VDC Research

DESIGNING RESILIENT SOLUTIONS FOR AN OPERATIONAL EDGE

ADAPTING TO NEW REQUIREMENTS AND ARCHITECTURES AT THE EDGE

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DELL Technologies OEM Solutions intel

TABLE OF CONTENTS

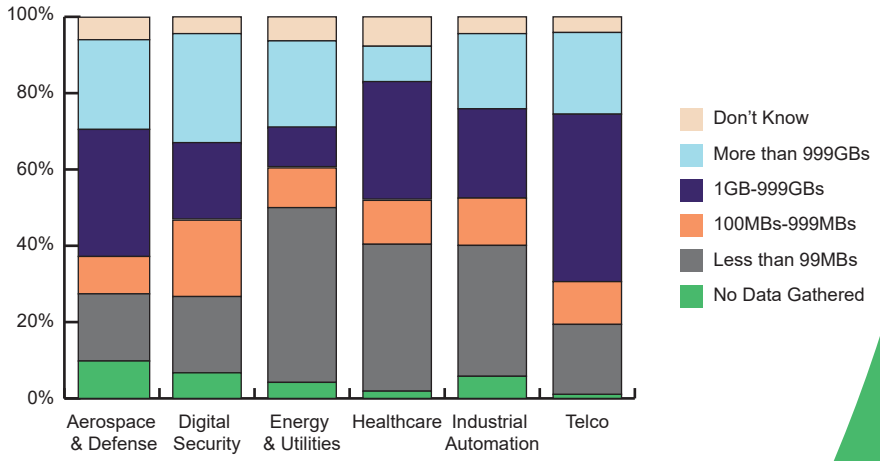
OVERVIEW

Operational Environment Designs for Edge Workloads are Evolving

The events of the past couple of years have driven dramatic business and technological transformation that would have traditionally taken decades to take effect in the slow-moving OT space. The world has become globally connected and placed unprecedented requirements on technology and solution providers, which will drive further change in the competitive landscape favoring those that can adapt. The edge computing realm, in particular, is emerging as a point of strategic value managing and feeding progressively more data for all industries into (multi-)cloud infrastructure and solutions. Customer/enterprise requirements are now the leading factor pushing more organizations towards using/providing edge computing solutions.

A variety of different routes to market exist for solution builders to satisfy emerging requirements while generating more revenue helping their customers with their new norms supporting greater automation, connectivity, and protection of data, systems, and processes. Designing for OT and edge environments (outside the data center) features many additional considerations and requirements including systems hardening, manageability, regulatory compliance/certifications, and customization. One way to avoid costly and potentially inefficient in-house design and development is through collaborating with technology platform providers like Dell Technologies OEM Solutions, which can provide a competitive advantage.

Estimation of Data Gathered by Organization's Product Systems Each Day Per Unit/Device
(*Percentage of Respondents)*



In-Field Computing Demands Architectural Change

The explosion of data at the distributed edge and new heterogeneous computing architectures needed for OT transformation can put solution builders without a strong technology partner in a difficult position. Solution builders need access to not just efficient hardware featuring support for different accelerators (e.g., GPUs, FPGAs, etc.), but also more application development support. For example, access and availability of OT AI/ML talent is very limited. Solution providers can remain agile by filling gaps in AI/ML or other areas like security or cloud development using commercial technology platforms and/or solution design and engineering capabilities offered by platform providers. In-field computing demands a variety of platform and architectural choices for the edge, which is actually a continuum of several domains stretching from the near edge closer to IT infrastructure to the far/rugged edge where the need for more resilient solutions is even greater.

Software-defined systems and hyperconverged infrastructure (HCI) are important for this architectural change in edge applications and are often the optimal path to enable device/systems lifecycle management, high availability, and high performance workload support as compared to the previous computing generations. The static hardware architectures of past/legacy deployments do not align with the long deployment lifetimes that sometimes are necessary to support. Further, architectural decisions for the distributed edge stretch out to the cloud domain, requiring a flexible technology platform to integrate with existing and new customer deployments.

