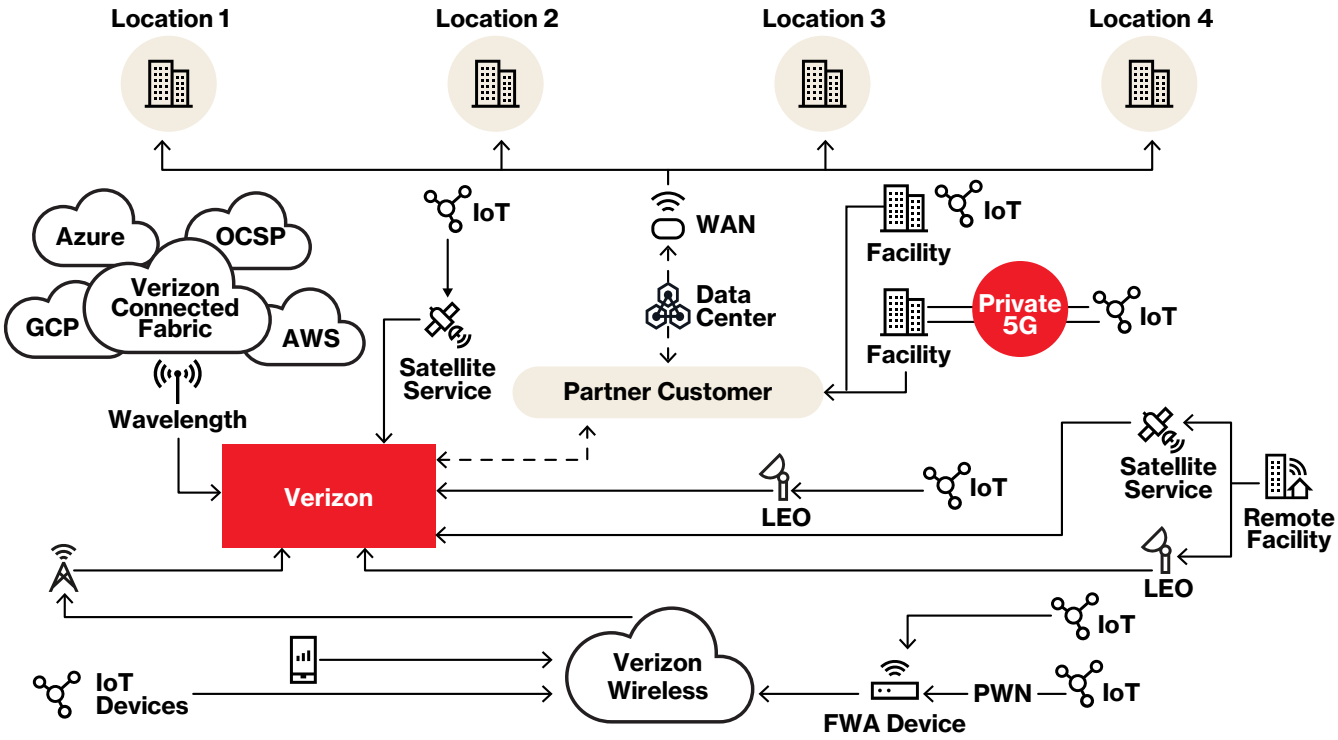
The network of the future

Verizon Connected Fabric

The future is any device connecting to any network with a managed and controlled connection. Connectivity is critical, and near universal connectivity must be part of your organization's journey to the connected future. The Verizon Connected Fabric delivers near universal connectivity for your organization. Verizon's Connected Fabric is a robust, future-proof network solution designed to provide near universal connectivity for organizations. It seamlessly supports various technologies, including AI, IoT, polycloud, and 5G, to create a secure, scalable, and adaptable infrastructure. This interconnected network facilitates data collection, real-time analysis, and distributed processing, empowering organizations to optimize operations, enhance customer experiences, and drive innovation. By leveraging the Verizon Connected Fabric, organizations can unlock the full potential of their data, regardless of its source or location, and thrive in an increasingly interconnected world.

