



SDM

Whitepaper

Software Defined Metro

(an advanced SD-WAN)

For Operators last mile and global ethernet.

Accelerate Market Entry with SDM:

The Operator's Edge for Modern Connectivity

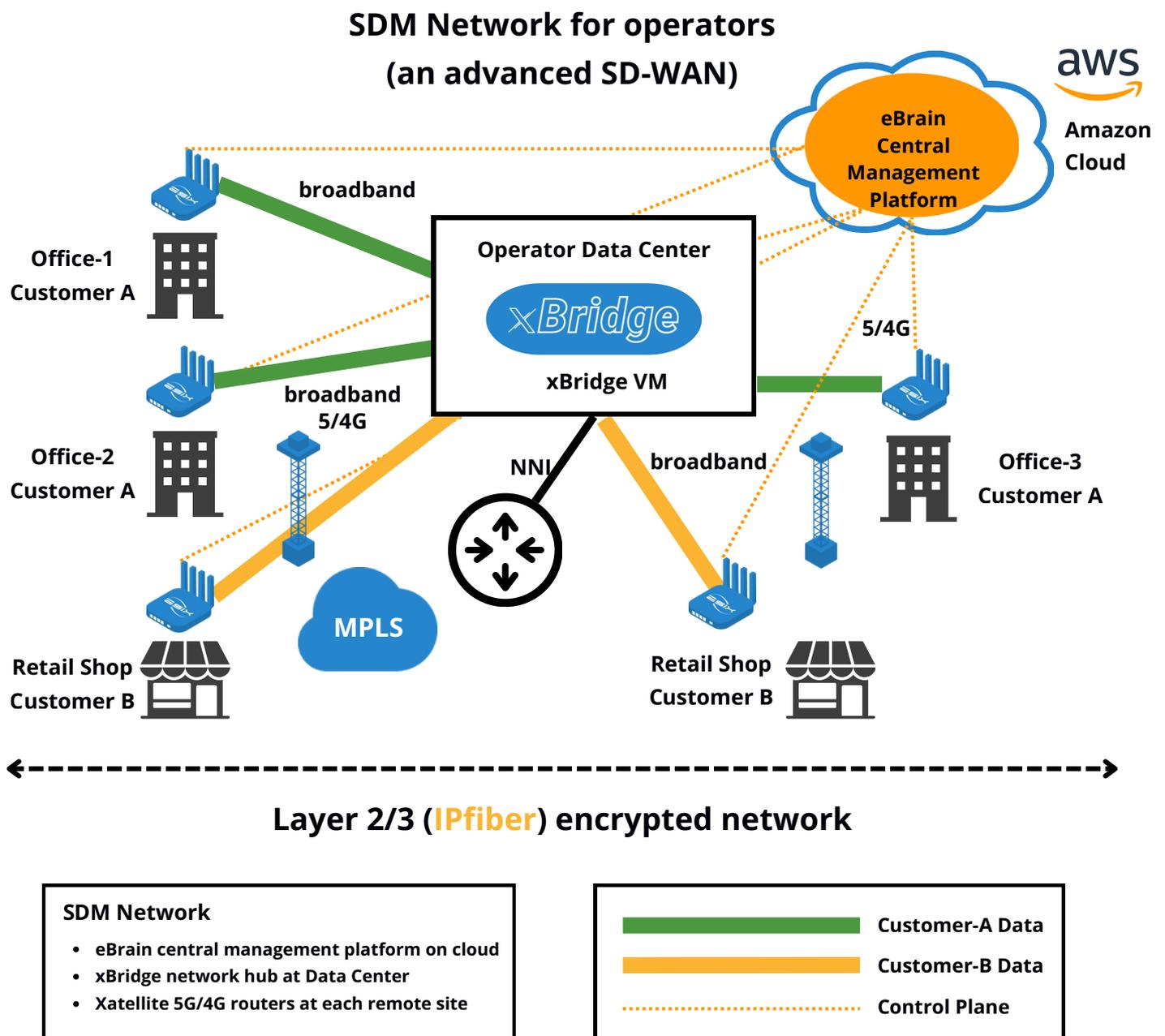
Operators and virtual providers expanding into new markets face limited fiber and costly backhaul. eSIX's SDM enables rapid, secure Layer 2 (MACsec security ready) overlay connectivity using any 4G, 5G, or Internet Broadband—without fixed public IPs or complex onsite IT.

With instant onboarding, automated failover, and centralized management, SDM supports multi-carrier, application-agnostic deployments—empowering seamless expansion, reducing costs, and ensuring business continuity worldwide.

Introduction

SDM seamlessly integrating various technologies such as Metro Ethernet, MPLS, WiFi, 5G, 4G, satellite and Internet broadband. By combining these diverse connectivity options, SDM enables organizations to build a unified and highly efficient network ecosystem.

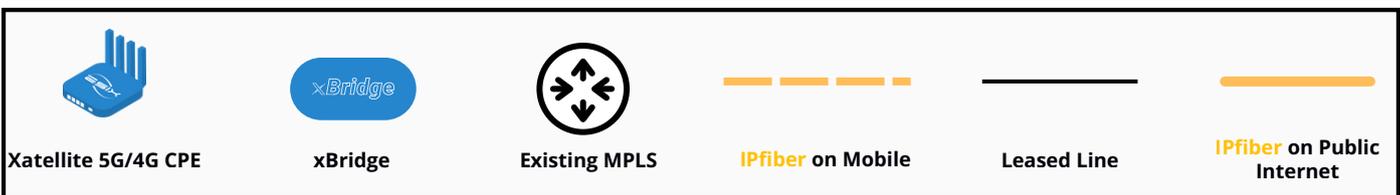
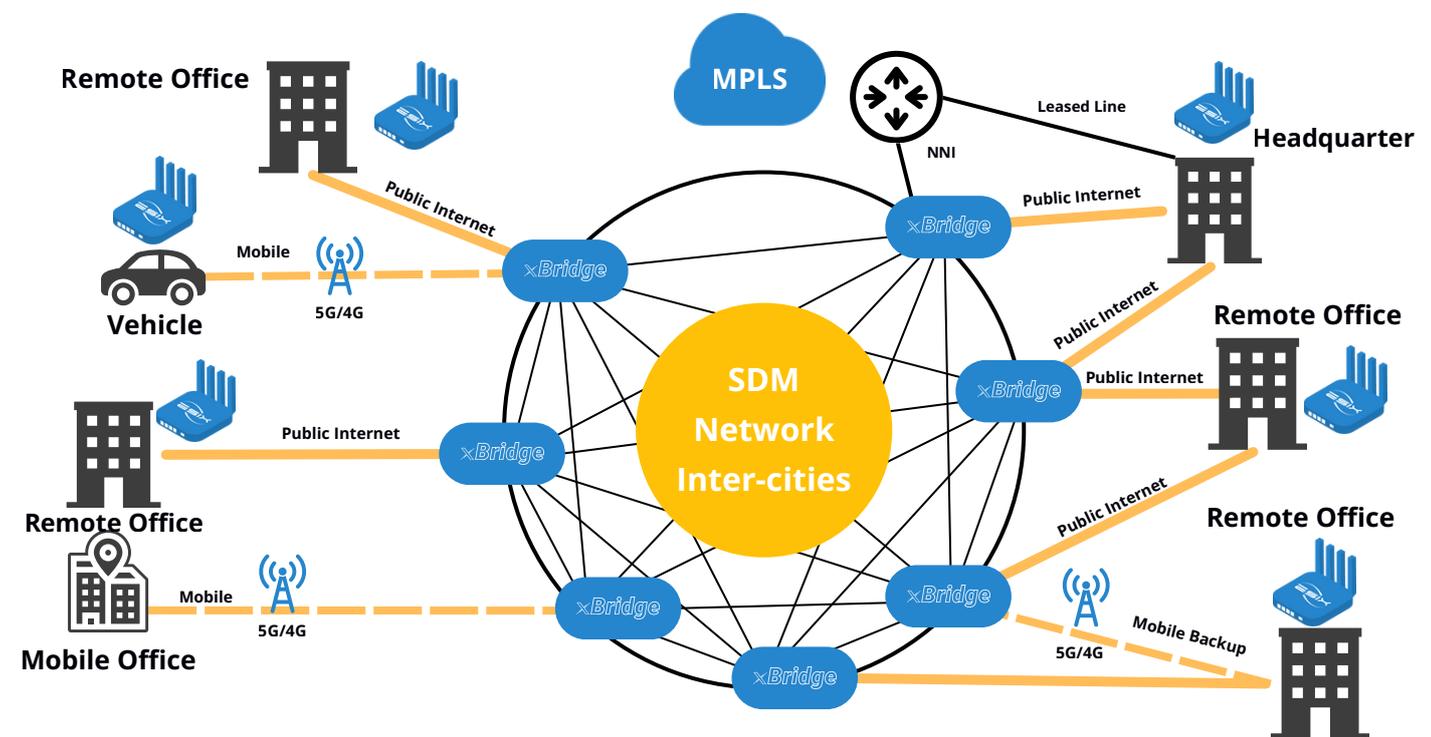
SDM offers centralized management for businesses, simplifying network operations and enhancing performance. Unlike traditional SD-WAN solutions, SDM utilize of **IPfiber™** operates at layer 2 overlay (MACsec security ready), seamlessly integrating with existing infrastructure for advanced control and flexibility. It optimizes network connectivity, improves efficiency, and enables growth opportunities.



