WHITE PAPER

10G E-BAND MESH NETWORKS

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ELVA-1
Millimeter Wave Division

ABOUT
MESH NETWORKS

INTRODUCTION

As our cities become increasingly connected, the need for reliable and high-speed wireless data networks increases. Urban-scale E-band mesh networks from ELVA-1 offer a great solution to this problem, providing 10 to 40 Gbps wireless data connectivity in the 70-80 GHz frequency spectrum.

A mesh network is made up of many peer-to-peer nodes that are interconnected with each other. Each node in a mesh network has an edge router with a network management feature, meaning traffic can be automatically distributed across the network nodes by algorithmically finding optimal routes.

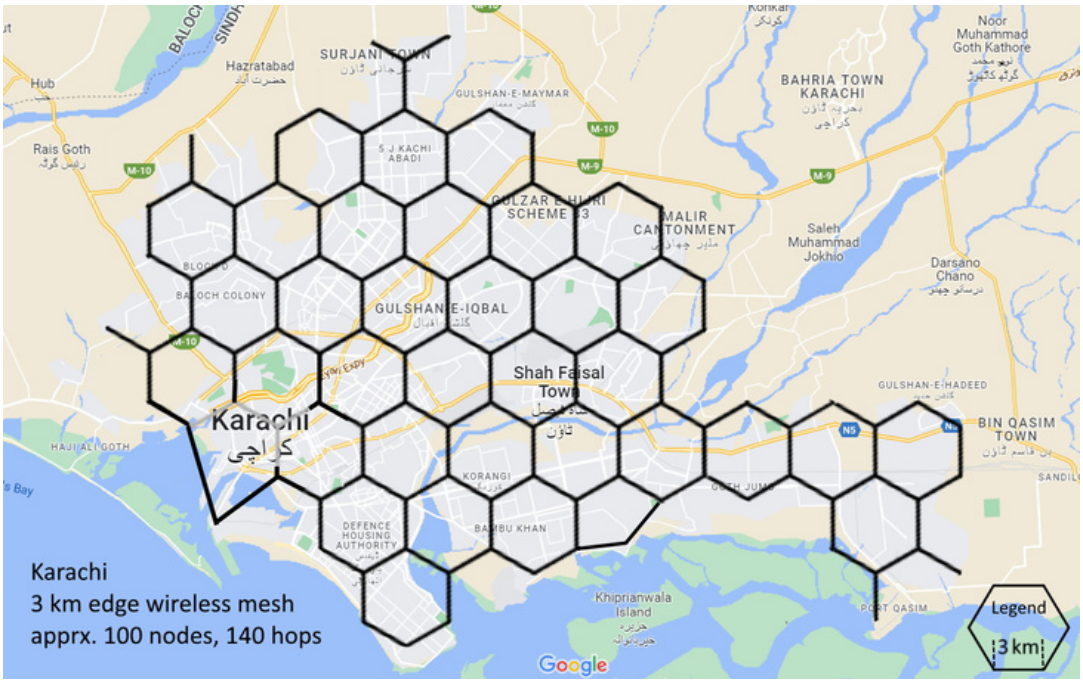
Urban-scale outdoor E-band mesh networks offer many advantages over traditional data networks, including higher speeds, lower costs and improved reliability.

Business benefits of urban-scale E-band mesh network deployment include:

