



Edge Compute and Networking Ready for AI

Reference Architectures

Infrastructure Services CSA

Technical Marketing



Agenda

- 1. Edge Portfolio Reference Architectures**
 - Edge Bare Metal
 - Edge Private Cloud
 - Network Storage
 - Data Protect
- 2. Top Use Cases**
 - Low latency high bandwidth media streaming
 - Distributed application and database hosting
 - Enterprise IT Infrastructure optimization
- 3. Cyber Resiliency Architecture**
- 4. Edge AI Inferencing**
- 5. Edge - NaaS Architecture**

The background of the slide is a photograph of a modern office interior, overlaid with a semi-transparent orange filter. In the foreground, a long wooden conference table is surrounded by orange chairs. A laptop is open on the table. In the background, there are glass-walled meeting rooms, a kitchen area with a white countertop, and a large blackboard. The lighting is warm and modern, with several pendant lights hanging from the ceiling.

Edge Product Portfolio Architectures

Scalable Frameworks for Individual Products

Lumen Edge Solutions

Core Value Proposition

- Customizable local compute and storage turn-key solutions.
- Flexible and scalable from single server Edge Bare Metal to Edge Private Cloud data centers.
- Forest-level cleanroom Data Protect cloud backups with Commvault Cloud.
- Data Storage with AI-assisted malware detection powered by NetApp to ensure Cyber Resiliency and peace of mind.
- Tightly connected to Lumen's NaaS network infrastructure designed to streamline and simplify your environment from the cloud to the edge endpoint.

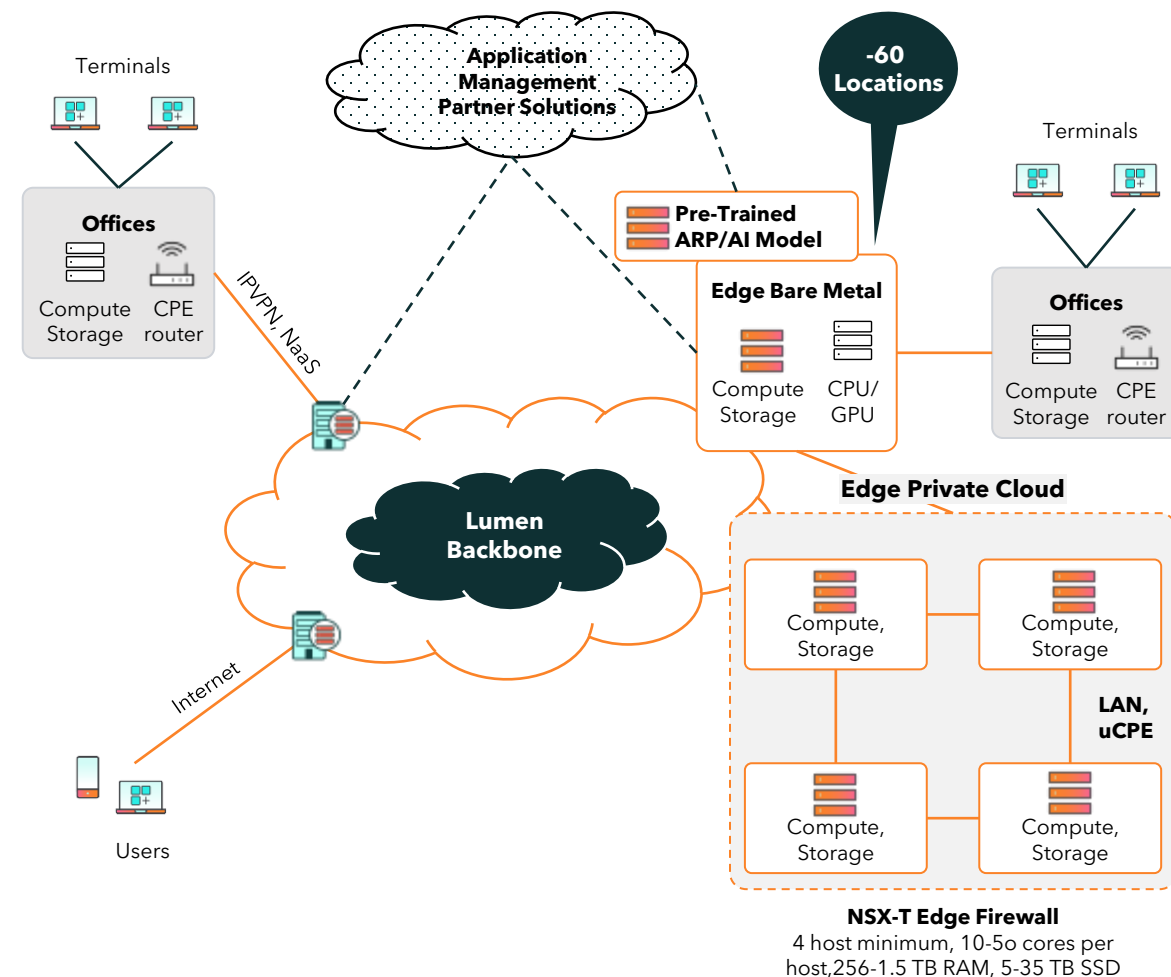
Lumen Advantage

- ~60 Edge Bare Metal sites within 250 miles of 95% of US brings workloads close where they are accessed.
- > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.
- ≤ 5ms of latency designed to cover up to 97% of U.S. enterprise demand.
- Strong partnerships with application management solution providers, cloud service providers, compute and network equipment suppliers.

Use Cases and Verticals

- **Key Use Cases:** low latency high bandwidth media streaming, distributed shared application and database hosting including virtual desktop infrastructure (VDI), enterprise IT infrastructure optimization, data analytics, and secure confidential data management.
- **Key Verticals:** live event hosting, media streaming services, retail, enterprise, transportation and logistics, healthcare, finance, waste management, manufacturing.

Built for the capacity, bandwidth, compute, number of locations, resiliency and security you require



Lumen Edge Product Stack

Core Value Proposition

- Customizable local compute and storage turn-key solutions. Let us size and configure your Edge IT infrastructure to meet your exact needs.
- Flexible and scalable from single server Edge Bare Metal to Edge Private Cloud data centers.
- Forest-level cleanroom Data Protect cloud backups with Commvault Cloud .
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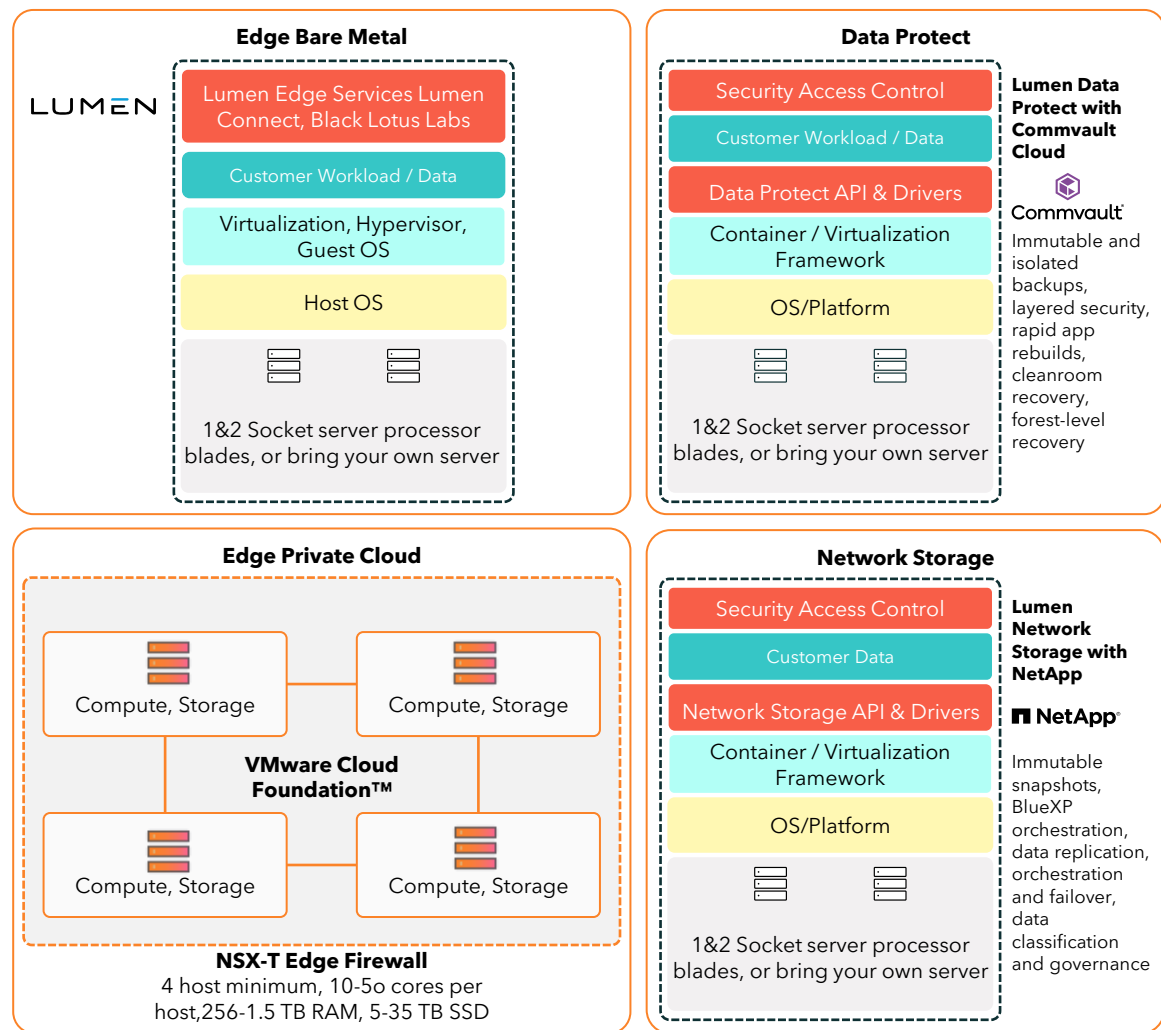
Lumen Advantage

- ~60 Edge Bare Metal sites within 250 miles of 95% of US.
- > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.
- ≤ 5ms of latency designed to cover up to 97% of U.S. business demand.
- Strong partnerships with multiple data center hypervisor and private cloud virtualization providers.
- Strong partnerships with application management solution providers, cloud service providers, compute and network equipment suppliers.

Use Cases and Verticals

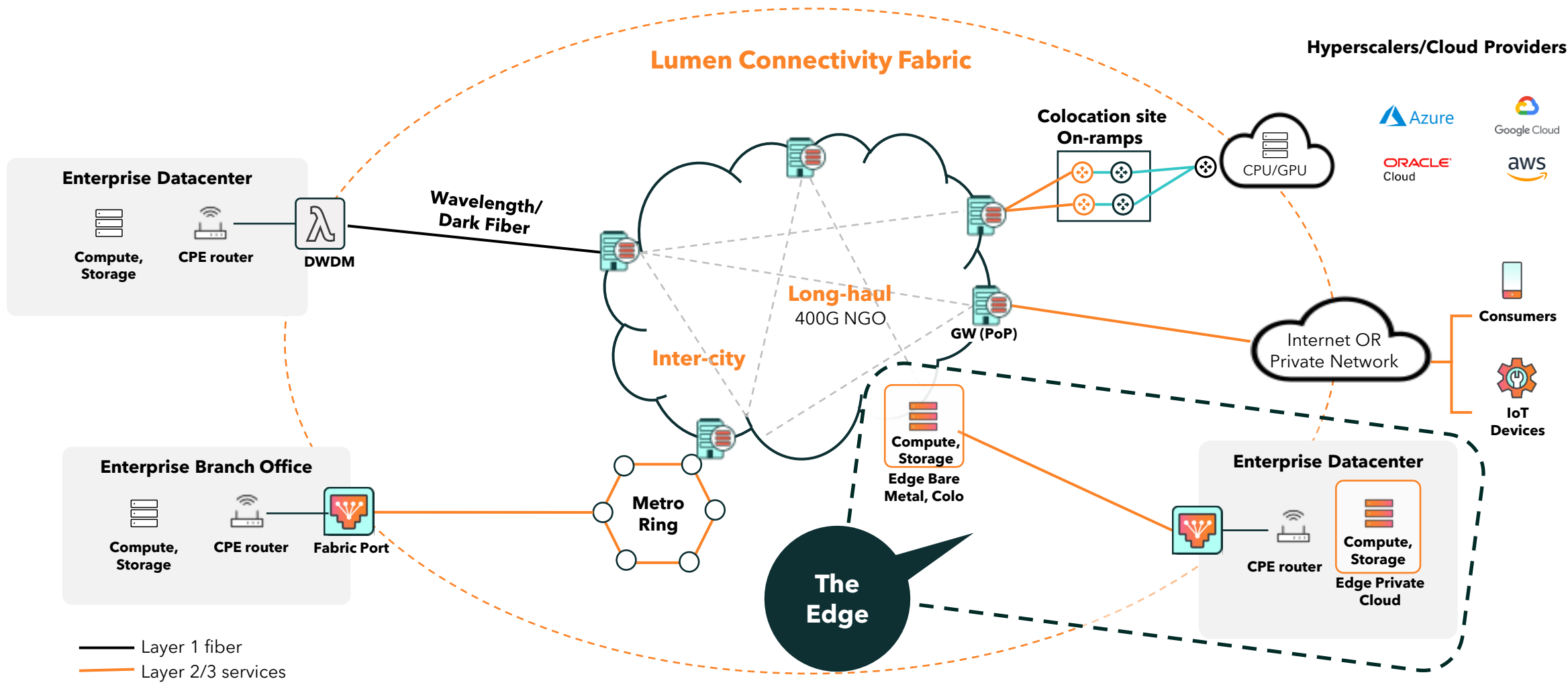
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A Composable Edge Product Portfolio



