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Tech RADAR - Strategic technology themes that align Dell Technologies' research & development focus

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Table of contents

Introduction

As digital transformation becomes more entwined with business models across industries, IT leaders are expected to advocate for and support strategic change. To help our customers achieve and sustain competitive advantage in a data-driven world, Dell Technologies' Office of the Chief Technology Officer has developed a framework and methodology to surface key emerging trends and technologies which then are used to align Dell Technologies' research and development efforts. This framework is called the Tech RADAR by Dell Technologies, and this white paper provides a view of the themes that are driving Dell Technologies' investments.

Enterprise IT technology requirements are changing, driven by Digital Transformation

Enterprises are continuing to embrace digital transformation initiatives worldwide and by IDC's estimates, will invest a total of $7.4T[1] in related technology and services from now until 2023. In the digital enterprise, data is central to running the business. Data will increasingly be used for interacting with and understanding customers, as well as for enhancing internal IT operations and managing security. Moreover, data will be distributed and will grow exponentially, from 16.3 zettabytes (ZB) of data in 2017 to 175 ZB[2] of data in 2025. Data, and the analysis of it, will drive the pace of innovation in IT Technology.

Enterprises are also decentralizing their IT systems, establishing IT footprints in public clouds, co-locations and privately-owned data centers and at the edge of their networks in order to host workloads in the most appropriate location for their application. The multi-cloud reality is already here, but it will become even more entrenched in the future with the proliferation of edge use cases. Over the next decade, enterprises will need to invest in technologies, immersive interfaces and skillsets that enable them to consume and exploit the data at their fingertips for competitive differentiation and productivity advancements.

Developers and data scientists are creating new value and transforming enterprises into digital businesses. With the increasing impact these individuals have on their enterprises' future, they will have even greater influence on how IT selects and deploys infrastructure in support of their needs.

With cloud-based models becoming a central foundation for IT strategies, the demand for 'as-a-service' consumption is also becoming key to how enterprises expect to procure technology. The cloud services operational model allows enterprises to use only the resources they need and in turn lower direct expenditures for assets with low or sporadic utilization. Services-centric operations and consumption-based economics will permeate across all IT technology markets.

[1]IDC Worldwide Semiannual Digital Transformation Spending Guide, 2018H2
[2]IDC White Paper, sponsored by Seagate, Data Age 2025: The Digitization of the World from Edge to Core, November 2018.