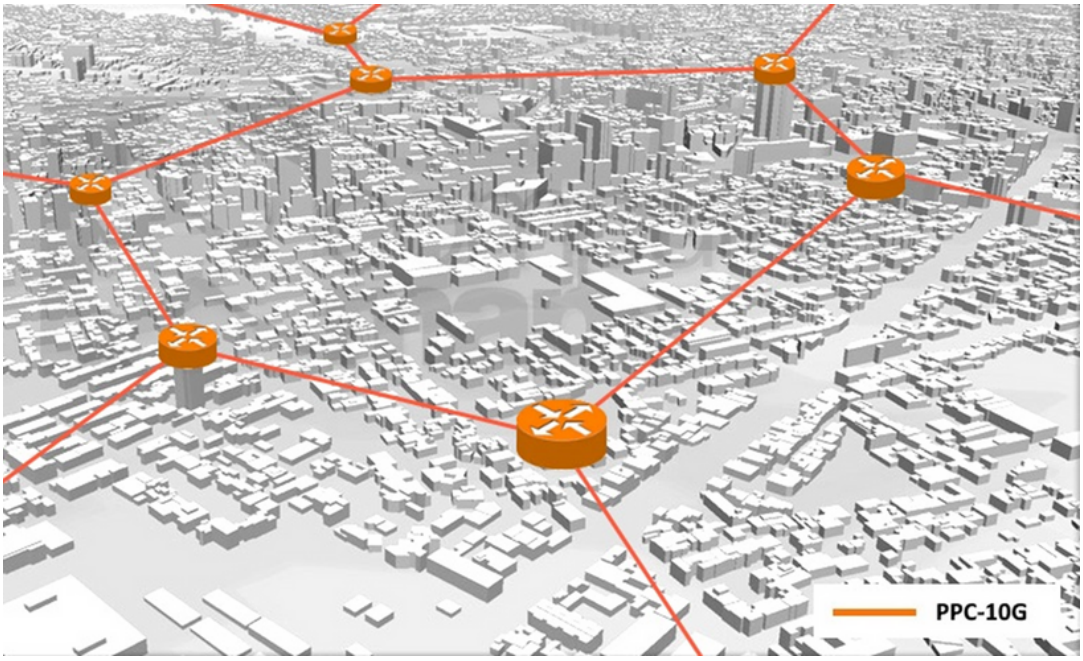
- The dropping cost of wireless solutions, while the cost of fibre work is rising;
- 10 to 40 Gbps wireless connectivity with fibre-like capacity, and five nines reliability, which means business stability for the network operator;
- Elimination of license costs (open-source software);
- The minimal energy consumption and low regular maintenance requirements of each node ensure a lower cost of ownership.

EXAMPLE OF MESH NETWORK TOPOLOGY

An example of a mesh network topology based on hexagons with 3km edges above a city map.

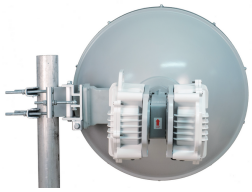


Mesh network nodes are proposed to be installed on the tallest buildings, forming a wireless mesh topology of 10 Gbps links.



TECHNOLOGICAL ADVANTAGES

10 GBPS PPC-10G-E LINK



20 GBPS PPC-10G-E LINK

- The reliability (availability) level of the network is up to 99.999%, corresponding to the carrier class;
- Total network capacity is determined by the number of alternate 10-40 Gbps wireless routes from one network node to another, and reach 100 Gbit/s and more:
- The decentralized wireless network is resistant to failure of any elements in the network and has multiple alternative routes for traffic;
- Automatic linking of nodes is available along the best route with dynamic realignment ;
- There is no need to reconfigure the network (servers) when adding new nodes;
- The addition of new nodes increases network throughput as new routes for traffic appear;
- Traffic is evenly distributed across the network, there is less chance of a bottleneck;
- Redundancy (central nodes have connectivity in 3 directions, edge nodes have connectivity in 2 directions) provides network resilience to vandalism and bad weather conditions;
- Peer-to-peer node redundancy allows for higher recovery SLAs, as traffic will follow an alternate route;
- Implementation through multiple nodes, no "administrative" central node, increases the security of the system as a whole; there is no single point of vulnerability in the network that can be attacked;
- If the server is shut down, the network will continue to run on the last configuration and can still rebuild routes.

FTTH, WI-FI / WI-GIG
VS. E-BAND WIRELESS MESH

Below is a comparison of the characteristics of different traditional technologies when deployed at a city environment.

- In mid 2010x Fiber to the home (FTTH) deployment was considered as a principal approach for gigabit traffic delivery to each household and SMB clients. In practice, it appeared as extremely costly and time-consuming projects, often taking years to complete. This is because fiber optic cable must be run to every individual home in order to provide service. In addition, FTTH networks require a complex network management equipment and high skilled stuff. As a result, many households only receive a fraction of the advertised speeds.

- 2.4 GHz wireless mesh networks have a number of disadvantages in terms of throughput. The main problem is that the 2.4 GHz band is quite crowded, and the mesh nodes have to compete for bandwidth with other devices.. This can lead to reduced throughput and increased latency. In addition, 2.4 GHz mesh networks are subject to interference from both natural sources (such as trees and buildings) and man-made sources (such as power lines). This can further reduce throughput and increase latency. Finally, 2.4 GHz mesh networks tend to have a shorter range than 5 GHz mesh networks, which can limit their usefulness in large urban areas.