Figure 1. Verizon Connected Fabric conceptual diagram



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Connectivity ensures reliable connections for any device, anywhere, anytime. Verizon's Connected Fabric is the model for building and delivering near universal connectivity.

Benefits for organizations: The Verizon Connected Fabric[1] provides a robust information framework that empowers organizations to operate more efficiently and make data-driven decisions. It empowers any device to securely connect to any network.

Simply put, in a world increasingly reliant on data, Verizon's Connected Fabric acts as the foundation for a connected future by providing reliable and widespread connectivity. This connectivity, in turn, allows organizations to more effectively gather, analyze, and act on data.

An organization has to understand where its data resides. For each type or source of data, definitive or "truth" sources must be selected. This allows the "true" data source to supersede other sources in cases of data validity disputes. All of these independent sources are connected in the Verizon Connected Fabric.

Connection via any method—from and to any device anywhere in the Verizon Connected Fabric—provides that near universal connectivity fabric. It gives your organization an anywhere, anytime, any device information framework. The near universal connectivity of the Verizon Connected Fabric helps your organization drive multiple functions. In this paper, we align three topics within the concept of the Verizon Connected Fabric. The first is the concept of data collection and data sharing. The second is support for and augmentation of real-time analytics. The last focuses on the concepts of data decentralization and scalable connectivity to make that data available across your organization.

Data collection and sharing

- **Internet of Things (IoT)**: The IoT represents millions if not billions of devices that are network connected today. These devices can be cameras, sensors or many other data collection devices. IoT devices generate massive amounts of data. near universal connectivity allows this data to be collected in near real-time from various locations and devices. This near real-time data flow is crucial for analysis, decision-making, and automation in areas like smart homes, cities, and industries. For high speed or critical IoT sensors, the Verizon Connected Fabric would implement a Remote Direct Memory Access (RDMA). It is a technology that allows computers in a network to access each other's memory directly, without involving the operating system or CPU of the remote machine. This results in very low latency and high throughput, making it suitable for high-performance computing, data center networking, and storage applications. Over-Converged Ethernet version 2 (RoCEv2) enhances data transport efficiency by allowing direct memory access between computers without CPU involvement, reducing latency and freeing up CPU resources.
- **Artificial Intelligence (AI):** AI algorithms thrive on data. Constant data streams from interconnected IoT devices provide the fuel for AI to learn, adapt, and improve its performance. The more data AI has access to, the more accurate, efficient, and intelligent it becomes.[2] Why should we consider the network as a critical part of the implementation of an AI system? First, it allows for access to the various sources for the data. Second, it has to support AI workloads that generate between 8 and 15 times the existing network traffic on the same ports.
- **Polycloud:** Polycloud presents two distinct components. The first is management and structure of the Cloud Services Providers (CSPs). The second component of Polycloud is creating a private network allowing connection to any Cloud provider. Verizon empowers the second component supporting you as you build the near universal Cloud connectivity environment for your organization.

Near real-time analysis and response

- **IoT:** near universal connectivity enables near real-time analysis of data from connected devices. This allows for fast responses to changing conditions, such as automatically adjusting a building's temperature based on occupancy data or rerouting traffic based on near real-time road conditions. Building on ethernet connectivity, you can now add satellite, broadband, Wi-Fi, cellular, and packet-based communications structures to keep the IoT sensors always connected.

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1 The Verizon Connected Fabric is a service concept designed around stitching multiple service modes together into a near universal connection platform.
2 Within locations, hosting physical GPUs utilize InfiniBand for optimal throughput. Basically, what happens is that within the GPU cluster implement GPUDirect RDMA#. This creates the "Infiniband connections." It should be noted that today these are limited to no more than 400 gig. Beyond Infiniband there is a new Ethernet or Ethernet 2 protocol available, the organization can consider the solution using Ethernet version 2 (RoCEv2) for data center routing.

- **AI**: With constant data flowing in, AI can analyze situations in near real-time and trigger actions through connected systems. For example, in healthcare, AI could analyze patient data from wearables and alert medical professionals in case of an emergency. Near real-time analytics engages the InfiniBand[3] we've deployed but also now integrates edge services. Moving the analytics closer to the consumer reduces the lag in building and delivering the information.
- **Polycloud**: Polycloud moves data between Clouds to optimize analytics and capabilities. It uses the near universal connectivity of the Verizon Connected Fabric to create a layered ingestion structure to rapidly ingest, analyze, and respond to data.