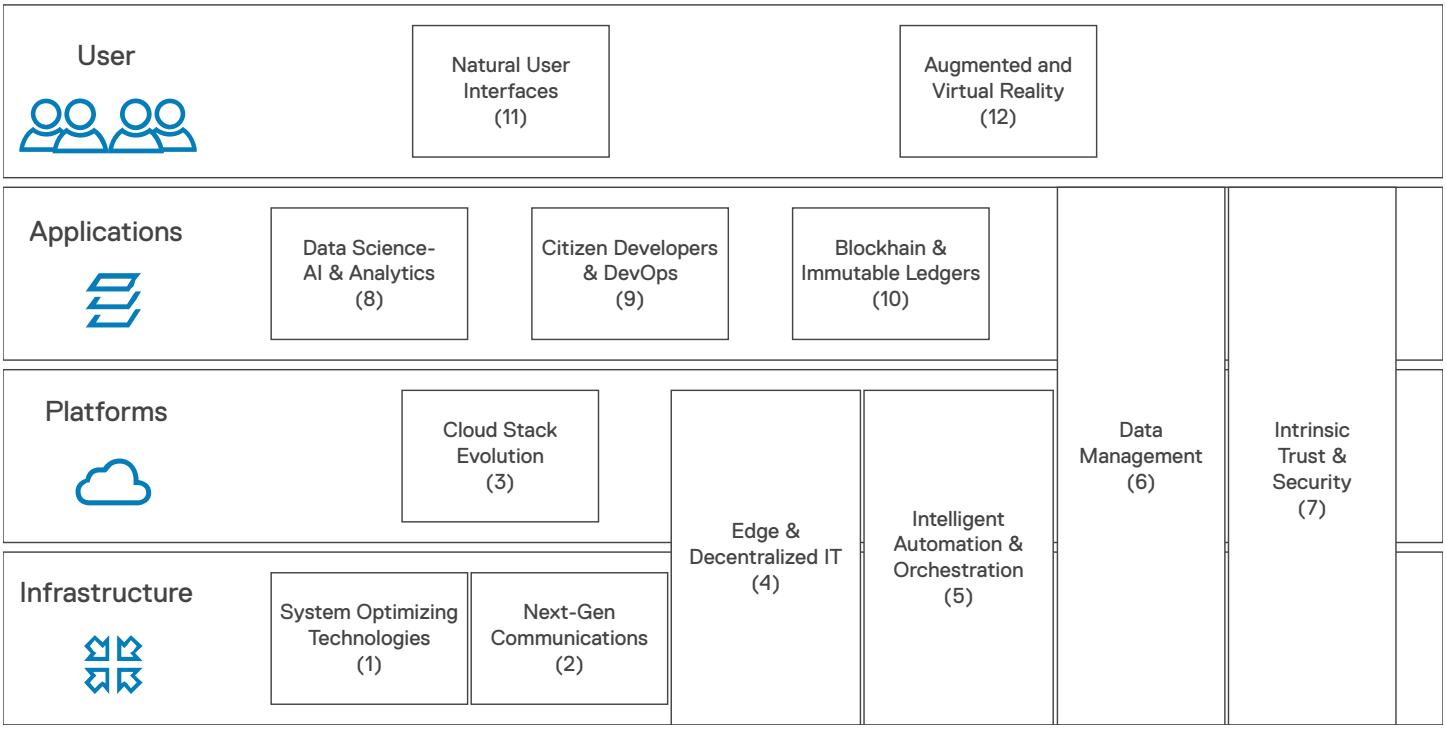
Tech RADAR - Technology themes that will define investments over the next three years

Dell Technologies RADAR provides a thematic view of the key emerging technologies that will be the most meaningful to Dell's customers over the next two to three years. These themes are themselves representative of a myriad of individual technologies and use case trends. Rather than taking a splintered approach that names many individual technologies, we've chosen to leverage a thematic approach to identify trends and provide context that reveals the emerging demands of enterprises.

The RADAR's themes are defined across a hierarchy representing the most common focus areas for enterprise organizations; Infrastructure, Platforms (software), Applications and Users. The Infrastructure layer is representative of the emerging technologies and requirements for IT infrastructure devices and systems. The Platform layer represents software infrastructure layers such as Cloud and virtualization stacks, as well as systems such as databases.The Application layer focuses on the emerging technologies and frameworks enabling the next generation of applications. The User layer focuses on technologies that represent how people and things interact with applications and systems. In some of the themes, innovation is occurring at multiple levels of the stack and, as such, the theme is identified as multi-dimensional.

Below are the top technology themes driving Dell Technologies' investments. We discuss the scope of these themes, and highlight emerging technologies and use cases associated with each theme in the following section of this white paper.

Top strategic technology themes through 2022



System optimizing technologies: Building blocks enabling next generation workloads

Digital transformation is creating significant new demands on IT infrastructure in order to support the deluge of new data being created and the processing required to glean insights from it. The industry is moving into the zettabyte and artificial intelligence era, and systems technology must adapt. The "System Optimizing Technologies" theme represents the change that is coming to compute, storage, data center fabrics and data center system design. Beyond Digital Transformation, other technical realities are forcing change. Moore's Law is quickly sunsetting, replaced by new processor paradigms. Industry standard processor technology is being challenged to deliver the improvements in performance and throughput required to support emerging analytics and AI workloads. The rate of deployment of non-x86 processors could reach greater than 20% in some buyer communities. Meanwhile, the economics of storing massive amounts of data are forcing the evolution of storage media, while moving the data from disk to processor requires new technologies and methods to faster access across data center fabrics. NVMe is already the leading storage medium in the market. In the near-future, the combination of NVMe with new NVMe-over-fabric SANs will complete the transition to new high-performance storage in demanding Digital Transformation use cases.