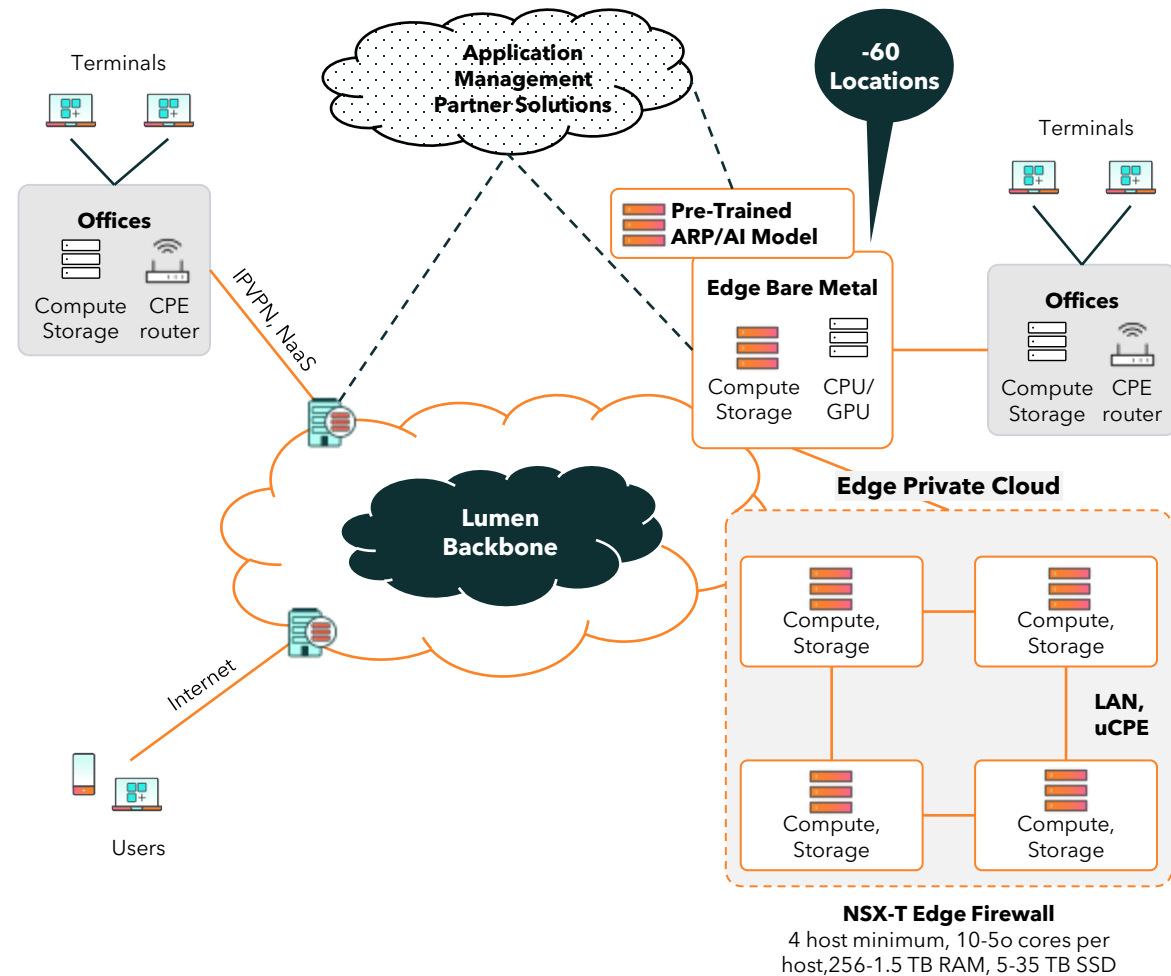
Secure and confidential compute powered by Lumen's widely available network and strong software solution partners

Network Infrastructure Architecture



Largest high-capacity, ultra-low loss intercity fiber network in the North America connecting data centers, cloud providers and consumers

Typical Edge Use Case Architecture Overview



Fast and local compute with reliable distributed network and data center access where you need it most

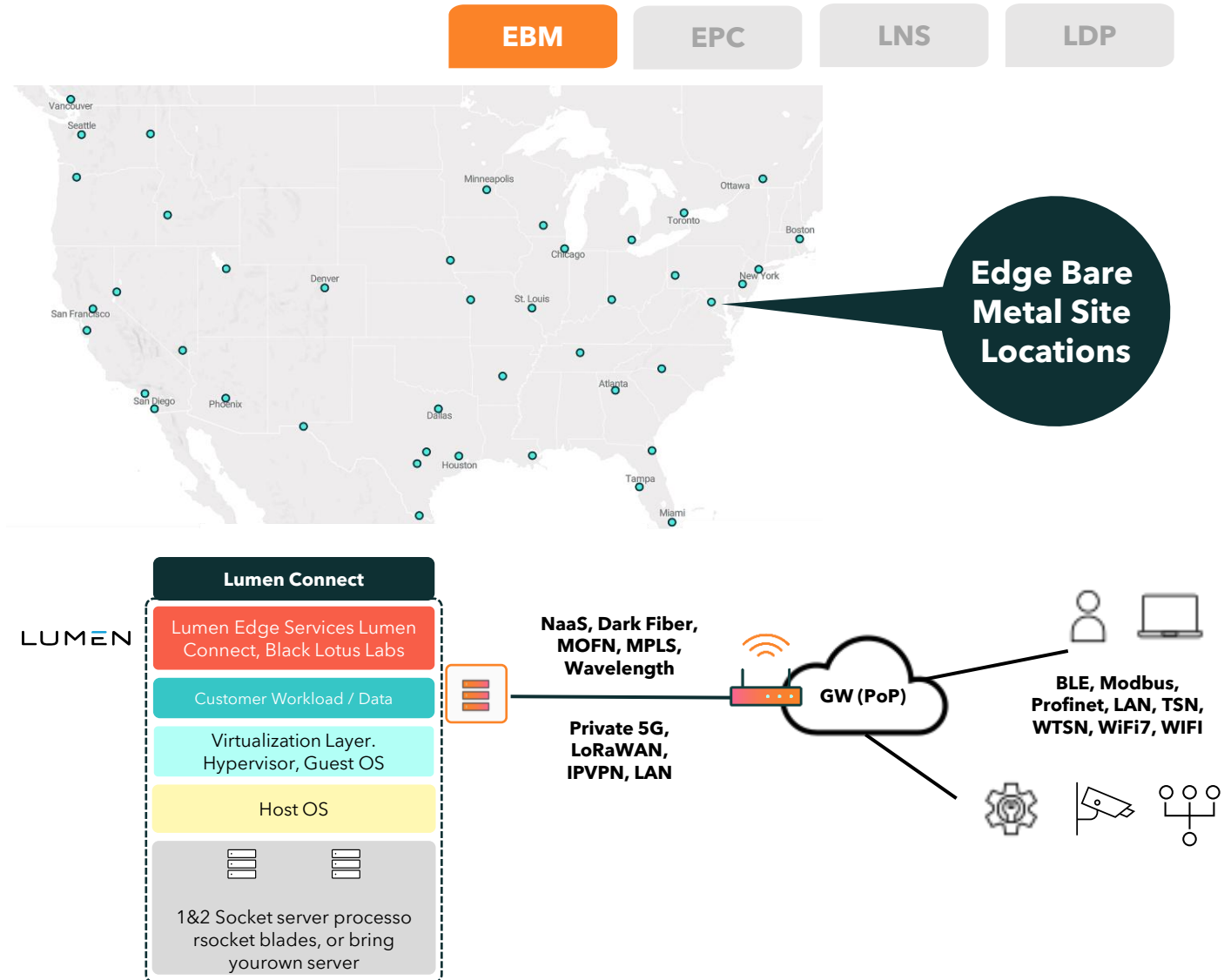
Edge Bare Metal

Core Value Proposition

- Bring intensive workloads and near real-time data processing closer to the source of digital interaction.
- Customizable local compute turn-key solutions. Let us size and configure your Edge IT infrastructure to meet your exact needs.
- Hosted in our Lumen data centers close to your corporate location.
- OS, type 2 hypervisor virtualization, and Lumen Connect SaaS service orchestration and network interconnect configuration included.

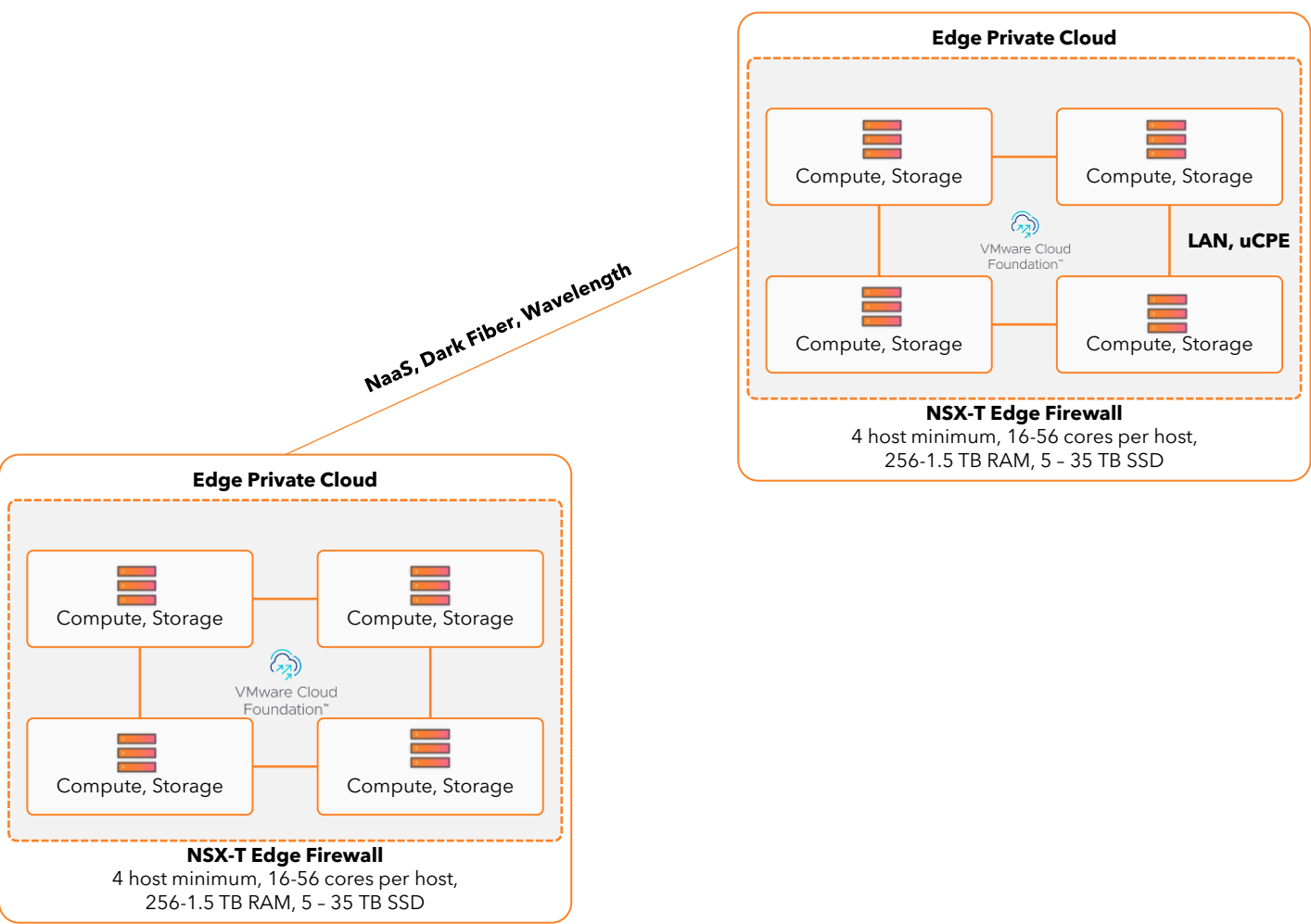
Lumen Advantage

- ~60 EBM sites within 250 miles of 95% of US brings workloads close to the digital interaction.
- > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.
 - Amazon Web Services has 31 edge network locations and > 340 data center sites.
 - Microsoft Azure has 192 edge network locations and > 400 data center sites
- Tightly connected to Lumen's NaaS network infrastructure, ensuring ≤ 5ms of latency designed to cover up to 97% of U.S. enterprise demand.