OT–IT Edge Convergence

	The OT/Distributed Edge			IT Edge
Edge Computing Segments	Endpoints	Field-Grade Systems	Micro Data Centers	Cloud & Multi-Cloud Compute
Hardware Platforms	Thin Clients Gateways Rugged Laptops & Tablets	Operational/ Tactical Platforms Rugged Servers/HCI Industrial PCs & Workstations	Servers/HCI/ Appliances Storage/Data Protection Modular Data Center	Enterprise Appliances Storage & HCI

OT EVOLUTION IS DRIVEN BY NEWER TECHNOLOGIES

5G Redefines Cellular Edge Data

5G is a transformative technology that is radically expanding the capabilities of long-range cellular-based data transport. Previous cellular generations were not always the best choice for edge and IoT deployments, with varying restrictions on connectivity coverage, data latency, and throughput. However, 5G is being created specifically with features designed to support enterprise use cases. Meanwhile, the consumer space is providing a topology that realistically can revolutionize how technology and solution providers design for connectivity at the edge.

The latest cellular generation has the capability to support near-real-time transmission of relatively heavy data streams (e.g., video, vision sensors, radar, V2X communications, etc.) to enable advanced industry and/or mission-critical applications. For example, over the past several years, the 3GPP has published standards that help define the integration of 5G with the time-sensitive networking standard from the IEEE. As a result, 5G cellular is a primary consideration for emerging edge computing deployments and solutions that may have historically been confined to using wired/limited networking types.

AI is Spreading Within Solution Stacks

AI is another massive component of emerging technology and industry solutions impacting every layer of the OT/distributed and IT edge. The automated processing and intelligent sharing of OT data is necessary to support most high-growth embedded and edge applications.

Fortunately, the development and deployment of OT AI solutions is getting greater support. The global market for embedded and edge AI systems and servers is rapidly expanding, at a revenue CAGR of 27.5% between 2021-2025, offering solution providers evermore platforms to jump start their development. Built off of these growing AI hardware platforms from technology platform providers like Dell Technologies, combined with ongoing silicon innovation from Intel and others, AI developer ecosystems and their frameworks are expanding with a focus on support for relatively resource-constrained edge systems as compared to widespread cloud-based deployments.

OT Transformation is Driving High-Growth Applications in Every Industry

Energy & Utilities
Real-time Activity/Safety Monitoring, Microgrid, Equipment Condition Monitoring, Smart Meters

Healthcare
Connected Healthcare, Digital Pathology, PACS, Latency-sensitive Front-line/Bedside Diagnosis

Industrial Automation
Autonomous/Smart Manufacturing, Cloud-based SCADA, Connected Supply Chain, Robotics

Marine
Environmental Monitoring/Protection, Offshore Automation, Ship Condition Monitoring

Military & Defense
Distributed Electronic Warfare, Facility Security/Automation, On-Vehicle/Ship/Airplane Computing

Retail
AI-powered Loss Prevention, Augmented Reality Shopping, Customer Tracking, Personalized Advertising

Safety & Security
Automated Threat Identification, People/Object Detection, Intelligent Access Control

Telecommunications
Virtualized 5G Wireless Access, Private Cellular Networks, Hyperscale Computing

INDUSTRY SOLUTIONS LEAN ON RESILIENT ARCHITECTURES

Defense

The defense industry requires extremely rugged, stable and secure computing solutions for a variety of sensitive applications. However, maintaining that protection and reliability while increasing performance for new capabilities is a great challenge. At the same time, defense platforms must also be tailored to meet stringent electrical, mechanical, software, and systems requirements for **certification compliance** (e.g., MIL-STD, NEBS) and application success.

Defense OEMs, subcontractors, and prime integrators require a broad portfolio of **temperature-extended** (i.e., -5° to 55°C) and certifiable hardware platforms that can be **customized** to mission-critical edge workloads and environments.