Decentralization and scalability

- **IoT**: A network of interconnected devices requires a decentralized structure. near universal connectivity facilitates this by allowing devices to communicate directly with each other (machine-to-machine communication) and distribute processing power, making the entire system more robust and scalable.
- **AI**: AI processing can be distributed across the network of connected devices, leveraging the collective processing power instead of relying on a centralized system. This distributed approach enhances efficiency, speed, and scalability of AI applications.
- **Polycloud**: Polycloud builds to the edge of the Verizon network with Multi-access Edge Computing (MEC) and allows your Polycloud workloads to be distributed in a low latency environment, giving users the power of data on their devices. Your organization can integrate Edge, AI, Polycloud and IoT services into a unified Poly-Organization[4] environment.

New possibilities and innovations

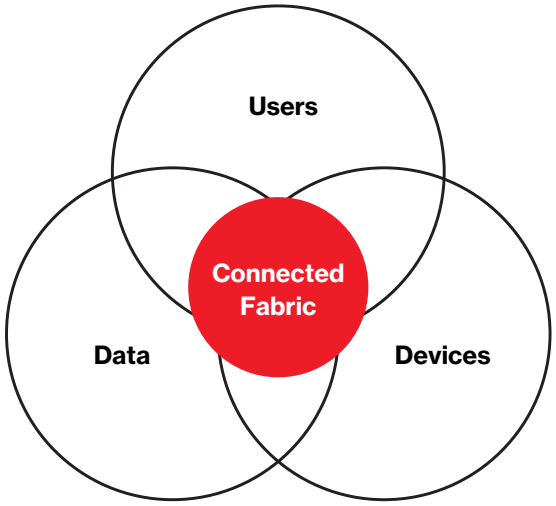
In building capabilities on top of the Verizon Connected Fabric, it is critical to consider how this overall solution empowers each of the core components and enables use cases.

near universal connectivity is the fundamental backbone upon which the future of IoT, Polycloud, and AI rests. It enables the seamless flow of data, near real-time analysis, and the creation of intelligent, interconnected systems.

The network of the future is built with future services at the forefront. This starts with Connected Fabric. In the early days of networks, many organizations had local area and wide area networks. Originally called Arpanet and funded by the US Government, Arpanet became the internet; or, more specifically, a vast interconnected fabric.

The first phase in networks was the creation of local area networks and wide area networks devoted to an organization. The internet brought the second change for networks with the rise of an interconnected fabric that spans the globe. With the rise of the internet, the world of cellular phones began to change how and from where people connected. The initial connectivity concept was an organization's users. With the Cloud, the internet and cellular phone networks can be anywhere and provide connected platforms to various devices. The newest devices, the IoT, have data, users, and devices connecting from anywhere. Figure 1 depicts the concept of the Connected Fabric—all connections, all devices allowing and empowering users to realize world class capabilities. The figure depicts a framework of connections available today but delivered in a private connectivity fabric that can be expanded as an organization's needs grow.

Figure 1 also illustrates the Connected Fabric that provides seamless and near universal connectivity between various devices, applications, and systems within an organization or across the internet. This interconnected network facilitates data exchange, communication, and collaboration. In addition to connectivity, Connected Fabric offers services like enhanced security through centralized policy management, improved application performance through optimized data routing, and simplified management and orchestration of the entire network infrastructure. It also enables advanced features like data analytics, automation, and support for IoT devices.



The concept of the network of tomorrow using a Connected Fabric focuses on building a Connected Fabric that supports the original industry concept of Hybrid-Cloud and the newer Polycloud, giving an organization the power of multiple connected Clouds. IoT represents the millions of managed and unmanaged devices providing information to your company. The concept or implementation of AI requires an

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[3] Infiniband is a networking solution designed by NVIDEA to support data transfer environments around large number of GPU solutions in what is called a cluster.
[4] Poly-Organization represents the concept of an organization that has Multiple Clouds as well as multiple connections between locations, partners and other organizations.

integrated or near universal connectivity environment. The environment would represent the integration not just of the on-premise traditional network but also integrating with that of a carrier.