- 5 GHz wireless mesh networks have several disadvantages when it comes to throughput. Firstly, the 5 GHz frequency band has fewer channels available for data transmission. This results in increased interference and lower overall throughput. Secondly, the 5 GHz frequency is absorbed more easily by walls and other obstacles, which again results in reduced signal strength and lower overall throughput.

- Finally, 5 GHz mesh networks are typically more expensive to implement than their 2.4 GHz counterparts due to the higher equipment and installation costs.

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E-BAND TECHNOLOGY

ADVANTAGES OVER WI-FI / WI-GIG

- PPC-10G-E 70-80 GHz radio is full-duplex, so each link is capable of transmitting up to 10 Gbps (20 or 40 Gbps with 2+0 models) in both directions. In comparison, Wi-Fi or Wi-Gig technologies are half-duplex, which means the capacity of such channels will be distributed between Up-link and Down-link directions.
- The ELVA-1 backbone network is capable to work with Sync-E synchronization protocols and PTP 1588v2 timing protocols, the presence of which is a mandatory requirement for carrier-grade equipment. Wi-Fi and Wi-Gig technologies are not adapted for such services due to the half-duplex channel.
- The total packet propagation delay over several hops of the backbone network created on ELVA-1 equipment will be significantly lower than over a similar number of Wi-Fi or Wi-Gig hops. This is due to two reasons: the full-duplex link of ELVA-1 links and the high transmission speed on each link.
- Wi-Fi and Wi-Gig are not carrier-grade equipment, but rather Enterprise-grade. On the contrary, ELVA's equipment is designed specifically for operators. It pays special attention to the availability factor of 99.999% and hardware reliability under any traffic load, up to 100%. Enterprise-class equipment is not subject to such strong requirements.
- Total aggregated mesh network capacity is determined by the number of alternate routes from one network node to another, reaching 100 Gbit/s throughputs and more. The transmission capacity is kept constant, regardless of the number of hops used on the IP packets route.
- Wi-Fi channels due to the half-duplex mode of operation poorly operate in the mode of fully loaded and overloaded channels. In particular, according to tests, even on large packets (1518 bytes) in the channel is lost up to 25% of packages are when the channel is loaded by more than 80%. Thus, it should be taken into account that the channel load Wi-Fi should not be more than 50%, which is easily ensured for client channels and absolutely not guaranteed for operator-class channels.

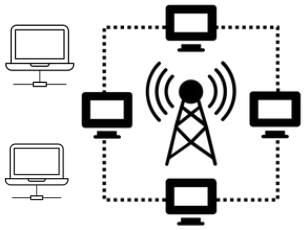
NETWORK TECHNOLOGIES
COMPARISON TABLE

Network types	Fiber	Wi-Fi or Wi-Gig	E-band mesh
Low deployment time	-	+	+
Low deployment cost	-	+	+
Low ownership cost	-	+	+
High throughput capability	+	-	+
Full-duplex capability	+	-	+
Sync-E support for 4G/5G	+	-	+
High availability	+	-	+
Short repair time	-	+	+
Easy authority approval	-	+	+

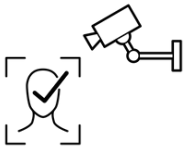
URBAN-SCALE MESH NETWORK SERVICES

With the E-band mesh network, high-speed wireless data transmission can be provided covering all urban areas. Each node of the mesh network is equipped with a Linux edge router that provides connectivity to the public Internet and a host of IP services required in an urban environment.

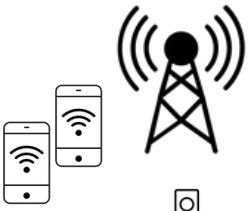
Typical wireless mesh network services include various isolated services over the network:



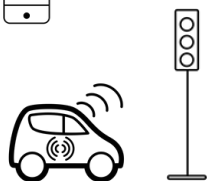
- Access to the public internet, dedicated local area networks



- Surveillance networks with face recognition



- 5G/4G mobile networks



- Smart devices networks and urban-scale IoT connectivity

- Management of traffic on your network by any rules, authorize users (devices), and control access to the network via Web and API-level applications
- Assignment of users rights to manage their virtual networks (e.g., police manage their own camera network)

MESH NETWORK

A FUTURE OF 10G CONNECTIVITY

10Gbps 70-80GHz E-band radio links are ideal for the deployment of wireless mesh network at the city scale.