Data, bandwidth, and compute wherever you need them., using the largest data center access footprint in the industry

Edge Private Cloud



- EBM
- EPC**
- LNS
- LDP

Core Value Proposition

- We build your flexible and scalable compute cluster for you.
- Prebuilt or build to order.
- Add additional compute nodes or GPUs.
- Integrated Firewall protection.
- Stack deployment and management assistance available.

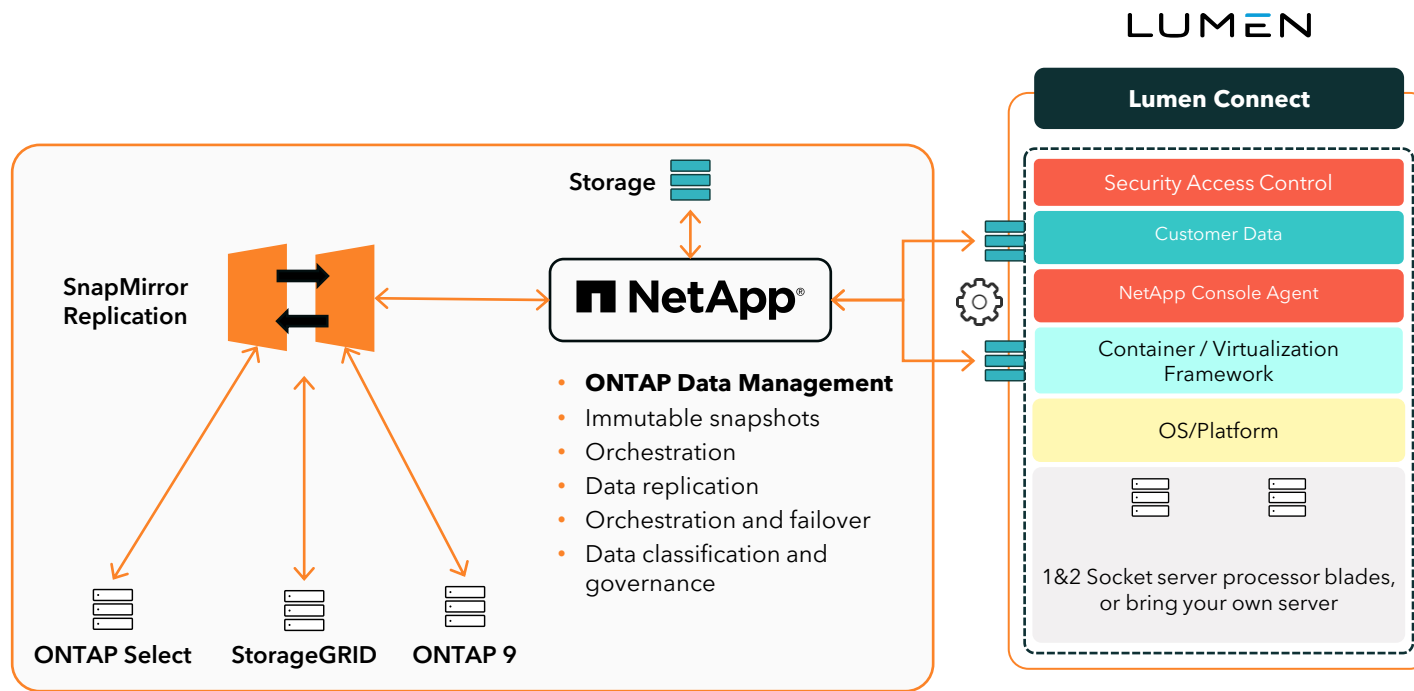
Lumen Advantage

- Strong partnership with Broadcom VMware and HPE Greenlake
- Tightly connected to Lumen's NaaS network infrastructure, ensuring $\leq 5\text{ms}$ of latency designed to cover up to 97% of U.S. enterprise demand.
- > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.
- Full Composability with Colocation, Managed Infrastructure, Edge Bare Metal, Data Protect, Network Storage and other Lumen solutions

Your Personalized Scalable Edge Compute Data Center

Medium option Pre-built, per host	Large option Pre-built, per host	Custom option Pre-built, per host
• 32 cores • 384 GB RAM • 5 TB usable SSD	• 32 cores • 768 GB RAM • 20 TB usable SSD	• 16-56 core • 256 GB - 1.5 TB RAM • 5-35 TB usable SSD

Lumen Network Storage



EBM

EPC

LNS

LDP

Core Value Proposition

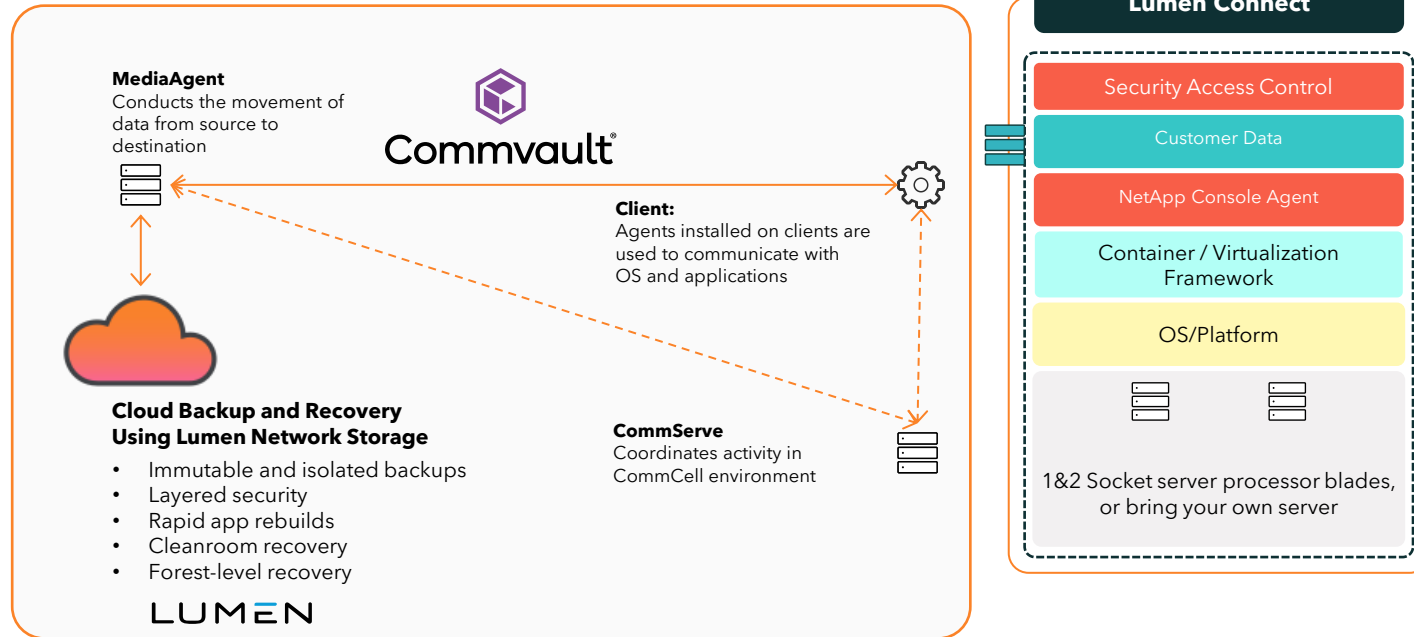
- Fully-managed storage service with data management orchestration.
- Flexible deployment through standardized, repeatable architecture and Open Network Technology for Appliance Products (ONTAP) everywhere.
- Available in many types of locations: Lumen Edge, 3rd-party Colocation, Managed Hosting, Customer premises and Public Cloud.
- AI-assisted data anomaly, access violation and ransomware detection.
- Building block architecture. No need to build configurations.

Lumen Advantage

- Strong partnership with NetApp.
- NetApp configuration access from Lumen Connect.
- Tightly connected to Lumen's NaaS network infrastructure, ensuring $\leq 5\text{ms}$ of latency designed to cover up to 97% of U.S. enterprise demand.
- Available from
 - ~60 EBM sites within 250 miles of 95% of US brings workloads close to the digital interaction.
 - > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.

Fully integrated with Edge Bare Metal and Lumen Connect

Lumen Data Protect



EBM

EPC

LNS

LDP

Core Value Proposition

- Lumen Data Protect with Commvault Cloud takes forest-level installation and data snapshots of your data center, uploads the data to a secure isolated location and keeps it ready for rapid redeployment.
- Enterprise-grade backup and recovery for simplified, scalable protection:
 - Maintain a known good cleanroom copy to ensure full recovery.
 - Require multi-layer security to air-gap backups.
 - Include the full configuration and functional forest level installation in backups.
 - Enable rapid rebuild and reprovisioning once threat vector is addressed.

Lumen Advantage

- Strong partnership with Commvault.
- Commvault configuration access from Lumen Connect.
- Tightly connected to Lumen's NaaS network infrastructure, ensuring $\leq 5\text{ms}$ of latency designed to cover up to 97% of U.S. enterprise demand.
- Available from
 - ~60 EBM sites within 250 miles of 95% of US brings workloads close to the digital interaction.
 - > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.