Building on the single-site architecture, SDM supports distributed deployments with multiple xBridge VMs placed in operator data centers across different cities. These xBridges are interconnected using broadband or private lines, forming a resilient, unified backbone.

Customers connect lastmile locally via 4G, 5G, or broadband, while SDM transparently extends secure, high-performance connectivity between cities—enabling true private line services for multi-office or multi-region organizations, all managed from a single platform.

Distributed SDM Network for inter-cities



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The Challenges

How can we ensure **RELIABLE, ALWAYS-ON** connectivity—including the last mile—while keeping the network **SECURE, SIMPLE, COST-EFFECTIVE**, and easy to maintain?

Empowering Operators to Deliver Metro-Grade Connectivity Anywhere

In today's competitive telecom landscape, deploying reliable last-mile connectivity in foreign markets or hard-to-reach areas is both a necessity and a challenge. Whether you're a major operator expanding your footprint or an MVNO seeking service agility, secure network, eSIX's Software Defined Metro (SDM) transforms how you connect sites. Leverage 4G/5G, Wi-Fi, satellite or any Internet backhaul for seamless Layer 2 overlay (MACsec security ready) —with no fixed public IP requirement, instant failover, and ultra-fast provisioning. Expand, compete, and win—without local fiber buildout or high recurring costs.

Networks / Protocols Agnostic

There are various limitations to connecting different networks and even crossing borders, like public fixed IPs, AAA policy, bi-directional control..., etc. Moreover, it is complex and costly to build that IT infrastructure.

The Solution

The SDM Network empowered by **IPfiber™** technology from eSIX Limited provided the complete network connector approach for Overlay and Underlay to connect the system between different networks anywhere.

SDM

The Software Defined Metro Architecture

eSIX SDM comprises three core components: the eBrain Central Management Platform, the xBridge hub, and the Xatellite CPE. Each component plays a crucial role in managing and orchestrating network resources, traffic flows, and security policies.

eBrain Central Management Platform

The central intelligence platform of eSIX SDM, responsible for managing and controlling the network infrastructure. It monitors performance, collects data, and enforces network configurations and security policies.

xBridge hub:

Its serves as a centralized hub that connects Xatellite CPE devices in a star topology, forming the data plane of the network. Along with the eBrain Central Management Platform, it forms the core of the SDM Network.

Xatellite CPE:

An SD-WAN-enabled device supporting various connectivity options (5G, 4G, fixed line, WiFi). Implements policies and configurations from the eBrain Central Management Platform and xBridge hub, managing network resources, traffic flows, and security policies efficiently.

xBridge / Xatellite:

Architecture uses gRPC on Ubuntu for control and TCP for transport. It is a modern, high-performance RPC framework developed by Google for connecting client-server applications across data centers. Unlike IPsec, eSIX SDM uses **IPfiber™** which is an efficient Overlay Layer 2 Virtual Tunneling technology that supports Layer 3 and Layer 2 protocols. It is agnostic to underlay networks, whether fixed or wireless, creating a Software Defined Ethernet on public networks without the need for fixed IP addresses..

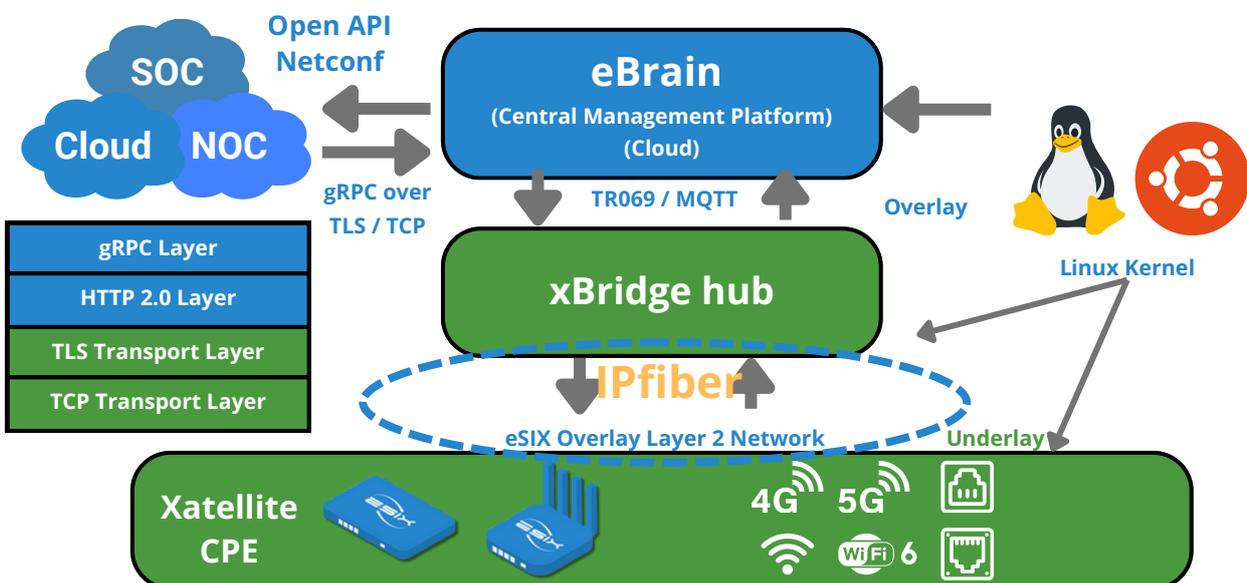


Figure 1. SDM Overlay & Underlay Connectivity Solution

SDM Network Comparison Framing

While traditional WAN and SD-WAN solutions have advanced enterprise connectivity, eSIX's Software Defined Metro (SDM) offers a unique layer 2 approach that integrates diverse access technologies—such as 4G/5G, broadband, MPLS, and Ethernet—into a unified, operator-friendly platform.

SDM distinguishes itself by providing true metro Ethernet simulation over any network, eliminating the need for public IPs, and delivering sub-second failover with advanced security and centralized management. The following comparison highlights how SDM outperforms conventional alternatives to meet the complex demands of modern telecom operators and virtual providers.

Aspect	SDM / IPfiber	SD-WAN	MPLS	VPN / IPSec
Layer 2 Support	Yes	Partial	No	No
MACsec security	Yes broadband & 5G	No	No	No
Fixed public IP Need	No need	Often need	need	need
Failover Speed	Subsecond	Seconds-Min	Seconds	Minutes
Multi-Carrier Support	Yes	Limited	Complex	No
Application Agnostic	Yes	Limited	Yes	Limited
CAPEX / OPEX	Low	Med-High	High	Low
Zero Touch Provision	Yes	Yes, some of them	No	No

Tunneling Architecture of IPfiber™

The eSIX unique private tunneling technology can provide more efficient and reliable tunnels than legacy IPsec with up to 50%~300% higher performance under the same eSIX hardware environment. The most beneficial is Layer-2 network and protocol agnostic and easy to build up.