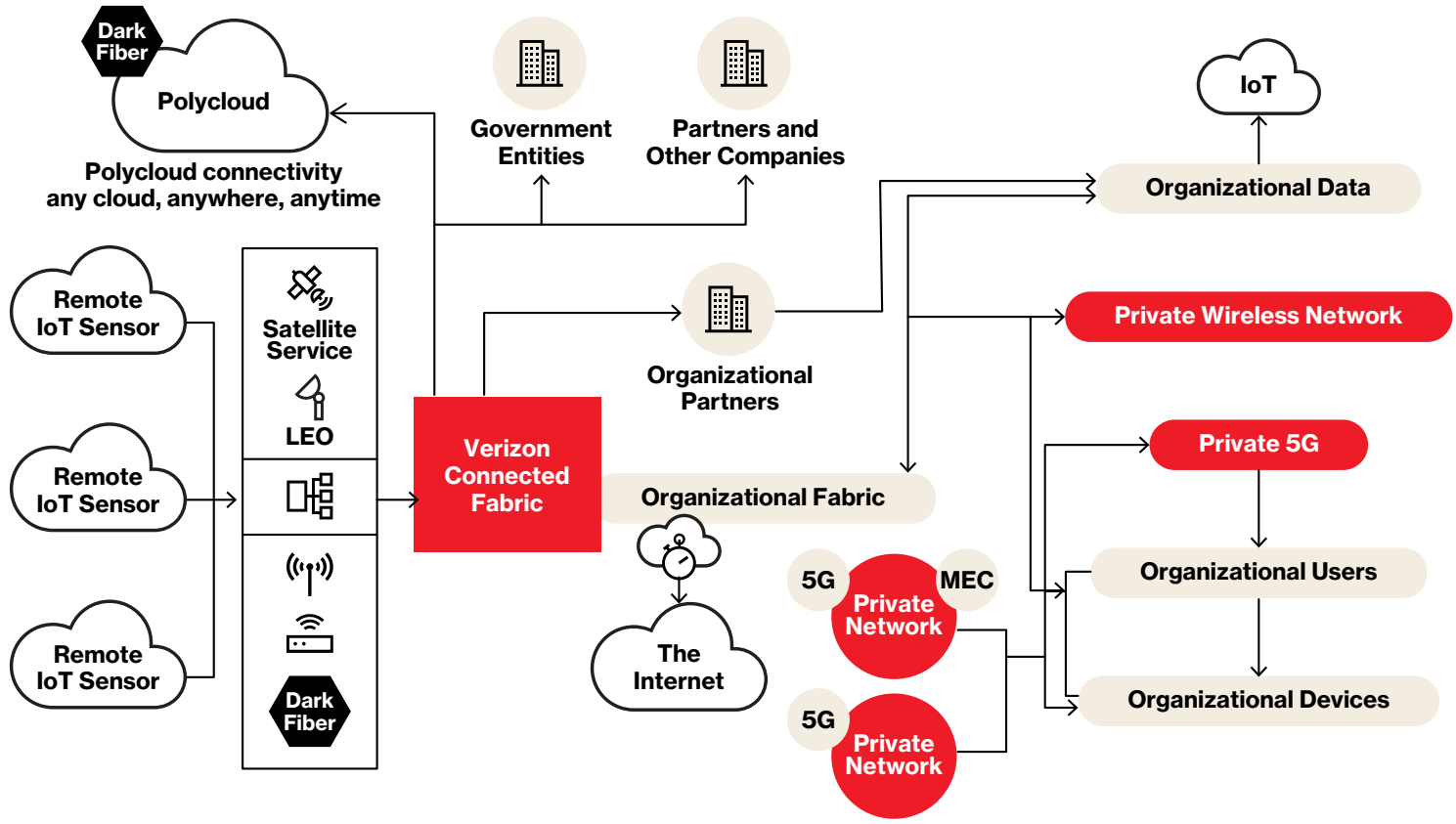
Each of these represents the concept of users, devices, and data convergence. To easily build and support users, devices, and data, it is critical that an organization establish a connected framework. This convergence empowers organizations to collect vast amounts of data from diverse sources (IoT), leverage flexible and scalable computing resources either in the Cloud or on the edge, and extract actionable insights from the data (AI).

