network is created, this concludes the first part – creating a network.



Final_Project

8bd5124fd6e6ad2b

A network created to demonstrate ZeroTier.

Network ID: 8bd5124fd6e6ad2b

Name: Final_Project

Description: A network created to demonstrate ZeroTier.

Figure 5. Name of the network along with Network ID

Setting Up Devices.

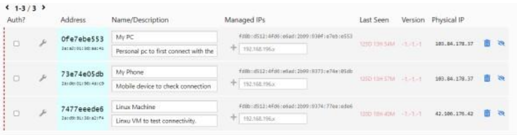
Once the network is created, the next step is to connect the devices to the newly created ZeroTier Network. For this, the ZeroTier application needs to be installed. After installation, there are two ways to connect to the network. One method is to enter the network Id of the network you want to connect in the ZeroTier application. The other method is to utilize the node Id to add the device manually to the network. The Ip address range that need to be assigned to the connecting devices are set by default. We can also use our own IP address range to be assigned.

Controlling traffic and Setting Policies.

The Rules engine, capable of control traffic based on certain criteria, is used to create two rules that restrict the type of packet that enters the networks and the type of connection to be established

Results and Discussion

A sample network is created using ZeroTier Central , shown in Figure 4. This prototype network is connected with three cross platform devices – An Android Device, a Windows machine and a Linux VM.



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Auth?		Address	Name/Description	Managed IPs	Last Seen	Version	Physical IP
□		0fe7ebe553 2a:a2:01:3d:aa:41	My PC Personal pc to first connect with the	fd8b:d512:4fd6:e6ad:2b99:930f:e7eb:e553 + 192.168.196.x	120D 13H 54M	-1.-1.-1	103.84.178.37
□		73e74e05db [illegible]	My Phone Mobile device to check connection	fd8b:d512:4fd6:e6ad:2b99:9373:e74e:05db + 192.168.196.x	120D 13H 57M	-1.-1.-1	103.84.178.37
□		7477eeede6 [illegible]	Linux Machine Linxu VM to test connectivity.	fd8b:d512:4fd6:e6ad:2b99:9374:77ee:ede6 + 192.168.196.x	120D 18H 40M	-1.-1.-1	42.106.176.42

Figure 6. Devices Connected to Test Network

The devices were also installed with ZeroTier application, where I entered the network ID of the network to connect to this newly created ZeroTier network.

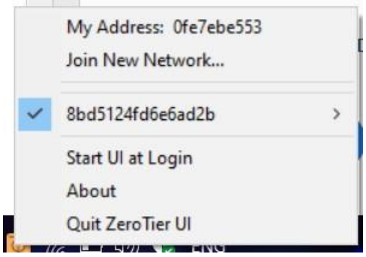
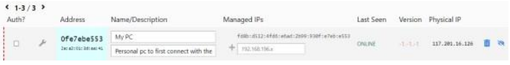


Figure 7. Windows machine connected to the ZeroTier network.



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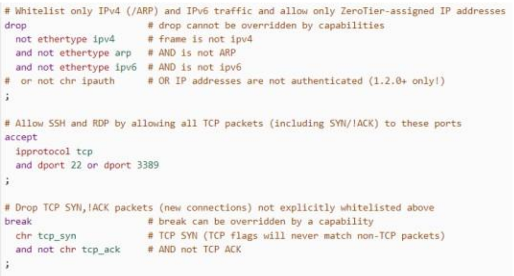
Auth?		Address	Name/Description	Managed IPs	Last Seen	Version	Physical IP
□		0fe7ebe553 2a:a2:01:3d:aa:41	My PC Personal pc to first connect with the	fd8b:d512:4fd6:e6ad:2b99:930f:e7eb:e553 + 192.168.196.x	ONLINE	-1.-1.-1	117.201.16.126

Figure 8. Status of the Windows device turning online after connecting tothe network.

Figure 8 shows how the device status is changed after connecting to the ZeroTier network, the status of first device changed to online.

Rules engine is a powerful tool that allows control over networking traffic, thus improving the security and integrity of ZeroTier networks. Three Rules were added for extra layer of security.

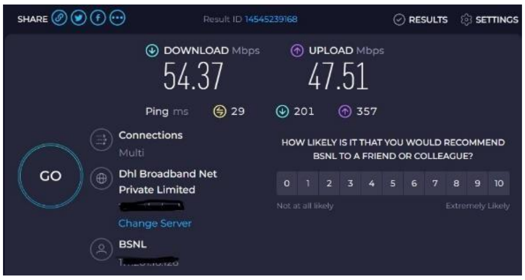


```
# Whitelist only IPv4 (/ARP) and IPv6 traffic and allow only ZeroTier-assigned IP addresses
drop                     # drop cannot be overridden by capabilities
  not ethertype ipv4     # frame is not ipv4
  and not ethertype arp  # AND is not ARP
  and not ethertype ipv6 # AND is not ipv6
#  or not chr ipauth     # OR IP addresses are not authenticated (1.2.0+ only!)
;

# Allow SSH and RDP by allowing all TCP packets (including SYN/!ACK) to these ports
accept
  ipprotocol tcp
  and dport 22 or dport 3389
;

# Drop TCP SYN,!ACK packets (new connections) not explicitly whitelisted above
break                    # break can be overridden by a capability
  chr tcp_syn            # TCP SYN (TCP flags will never match non-TCP packets)
  and not chr tcp_ack    # AND not TCP ACK
;
```

Figure 9. Rules added to the rules engine in ZeroTier Central portal.

Conclusion

The prototype network was created with custom rules added to the Rules engine. The connected device worked seamlessly without any lag/jitter and the Internet speed was not affected in any way while using ZeroTier. The comparison is shown in Figure 10.



Result ID 14545239168

DOWNLOAD Mbps 54.37

UPLOAD Mbps 47.51

Ping ms 29 201 357

Connections Multi

Dhl Broadband Net Private Limited

[redacted]

Change Server

BSNL

[redacted]

HOW LIKELY IS IT THAT YOU WOULD RECOMMEND BSNL TO A FRIEND OR COLLEAGUE?

Figure 10. Internet Speed test results (Credit: Ookla)

ZeroTier looks promising as an alternative to enterprise networks with it's simple yet effective setup, simple management using the web-based Application, and Rules engine to control the traffic to improve security and integrity. Although it is a relatively new technology, The ability to be integrated with existing hardware and converting to the network without having to change the entire existing topology, is a major advantage. Also, ZeroTier being open-source, is another advantage to be considered as community support can further improve the shortcomings and has the potential to turn it into a perfect modern alternative to existing enterprise network.

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