Look into Figure 2, the devices are located at different networks and even regions. A virtual switch (vSwitch) could be created anywhere in the control center or deployed on cloud, the connected clients could be the TAP devices, VETH devices, and physical devices. Through wired or wireless networks like 4G/5G, the IPfiber™ tunnel is established as a virtual local LAN to bridge these devices in just milliseconds.

The tunnel is supported to build in Layer 3 and Layer 2, and is capable of package retransmission. For capacity and performance optimization, there could be multiple tunnels in Layer 3 for load balancing, in Layer 2 for local breakout, that are built for high availability redundancy as well as optimize the network resources. And all these professional setups could be done by the eSIX GUI by finger taps that IT free.

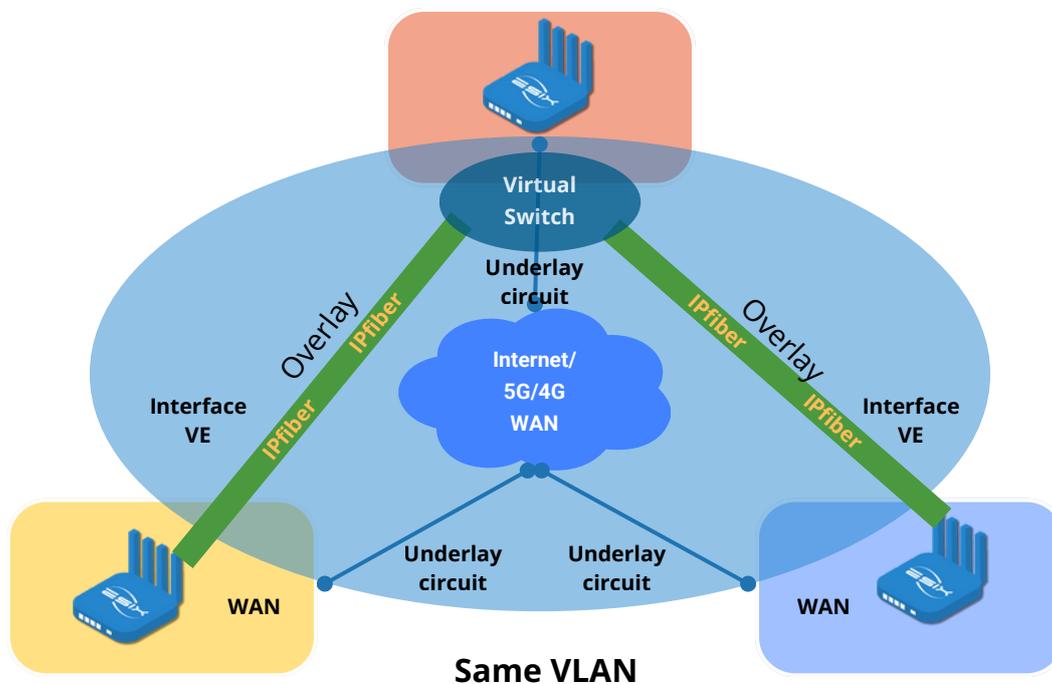


Figure 2. IPfiber Tunneling Architecture

Remote work and coworkers with multi-location teams are the new trend and have become more and more common nowadays. It is essential to build a secure intranet with enhanced effectiveness that crosses networks and borders for enterprises, especially industrial enterprises.

To secure network connection between site-to-site, the most popular technology is to create a VPN tunnel using Carrier Ethernet, VPLS, MSTP, MPLS, IPSec, and WireGuard protocols, as shown in Figure 3. Following the rising need for transmitting large volumes of data, audio, video, and multimedia across networks, and also to fulfill the network bandwidth requirement, there should need a new technology able to integrate Layer 2 and Layer 3 networks, to provide a simple and efficient architecture for easy expanding of the network capacity and securing the high availability, to sustain the demands of the application, especially in this 5G era.

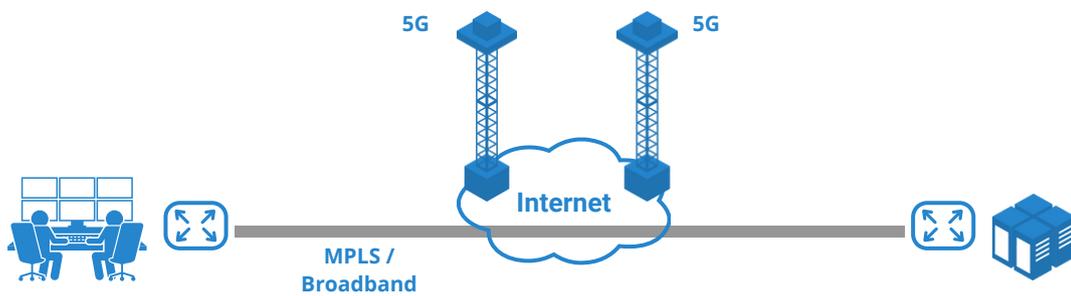


Figure 3. The Tunnel Between Control Center and Field Site

In our approach in Figure 4, the system can create a large overlay Layer 2 topology with network agnostic and application agnostic. At the same time, it also creates a secondary link for emergency failover through the 5G network.

The SDM Network consists of eBrain as a central management located at the cloud cloud, which is the Overlay software of the edge connector; the xBridge acts as the Hub while the Xatellite 5G CPE acts as the node, which is installed at each local site. The system architecture could also support mobility applications that benefit the 5G mobile network. When the wired connection is broken unexpectedly, the IPfiber™ technology will take over immediately, see Figure 5, 6.

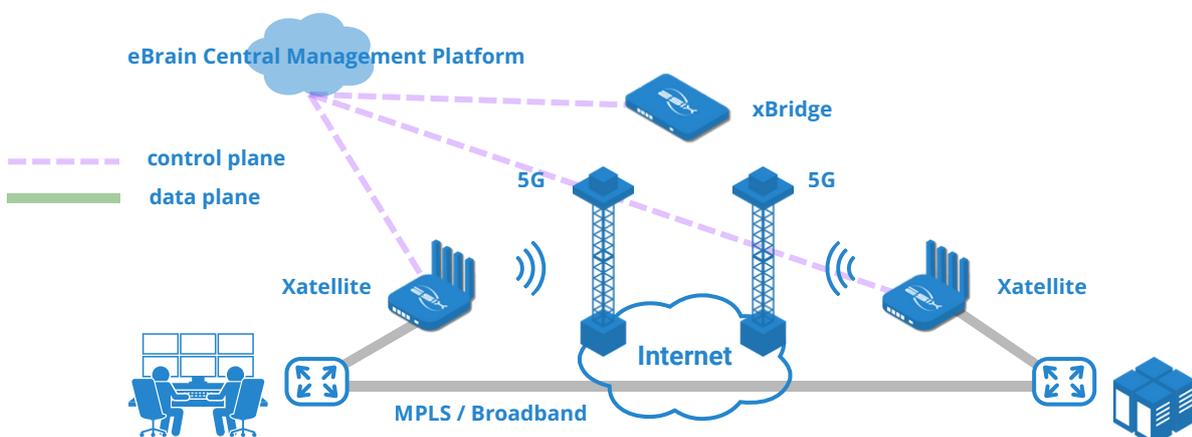


Figure 4. The Emergency Failover Link Through 5G network

Control and Data

Most of the enterprise and industrial IT networks would not provide public IP and set up a firewall in the middle to isolate the intranet and internet. It is a reasonable and standard approach to protect the company's digital property but also causes the complexity of connecting outside branches in different networks, even in foreign areas. Especially when connecting with multi-sites, the IT setup and bandwidth allocated would both increase the TCO (Total Cost of Ownership = OPEX + CAPEX).

To deal with the limitation of local intra-network, as shown in Figure 4, the eBrain is located at a cloud site with a public IP that provides the control signaling setup for each Xatellite, which connects with a 5G network. After signaling build-up, the tunnel between each Xatellite instantly links up and seamlessly exchanges data just like within the intranet. It provides the failover capability for the original wired connection, and even improves the transport performance through the 5G network.