Manufacturing

Manufacturing environments are becoming increasingly dense connected and computational-intensive environments enabling new automation capabilities and process efficiencies. An **open technology platform** is necessary for valuable AI integrations to enable applications such as real-time product line analytics and condition monitoring. In addition, **rugged client devices** (e.g., laptops, tablets, workstations) are needed to interact with intelligent machines on the shop floor.

Given the sensitive nature of modern connected manufacturing architectures (and potential for ransomware, targeted hacks, etc.), **built-in security** and a **trusted supply chain** are necessary to protect data, critical infrastructure, and operations.

Energy & Utilities

In the energy and utilities domain, building out smart grids can enable a range of benefits including strategic modernization, outage risk reduction, and the enablement of new business models for solution providers. Smart grid infrastructure providers, though, face increasingly complex requirements for functional safety compliance, **device/connectivity management,** and constant challenges for **environmental protection** from water/dust ingress.

Flexible hardware platform design services are crucial for maintaining adherence with these various requirements with other added benefits (e.g., integrating OEM software with appliances prior to delivery). Rugged systems such as edge gateways are also important for solution builders enabling such digital transformation and cloud solutions.

Safety & Security

Emerging technologies have greatly extended the potential solution capabilities for safety and security applications keeping employees, facilities, and the public safe. Whether for intelligent access control, mobile device management for bring-your-own-device policies, and safety monitoring (of objects, people, etc.), **repeatable and scalable architectures** are needed to simplify and accelerate deployments.

Particularly when leveraging computer vision, analytics, and machine learning to inspect and monitor facilities for physical security, hazard alerts, etc., **flexible data storage, management, and protection** services with multi-/hybrid-cloud support are critical to support modern safety and security solutions and services.

KEY SOLUTIONS TRENDS OUTSIDE THE DATA CENTER

Rugged Hardware is Valuable at the Edge & Closer to Data Sources

The edge and OT environment is a physical place that in many cases faces dramatically more footprint limitations and physical stress than in an enterprise data center. Depending on the industry applications, systems must be hardened against extended temperatures, vibration, shock, and/or ingress or water and particulates. The right mix of embedded components are needed for designs to stand up to environmental challenges, whether it is an application processor, cooling, memory, power supply, I/O, etc. This mix of components needs to be elegantly packaged for in-field deployments, where space is at a premium. (See Image 1)

Manageability is Now a Core Consideration

Device, network, and systems management of deployed technology infrastructure is critical as business models become more dependent on systems uptime and quality of service. Some deployed systems and infrastructure can be extremely difficult or costly to deploy by technicians for regular updates or to fix crashed systems. Advances in wired and wireless networking in OT environments has greatly enhanced the number of updateable industry systems and the capabilities of management platforms. (See Image 2)

Lifecycle & Operational Management is Complex

HCI has clear, established benefits in the enterprise enabling full stack management for IT infrastructure. The edge is another environment requiring such solution flexibility to support increasingly dense computing deployments, new AI-based analytics and other workloads, and hybrid clouds. A software-defined architecture consolidating compute, storage, and management into a single platform can help mitigate rising lifecycle and operational management challenges in the field. (See Image 3)

Regulatory Compliance is Spreading

Regulatory bodies are becoming more stringent worldwide in a variety of industries. There is a widespread ambition across geographies to move to more safe and secure industry deployments, with increased regulation/auditing of OT embedded software code bases and functional safety standards adoption. The U.S. government, for example, has issued new regulations on mission-critical infrastructure. Certifying industry edge systems is extremely costly, as any unplanned revisions to hardware could trigger re-work for re-certification compliance. By sourcing edge-optimized infrastructure from leading technology companies like Dell Technologies, solution builders do not need to worry about the certification process. (See Image 4)

Image 1: Dell PowerEdge XR11 & XR12 Rack Servers Powered by Intel Xeon Scalable Processors