There are 8 main advantage features of 70-80 GHz E-band communications compared to technologies based on 802.xx standards:

- The distance range of radios between the nodes of a mesh network is 3-5 km;
- Full-duplex mode 10 Gigabit Ethernet;
- Carrier-grade equipment to deploy 4G/5G base stations;
- Low latency over a large number of hops;
- Low BER (Bit Error Rate), with a difference of up to 6 orders of magnitude compared to Wi-Fi and Wi-Gig;
- Availability rate up to 99.999%;
- Up to 100% of wireless traffic load per radio link;
- Light frequency licensing in most countries.

THE FUTUE OF URBAN-SCALE NETWORKS

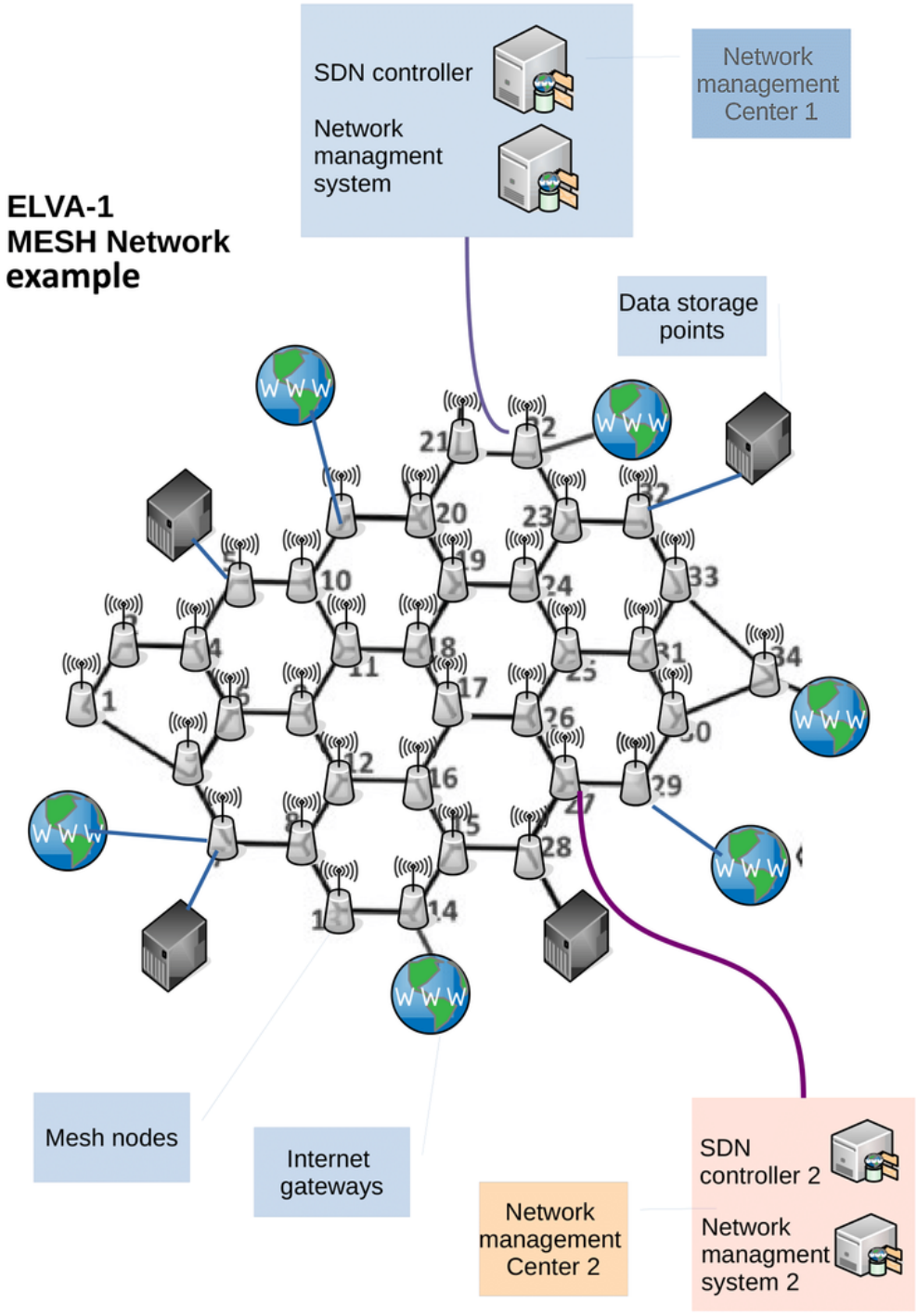
Classic IP networks have been evolving for a long time and have a number of problems when building a large infrastructure:

- Dependence on central routers,
- Network infrastructure requires administration,
- Dependence on vendor licenses, updates and support,
- The need to increase the hardware nodes and build new data centers.