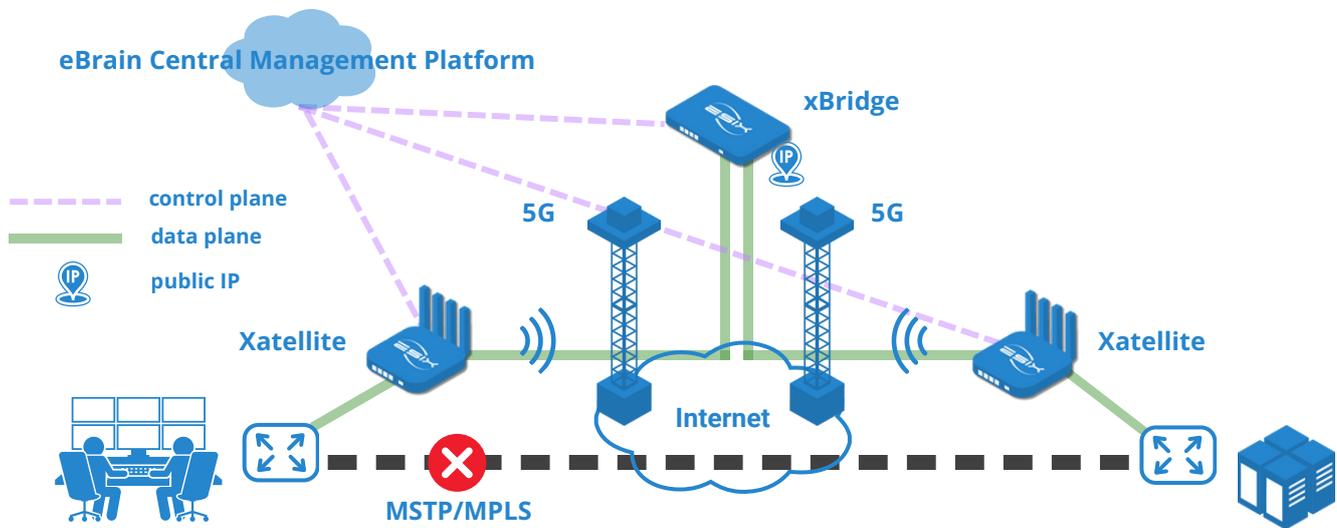


Figure 5. The Relay Data Path based on NO Public IP

More easily if there is a Public IP at one site, as shown in Figure 6, after building up the control plane by xBridge, the data is transmitted directly between Xatellite client through QoS tunneling instantly and efficiently. The remote site dose NOT require a fix-IP, even a private IP works well.

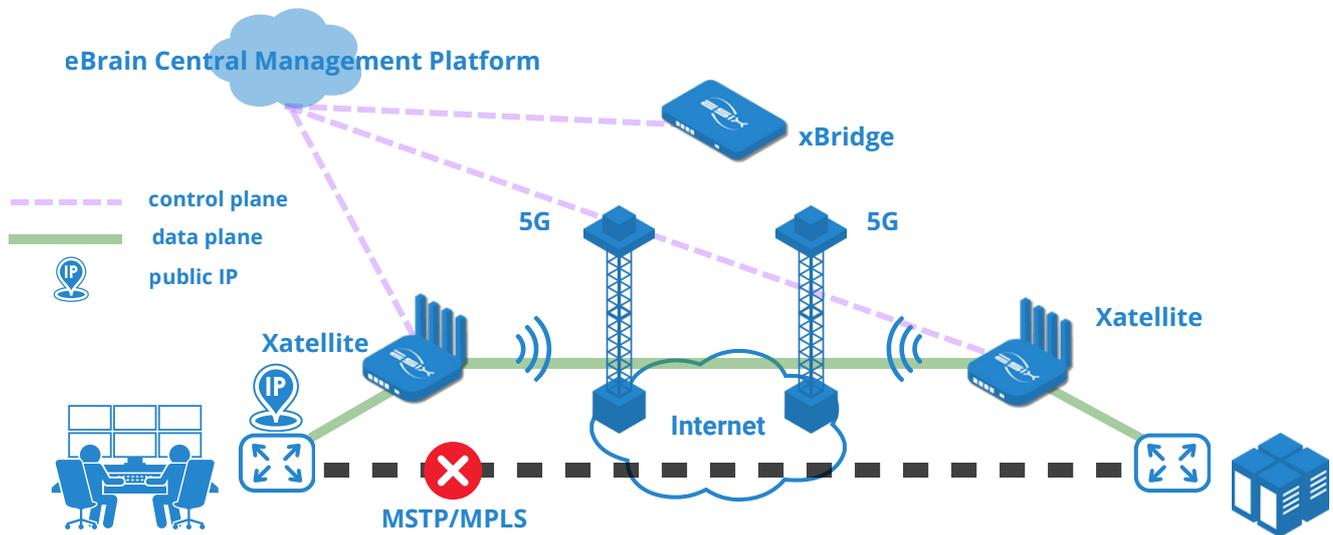


Figure 6. The Site-to-Site Direct Data Path based on Public IP

More easily if there is a Public IP at one site, as shown in Figure 6, after building up the control plane by xBridge, the data is transmitted directly between Xatellite client through QoS tunneling instantly and efficiently. The remote site dose NOT require a fix-IP, even a private IP works well.

SDM Networking (Software Defined Metro)

Within the operation center, as shown in Figure 7a, the network scale could be a city or Country. With this Hub-and-Spoke architecture, the system can manage to connect the whole nodes and form a so-called SDM networking. The system is capable of multiple-link, central to multi-site connection with high bandwidth under encryption, offering QoS enhancement, guaranteed audio & video, and clustering, the most exciting feature for high availability.

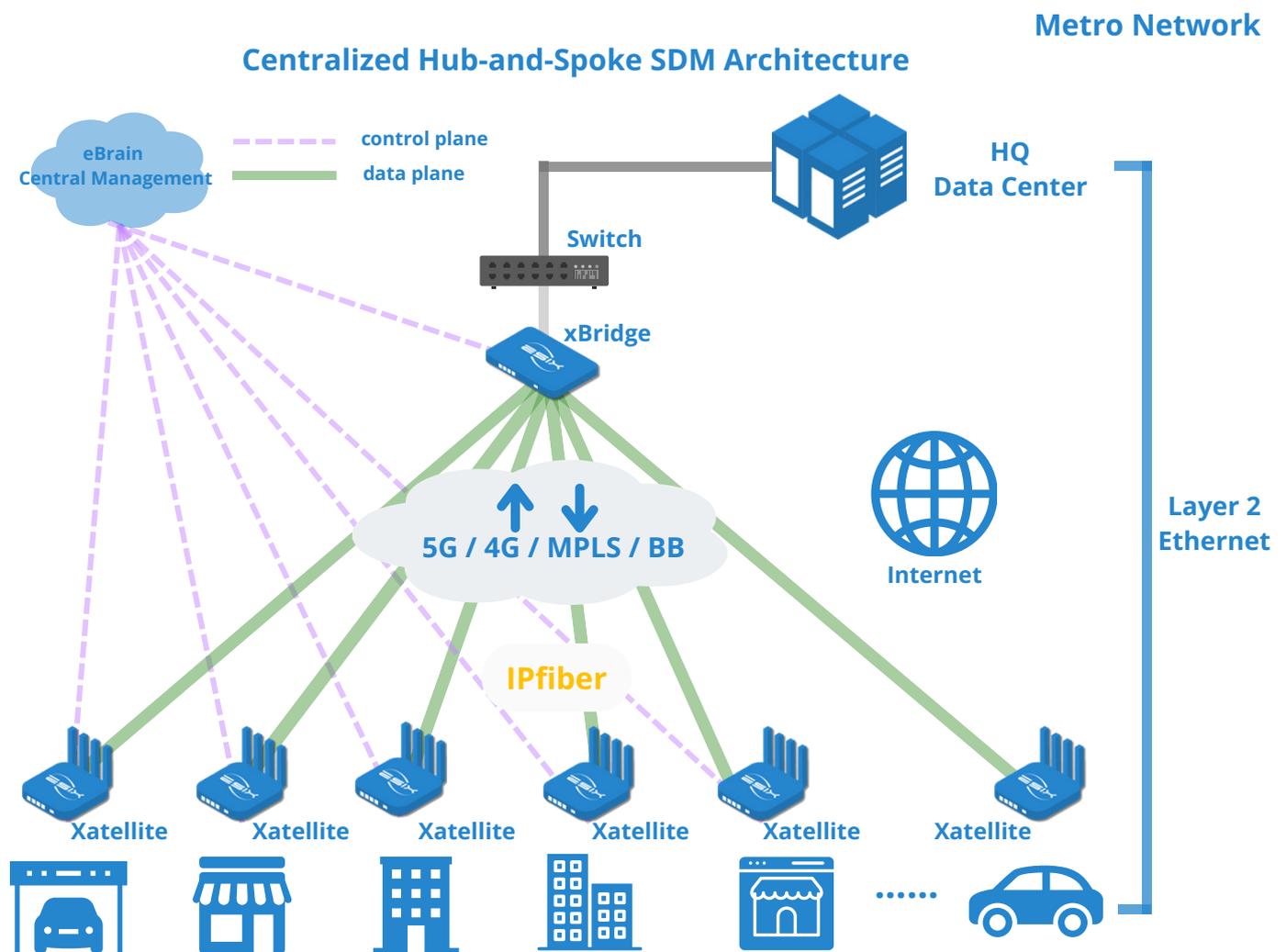


Figure 7a. SDM Hub-and-Spoke architecture in a metro network

For more advanced usage, for cross-network or cross-border, there is a demand to create an extensive complex network system to connect over site-to-site and center-to-multisite, as shown in Figure 7b topology.