Image 2: Integrated Dell Remote Access Controller (iDRAC) for Dell PowerEdge Servers

Image 3: Dell VxRail HCI Powered by Intel Xeon Scalable Processors

Image 4: Dell Edge Gateway 3200 Powered by Intel Atom Processors

IN-FIELD DEPLOYMENTS ARE UNIQUE

Solution Providers Need Customization Services

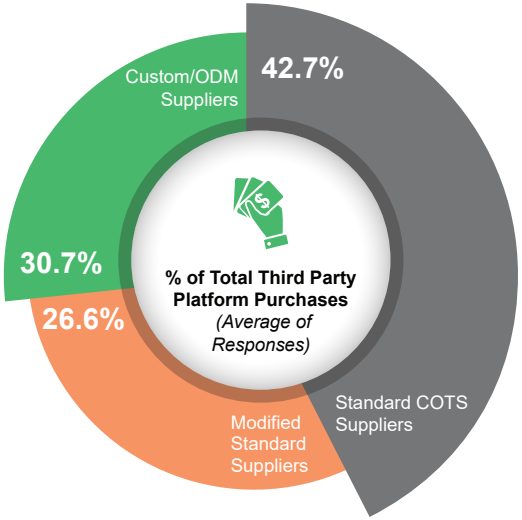
Many deployments have unique requirements and need flexible platforms to support a variety of dynamic end user workloads, physical environments, and general preferences for aesthetics, etc. As a result of the increasing diversity of edge deployments, solution providers need more personalized technology platform sourcing to remain adaptable to requirements downstream with their customers. The broad standard/off-the-shelf hardware catalogs of organizations like Dell Technologies can satisfy many solution builder requirements, but it also provides modified standard and custom/ODM hardware as a product of its design and engineering services.

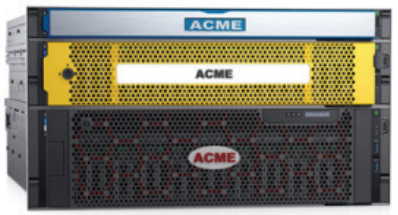
Customization does not always mean a ground-up development of a system, as it could involve something as simple as a bezel change to extend the solution provider's branding or a different loading screen graphic or other elements that are not necessarily related to the industry application and would thereby be a drag on development resources. However, more in-depth customization and services are increasingly needed and valuable, such as for edge platform design, third-party card/accelerator integration, and deployment-specific packaging.

OT Trends are Driving Demand for Modified/Custom Technology Platforms

Given the many different deployment-specific parameters that OEMs need to support, they need to source equally flexible technology platforms. A versatile technology platform and provider can help address a number of OT challenges outside the data center, such as:

1. Adding physical hardening can greatly complicate the cooling of embedded components, which in the high-performance edge remains a tough challenge.
2. Management platforms can be costly to develop internally but commercial technology platforms often feature sophisticated cloud-based management capabilities for maintaining legacy and new deployed systems over extended lifetimes.
3. Pre-certified hardware platforms can enable dramatic development cost savings while mitigating certification risks as requirements mount for greater safety/security compliance.





Example of OEM Custom-branded Solution

Benefits to Commercial Platform Sourcing vs. Internal Development

39.1% Lower Average Total Cost of Development

36.5% Lower Average Bill of Materials

20.8% Better Project Schedule Adherence

10.3% Average Savings on Project Length

THE SOFTWARE-DEFINED EDGE & OT CLOUDS

Maintain OT & Edge Systems through Software

Industry deployment and manufacturing lifetimes are growing. To keep hardware platforms nimble but stable and predictable, a software-defined architecture must be in place to maximize embedded resources and performance for as long as possible. At the same time, systems software itself needs to be adaptable over time to support distributed and intelligent solutions. Virtualization and containers are critical elements of a software-defined architecture.