Figure 1 highlights the key technology areas as well as technologies and use cases we consider within the "System Optimizing Technologies" theme.

Figure 1: System optimizing technology inventory

Technology area	Rationale	Technology & Use case examples
Accelerators and new processors	Accelerators are key enablers for machine learning and AI inferencing, and extend to areas such as compression/encryption, video processing, etc. The slow improvement in physical semiconductor performance has reinvigorated custom chip design. Accelerators on pluggable modules, SmartNics, will enable even existing systems to realize improved performance and new capabilities.	» SmartNICs » FPGA » eFPGA » Deep neural networks accelerators » AI algorithm specific processors » Neuromorphic hardware » High bandwidth memory
Next generation bulk storage	Improvements in high-density flash and hard drives will lower the cost of active archive and other cool storage systems while dramatically increasing capacity.	» Penta level cell flash » Heat assisted magnetic record (HAMR) hard drives
Persistent memory and high-performance solid-state storage	Persistent memory can substantially lower the cost of in-memory use cases such as the SAP HANA or Redis databases without a huge performance hit. The unique characteristics of these technologies (e.g. asymmetric read/write performance), however, will require new architectures to best use the technology.	» 3D xpoint » NRAM » STT-MRAM » ReRAM » PCM
Data center fabrics	New fabric technologies and specifications are required to meet performance goals and support persistent memory and accelerators. We look at both I/O and cache coherent co-processor fabrics, from 1 Terabit Ethernet to Gen-Z.	» NVMe-oF » Gen-Z fabric » CXL fabric » RMDA » Silicon photonics » Terahertz wireless » Terabit ethernet
Optimized data center system mechanicals and environmental	Utilization is a major driver in the total cost of systems. Composable infrastructure increases utilization by allowing resources to be shared across individual systems.	» Composable infrastructure » Modular systems » Virtual and logical composition » Composed disaggregated systems

Next generation communications: Extending IT beyond the data center to the edge and multi-cloud

Communications outside the data center are rising as the demand for “always-on” is true for consumers and things alike, as well as between clouds, cloud functions/microservices and virtualized systems. Emerging high-performance wireless, wireline and virtualized networking technologies such as 5G, Wi-Fi 6 and SD-WAN promise ubiquitous, always-on and high-bandwidth connectivity and will enable distributed applications beyond the data center. These networking technologies will enable the proliferation of enterprise applications across private, public and edge clouds.

Boasting massive bandwidth, ultra-low latency and better performance per watt, 5G will be a key building block of edge/IoT use cases and should be factored into IT system design. 5G promises a dynamic, virtual network that can be sliced into different layers, with each slice customized to meet the requirements of the applications it supports. Likewise, Wi-Fi 6 (802.11ax), the next generation of Wi-Fi, will deliver better performance in dense areas, faster throughput and enhanced security. Together, 5G and Wi-Fi 6 will change how we work, and may replace wired connectivity technologies for campus network infrastructure.

SD-WAN has quickly garnered market acceptance over the past few years as an alternative to MPLS for cloud connectivity. Network virtualization through SD-WAN will be key to enabling many multi-cloud use cases. Enterprises are leveraging SD-WAN solutions not just between corporate data centers and public cloud but also the branch office and edge to achieve end-to-end microservice connectivity. SD-WAN solutions provide more control over applications on edge networks, enabling better security and optimizing workloads.