For each local area within a subnet, Xatellite could communicate with each other to structure a site-to-site local meshing, lowering the latency inside the same group. The system is capable of carrying up to 252 sites per group and aggregates bandwidth in each local area to reach *10G, which can be handled by one xBridge.

(*could be managed with higher bandwidth by upgrading xBridge HW configuration)

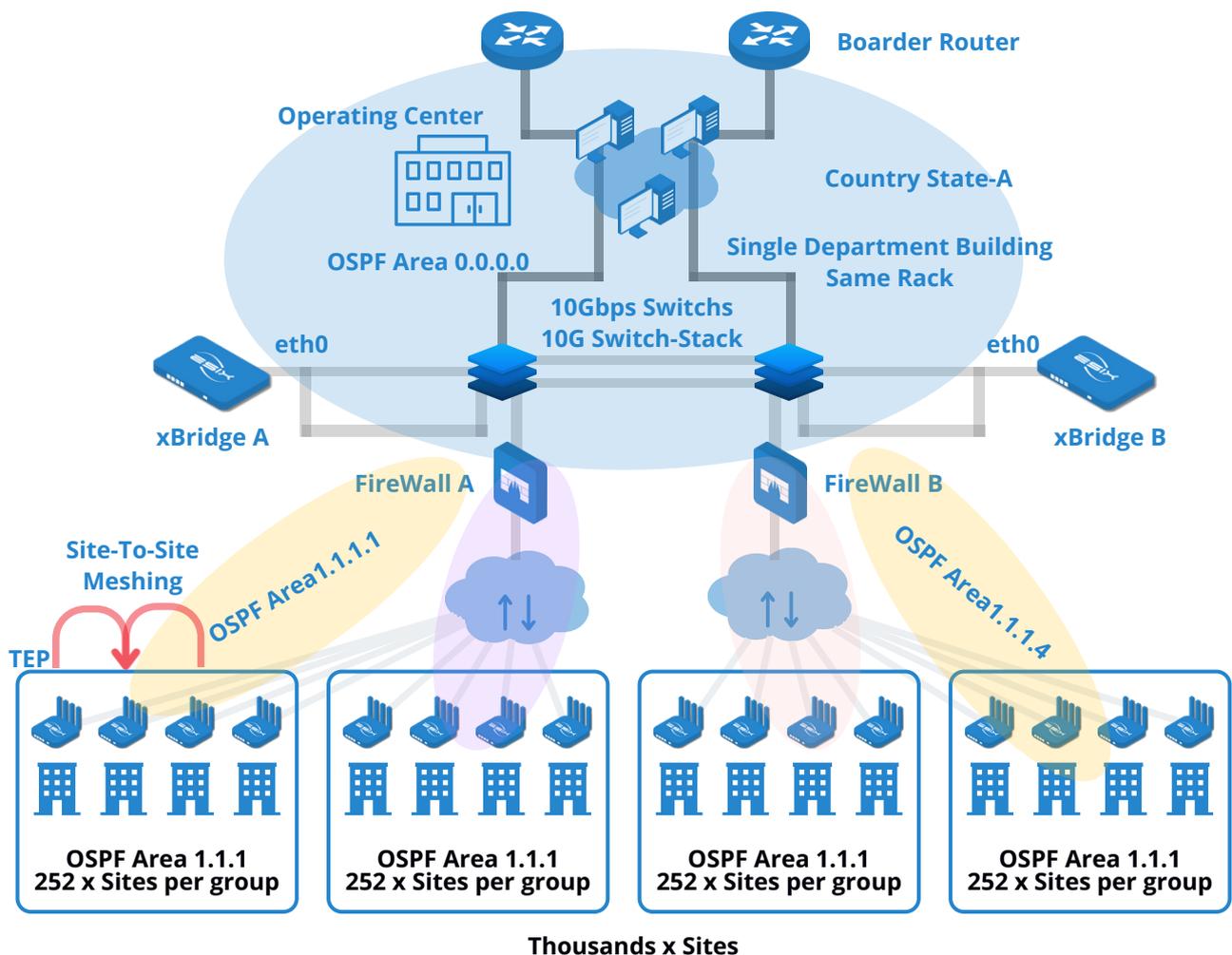


Figure 7b. SDM (Software Defined Metro) Networking

Load Balancing / Bonding

The IPfiber™ Load Balancing feature maximizes the utility of Xatellite and network resources. In Figure 8, the Xatellite can aggregate the multiple and different ISP WAN network resources to scale up the high bandwidth. It's session-based load balancing and flexible to add bandwidth anytime and with high security. The different types of applications could be well prioritized and traffic balanced within the session tunnel. The most significant advantage is the automatic failover between links and different operators. The recovery uptime is extremely low to fulfill the High Availability approach for mission-critical applications.

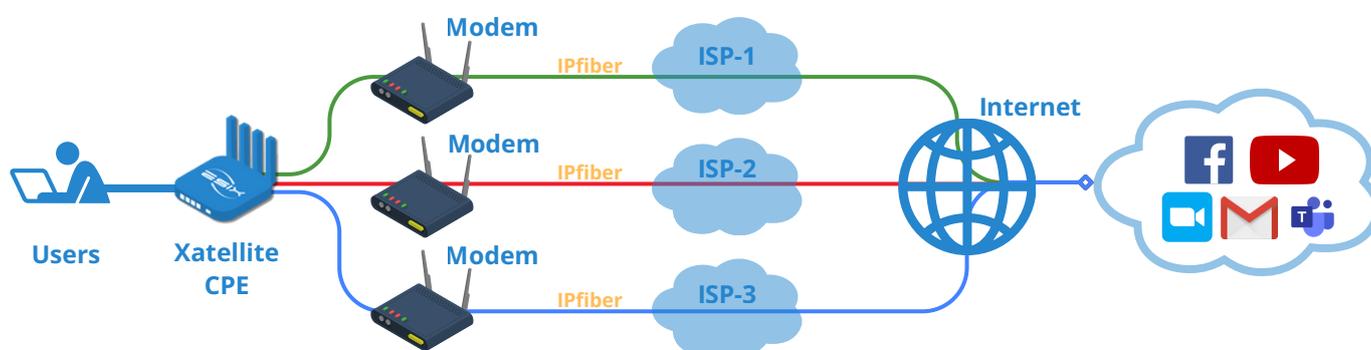


Figure 8. Load Balance / Bonding Design

SVI Routing Design

Zooming into a local area network, as shown in Figure 9, an xBridge is set up behind each firewall and a switch at the center, downside through different broadband or mobile networks to connect to each local area that has installed Xatellite for connecting with various sites. The eBrain acts as a central management to manage and connect each Xatellite, creating a virtual circuit and looking for and optimizing the best route, as shown in the OSPF Neighbor path in Figure 6 previously.

The xBridge builds up an L2 tunnel endpoint and sets up L3 routing, to allocate the IP address tunneling between each Xatellite client that implements the SVI routing protocol, to form a large Layer2 network. Simply set the port forwarding behind NAT and firewall, and the data path will flow from the local site to the application server, which can be located anywhere outside the border. This benefits by removing the boundary of cross-networks and effectively implementing traffic and dynamic routing. The remote client sites do not require a fix-IP address, dynamic IP works well.