Air-gapped protection and rapid recovery for your critical data, using Lumen Network Storage and Lumen Data Protects' seamless coordination

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Top 3 Use Cases

Edge Compute Value Proposition

Edge Compute and Storage - Top Use Cases

1 Low Latency High Bandwidth Media Streaming

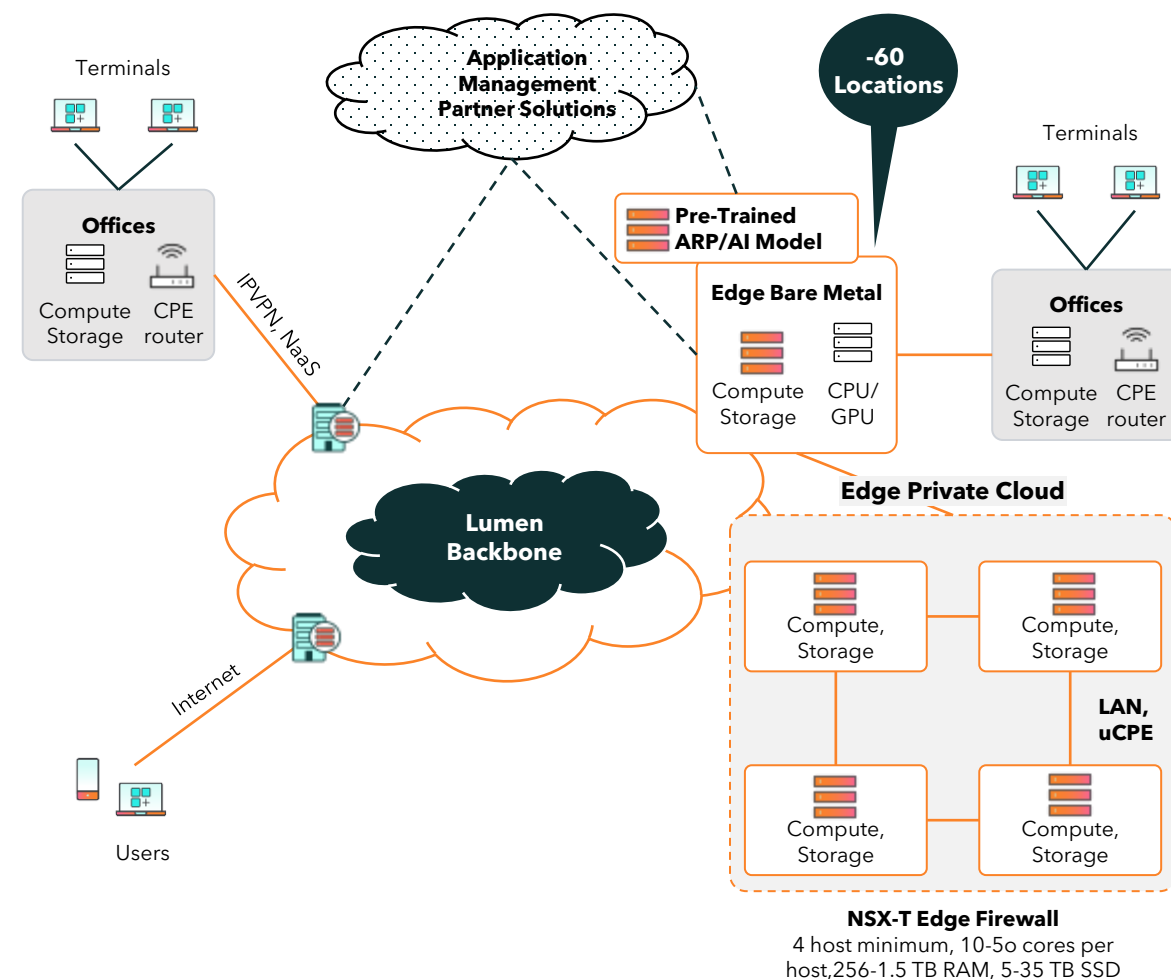
- Edge Bare Metal at scale enables digital media fan-out together with Lumen NaaS and Dark Fiber
- Ready-to-use reliable and secure low-latency high-bandwidth data stream optimization

2 Distributed/Shared Application and Database Hosting

- Edge Private Cloud and Edge Bare Metal for reliable, fast, and low-latency business application and desktop sharing across the entire organization
- Supported through strong ecosystem partner relationships

3 Enterprise IT Infrastructure Optimization

- Edge Private Cloud and Network Storage access close to corporate hubs for business application hosting
- Compute for local enterprise operations, analytics, production, and execution; Simplified enterprise network storage and data recovery



Combination of local data center, software stack and network infrastructure ownership. A composable and flexible one-stop-shop for M&P and IT infrastructure

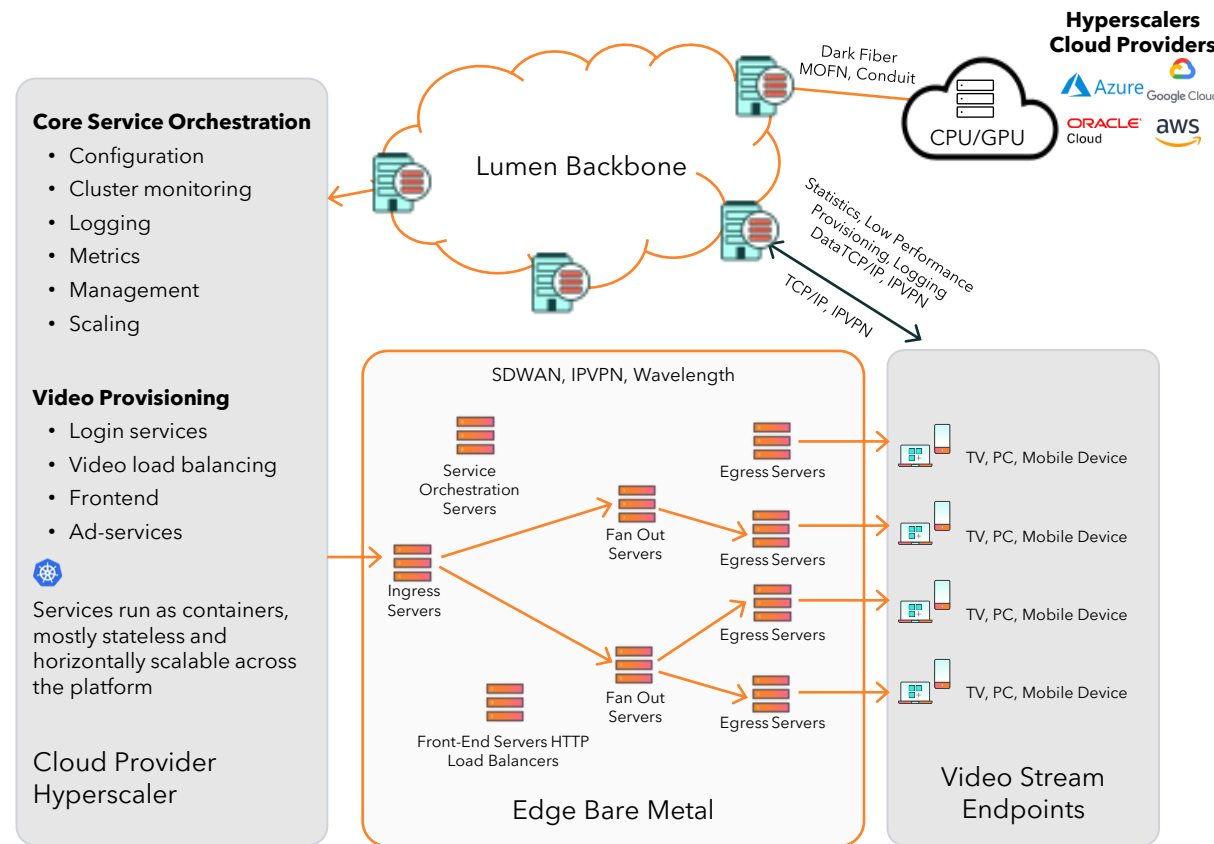
1. Low Latency High Bandwidth Media Streaming

Core Value Proposition

- Fast, reliable and secure media stream fan-out across the entire network using Edge Bare Metal (EBM)
- End-to-End Lumen solution

Lumen Advantage

- Anycast configuration with efficient fan-out through Edge Bare Metal
- Number 1 peered global network.* Compute plugs direct into the provider edge. Managed servers support live events
- High-end Vyvx media intake processing in some use cases
- ~60 EBM sites within 250 miles of 95% of US brings workloads close to the digital interaction
- Peering with AWS, Microsoft, Google and major network providers
- NaaS Integration
- Secure environment with Data Protect, mitigate unauthorized access, avoid service disruptions with Lumen DDoS services
- No egress fees



*The Center for Applied Internet Data Analysis (CAIDA), AS Rank, January 2025

Using Edge Bare Metal and Lumen Network at scale = low latency and high throughput

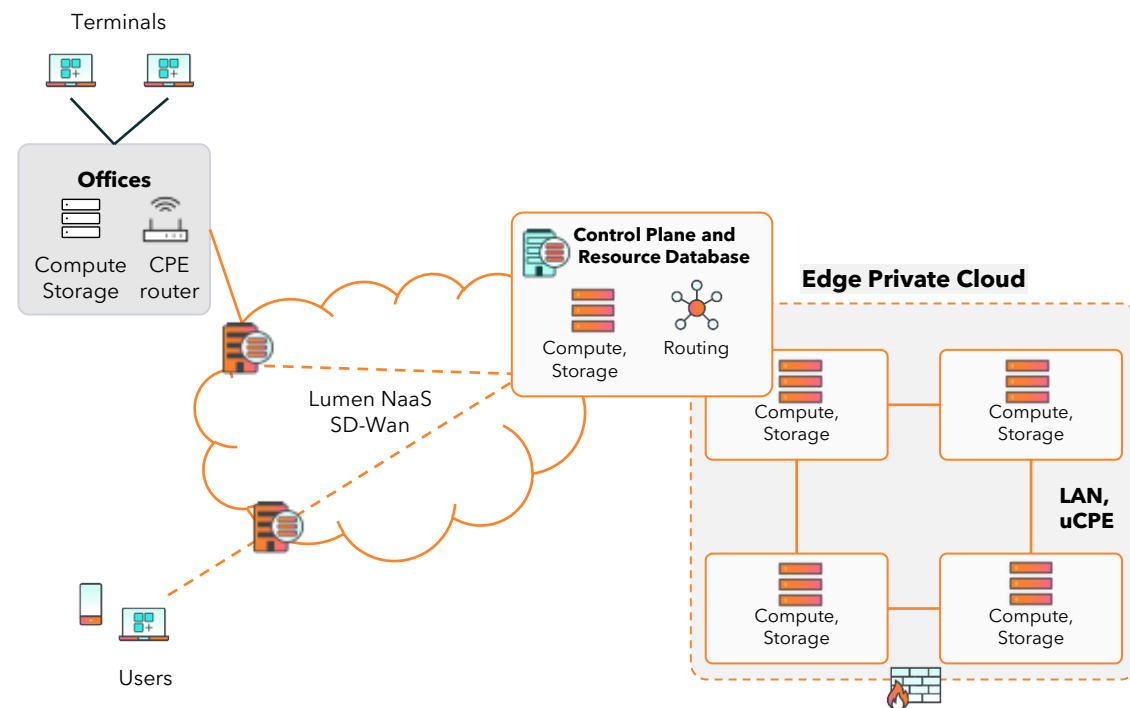
2. Distributed/Shared Application and Database Hosting

Core Value Proposition

- End-to-end reliable, fast, and low-latency application and desktop sharing across the entire organization
- Local private and secure solution hosting
- Easy to provision and manage
- Easy and deep integration with enterprise IT infrastructure

Lumen Advantage

- Local and secure private access near you
- ~60 available edge data center locations
- Well-established solution partners
- Network Storage for App Staging
- Fully virtualizable IT stack
- No egress fees



Architecture Zoom In

Local, secure, reliable, fast, and complete networked application management

3. Enterprise IT Infrastructure Optimization

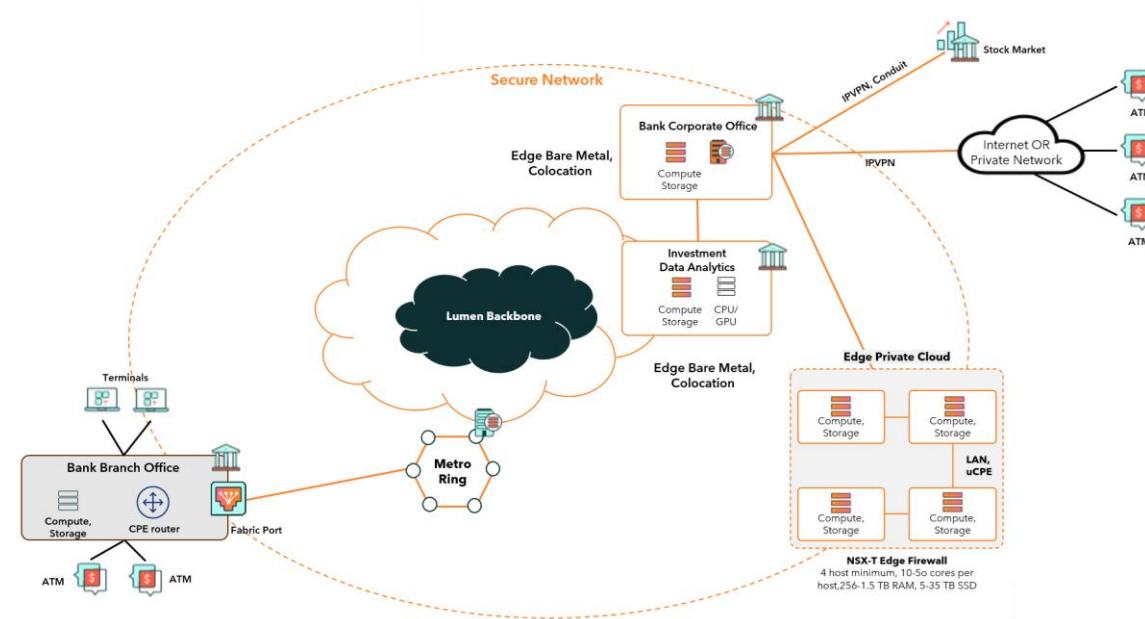
Core Value Proposition

- Simplify your IT infrastructure and M&P operations
- One-stop solution combining local compute, network storage, data protection, firewall and cyber security
- Move enterprise compute and analytics onto a standardized data center configuration
- Robust, connected solution where the customer needs it
- Designed to reduce OpEx through use of EBM and EPC instead of custom on-prem or network solution
- Built to improve reliability, responsiveness (latency), and solution security