Figure 2: Next generation communications technology inventory

Technology area		Rationale	Technology & Use case examples
	5G	5G will be crucial for enterprise networking because it will enable edge/IoT use cases built upon its bandwidth, low latency and network slicing capabilities.	» 5G » 5G eMMB » 5G mMTC » 5G URLLC » Network slicing » Cognitive radio
	Wi-Fi 6	802.11ax promises higher throughput, lower latency and improved battery life than the previous generation, and it will support substantially more devices on each access point than previous standards.	» Managed WLAN
	SD-WAN	Network virtualization through SD-WAN will be key to enabling many multi-cloud use cases.	» Software-defined WAN

Cloud stack evolution: Transition to a multi-cloud landscape and cloud native architectures

The pace of enterprise cloud adoption has accelerated with the growing appetite for cloud native architectures, which enable enterprises to introduce services quickly to respond to business needs. Enterprises are increasingly turning to containers and Kubernetes to make their cloud applications portable and scalable, and cloud native applications represent the top use case for containers to date. With more and more enterprises deploying multiple private and public clouds to meet different business needs, new technologies are needed to optimize multi-cloud systems such as cross-organizational resource management and smart placement. The cloud stack evolution theme is about such emerging technologies and solutions that will enable the smart placement of enterprise workloads and the development of cloud native applications while tying together the disparate clouds so that they work as an aggregated system.

Figure 3: Cloud stack evolution technology inventory

Technology area	Rationale	Technology & Use case examples
Containers & service meshes	Docker containers with Kubernetes clustering have become mainstream in the enterprise market; with service meshes, enterprises can have common configuration across containers.	» Kubernetes container management » Micro operating systems » Service mesh
Serverless & service-full	Serverless abstracts even the container orchestration, allowing developers to use arbitrary code modules (functions) that react in response to events.	» Serverless infrastructure
Multi-cloud	Multi-cloud refers to the ability to deploy an application to separate clouds without the developer performing cloud specific configuration. The system should automate any customization needed for the target cloud.	» Multi-cloud management platforms

Edge and decentralized IT: Disaggregating enterprise systems

Edge computing is a part of a distributed computing topology where information processing, applications, data and services are deployed away from a centralized data center and closer to logical extremes of the network, generally known as the edge. Most enterprise data will be created and processed outside of centralized data centers or private or public clouds within the next five years. While IoT is a significant contributor to edge computing, software-defined radio access networks associated with 5G will also drive many use cases in edge computing and decentralization of IT systems. This theme explores emerging technologies, system designs, frameworks and security and management tools that will drive the creation of edge-centric architectures and software.

Figure 4: Edge and decentralized IT technology inventory

Technology area	Rationale	Technology & Use case examples
Edge architectures	By moving applications, data, and compute power from the datacenter to the logical extremes of the network, edge architectures reduce latency and minimize bandwidth requirement. IT systems must be optimized to work with local information and make decisions in a decentralized fashion.	» Sensor fusion » Edge AI » Autonomous mobile robots » Autonomous driving
Edge optimized systems	Edge-optimized systems ensure efficiency across power, cooling and other factors involved in infrastructure deployment outside the datacenter.	» Edge optimized system HW » Virtualized RAN optimized system HW
IoT frameworks	IoT frameworks facilitate the development of applications interacting with real-world environments; decentralized edge architectures must be available in IoT developers' preferred framework.	» IoT platforms » Distributed services architectures
Digital twins	Digital twins make the connection between the actual devices and the simulation environment used in machine learning and other IoT development. Making the right trade-off for edge architectures means taking these into account to get the right balance between cost and value of data centralization.	» Digital twins
Telecom micro-datacenters	The compute model accompanying the 5G rollout introduces more opportunities to place high-performance compute closer to the communication users and devices. IT systems should meet the physical needs of these small telco data centers.	» Micro datacenters » Discoverable » Composable
Edge-centric data services	Edge creates new requirements for handling widely distributed applications and requires innovative new solutions for protecting and processing the data stored there.	» Edge data fabric » Edge AI/ML training » Edge analytics » Edge data brokerage » Edge data persistence

Intelligent automation and orchestration: Heading towards self-driving infrastructure

The automation of IT systems and software has become commonplace in recent years. Enterprises are striving to make their systems agile and to reduce the overall operational costs. While automation and monitoring tools and orchestration platforms are not new, they are being dramatically improved by the integration of artificial intelligence (AI) capabilities. These smart management systems will further simplify IT operations, fine tune device configurations, maximize system availability and provide total environment visibility. AI technologies will also increasingly be integrated into IT systems such as storage arrays and network switches. This embedded intelligence with enable these systems to self-optimize, while simplifying the process of configuration for IT operations.