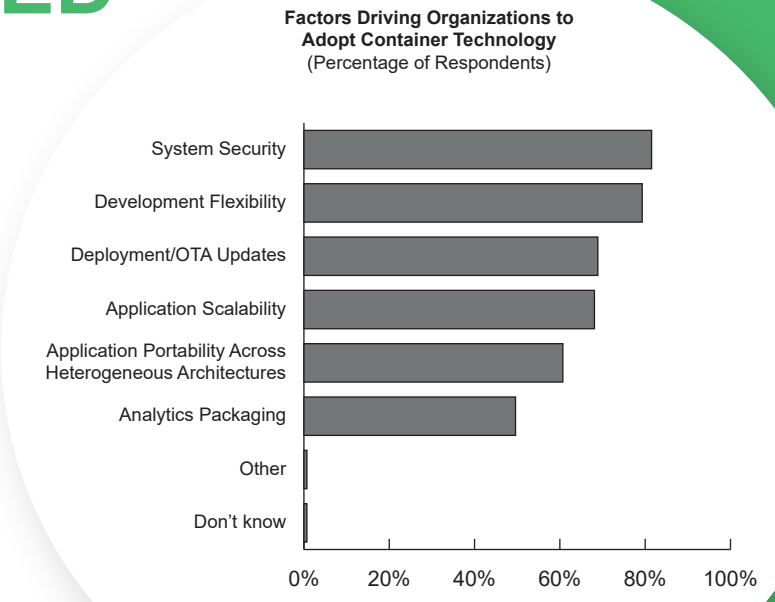
Compartmentalize Complexity

Virtualization is a mature technology that can support multiple applications and operating systems independently on the same server or appliance to maximize capacity and performance for processing, storage, etc. The technology features inherent cybersecurity strengths and benefits for deployment at the edge and can simplify configuration and deployments of new infrastructure for greater scalability.

Container technology is spreading beyond the enterprise into OT on the back of HCI. VDC forecasts the global market for container solutions and related services for edge and embedded systems to grow at a CAGR of 30%+ from 2021-2024. Containers offer several benefits ranging security, updating deployed systems, delivering different software products, and providing more flexibility for development. As an example, the Dell PowerStore family of all-flash data storage appliances, with its container-based design, is continuously modernized while delivering non-disruptive microservices.

Hybrid Clouds Build Off of Established Multi-Cloud Benefits

While many workloads are already being deployed across a variety of public and private cloud environments in multi-cloud architectures, hybrid clouds help simplify the great complexity of managing and securing an array of deployment configurations. This requires a sophisticated management platform to ensure a consistent and seamless experience across all cloud combinations to support dynamic and evolving OT workloads. Each cloud services provider has their own tools, governance, and security – hybrid clouds can offer a single pane of glass and reduce the complexity of multi-cloud deployments.



Dell PowerStore Storage Appliance
Powered by Intel Xeon Scalable Processors

ARCHITECTURAL CHOICES FOR SOLUTION BUILDERS

Standalone Systems Feature Limitations in Comparison with HCI

Many customers today are still running standalone systems or appliances, with minimal ability to scale, run different applications, and support more complex/preferred delivery models. While those systems might be optimized for a current edge environment or workload, any benefits would be short-lived and the negatives mentioned above take hold quickly towards the tail end of deployment lifetimes.