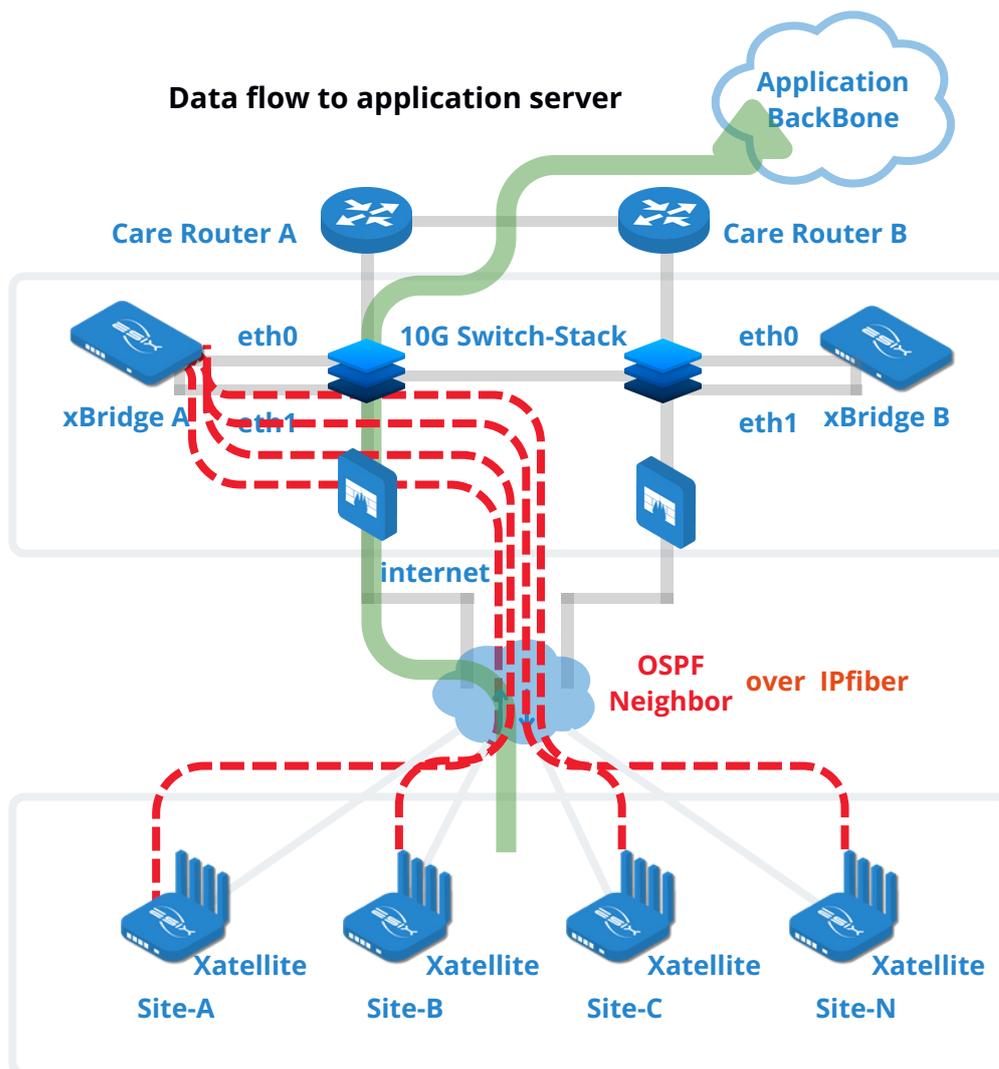


Figure 9. L2 & L3 SVI (Switched Virtual Interface) based Routing Design

Dual Homing Network Redundancy

To achieve High Availability in network architecture, it would be designed with more than two devices for failover backup. The typical approach is to set up a secondary device to sustain the network functions of the primary one when it becomes unavailable due to a failure or scheduled downtime. Failover is an essential feature in mission-critical applications that continuities serve in the network, and the recovery time is considered the key factor of performance and efficiency.

VRRP (Virtual Router Redundancy Protocol) provides a mechanism for dynamic failover. If the original operation device fails, the tunnel will be lost, all the existing sessions will be dropped. When the VRRP group is established, the highest priority device will take over the network node tasks to forward the package.

In Figure 10, Xatellite 1 and Xatellite 2 have built up a VRRP group that sets a virtual IP with the same default gateway IP. Once Xatellite 1 fails or is down, the virtual IP will automatically switch over to Xatellite 2. In the meantime, the tunnel is instantly rebuilt through Xatellite 2 to the same xBridge A. All the packages will be transparent forwarded by Xatellite 2 to the original destination. During this failover processing from device failure to re-establish the tunnel to recover the network processes, the users do not need to change any configurations. The switch over time is set to around 5 seconds, which is recommended to avoid flapping, and the delay could be faster according to the application's needs.

This network redundancy design with the VRRP switchover approach, guarantees the network availability to fulfill the continuous requirement of critical missions.

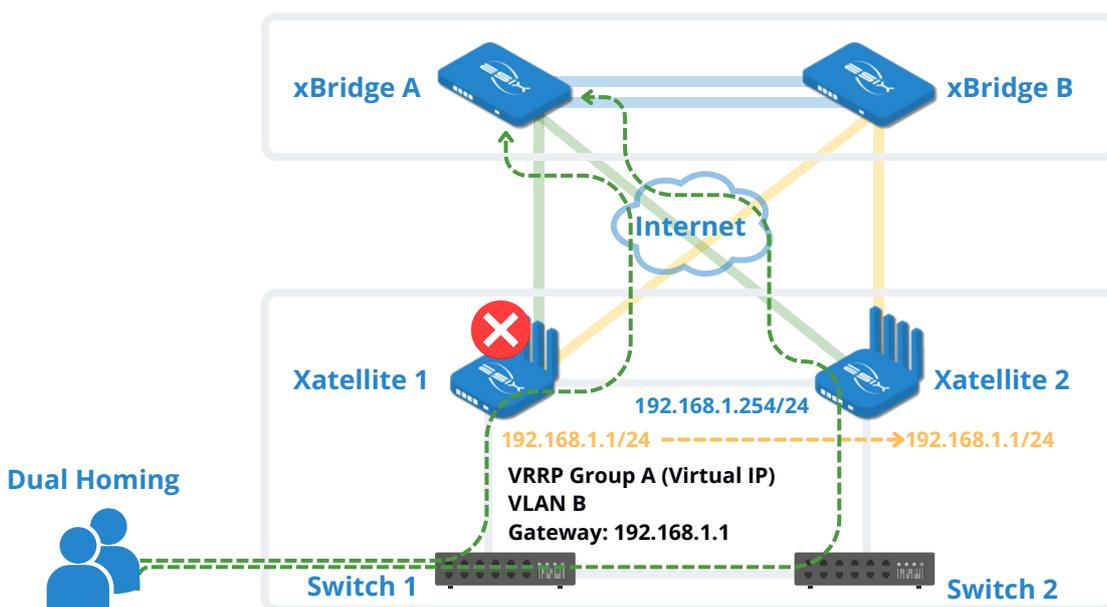


Figure 10. Network Redundancy Design

Traffic Local Breakout

The Hub-and-Spoke network architecture typically adopts multiprotocol label switching (MPLS) protocol to route traffic from the local site to the application server. There are various kinds of data flow apart from internet-based services unrelated to enterprise intranet applications. The enterprise data centers can suffer from non-valued traffic loading since the bandwidth resource is consumed by traffic destined for the internet.

In Figure 11, the traffic local breakout feature will pre-set the destination IP subnet that forwards the data flow through the tunnel to the data center or directly sent to the internet. Enterprise could hugely offload the internet-bound traffic from the local site and remote center and route it straight out. The bandwidth is limited and related to cost, while efficient use of bandwidth would reduce the system cost, lower the latency, and enhance the user experience.