The mesh network architecture consists of peer-to-peer compact nodes connected by wireless radio links with multiple peer-to-peer links, which ensures resiliency in case of failure of up to 60% of the links without losing access to the Internet. The Service Delivery Point im the mesh is a node in the network, which multiplies the total throughput up to 30 Gbps (@ 10 Gbps per link).

We offer a mesh network where single nodes automatically configure to the network architecture, and users determine services they need via SDN-like cloud controllers.

MESH NETWORK
ARCHITECTURAL EXAMPLE



MESH NETWORK

10 GBPS NODES

Typical 10 Gbps mesh network communication node includes:

- 3x 10 Gbps radios (optionally 20-40 Gbps) for connectivity to three neighbouring nodes
- Linux-based EDGE router

Mesh network node

- Located on a roof or mast, it consists of several 10 Gigabit radio links connected to a single Linux edge router

Public connectivity servers (routers)

- Located in nodes connected by fibre to a central node or ISP data center

SDN network management servers

- Located in several nodes, in fact, the management server is one, but is duplicated in several nodes).

- Service provisioning nodes are located in different parts of the mesh network for stability and even distribution of traffic. These are Internet traffic routers, processing and storage servers (e.g., video data storage).

- The network management nodes include SDN- controllers and NMS servers.
- They are located in the central node service provisioning node and can be duplicated at various points in the network.

MESH NETWORK

10 GBPS LINUX-BASED EDGE ROUTERS

MESH network node routers (EDGE routers) are located in close proximity to radios and are used to manage routes, bandwidth, QoS, etc. Unlike classic network routers, they are less expensive, compact, cooler and use less electricity.

EDGE router solutions are based on NXP platforms running open-source Linux software and enable the required functionality at a lower installation and ownership cost than classical routers.

Service provisioning nodes are located in different parts of the MESH network for stability and even distribution of traffic. Nodes include Internet traffic routers, data processing and storage servers (e.g., video data storage or smart city sensor data).

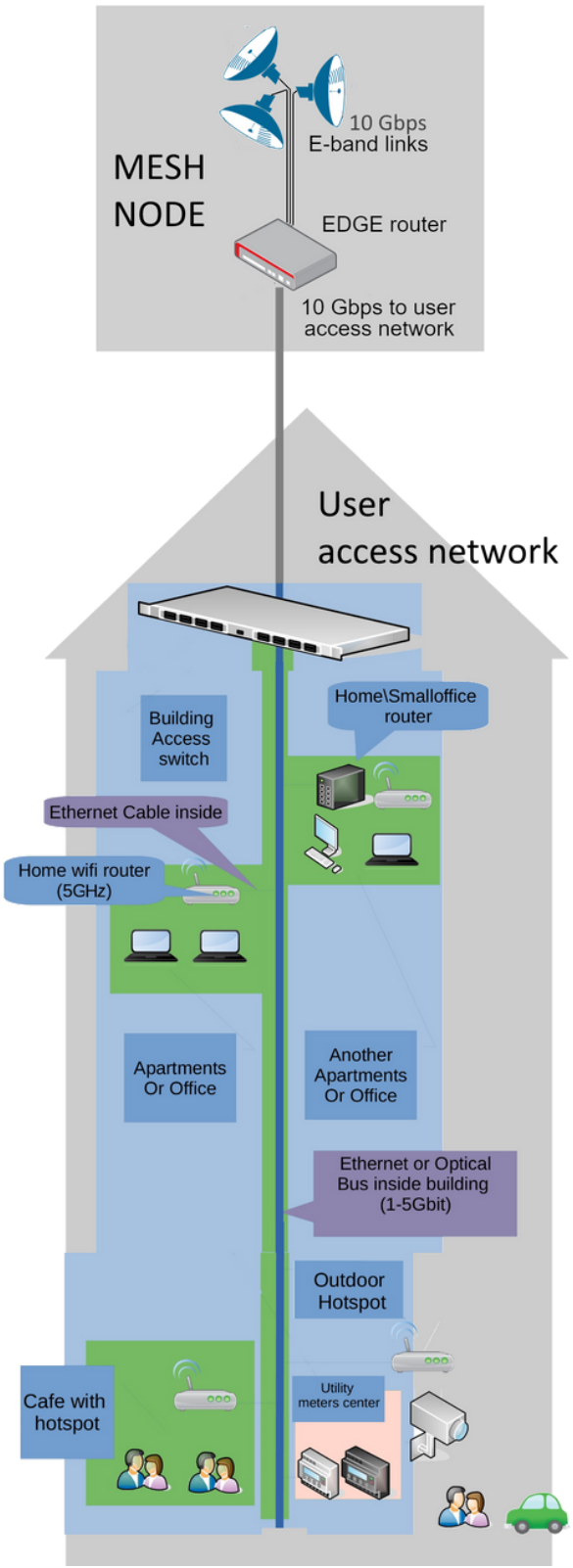
- Support both dynamic routing protocols (ISIS, OSPF, BGP) and MESH routing (BATMAN)
- Compact size, passive cooling
- Could to be placed in cabinets directly next to the antennas
- Support of all NMS (Network Management System), both classic (Zabbix) and specialized (Telegraf+Grafana)
- The openness of Linux allows you to develop your own APIs, systems and control protocols.