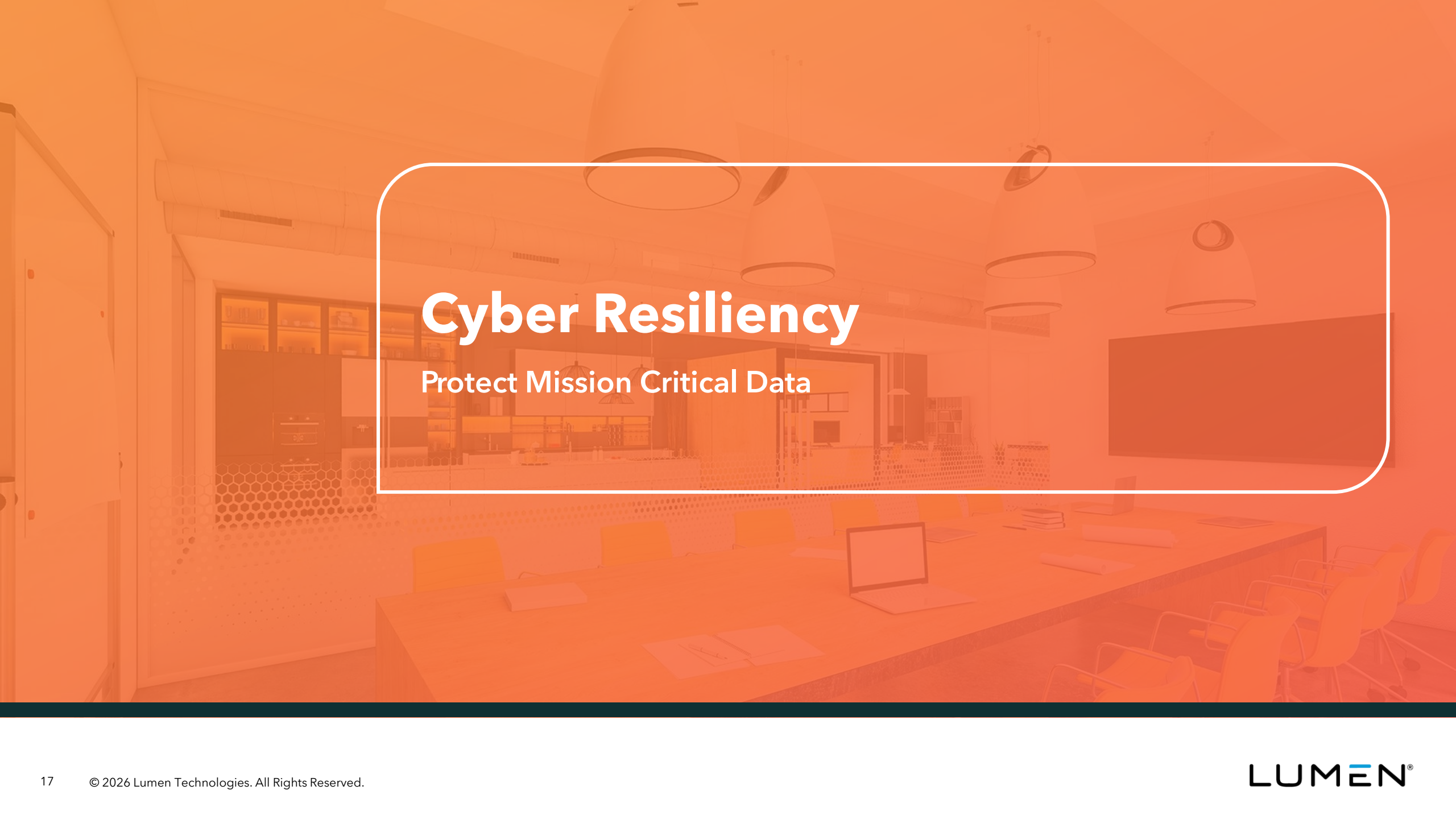
Lumen Advantage

- Easy integration with existing IT infrastructure
- Deployable anywhere. Over 2000 (public, private, 3rd party) data centers are connected to Lumen's network
- Low latency
- Network Storage, Data Protect, Firewall, Network Threat Assessment all included
- Scalable NaaS Access
- No egress fees

Example: Finance Vertical



Built for cost efficient, local, secure, reliable and fast access to compute and network assets across the entire enterprise

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Cyber Resiliency

Protect Mission Critical Data

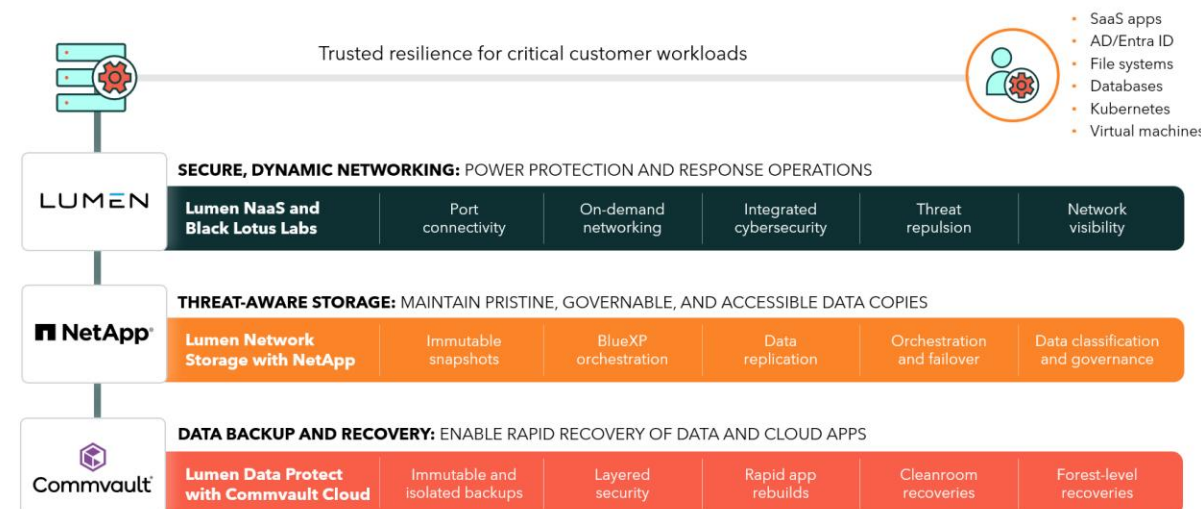
Cyber Resiliency

Core Value Proposition

- Data recovery, data storage, data loss prevention, anomaly and ransomware detection, and network threat protection in one solution
- Protection for data at rest and data in motion
- Based on long-standing and well-established industry relationships
- Easy integration with and extension to existing IT infrastructure
- Local and secure private access near you to enable low latency, fast response, and fast recovery

Lumen Advantage

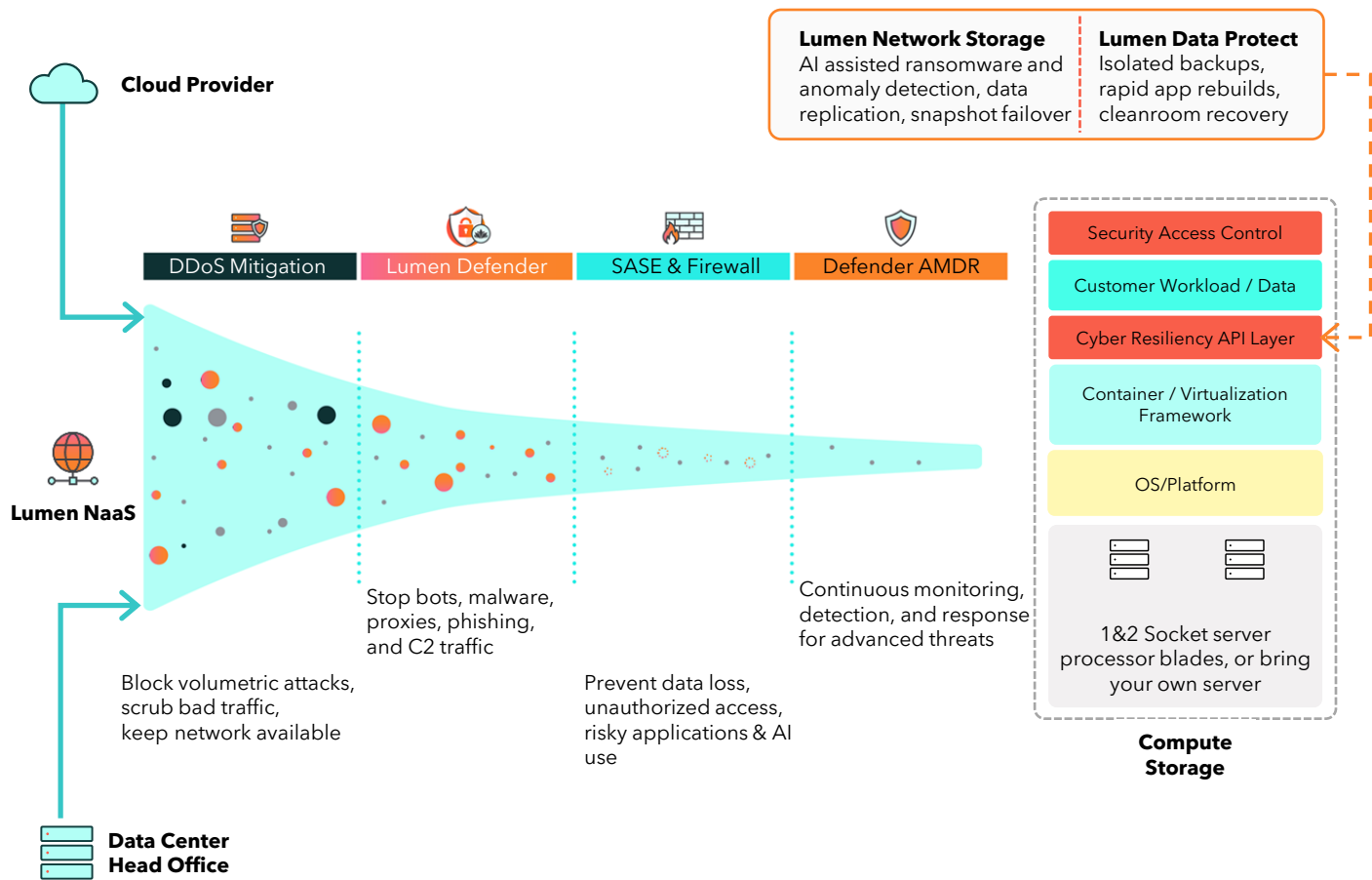
- Cyber security and network threat detection expertise through Black Lotus Labs and NaaS infrastructure
- Established partnership with Commvault and NetApp
- Automated AI-assisted ransomware detection and mitigation
- Close integration of network security with file inspection, data recovery and data storage
- Network and IT infrastructure know how
- Local private and secure solution hosting with ~60 available data center locations



All-in-one data recovery, data storage, data loss prevention, anomaly detection, and network threat protection

Cyber Resiliency: 3 Steps to Peace of Mind

1. Designed to Ensure Network Reliability and Security



Business Challenge

- Operational continuity expectations
- Rising cyber threats, data privacy and security concerns
- Legacy network and storage infrastructure
- Regulatory compliance pressure
- Cloud dependency risks
- Intrusion and ransomware attacks