A connected framework creates a Connected Fabric. The framework shown depicts a logical architecture that allows the consumption of services within the network. The services may include Low Earth Orbit (LEO) satellites services. LEO satellites allow for globally diverse connections options. The Verizon Connected Fabric solution provides connection to LEO solutions as well as traditional satellite services. Fixed wireless access (FWA) can be used as backup or secondary network connections facilitating hybrid or polycloud.

The Verizon Connected Fabric or "network fabric" helps the organization leverage its connectivity infrastructure as a key supporting component of the future. Beyond the advantages and value, there are other considerations.

- **Security:** A robust and layered security approach is paramount to addressing vulnerabilities across all aspects of this converged environment.
- **Hybrid multi-cloud services and adding Polycloud:** Polycloud refers to the strategy of using services from multiple Cloud providers, allowing organizations to select the best options for their specific needs while mitigating risks associated with vendor lock-in. This approach offers flexibility in geographic coverage, compliance, and access to unique features, while enabling cost and performance optimization. As Cloud services continue to mature, polycloud is becoming an increasingly popular trend among organizations seeking to maximize benefits and minimize risks in their Cloud adoption journey.
- **Rapid provisioning and weather resilience:** It is important to have a solution that allows the organization to rapidly provision new connections and provides broad support for short term or tactical connectivity that can be brought up and down quickly.
- **IoT sensors, data collection and aggregation:** Implementing efficient data collection, aggregation, and processing mechanisms from diverse IoT sensors is vital for extracting meaningful insights. Regardless of the source, location or type, you can easily connect to and consume data in a private network solution.

Figure 2. Logical Verizon Fabric diagram



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- **Secure private network connectivity:** A secure private network is simply a network that is not visible on the public internet. In this case, private represents a solution dedicated to the customer's environment.
- **Interconnection framework:** Regardless of the network connection type, the Connected Fabric allows the organization to empower its network by connecting any device, from any connection into the broader managed network of the organization.
- **AI and the future:** AI-powered analytics and automation will be essential for unlocking the full potential of this technological convergence, driving innovation and creating new opportunities for businesses. The Verizon Connected Fabric empowers the organization to consume data at the location source within its network. What this means is the organization can easily get to the data and computing services they need to deploy their new solutions. They will no longer require a project to centralize all their data.

An initial set of connections represent the "how," and provides the fabric for the "what" is connected. There are three primary "whats" to consider. The first is the IoT made up of sensors and devices connected to the internet sharing data. It could be a rain gauge or a device monitoring flood stage on a river. Another "what" to consider is the Cloud. CSPs offer a variety of data for connection. Finally, the last of the "what" is the concept of on-premise data. Data exists in both Cloud services and throughout your organization. With the Cloud fabric, you have the ability to access and manage every on-premise location edge to data center where your data is stored today.

A Connected Fabric gives connection flexibility, and a device-independent connection for data access. That access can now be inside your organization's secure bubble as well as outside that bubble. Access to the Connected Fabric becomes a strength for your organization.

A Connected Fabric provides unparalleled connection flexibility, enabling device-independent data access both inside and outside an organization's secure bubble. This access becomes a significant strength when we consider the expanding landscape of AI, IoT, and polycloud environments:

- **AI-powered insights:** The Connected Fabric facilitates the flow of data from various sources, including IoT devices into AI algorithms. This data fuels AI-powered insights, enabling organizations to:
  - **Optimize operations:** Predict equipment failures, automate tasks, and improve resource allocation.
  - **Enhance customer experiences:** Personalize interactions, anticipate needs, and deliver targeted solutions.
  - **Drive innovation:** Identify trends, uncover hidden patterns, and develop new products and services.
- **Seamless IoT integration:** A Connected Fabric seamlessly integrates diverse IoT devices, regardless of their underlying protocols or operating systems. This interoperability enables:
  - **Near real-time data collection:** Capture data from sensors, actuators, and other connected devices in near real-time.
  - **Remote monitoring and control:** Manage and control devices remotely, improving efficiency and responsiveness.
  - **Scalable deployments:** Easily onboard and manage a growing number of connected devices.
- **Polycloud agility:** The Connected Fabric extends its reach across multiple Cloud environments, enabling organizations to leverage a polycloud strategy for:
  - **Increased flexibility:** Choose the best Cloud provider and services for specific workloads.
  - **Reduced vendor lock-in:** Avoid dependence on a single Cloud provider.
  - **Improved resilience:** Enhance business continuity by distributing workloads across multiple Clouds.

A connected fabric, empowered by AI, IoT, and polycloud capabilities, transforms data access into a strategic advantage. It allows organizations to unlock the full potential of their cloud-based data, drive innovation, and thrive in today's increasingly interconnected world.

To illustrate this, we selected several Use Cases to demonstrate the value and power of the Verizon Connected Fabric.

Connected Fabric	Transformational evolution of data connectivity for the organization	Rapid Provisioning, Digital Twin, support for inbound data and an environment to deliver AI
Polycloud	Building on the Connected Fabric to integrate Cloud service providers	Private CSP connectivity with support for a structured consistent Cloud experience
Private 5G connectivity	Extremely low latency connectivity environment offered in a secure private enclave	A secure private connected network focused on delivering low latency connected services

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Verizon connected fabric use cases

A rapid provisioning network infrastructure allows the organization to quickly add or remove locations within a short time period. This means the organization can, within its deployed fabric, have multiple connectivity types. These include LEO satellites, traditional satellites, traditional networks, software defined networking services, private and public 5G connectivity, and others. All of this is in a private network focused on connecting the organization. Some network connections can support rapid provisioning, being enabled and routing traffic within a matter of hours.

As we consider the diagram Figure 2 presented in the logical layout for the Connected Fabric, we can see a number of critical components the overall solution addresses including:

- **End devices:** Includes servers, workstations, printers, cellphones, laptops, and more representing the data consumers and producers.
- **Access layer:** Depicts the connection point for end devices, often using switches with specific port configurations. This can also be the public cellular network with a dedicated Private Wireless Network connection.
- **Aggregation/distribution layer:** Illustrates how traffic is aggregated and managed before moving to the core. This layer often includes higher-capacity switches or routers.
- **Core layer:** Serves as the network's backbone, focused on high-speed data transfer between different network segments or to external networks.
- **Network services:** Supports security appliances (firewalls, intrusion detection systems), load balancers, and other services ensuring network security, performance, and reliability.
- **Connections:** Provides logical connections between components, often represented by lines with labels indicating protocols or bandwidth.

Polycloud use case

Leveraging Specialized Services: Different Cloud providers offer unique and specialized services, such as AI/ML platforms, IoT solutions, or industry-specific offerings. Polycloud allows organizations to access and use these services from various providers, fostering innovation and enhancing capabilities.

Polycloud in this scenario starts with connectivity and builds from that point. Automated connectivity matters in a Cloud compute scenario matters because it provides the ability to:

- Automatically terminate Cloud access to a specific Cloud service provider
- Manage cost across all Cloud providers offering services to your organization
- Provision and de-provision a new Cloud provider in a short time period.

Using the Verizon Connected Fabric, an organization can also build a complete digital twin of its Cloud computing environment. This reduces security risks of actual Cloud deployments by modeling that structure before the deployment.

5G and private 5G use case

- **Digital twins:** Create a real-time digital replica of a factory floor to optimize processes, simulate changes, and improve efficiency.
- **Private 5G network:** Deploy a Private 5G network with MEC to enable near real-time data analysis for predictive maintenance. MEC brings computation and data storage closer to IoT devices, reducing latency and enabling real-time data analysis for applications like AI-driven decision-making. This proximity also enhances security by enabling localized data processing and reducing reliance on transferring sensitive information to the Cloud. For AI, MEC provides the low-latency environment needed for real-time inference and model training on data generated by IoT devices, leading to more responsive and intelligent applications. MEC facilitates efficient data ingestion by filtering, aggregating, and pre-processing data at the edge, reducing the volume of data transmitted to the Cloud for storage and further analysis.