Linux-based software firmware enables rich functionality:

- Support for dynamic routing protocols (ISIS, OSPF, BGP protocols) and MESH routing (BATMAN protocol);
- Support for all NMS (Network Management System), both classic (Zabbix), and specialized (Telegraf +rafana) systems of remote control and monitoring;
- The openness of Linux allows to development own APIs, systems and control protocols.

SERVICES FOR

USER ACCESS NETWORK



[1]
The user access network includes cable and wi-fi internet access for households and offices, public services for small businesses, cafes, video surveillance and IoT device management services.

All of these users can benefit from gigabit Internet access for their office tasks and entertainment.

MESH NETWORK

SECURITY OF INFRASTRUCTURE

[1]
Operators using radio links to build a mesh network of urban scale might be concerned about the security of the infrastructure. This includes physical damage or theft of radio links and routers, the unauthorized connection of intruder's equipment to ports of the mesh node, and interception of data streams by radio sniffers. In fact, several layers of protection and encryption are provided by design and recommended use to keep the ELVA-1 mesh network nodes operating securely.

Channel level of the data security

Intercepting a 70-80 GHz signal from antennas that have a 0.4-degree beam pattern is a very difficult technical task. The signal does not lend to be detected by existing sniffers along the radio wave path, as is possible for Wi-Fi, for example.

Authorization of mesh nodes through SDN controller

Network controllers serve as certificate authorities for virtual networks. As such, their identity files should be guarded closely and backed up securely. All credentials issued by network controllers to member nodes in a given network are signed by the controller's secret key to allow all network members to verify them. A certificate of Membership is a certificate that a node presents to obtain the right to communicate on a given network. Otherwise, the node will not be able to access the network.

Network firewall protection

Router embedded firewall provides Ip-level filtering. For all nodes, this will protect the mesh network from unauthorized access and denial-of-service attacks.

Physical protection of the mesh node

Physical protection includes installation on the sites with restricted access like government-owned buildings, police stations, etc., and on high masts. Also, there is signaling messaging to the operator over NMS for a case of opening of the edge router's enclosure.

By following these security recommendations, the operator or network owner can be confident that their 10-gigabit backhaul nodes in a 70-80 GHz mesh network are well-protected.

ABOUT ELVA-1

10/40 Gbps 70-80 GHz and 42 GHz radio links for 4G/5G, Smart City backhauls, rail connectivity and industrial applications.






IELVA-1, the European manufacturer of ultra-high capacity millimeter wave point-to-point links, designs and produces long-range millimeter wave equipment for the communications sector since 2006.

In 2016, ELVA's experience has culminated in the release of the PPC-10G, the world's first commercially available 10-Gig radio. The PPC-10G 10-Gig IP platform is based on state-of-the-art MMIC chips that support QAM-256 at 70/80 GHz (E-band) for up to 15 km.

In 2019, ELVA-1 formed the ELVA-Tele telecommunications department to develop a network architecture based on mm-wave wireless communications and best practices in network design.

For any inquiry regarding the E-band mesh network, please contact us.