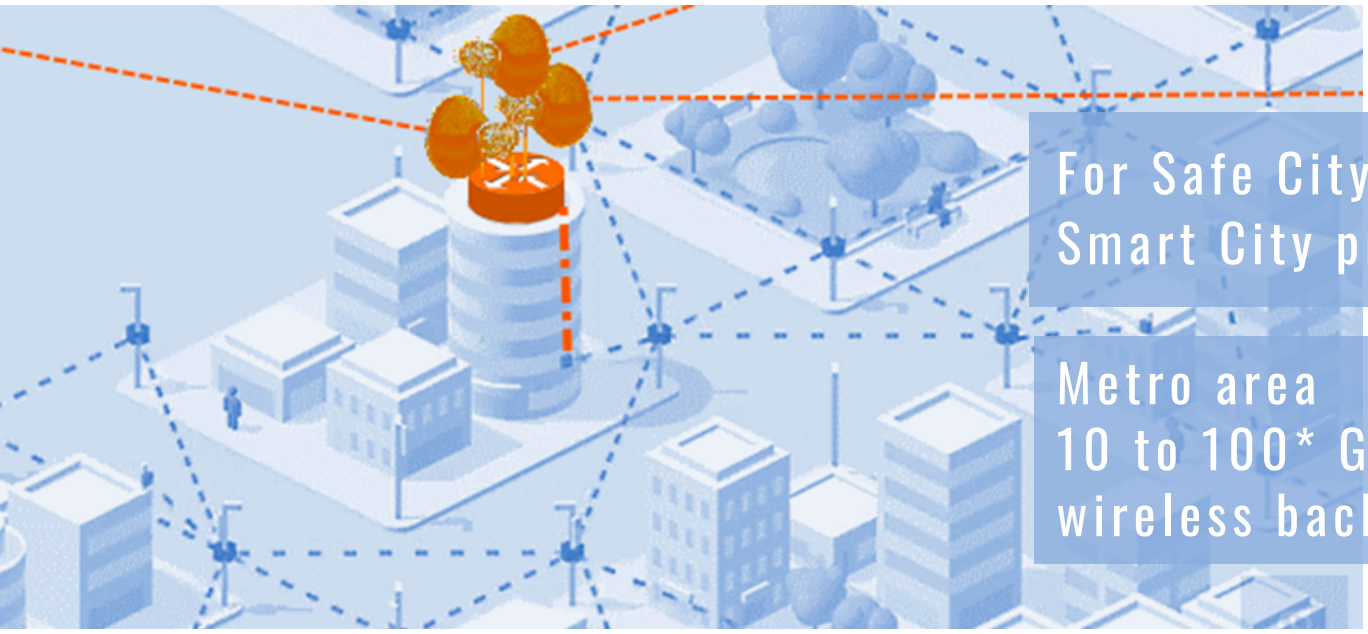
10 Gbps Wireless MESH Network

ELVA-1 Millimeter Wave Division

Wireless E-band mesh network on EDGE routers and open-source software for urban applications



For Safe City and Smart City projects

Metro area
10 to 100* Gbps
wireless backhaul

BENEFITS OF E-BAND WIRELESS URBAN-SCALE MESH NETWORKS

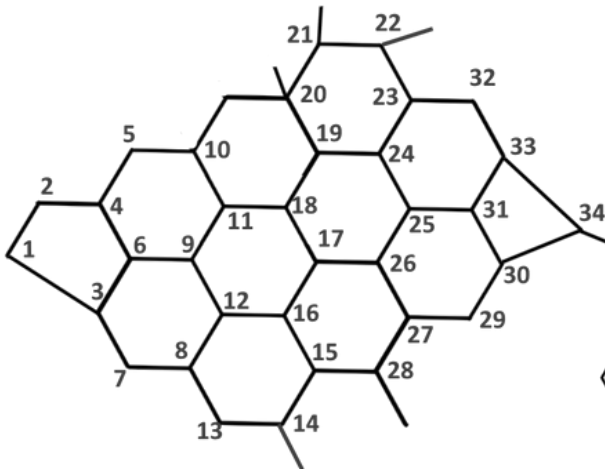
Economic advantages

- The cost of wireless solutions is dropping, while the cost of fibre work is rising;
- 10 to 40 Gbps wireless solutions have reached optical line speeds and exceeded them in reliability, which means business stability for the network operator;
- Elimination of license costs (open-source software);
- The minimal configuration of each node ensures a lower cost of ownership.

Technological advantages

- 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, reaching 100 Gbit/s and more:
- Decentralized wireless network is resistant to failure of any elements in the network and have 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 effect;
- 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.