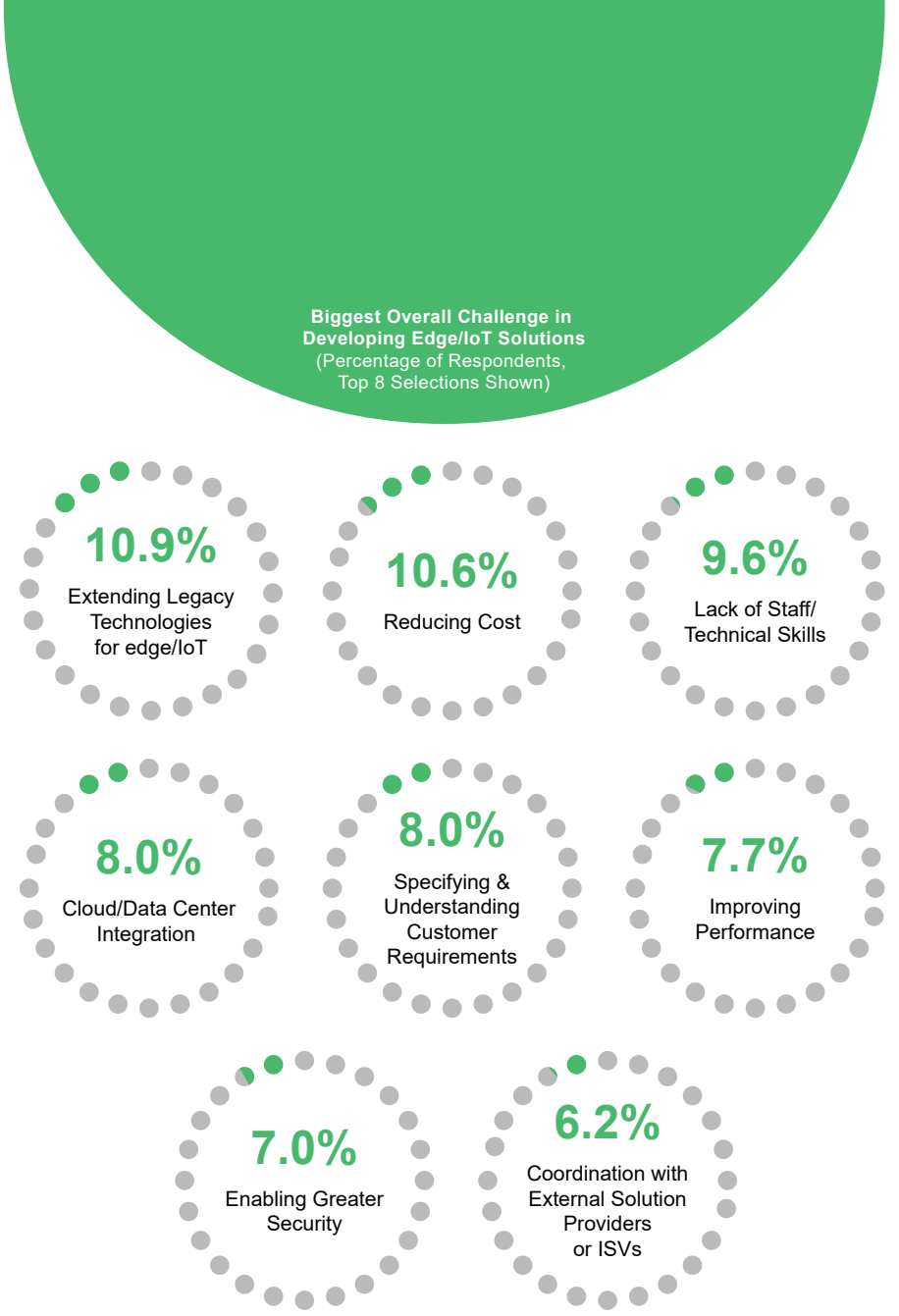
Intelligent system platforms are growing in availability from a growing pool of technology and solution providers. A fixed hardware architecture fuels the leading overall challenge in developing edge/IoT solutions today, which is extending legacy technology and systems for edge/IoT applications and services. As a result, the potential benefits in sourcing/developing hyperconverged and software-defined systems are gaining more traction and use as opposed to standalones for current and future OT computing environments.

Standalone Systems are Increasingly Moving to Hyperconvergence

Systems consolidation is an ongoing trend picking up steam with the prevalence of hyperconverged infrastructure and emergence of container technology, remote services, and OT-IT Convergence. Hyperconverged systems provide high performance for sensitive and near-real-time workloads in the field to feed high-value on premise services and off premise cloud analytics. For example, platforms such as Dell's VxRail HCI provide flexible deployment models for workloads across core, edge, and cloud environments, supporting secure storage-dense and mission-critical applications with full stack lifecycle management.