Lumen Solution

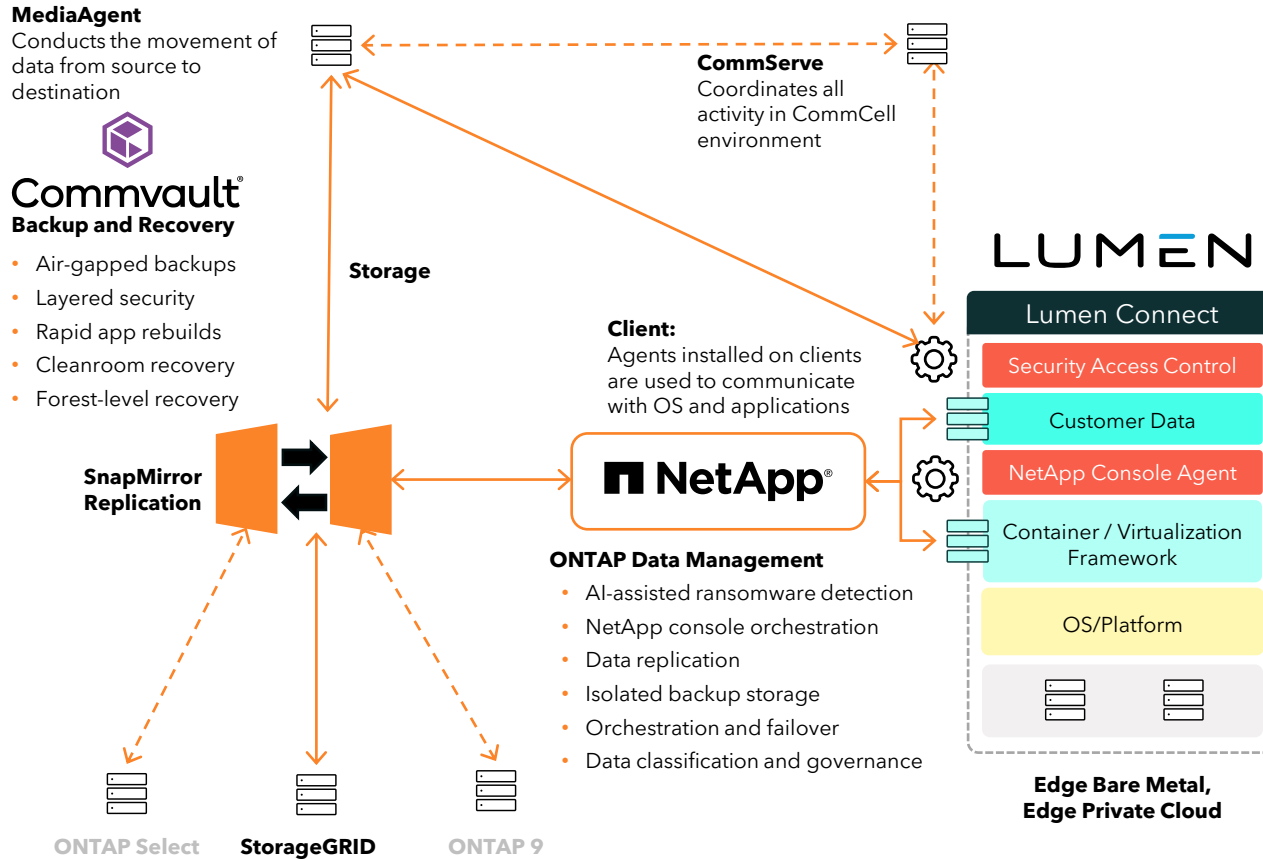
Cyber Resiliency is a fully integrated three-step solution to monitor the network and attack surfaces of your IT infrastructure, protect your configurations and data, and recover seamlessly.

- 1 Block threats and attack vectors** before they reach you:
Lumen NaaS and **Lumen Black Lotus Labs** provide on-demand networking connectivity, advanced actor tracking, high network visibility, and automated threat repulsion.
- 2 Stop bad actors and ransomware in its tracks:**
Lumen Network Storage provides near real-time AI-assisted data access anomaly and ransomware detection, storage orchestration service, efficient data replication, and rapid failover to save configurations.
- 3 Be prepared with advanced backup solutions:**
Lumen Data Protect for scalable protection. Immutable, cleanroom backups, comprehensive workload coverage, and rapid forest-level reprovisioning of a healthy environment.
- 4 Reliable, maintained and persistent tight integration:**
Lumen Managed Services enable tight integration of all solution components and the ability to customize to your needs.

Be ready to defend your data and recover quickly when the worst happens

Storage & Recovery Architecture

2. Protect your IT Infrastructure and Data at Rest



Business Challenge

Minimize downtime, when malware can corrupt multiple generations of backups:

- Maintain a known good cleanroom copy to ensure full recovery
- Require multi-layer security to air-gap backups
- Include the full configuration and functional forest level installation in backups
- Enable rapid rebuild and reprovisioning once threat vector is addressed

Lumen Solution

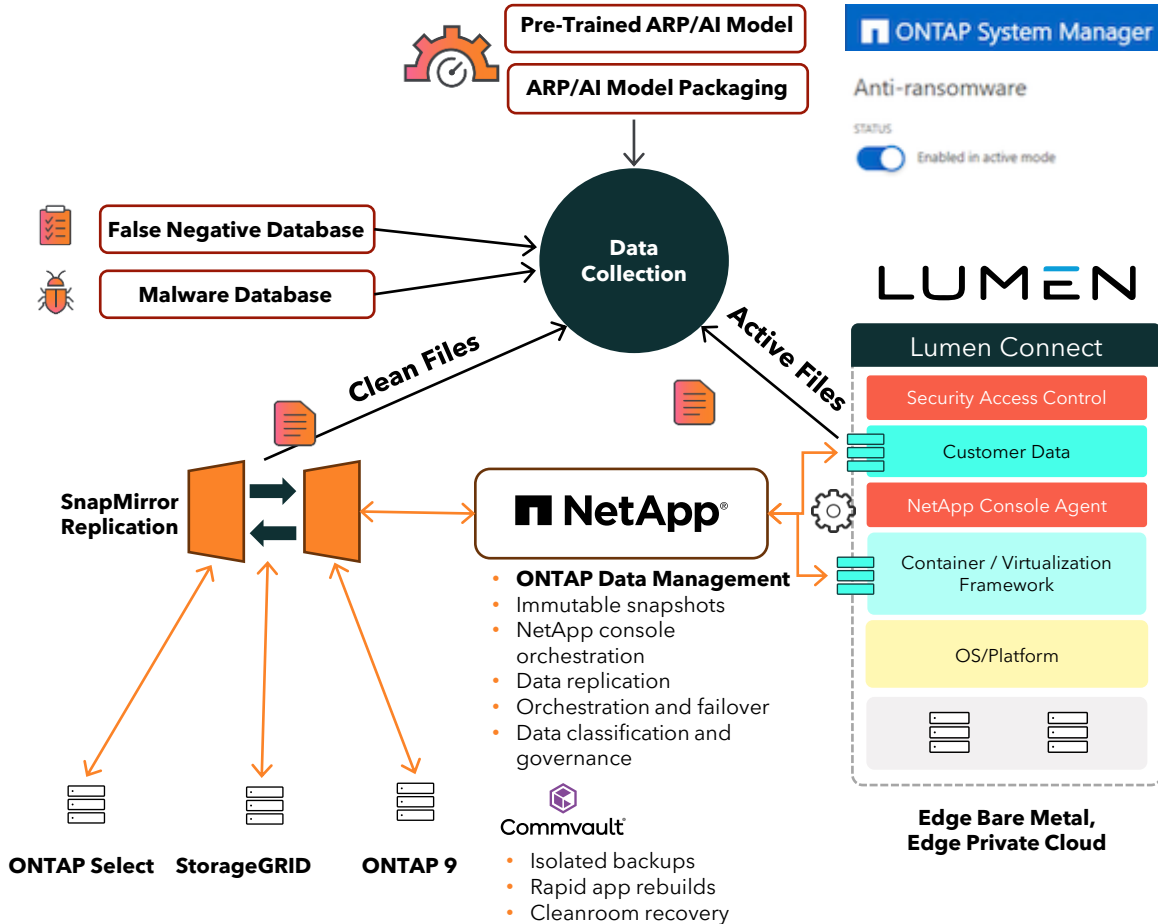
Air-Gapped Protection and Rapid Cleanroom Recovery

- 1 **Lumen Network Storage on NetApp StorageGRID** with NetApp data management **handles** isolated backup copies, regular **data replication, orchestration of scenario responses**, governance and classification of data types, and automated responses to unusual data movement including the orchestration of rapid recovery using Commvault backups.
- 2 **Lumen Data Protect** with **Commvault Cloud** takes forest-level installation and data **snapshots of your data center**, uploads the data to a secure isolated location under NetApp governance, and keeps it ready for rapid redeployment.
- 3 **If the worst happens you will recover quickly.** Corruption is halted using NetApp data management intelligence and your installation is rebuild using a Commvault cleanroom image with minimal downtime.
- 4 **Flexible and composable** to meet your exact requirements.

Keep your data safe and ready for rapid reprovisioning

Ransomware Detection and Recovery

3. Detect and Mitigate Data Access Anomalies Quickly with AI



Business Challenge

The frequency of ransomware has been increasing rapidly in recent years, causing

- Downtime of critical and sensitive systems in Finance, Healthcare, Security and Services
- Financially stress on organization
- Exposure of confidential and critical data to bad actors

Solution must

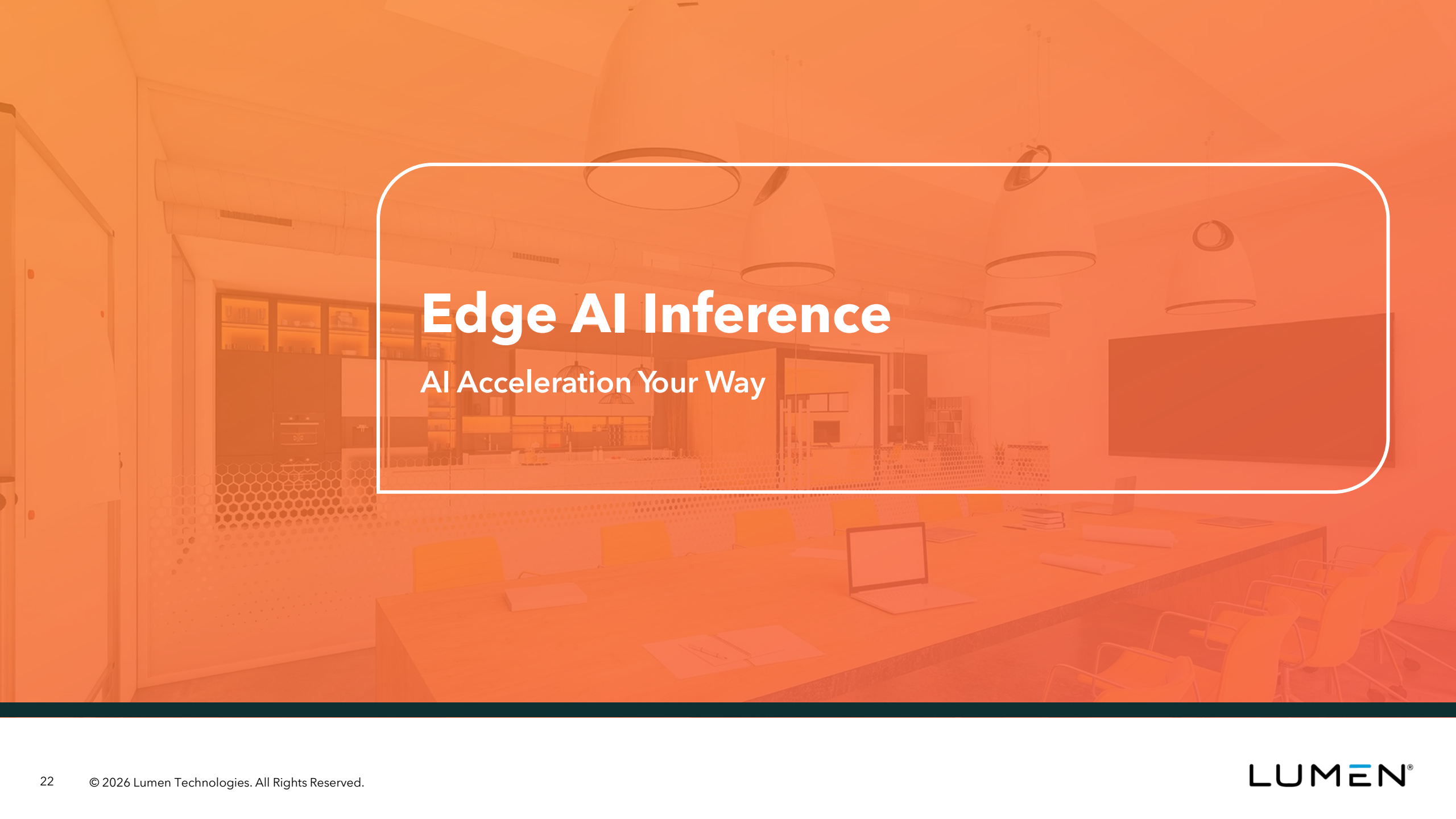
- Identify ransomware and malware intrusion quickly
- Protect data from corruption
- Recover to a clean known good installation quickly