Intelligent automation will be critical particularly as cloud native applications proliferate, given the frequency of their production releases. Intelligent automation requires extensive telemetry and an infrastructure-as-code style of automation, with AI to match the two in response to actions. Ultimately, we envision that self-driving infrastructure will deliver an automated management experience based on operational targets, application requirements, and declarative interfaces where the system dynamically composes infrastructure to meet goals that are meaningful to developers and users.

Figure 5: Intelligent automation and orchestration technology inventory

Technology area	Rationale	Technology & Use case examples
Cloud-based telemetry, analytics & automation	Having centralized access to transaction-level metrics from servers, networking and storage would enable cross-system analysis, troubleshooting, and optimization, including the development of AI models.	» ITIL » Predictive support
Infrastructure as code automation	Infrastructure should provide an API and integration with common infrastructure-as-code frameworks. Being able to configure infrastructure programmatically enables new types of automation, including the incorporation of provisioning actions into tool chains and pipelines.	» Software-defined compute » Management SDS
Declarative configuration	Declarative configuration allows the system to coordinate actions across infrastructure systems to meet goals that are meaningful to developers and users.	» Software-defined Infrastructure » Heuristic automation » Workload orchestration (Compute, network, storage)
AI-Enhanced configuration	AI-enhanced configuration leverages AI to simplify and automate management and orchestration, which is important for simplifying operations and improving utilization.	» Continuous configuration automation
AI operations	AIOps would continuously optimize the system to meet system goals even as the usage patterns change. This includes working with edge locations and other data centers to find global optimums.	» ML-Augmented datacenters » Dynamic optimization tech
Embedded device-level intelligence & orchestration	Just as enterprises will expect their overall orchestration systems to intelligently automate their systems, they will expect the devices they deploy to integrate intelligence and self-optimization.	» Self-healing system tech » Embedded ML

Data management: Unlocking the latent value of data

Data is a key enabler of many IT use cases and an important control in managing regulatory obligations and data protection. Distributed IT architectures, however, pose challenges to easily and flexibly access, manage and govern data. Enterprises are increasingly demanding data management capabilities in their IT systems and investing in new technologies to maximize the utility of data. Data management is a broad collection of activities and supporting processes applied to data throughout its lifecycle.

Emerging technologies and solutions augment data with security, governance, discovery, transformation and other capabilities. Data mobility services, for example, help scale data processing to the needs of cloud native applications. Robust data pipelines are crucial for data science and versioning, testing and monitoring activities. Likewise, metadata annotations are the basis for many advanced use cases.

Figure 6: Data management technology inventory

Technology area	Rationale	Technology & Use case examples
 Data ingest & preparation	Data ingest and preparation involves technologies and processes related to data ingestion and annotation, cataloging, cleansing, enrichment and self-service data integration, which help improve data quality, time to insight and productivity.	» Dynamic data masking » Data sanitization » Self-service data preparation » ML-Enabled data management » Automated data catalog » Data as a service
 Metadata management	The basis for many of the advanced use cases is robust metadata annotations that need to be tracked and protected with the data, preferably directly in the infrastructure so that it can share the same service level agreements and data policies.	» Metadata management » Master data management
 Data governance	By integrating data governance into security and compliance workflows, IT systems can help remove a concern that would otherwise slow down developers.	» Cross-platform structured archival » File analysis
 Data mobility	Data must be delivered to the appropriate locations proactively to achieve the scalability goals of cloud native applications.	» Application data management » Data lakes
 Data processing pipeline	Building data pipelines is a core component of data science, and ensuring low event latency and high scalability as well as tools for versioning, testing and monitoring are key for robust pipelines.	» Data processing pipeline
 Databases & DBMS	DBMS verticalize formerly horizontal purchases such as when a high availability database service includes compute, storage, disaster recovery replication, backup, and audit in a to the customer.	» Document store DBMS » Wide-column DBMS » Multi-modal DBMS » Private cloud dbPaaS » Time-series DBMS » Graph DBMS » SQL DBMS