Hyperconverged systems offer many benefits, including:

- Flexibility for enabling a software-defined OT data center
- Optimized integrations between embedded processing, networking, and storage technology
- Simplified deployment management for IT teams
- Built-in data protection



CYBER SECURITY & CYBER-RESILIENCE

Both are Now Critical Concepts

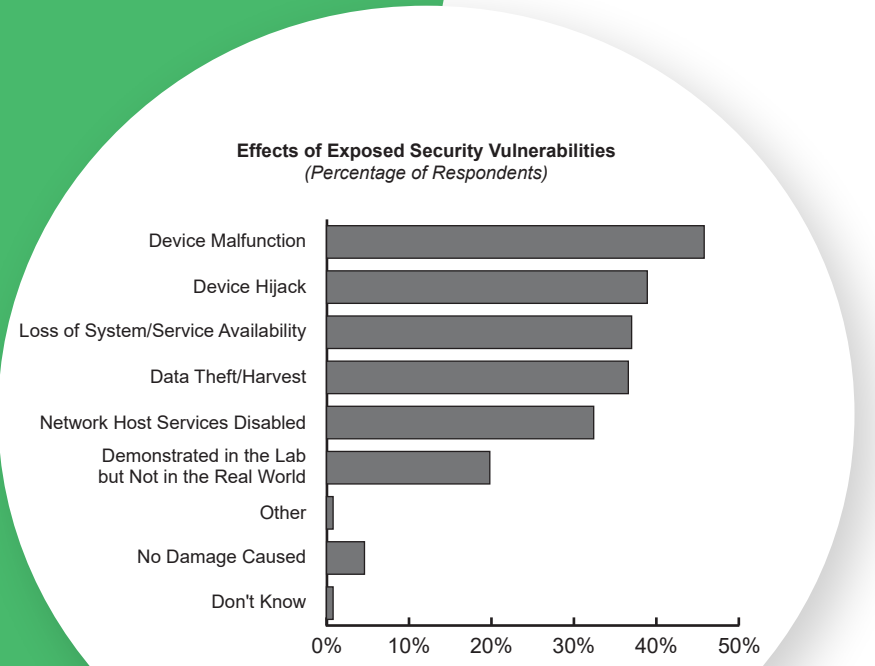
The computing or IoT edge of the past was fairly simple, with basic data aggregation devices primarily relaying data to back-end data centers and clouds. However, modern edge technology infrastructure has evolved to support more on-device application processing and data services. With increased connectivity and roles in the solution topology, edge systems in the field are critical infrastructure that still need to be well-supported post deployment.

As a result, security and cyber-resilience trends are impacting solution builders at every level – from hardware, software, and through into the cloud to ensure data protection at all stages – whether at rest or in flight. A trusted supply chain, operations, and services support from technology platform providers is crucial to scale security solutions/management with more and larger deployments. Intrinsically secure platforms require strong physical and multimode software resilience, which is spurring growth in modular data centers and clustered deployments.

Data & Systems Protection is a Core Requirement for OT Environments

Solution providers are adapting by adopting more embedded security solutions to reduce the risk of an exposed vulnerability and the detrimental effects thereof. According to VDC's data, the embedded security software solutions with the greatest use today include communications security and encryption (HTTPS, IPsec, TLS/SSL, SHH), M2M authentication, and secure firmware updating. Technologies such as iDRAC from Dell Technologies are at the heart of security development for edge servers and similar infrastructure, enabling capabilities such as firmware verification at boot, BIOS tamper monitoring, component attestation, etc., through a trusted platform module.

However, the security challenge extends further into the cloud, making not just built-in security important but also security services. Offerings such as the APEX Backup Services available from Dell Technologies enable a resilient cloud infrastructure to meet SLAs while also focusing on minimizing TCO with automated and centralized security monitoring and management. Many solution providers in the ecosystem still have a long way to go in addressing their security requirements – internal adjustments to procedures and adding headcount will only go so far without a strong technology partner.