Lumen Solution

Lumen Network Storage with NetApp Ransomware Resilience

- 1 **Trained** expandable **AI models detect** unauthorized data access, **anomalous data movement and** malware in your data center automatically using agents in your data center as part of NetApp's Open Network Technology for Appliance Products (ONTAP).
- 2 NetApp's Automated Ransomware Protection (ARP/AI) analytics detects constantly evolving forms of **ransomware with 99% accuracy** in NAS environments.
- 3 **These findings are compared with a database of known malware** and a customer configurable database of false negatives (known harmless code).
If ransomware is detected, live **data access is blocked**.
- 4 **Data is recovered using Commvault cleanroom recovery images.**

Ransomware detection with automatic backup recovery trigger

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Edge AI Inference

AI Acceleration Your Way

AI Inference on the Edge

Core Value Proposition

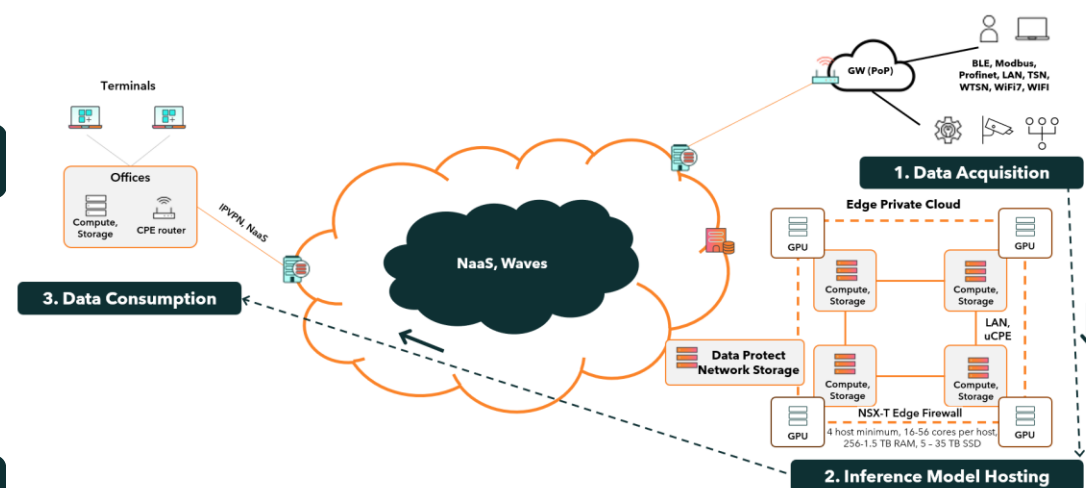
- Local, secure and low latency AI Inference
- Ideal for proprietary or sensitive data
- Simplify and move AI compute infrastructure maintenance and updates off-prem, while keeping latency low and keeping full control over your data
- Available compute scales and flexes with your needs
- Deploy custom models and datasets with the weights, biases and optimizations of your choice

Lumen Advantage

- Customers may procure GPUs and NPUs through Lumen including Managed Services around today's workloads.
- Intended to deploy across build to order Edge Private Cloud environments, as well as future edge platforms.
- Network ownership without egress fees

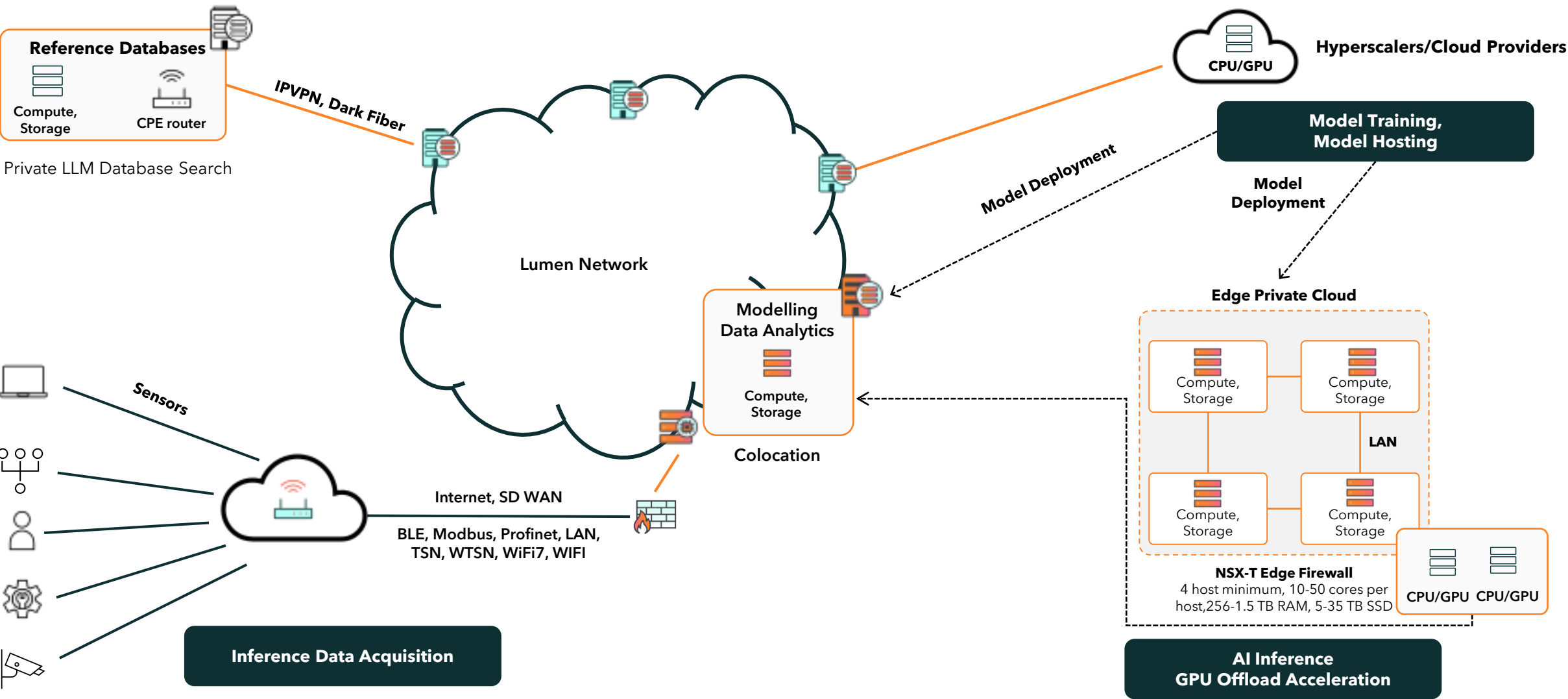
Use Cases and Verticals

- **Key Verticals:** Industrial/Manufacturing, Municipalities, Public Sector, Enterprise, Healthcare, Finance, Gaming
- **Key Use Cases:** Predictive Maintenance, Data Analytics, Fraud Detection, Smart City, Diagnostics, Robotics, Quality Assurance, Robotics, UAVs, Facial Recognition, Simulations