Data collection: Sensors on manufacturing equipment continuously collect data (vibration, temperature, pressure) and transmit it over the high-bandwidth, low-latency private 5G network.

- **Edge processing:** The data is processed at the network edge using MEC, eliminating latency and bandwidth constraints associated with sending data to the Cloud.
- **AI/ML analysis:** AI/ML algorithms running on the MEC platform analyze the data in near real-time to identify patterns and anomalies indicative of potential equipment failures.
- **Predictive alerts:** The system generates alerts and notifications, enabling maintenance teams to proactively address issues before they lead to costly downtime.

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Digital Twins can be beyond the factory floor. They can be used for network management, information flow, and information delivery within the organization. The Verizon Connected Fabric provides access to all the data locations.

Another advantage of building out a Connectivity Fabric is its ability to support AI. This data Connectivity Fabric gives the organization the ability to have and integrate data from any source. Future AI applications can then leverage all data sources in the organization to build and deliver industry-leading services. Consider a future network solution where live network performance data is automatically applied by the network allowing the network to respond to security risks, all organization employees' meetings, or other short-term events. It would also be beneficial to have a network able to respond to a natural disaster by creating a mesh infrastructure that allows for traffic to be rerouted as quickly as possible by the automated system. That mesh infrastructure can be built over time. It is a layered improvement process that will continue to evolve for future developments.

At the heart of this connected ecosystem lies the transformative potential of AI and IoT. Sensors deployed throughout your organization, empowered by near universal connectivity, act as intelligent data collectors. These sensors provide real-time insights into your operations, enabling data-driven decision-making, predictive maintenance, and optimized resource allocation. The fusion of AI and IoT unlocks unprecedented levels of efficiency, automation, and innovation across all facets of your organization.

Furthermore, satellite connectivity provides an unparalleled level of flexibility and reach, enabling your network to transcend geographical limitations. This is particularly crucial in today's dynamic business environment where remote work, global collaboration, and access to geographically dispersed resources are paramount. By embracing satellite connectivity, you can rapidly extend your network's reach to underserved areas, providing seamless business continuity, and empowering your workforce regardless of their physical location. This potent combination of technologies, delivered through a rapid provisioning framework, paves the way for a truly near universal and secure IT environment, accessible from any device, anytime.

Right now

- Connectivity framework
- Rapid provisioning structure
- Private hybrid or Polycloud connectivity

Near term

- Edge services delivering low latency network connectivity
- Multiple inbound connectivity types supporting resistant network connectivity
- Increase data ingest intelligence

Future

- AI on edge devices
- The ability to integrate new data sources, locations and customers quickly
- Future proof modernized network

Moreover, moving to a Hybrid Multi-cloud solution helps the organization address two of the trends and associated challenges noted at the beginning of this paper. Hybrid Multi-cloud solutions greatly improve network resiliency, and thus make it easier to respond to changing circumstances, like extreme weather events, with no loss in connectivity. Similarly, a Hybrid Multi-cloud approach will reduce the need for skilled workers, and thus help the organization address demographic challenges.

The concept of a Connected Fabric empowers your organization with a future-looking network that seamlessly scales alongside your evolving needs. This private network infrastructure—leveraging the power of polycloud connectivity—offers unparalleled flexibility and adaptability. It seamlessly integrates diverse Cloud environments, enabling you to distribute workloads, optimize resources, and enhance application performance, regardless of their physical location. This forward-looking approach ensures your network remains agile and responsive to emerging technologies and connectivity paradigms.

Verizon's Connected Fabric offers comprehensive connectivity by combining AI, IoT, polycloud, and 5G technologies. This secure and adaptable infrastructure enables organizations to collect data, perform real-time analysis, and utilize distributed processing. The result is optimized operations, improved customer experiences, and increased innovation. Organizations can leverage data from any source to thrive in our increasingly interconnected world.

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