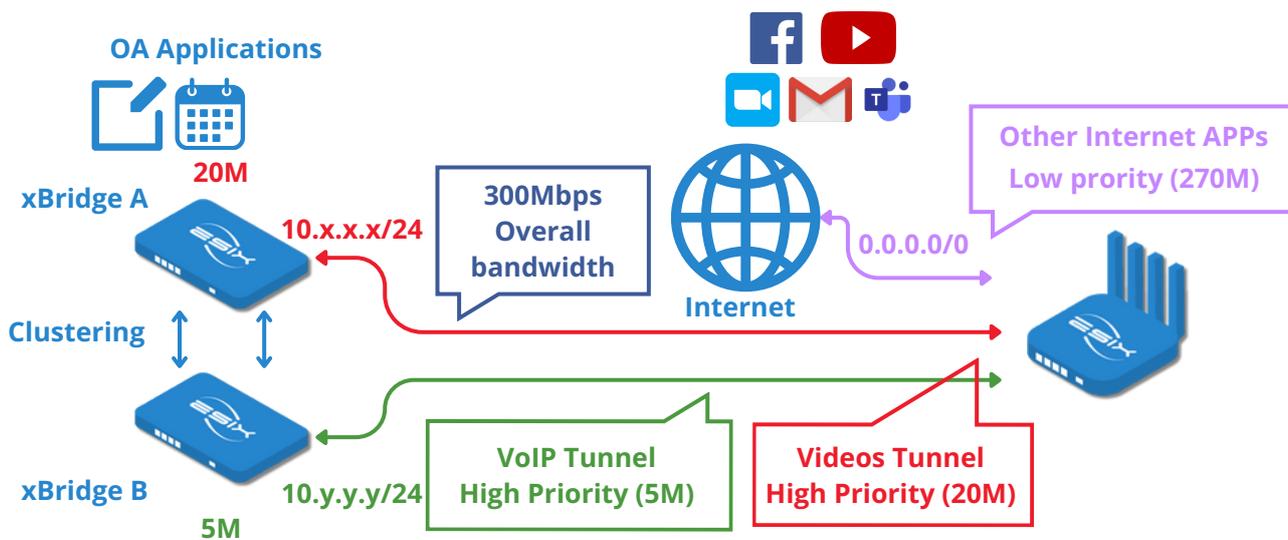


Figure 11. Internal Local Breakout (LBO) Traffic Classification Based

Zero Touching Provisioning

To optimize the OPEX, the SDM Network offers the advanced setup to minimize the skill of information technology and operation effort – Zero Touching Provisioning.

All of the Xatellite series routers could be deployed with zero configuration deployment.

- Step 1: Pre-Configuration

Operators pre-configure the primary eBrainM server address and account authentication password through the pre-configuration template of the internet connection method, for example, PPPoE, DHCP client, etc.

- Step 2: Insert Ethernet Cable and Power Up

Customers receive the CPE, wire the ethernet cables, and power up the Xatellite CPE.

- Step 3: Voilà~ Xatellite is now online

Xatellite goes online and establishes the virtual circuit automatically without users' configuration, gets a DHCP address from that internet circuit, and gets public DNS reachability.

This approach significantly reduces the installation, debugging time, and installation cost. It's hugely comforting and improves the confidence of the IT admin to maintain this network architecture.

Customer Portal

There is a complete network management suite for monitoring and controlling all the registered devices. This centralized management platform is web based so that the supervisor could easily log into the system anytime and everywhere. After device deployment and getting online, the status of all the devices is presented on the eSIX network platform, see Figure 12.

Two unique features here are useful for the management global business:

1. Multi-tenancy, the system could build multiple access accounts with different administration levels. It provides management flexibility and control insurance for the different job functions within the organization.
2. Location Info, the device will report its geo-location to the system to identify the visibility. It would easily spot the device on the map to check if it has been set up in the right place. Offering the global view of network structure to the supervisor.

It's a powerful central management platform that suitable for

- enterprise have branches office in multiple locations even abroad for finance monitoring
- organizations have multiple work locations for security documentation sharing
- industrial have different operation locations for high-volume data synchronization

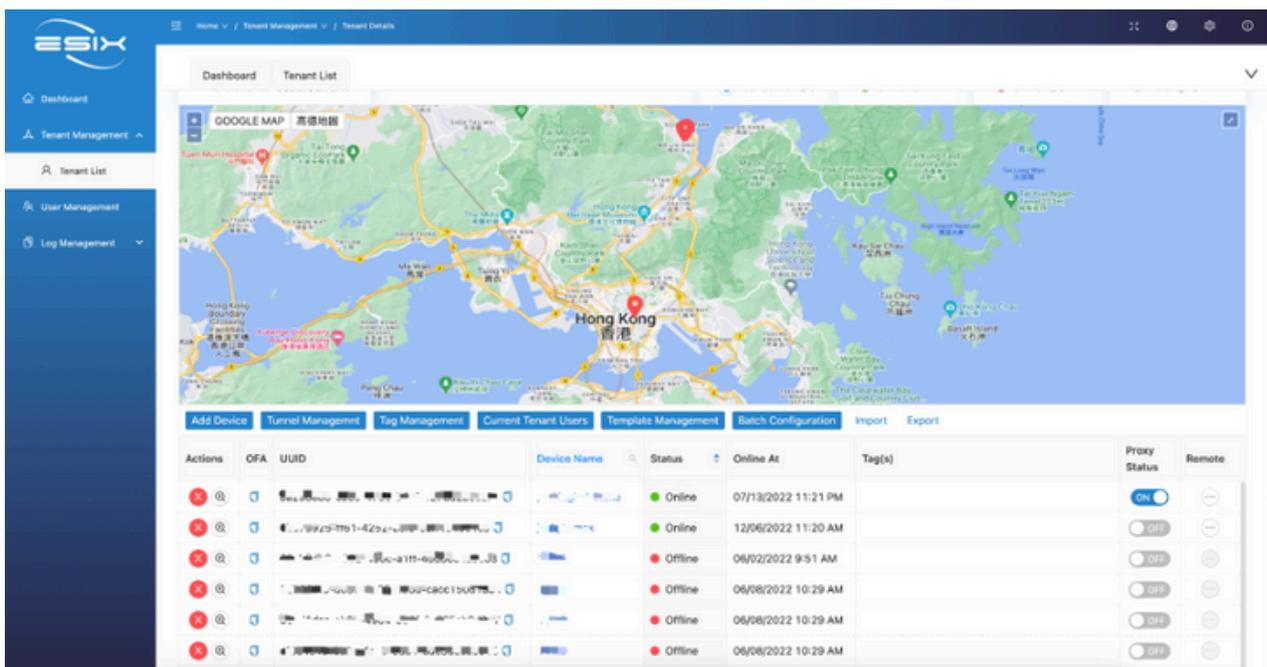


Figure 12. eBrain Central Management Platform

And in this platform, the device could be added, removed or modified. Looking into each individual device, it can see the tunnel type and connection status that is also shown in the map with color recognition. In addition to finding the device in the tenancy list, it could also check the map and pinout the device, see Figure 13.