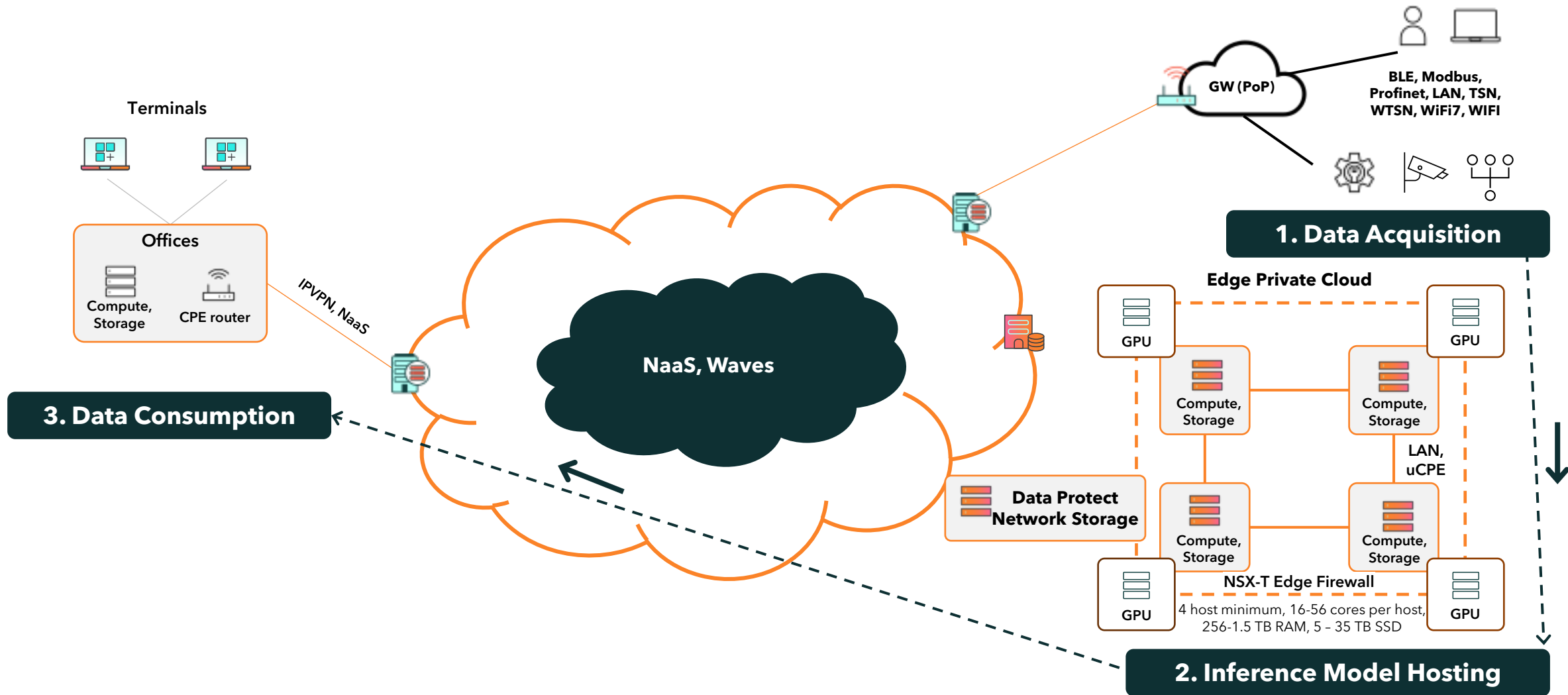


Local, secure and low latency AI/ML for custom and proprietary datasets

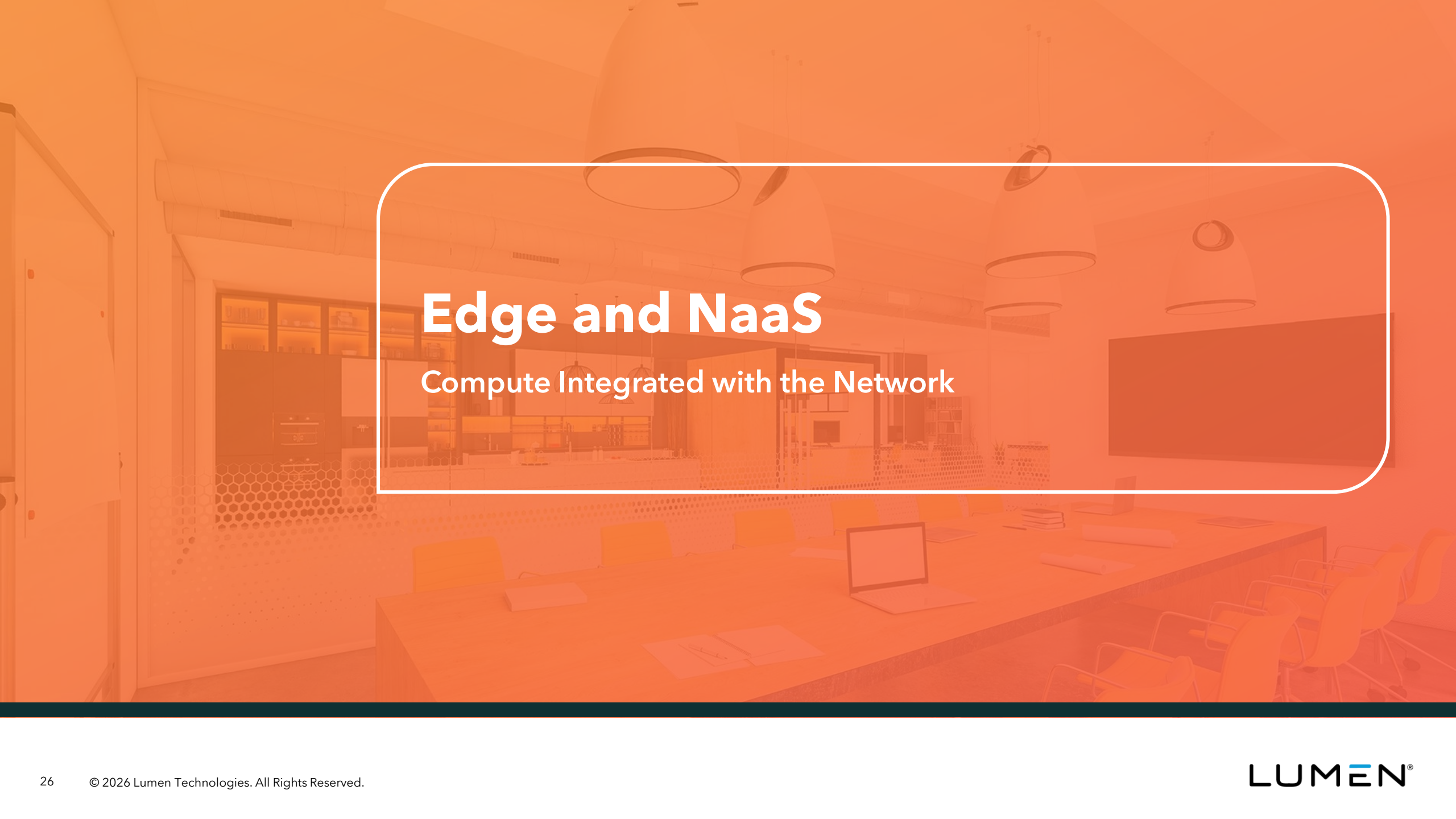
Edge AI Concept Overview



AI Inference on the Edge



Your private cloud for fast, secure and dedicated inference of proprietary datasets on your terms

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Edge and NaaS

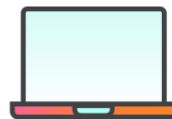
Compute Integrated with the Network

Lumen Network-as-a-Service is ready for digital



Activation and change within minutes

- Designed to accelerate time to market with self-service network purchase
- Service actions fully automated in minutes
- Move data with efficiency



Secure, cloud-like experience

- Simply accept Entitlement Terms and Conditions rather than negotiating contracts
- Transparent pricing billed hourly
- API or UI centric touchpoints
- Integrated security options for Internet on Demand



Flexible and cost-effective bandwidth

- Designed to reduce total cost of ownership with near real-time bandwidth allocation
- Connectivity to public and private data centers
- High-speed, low-latency connections for reliable network performance which is critical for AI applications

Lumen NaaS Portfolio

Port connectivity

Fast, easy, secure networking to power your data and applications. With Lumen NaaS you have your network, your way.



Lumen NaaS Port

Enabling multiple logical services over a single physical port - on-premises and in data centers - providing fast and efficient connectivity.

On-demand networking



Internet On-Demand

Adjustable, pay-as-you-go Internet provides high-speed, low-latency connections with reliable network performance.



Ethernet On-Demand

Flexible, scalable Ethernet best for private point-to-point connectivity between branches or cloud, providing reliable and secure data transfer.



IP VPN On-Demand

Dynamic IP VPN ideal for private multi-cloud solutions with dynamic routing, providing secure and efficient data exchange.

Integrated cybersecurity



DDoS Essentials

Designed to reduce risk by protecting businesses against the most common DDoS attacks, regardless of size or frequency.



Lumen Defender SM

Innovative solution blocking internet threats using intel from Black Lotus Labs to prevent breaches before they start.

Combine Lumen Edge Compute and Lumen NaaS

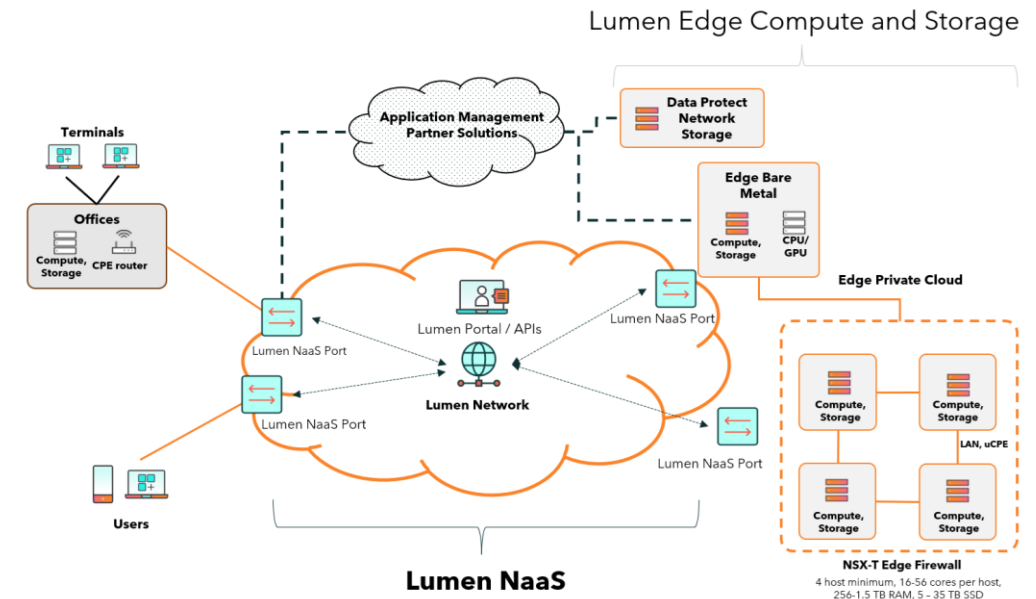
Accelerate distributed application hosting and compute

Core Value Proposition

- The Lumen Edge Portfolio extends Lumen's NaaS-enabled network with pre-deployed cloud-integrated compute and storage solutions inside the network and dedicated solutions at every endpoint of the network.
- Combining Lumen NaaS with Lumen Edge Fabric brings you:
 - Customizable local compute and storage turn-key solutions.
 - Flexible and scalable from single server Edge Bare Metal to Edge Private Cloud data centers.
 - Forest-level cleanroom Data Protect cloud backups with Commvault Cloud and Data Storage with AI-assisted malware detection powered by NetApp to enable Cyber Resiliency and peace of mind.
 - Tightly connected to Lumen's NaaS network infrastructure designed to streamline and simplify your environment from the cloud to the edge endpoint.
 - On-demand access and configuration of both flexible compute and high bandwidth low latency networking.
 - Ideal for distributed application hosting and distributed compute.

Lumen Advantage

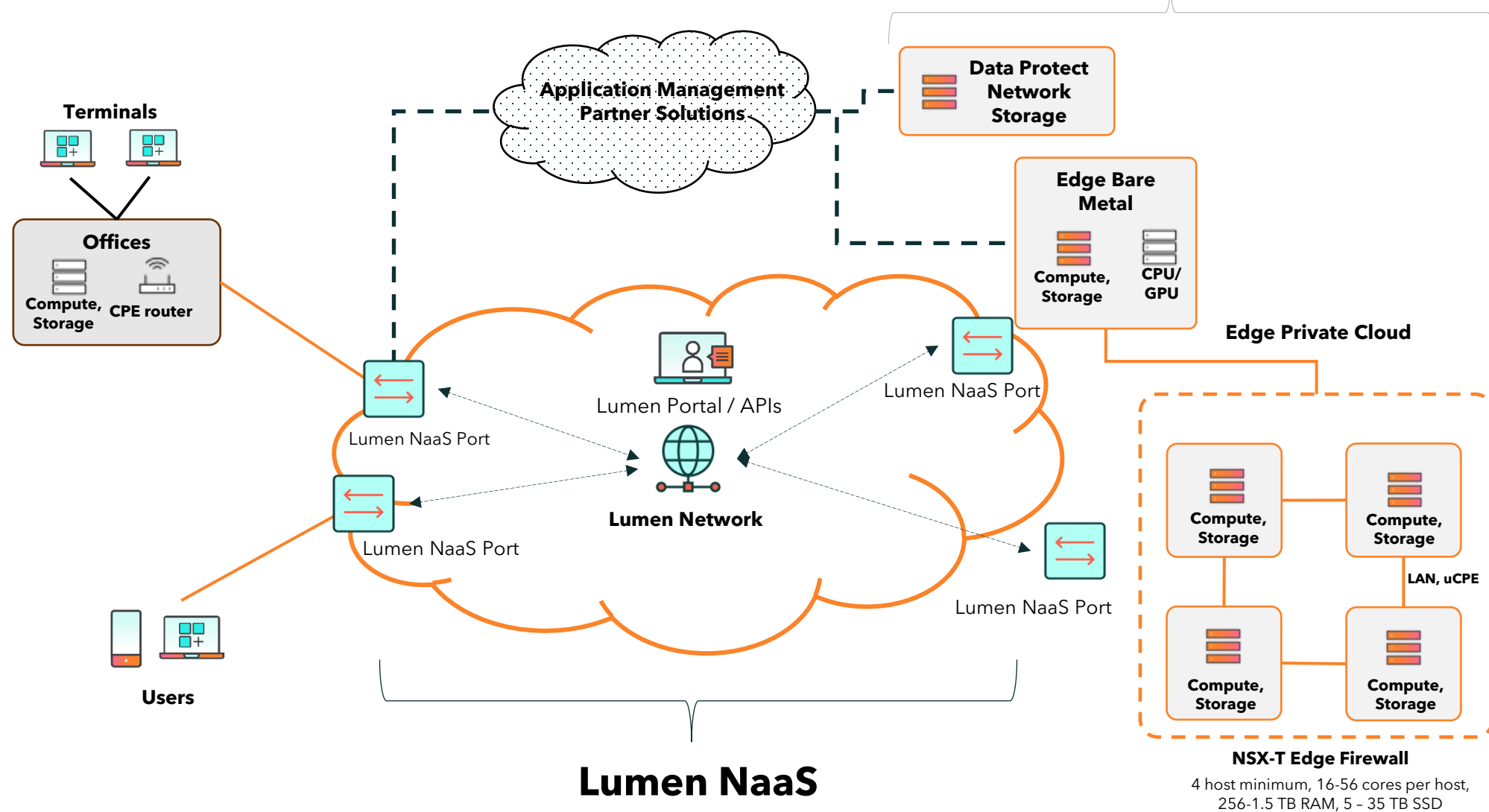
- ~60 Edge Bare Metal sites within 250 miles of 95% of US brings workloads close where they are accessed.
- > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.
- ≤ 5ms of latency designed to cover up to 97% of U.S. business demand.
- Strong partnerships with application management solution providers, cloud service providers, compute and network equipment suppliers.



Powerful edge compute and flexible low latency networking: Why not have both?

Lumen Edge and NaaS Together

Lumen Edge Compute and Storage



Lumen's Edge Connects Compute and NaaS

Working together to support your IT end-to-end

- **Scalable Lumen Edge Private Cloud (EPC)** located close to the end user.
- Flexible, expandable and **composable Lumen Edge Bare Metal (EBM) software stack**.
- ~60 EBM sites within 250 miles of 95% of US brings workloads close to the digital interaction.
- > 2000 (public, private, 3rd party) data centers are connected to Lumen's network.
- **The strength of Lumen's network** for reduced latency and distributed access.
- **≤ 5ms of latency** designed to cover up to 97% of U.S. enterprise demand.
- **Strong partnerships** with managed application providers.
- **Lumen's offering adapts to customer needs.**

Edge Computing and Storage Enable Reliable, Secure, and Fast IT Infrastructure



Accelerate Compute and Networking

The combination of a complete yet flexible edge compute offering, with strong partnerships and low latency networks