VDC'S VIEW

Highlight the Hardware-driven Differentiation of Your Edge Solutions

Much of the attention of edge solutions is being paid to cloud services and software, but the hardware is equally important in demonstrating the performance and capabilities of the technology solution. A highly secure and optimized hardware platform for a particular customer's edge environment and workloads is a competitive differentiator for selling broader industry solutions or services. Solutions for OT environments need to focus on traditional embedded characteristics of performance (with appropriate workload hardware acceleration), size, weight, power consumption, hardening as needed for harsh conditions, and built-in security.

Build a Data-First Solution Architecture

Standalone systems and appliances can have a number of challenges against the growing competitive landscape of software-defined systems and infrastructure. An optimized data architecture supports multi-/hybrid-clouds, which are needed by global customers to simplify deployments and lifecycle management. A data-first architecture puts security at the forefront, with a variety of hardware- and software-based solutions needed to ensure a stable, resilient, secure (e.g., zero trust, etc.), and efficient platform at the edge.

VDC'S VIEW

Maximize Addressability by Being Cloud Agnostic

Technology and solution providers must seek cloud-agnostic hardware platforms as to align with the preferred/established clouds that end users already use. Preferences can range widely for cloud solutions and their connected services for storage, etc. across industries, organization sizes, geographies, etc.

Support for private or on premise clouds will be increasingly important as OT and edge environments become more intelligent. As an example of this important ecosystem cooperation, Dell Technologies' APEX Cloud Services can be used with VMware Cloud to simplify OT integration and deployments. Integration support between different public and private clouds, or multi-/hybrid-clouds, will feature a similar rise in demand.

Use Technology Partners to Design Solutions for OT Environments

OT environments have many special considerations beyond the data center, including greater requirements for rugged systems, manageability, regulatory compliance, and customer-specific deployment needs. Technology platforms, such as those from Dell Technologies OEM Solutions and Intel, are optimized for the software-defined edge and its requirements for extended life support without sacrifices to availability or performance.

Dell Technologies, in particular, is a major influence in the market as the leading OEM system provider, with its dedicated product group, engineering, program management, procurement, sales, marketing, and other functions. Dell Technologies OEM Solutions has 20+ years of experience supporting industry technology and solution providers go to market leveraging the company's broad portfolio of edge hardware (e.g., appliances, HCI, IPCs and workstations, gateways, rugged laptops/tablets and servers, storage, and more), global supply chain with fast access to components, in-market manufacturing and certification programs, flexible financial program, extended lifecycle support, broad partner ecosystem, and suite of design and engineering services enabling a wide range of customer needs. Technology platform partners hold massive strategic value in expanding further at the high-value OT edge for solution builders.

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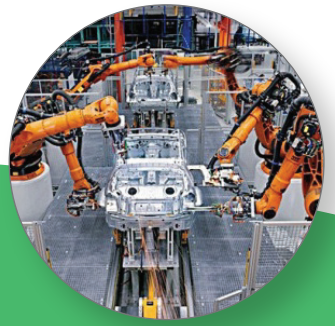
Founded in 1971, VDC Research provides in-depth insights to technology vendors, end users, and investors across the globe. As a market research and consulting firm, VDC's coverage of AutoID, Enterprise Mobility, Industrial Automation, and IoT & Embedded technology is among the most advanced in the industry, helping our clients make critical decisions with confidence. Offering syndicated reports and custom consultation, our methodologies consistently provide accurate forecasts and unmatched thought leadership for deeply technical markets. Located in Southborough, Massachusetts, VDC prides itself on its close personal relationships with clients, delivering an attention to detail and a unique perspective that is second to none. ©VDC Research

AutoID & Data Capture

IoT & Embedded Technology

Enterprise Mobility & Connected Devices



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