MESH NETWORK SERVICE CAPABILITIES



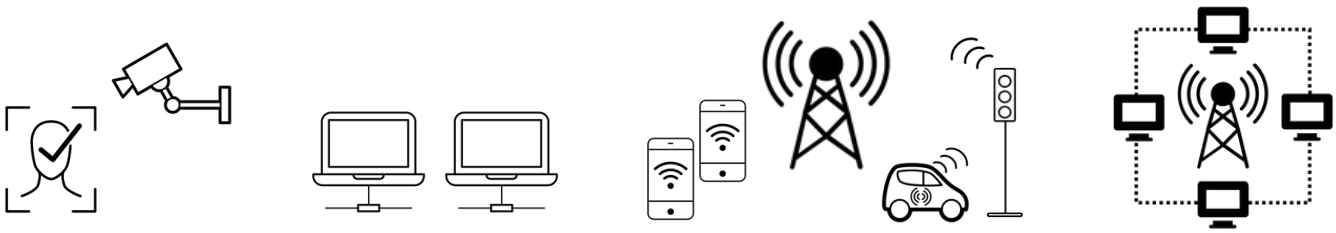
MESH network is a data transmission network consisting of peer nodes that have multiple connections to each other. Traffic is automatically distributed across the nodes of the network by algorithmically finding optimal routes.

The principle of modern mesh networks is a new generation architecture, which takes into account all the shortcomings of classical data networks.

- The transmission speed in a conventional Wi-Fi or Wi-Gig network degrades when transmitting sequentially over several spans (hops).
- In the ELVA-1 solution, the **transmission speed is kept constant**, regardless of the number of hops used on the route.

An example of a project of mesh network:

- Metro area wireless 10-40 Gpbs backbone network (orange)
- Access network (yellow), shown in limited area



Mesh network services

- Provide isolated services over the network
  - Access the public internet
  - Surveillance networks with face recognition
  - Dedicated local area networks
  - Smart devices networks and urban-scale IoT connectivity
- Manage traffic on your network by any rules
- Authorize users (devices), control access to the network via Web and API level applications
- Assign users rights to manage their virtual networks (e.g., police manage their own camera network)

ADVANTAGES OF THE TECHNOLOGY OFFERED BY ELVA-1 IN COMPARISON WITH CONVENTIONAL WI-FI AND WI-GIG TECHNOLOGIES

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

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

- Distance range of radio links between the nodes of a mesh network is 3-5 km on average;
- 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.

Total aggregated mesh network capacity is determined by the number of alternate routes from one network node to another, reaching 100 Gbit/s throughput and more

List of E-band wireless mesh advantages over Wi-Fi and Wi-Gig networks

- PPC-10G-E 70-80 GHz equipment 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. Wi-Fi or Wi-Gig technologies are half-duplex, which means the capacity of the such channel 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, the 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 throughput 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 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.

10+ GBPS MESH NETWORK NODE IN 70-80 GHZ E-BAND

Mesh network node

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

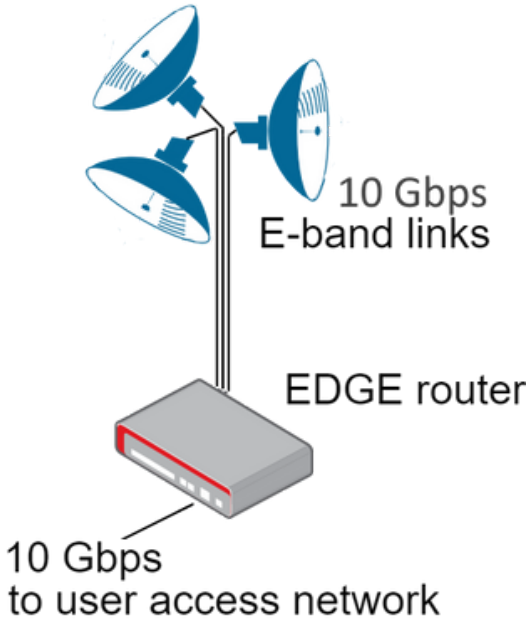
Public connectivity servers (routers)

- Located in nodes connected by a fibre connection 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)

Typical 10Gbit MESH network communication node:
- 10 Gbps radios (optionally 20-40 Gbps radios) for connectivity to three neighboring nodes
- EDGE router



MESH NETWORK NODE / 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).

Advantages of EDGE routers

- Support both dynamic routing protocols (ISIS, OSPF, BGP) and MESH routing (BATMAN)
- Compact size
- Passive cooling
- Ability 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 firmware

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 develop own APIs, systems and control protocols

PPC-10G-E radio link Specifications

Maximum throughput	10 Gbps (20 Gbps in 2+0, 40 Gbps in 2x 2+0) full duplex
Unlicensed band	71-76/81-86 GHz
Handover duration	10 ms (typical)
Occupied bandwidth	up to 2000 MHz with adaptive modulation QAM-128 to BPSK
Ethernet ports	1 × SFP + 10GBase-LR / SR, service 1xCopper 1000/100Base-Tx
Antenna type	Parabolic type
Antenna diameter	30 cm (1 ft) or smaller
Ethernet data streams	Transparent for all services Ethernet, Flow Control 802.3x, PTP
Remote control	NMS, Network Management System
Power	60 W 230 VAC / 54 VDC or PoE cable, 12 - 75 V (optional)
Enclosure protection	IP-65 (optionally IP-68)
Ambient temperature	-50 to + 60 °C / -58 to 140 °F
Relative humidity	up to 99%