Intrinsic trust and security: Transition from border security to an integrated model

Security continues to be a key enterprise requirement. Besides mounting regulatory requirements and privacy concerns, the move to distributed systems brings new security-related challenges. Intrinsic trust and security require transforming traditional security methods to effectively protect modern IT architectures. In distributed systems, hardware components are no longer ring-fenced by physical separation because they either are deployed at the edges of the network or comprise the shared resources in a cloud environment. For foolproof protection of disaggregated systems, security must be built into all components and layers of a solution. Moreover, this layered security should be automated to do away with the traditional security methods of reviewing releases prior to deployment, which often hold up innovation. Moving forward, embedded encryption, key management and rich telemetry will be a requirement for IT systems. SecDevOps and automation will be wrapped around intrinsically trustworthy components that generate highly granular telemetry to insure end-to-end security and compliance.

Figure 7: Intrinsic trust & security technology inventory

Technology area	Rationale	Technology & Use case examples
Cyber resilience	Cyber resilience is about strengthening information security and business continuity against cyber events and data breaches.	» Hardware root of trust » Chain of trust
Automated stack validation & remediation	Security issues will be found on the components of released applications. To be truly resilient, systems must identify issues without human intervention, alert those responsible, and ideally remediate the issue by installing patches or repairing configurations.	» Real-time intrusion detection » Automated security Configuration/hardening » Cloud access security brokers
Data-centric security	Security travels with the data and must be transferable across clouds. Capabilities should include end-to-end encryption, distributed shared secrets, deduplication, compression and indexing.	» Zero trust » Multi-party computation (MPC) » Homomorphic encryption
Identity and access management (IAM) evolution	Identity and access management methods have to be modernized for more secure user authentication and authorization, as well as to enable users to have control over their identity and data.	» Decentralized identity » Adaptive authentication/ Risk-Based authentication (RBA) » Password-less authentication » Biometrics » Privileged access management (PAM)

Data science (AI & Analytics): Accelerating time to actionable insight in the digital enterprise

Enterprises have been using analytics techniques such as regression or visualization for improving pricing, optimizing processes, and other data-based decision-making for decades. Traditional approaches are starting to fall short, however, with massive amounts of data increasingly distributed across the network. Enterprises must strengthen their analytics capabilities with machine learning and AI in order to process and transform data into insight effectively and efficiently and automate business actions. The data science theme focuses on emerging technologies that address the growing needs of data scientists and the ecosystems they leverage. Data scientists are demanding IT systems that support AL/ML learning frameworks and big data tools and that accelerate deployment of AI and advanced analytics use cases. Specialized accelerators will play a key role in improving the compute capacity because much of the data processing and analysis takes place at the edge.

Figure 8: Data science technology inventory

Technology area	Rationale	Technology & Use case examples
AI/ML accelerators	AI/ML accelerators deliver hardware acceleration to compute-intensive machine learning and inference. Accelerator fabrics are high performance, cache coherent interconnections between the central processors and these accelerators.	» FPGA accelerators » Deep neural networks accelerators » Neuromorphic hardware
AI/ML learning frameworks	AI/ML systems are one of the leading sources of compute growth in enterprises, and these systems will be the core of many new analytics application infrastructures.	» Machine learning » Deep learning » AI PaaS » Artificial general intelligence » AutoML
Big data ecosystem	Infrastructure solutions must leverage common big data tools to simplify data engineering and processing for cloud native implementations.	» Distributed file systems » Databases as file systems » Spark » SQL interface to object Stores » Event stream processing » Graph DBMS
Data analytics & BI	Data analytics creates actionable insights out of data to support business decision-making and activities. Visualization tools can help communicate complex problems and patterns in a more intuitive manner.	» Data visualization » Data analytics & BI