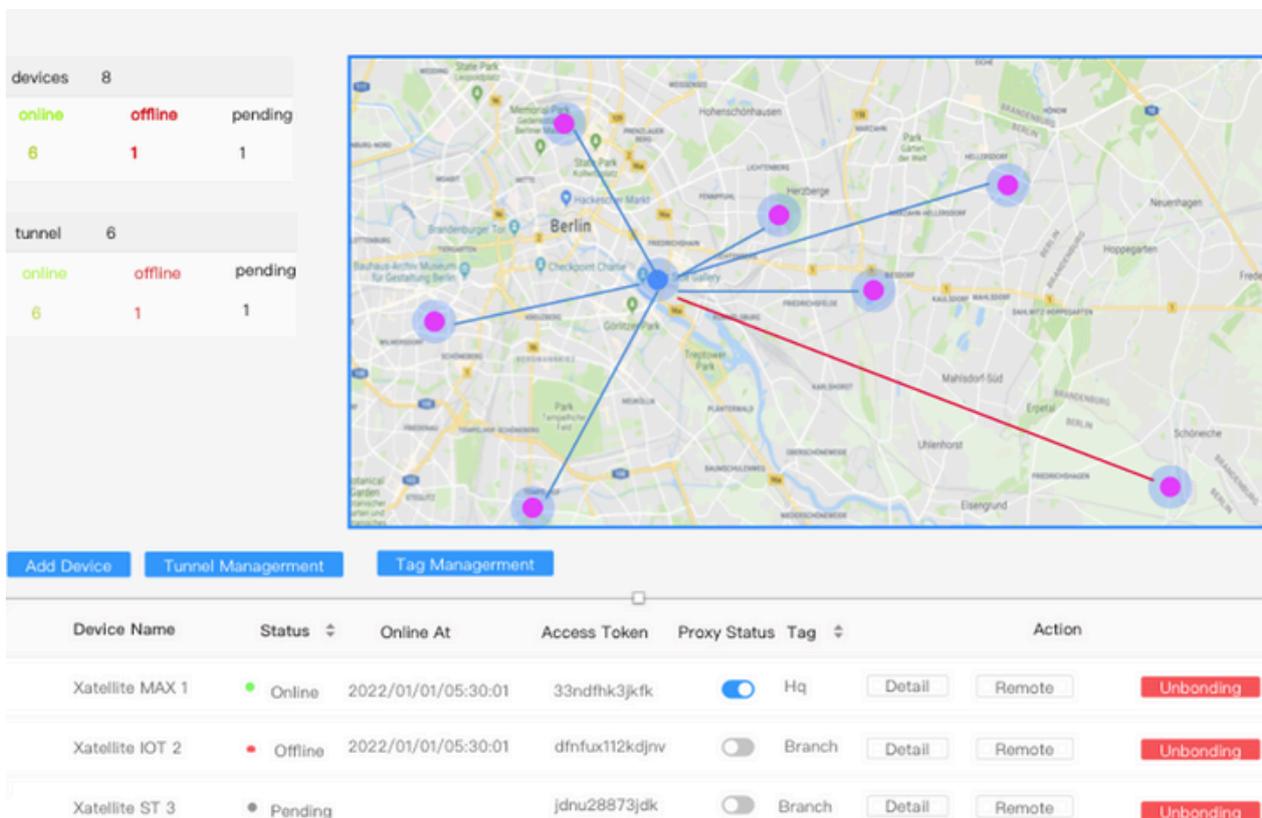


Figure 13. The Device Status in a Tenancy

Cases

Retail

Many pop-up stores face significant time-to-market challenges due to high costs and wiring delays in shopping malls.

CHALLENGE:

Some locations are unable to install wired networks due to policies and logistical obstacles. Existing fixed-line networks experience disruptions averaging 5.2 hours per month.

SOLUTION:

By implementing eSIX SDM, the organization achieved simplified network provisioning, enabling rapid deployment of new stores and seamless expansion. Troubleshooting became faster and more efficient, with centralized control and visibility across the entire network. The scalability of the network was significantly improved, allowing the organization to easily accommodate increased customer demand and adapt to changing business needs.



Use Case

Device to use:



Xatellite B

Smart Lamp Posts

Smart lamp posts are vital for modern urban infrastructure, enabling wireless networks that connect traffic lights, cameras, and sensors, ultimately improving traffic management and public safety. eSIX's IPfiber™ technology guarantees continuous network connectivity for these essential components.

CHALLENGE:

Integrating numerous sensors for real-time environmental analysis, simplifying wiring, and minimizing maintenance costs are key challenges for smart lamp post deployments.

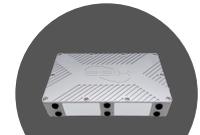
SOLUTION:

eSIX's SDM Network, powered by IPfiber™ technology, provides a robust and scalable network infrastructure for smart lamp post deployments and their diverse applications. SDM ensures seamless, secure, and reliable wireless connectivity for traffic lights, cameras, and environmental sensors by leveraging 4G, 5G, and other broadband access options. The integrated Xatellite CPEs offer Power over Ethernet (PoE) to simplify wiring at each site, while eBrain central management enables remote monitoring and streamlined maintenance, significantly reducing operational costs. Through secure network segmentation and traffic local breakout, SDM delivers optimized performance and protects sensitive data streams for different city departments. This comprehensive SDM Network empowers smart urban infrastructure with enhanced connectivity, supporting intelligent transportation systems, assisted driving, and public Wi-Fi services effectively and cost-efficiently.



Use Case

Device to use:



Xatellite PWR-L



Xatellite MAX

Chain Property Shops

A large property shop requires market sales data synchronization across hundreds of chain stores, and is principally engaged in the design, development, construction and sale of residential and commercial properties, as well as the provision of property management services.

CHALLENGE:

- Synchronizing and securing marketing data over a public network.
- High demand on professional IT staff.
- Complex infrastructure setup.
- Network operation, management, troubleshooting, and maintenance.

SOLUTION:

eSIX SDM provides an easily set up and centrally managed solution. The IPfiber™ technology creates virtual tunnels between chain stores and the HQ data center for secure marketing data synchronization. It offers adaptive QoS to prioritize different data. It can be wired into existing infrastructure.

ACHIEVEMENT:

- Plug-n-Play within the existing infrastructure: 80% off CAPEX.
- Installation & Deployment in minutes.
- Professional IT Unnecessary: 90% off OPEX.



Use Case

Device to use:



Xatellite B

Logistics

The surge in e-commerce has created a huge demand for logistics companies and a need to integrate IoT devices for greater capacity. Logistics companies are upgrading their systems with cameras, sensors, robots, and barcode systems, demanding secure and reliable networks.

CHALLENGE:

- Equipment Costs: Traditional routers have limited bandwidth, necessitating numerous units, thereby increasing expenses.
- Setup Costs: Fiber installation in large warehouses is expensive.
- Maintenance Costs: Wired networks are prone to physical damage, leading to high repair costs.

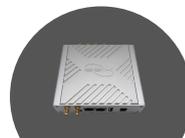
SOLUTION:

eSIX's SDM Network uses 5G wireless connectivity and IPfiber™ technology to support hundreds of IoT devices—cameras, sensors, robots, and barcode systems—with high reliability. This reduces equipment costs by cutting the number of routers and avoids expensive fiber installation in warehouses. Plug-and-play Xatellite CPEs simplify deployment without special skills. Wireless fiber over 5G and SDM's failover reduce maintenance costs linked to wired networks. Centralized eBrain management enables real-time inventory, remote monitoring, and ensures secure, continuous connectivity—offering logistics operators a cost-effective, scalable network solution.



Use Case

Device to use:



Xatellite ST2



Xatellite B

I Key Takeaway

***Deploy new points of presence—in days, not months:
SDM lets you offer
secure metro-grade services without local fiber.***

A Next-Generation Advanced SD-WAN Solution for Operators:

- **Advanced SD-WAN** designed for telecom operators, MVNOs, and virtual providers.
- True **Layer 2 and Layer 3 overlay** networking integrating 4G/5G, WiFi, MPLS, broadband, and satellite.
- **Seamless last-mile** reach without the need for fixed public IP addresses.
- **Sub-second failover** and multi-link load balancing with automatic 5G backup.
- **High-grade security** with optional MACsec, AES-256 encryption, and IP address hiding for privacy and compliance.
- **Centralized, cloud-based management** with multi-tenancy and geo-location tracking.
- **Zero-touch provisioning** reduces deployment time and operational complexity.
- **Application-agnostic** platform optimized for mission-critical and latency-sensitive services.
- Supports **cross-network and cross-border** connectivity with full protocol agnosticism.
- **Cost-effective** solution reducing CAPEX and OPEX for rapid market entry and scalable growth.

About eSIX Limited

eSIX Limited is a leading networking edge technology company headquartered in Hong Kong Science Park. Specializing in advanced network infrastructure solutions for telecom operators, MVNOs, and virtual providers, eSIX empowers its partners to rapidly deploy, manage, and scale next-generation connectivity services.

At the core of eSIX's innovation is its patented **IPfiber™** technology and Software Defined Metro (SDM) network—designed to seamlessly integrate multiple access networks including 4G, 5G, MPLS, WiFi, satellite and broadband, delivering true Layer 2/3 operator-grade performance. eSIX's solutions enable operators to overcome last-mile challenges, accelerate market entry, reduce total cost of ownership, and maintain mission-critical network availability.

With proven commercial deployments across enterprise and industrial sectors, eSIX combines cutting-edge technology with operator-centric design to meet the evolving demands of global connectivity in the 5G era.

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