Citizen developers and DevOps: New toolchains and frameworks to democratize application development

Developers play a prominent role in an enterprise's digital transformation journey, and their needs are helping define modern IT architectures. Developers are embracing cloud native architectures for new applications and are actively re-platforming legacy applications. They are widely adopting DevOps methodologies for software development and care about outcomes, agility and continuous delivery. They expect IT systems to react to their desires as specified in application code, without separate manual administration. Citizen developers in modern, digital enterprises are supporting application development efforts in increasing numbers. Citizen developers are not developers by trade; they sit across different lines of business in an organization. They can design and build IT applications to address business needs by leveraging low code/no code software development platforms and new, intuitive tools and frameworks. With the emerging AI/ML-powered toolchains that enable developer automation and consistent and repeatable application development, citizen developers' contribution should grow substantially in the coming years, bridging the skills gap that has slowed enterprise digitization initiatives. This theme examines emerging technologies, frameworks and toolchains that democratize application development and drive innovation across an enterprise.

Figure 9: Citizen developers and DevOps technology inventory

Technology area	Rationale	Technology & Use case examples
Continuous integration and Continuous delivery (CI/CD)	The CI/CD system coordinates the automated testing and production deployments of application components of micro-services, and provides the point of reference for policies and actions related infrastructure requirements and provisioning.	» DevSecOps » Continuous delivery » DataOps
DevOps & system reliability engineering	DevOps refers to the automation of IT operation actions where these actions apply the same development processes such as testing and automated deployment as applications.	» DevOps » Site reliability engineering » App release orchestration
Citizen data scientists & operations technologists as developers	As non-traditional developers include more intelligence into production systems, they need tools that retain their typical environment but allow for connection to application development systems.	» AIOps platforms
Cloud native tools	Cloud native development requires a new set of tools that are cognizant of the structure of microservices infrastructures.	» DevOps toolchain orchestration

Blockchain and immutable ledgers: Enabling smart contracts, data provenance and decentralized identities

While blockchain is synonymous with crypto currencies, blockchain enables a wide range of enterprise use cases. Blockchain supports a single shared version of immutable truth among participants, which means that there is no need for trust in a central authority. Any participant in a chain can independently verify records in a distributed ledger. Over the next three to five years, enterprises from all verticals are expected to make significant investments in blockchain. This theme is about emerging use cases and the blockchain technologies that enable them: Immutable Ledgers and Distributed Communal Databases are technical components of a blockchain implementation, while Smart Contracts, Distributed Identity and Chain of Custody are use cases solved using a Blockchain implementation.

Figure 10: Blockchain and immutable ledgers technology inventory

Technology area	Rationale	Technology & Use case examples
Immutable ledgers	Having an unchangeable record of transactions or events allows for audits and governance across a variety of interactions. These systems are typically log-based and provide some protection against change once a transaction is committed.	» Distributed ledgers • Consensus Algorithms (e.g. proof of work, proof of stake, etc.)
Distributed communal databases	Distributed communal databases allow for distributed databases at the edge or across on-premises data centers without a central cloud.	» Blockchain
Chain of custody	Chain of custody is about chronological documentation of all parties that come into contact with an item, and history of all transactions.	» Blockchain for supply chain » Backup copy integrity » Data provenance
Smart contracts	Smart contracts promote automation between systems by allowing for the trading of services with SLAs without requiring human intervention.	» Blockchain PaaS » Blockchain for data security
Distributed identity	Distributed identity transforms traditional authentication and authorization methods to establish self-owned, independent identities by leveraging blockchain and distributed ledger technology.	» Blockchain for IAM

Natural user interfaces: Transforming enterprise interactions

Key to digital enterprises' success is the effectiveness of how their customers, partners and employees interface with them. These interfaces make or break their digital products and services. Natural user interfaces can dramatically change traditional ways of interacting with machines to unlock the potential of cognitive computing and data. Natural user interface technologies enable users to interact real-time with the system in intuitive ways with minimal or no training, using natural interfaces like voice recognition, gestures, video processing and natural language text. Audio processing, context awareness, and AI/ML techniques will play a key role in enabling natural user interfaces and the future of human-to-machine experience. Combined with AI BOTs, natural interfaces will likely become a key part of an enterprise's interaction with its customers and even as a method to enable its employees to interact with internal systems.

Figure 11: Natural user interfaces technology inventory

Technology area	Rationale	Technology & Use case examples
Natural language processing	NLP has existed for decades, but recent advances in machine learning have improved the speed and accuracy to sufficiently make it viable for general purpose use cases, and consumer applications such as Siri, Alexa, or Google Home have increased awareness.	» Virtual assistants » Smart workspace » Connected home
Semantic domain analysis	NLP provides the raw materials, while semantic domain analysis adds context so that NLP may be applied to specific business problems. This area uses techniques such as knowledge graphs to uncover intent and guide appropriate responses.	» Knowledge graphs
Conversational bots	BOTs uses NLP and domain knowledge to automate business processes using natural user interfaces. These bots can take at least some actions without human intervention and can augment human agents for complex interactions.	» Conversational AI platform

Augmented and Virtual Reality: Immersive interfaces to take off to effectively sift and visualize massive amounts of data

Immersive interface models are well established in the consumer markets and are ascending in the enterprise market. According to an enterprise survey conducted by the 451 Research, 73% of the enterprises have plans to integrate AR/VR solutions in their IoT initiatives within the next three years[3]. AR/VR extends the digital environment into the physical realm and across multiple senses, including sight, sound, and touch. This can be done in pure digital virtual reality (VR), in augmented reality (AR) where data is overlaid on a live active view, or in mixed reality (both virtual and augmented). We expect enterprises to utilize AR/VR technologies for a wide variety of use cases, such as systems management and orchestration, data synthesis and presentation in the zettabyte world, and remote vehicular control.

Figure 12: Augmented and Virtual Reality technology inventory

Technology area	Rationale	Technology & Use case examples
VR gaming	Many point to AR/VR as a potential method to handle the complexity of data andiInsights in emerging enterprise applications. AR/VR will also have a role in IT Operations.	» Server-side client graphics
Simulated room collaboration	This requires capable networking and servers for coordination across locations.	» Volumetric & holographic displays
Data surfacing and presentation	The explosion of data makes human interpretation difficult. New immersive interfaces coupled with AI bring the ability to surface important details.	» Augmented reality
Game streaming	Streaming UX moves complex rendering from high-end clients into servers containing multiple GPUs.	» High-performance GPUs » Stream ingestion » Event stream processing
Remote vehicular control	This requires capable networking and servers for coordination across locations. It could leverage intelligent distributed edge architectures for prioritizing live data across networks.	» Mixed Reality

[3]451 Research, Voice of the Enterprise IoT, Voice of the OT Stakeholder, 2H2018

In summary

At Dell Technologies, we strive to stay ahead of strategic enterprise and consumer market trends and emerging technologies to drive product development and innovation initiatives, expand our customers' business opportunities and further human progress. The themes introduced above are part of the framework called the Dell Tech RADAR, which Dell employs to drive our research and development efforts.

Modern enterprises will be fueled by instrumented, automated and adaptive business processes and IT infrastructure. Data will be central to businesses and create competitive differentiation and new revenue opportunities. Exploiting massive amounts of data will require intelligent, optimized systems and immersive interfaces that can adapt to the desires of its users and react to changes in the environment.

Dell Technologies Office of the CTO will continue to follow these trends to make sure we remain on track and ahead of the technology evolution curve. Check back periodically for updates to ensure you stay up to date on what's coming.

