WHITE PAPER

IoT Healthcare
Edge Compute

Transforming Care Delivery with New Edge Computing

New edge computing offers provider organizations greater agility, reliability, and responsiveness for better operational and diagnostic performance with solutions that support multiple edge devices, applications, and services on a single common platform that complements cloud and data center resources.

Executive Summary

Today's healthcare systems must transform to a data-driven, patient-centric model that is more collaborative, distributed, and personalized. The growing demand for affordable quality healthcare drives a smart and connected care continuum where seamless and secure data capture, analysis, and sharing are standard. Digital technology is at last making this transformation possible, and continued advances in compute performance can deliver better clinician and patient experiences.

Technology advances in artificial intelligence (AI) and analytics are driving faster, better decision-making through interactions between edge, data center, and cloud. But with request volume and complexity increasing, the cloud alone is no longer enough. The next great leap requires real-time local data management and analytics to reduce response time and network congestion, and provide improved autonomy, reliability, resource utilization, and data coherency.

A key element in this shift is a new paradigm—recently dubbed edge computing—which places more compute resources beyond the data center and cloud and closer to the data to enhance care decision-making through greater speed, accuracy, and reliability. Edge computing, driven by the massive explosion in interconnected medical and non-medical devices, enables new applications and services that unlock enormous clinical value but cannot be easily supported by the current host-based and cloud-based application platforms.

Today's edge computing solutions skew towards single-function appliance or traditional embedded models where tightly coupled OS, firmware, and hardware make change or new application adoption difficult and costly. A new transformative foundation that delivers greater agility, responsiveness, and reliability at once, on a single common platform, can enable new levels of flexibility and robustness for critical health IT infrastructure.

Today, with software-defined, real-time edge computing, establishing a reconfigurable edge device, application and service delivery platform that adapts and adds value over time is possible, and adds a powerful complement to existing cloud and data center resources. The applications for this new edge computing span both the operational and diagnostic sides of healthcare — from asset tracking and inventory management to patient monitoring, smart imaging, and deep analytics.

These edge computing capabilities require a common architecture that easily scales, connects, and adapts to this range of computing needs. Intel envisions and can help enable these standards-based platform solutions to make edge computing innovation a reality today and a driver of what is possible for the future.

Note: *While Wind River* Titanium Control is the virtualization platform used in the example use cases here, other implementation options exist depending on the needs of a given design and deployment.*

Contents

The Promise of Edge Computing

The growth in healthcare IoT and the vast amount of new data produced present opportunities and challenges requiring more distributed compute performance and capabilities. System-wide collaboration with a holistic view of the patient places new demands on existing infrastructure where tightly coupled OS, firmware, and hardware make adding/changing functions difficult and costly. More analytics and devices introduced into healthcare networks require more advanced and flexible ways of managing data to ensure clinicians and organizations are extracting maximum and timely value from it. Addressing regulatory compliance and patient privacy concerns means keeping more data local and limiting its dispersion across multiple networks and locations.

Technology advances in compute performance, security, and analytics using AI, machine learning, deep learning, and inferencing, are all converging to transform all this new data into actionable insights, driving faster, more informed care decision-making. Solutions based on these capabilities are becoming a requisite part of operational performance and care delivery, and their viability in all conditions is increasingly important and routine for ensuring patient safety and quality of care.

As a complement to data center and cloud computing systems, edge computing places compute resources and data processing capabilities at the edge of the network, closer to the most relevant data and related operational or diagnostic objective. This helps mitigate potential resource constraints and other concerns that sole reliance on data center and cloud interactions present, including:

- Latency
- Privacy and data security
- Lack of persistent connectivity
- Bandwidth cost and availability

The current edge computing model is dominated by dedicated purpose systems and functional solutions where OS, firmware, and hardware are tightly coupled, making changes costly and repurposing nearly impossible. The next great leap demands scalable systems at the edge that share resources, expanding and adapting to fit changing healthcare requirements, and the devices, services, and applications needed to support them. This is what new edge computing offers.

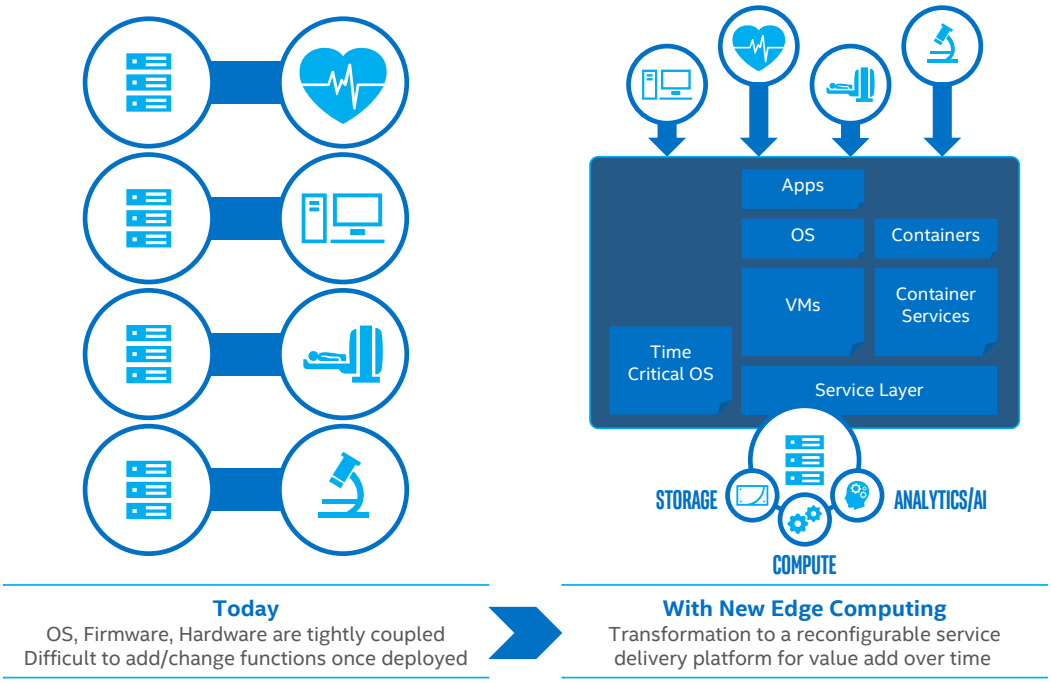

Figure 1. Edge Computing Transformation

A New Edge Computing Model: Agile, Responsive, Reliable

Single-purpose deployment is the dominant paradigm in healthcare today, where computing exists at the edge in mostly isolated islands of medical devices and patient systems. Now, using software-defined, real-time computing features, a new transformative foundation that is at once agile, responsive, and reliable, and can support multiple edge devices, applications, and services on a single common platform is possible.

This new edge computing model simultaneously offers:

- **Agility:** Virtualization and containerization enable software updates instead of hardware replacement, enabling more rapid deployment of new applications and services and operational consolidation for cost reduction;
- **Responsive Analytics:** Real time insights into operational performance and system loading enable next-generation AI capabilities to be delivered using multiple data sources to drive enhanced operations and deliver faster insights for better patient outcomes;
- **Reliability:** In the configuration below, a robust, fault-tolerant, mission-critical Wind River Titanium Control software platform delivers high availability for crucial application, services and systems uptime, and failover. Other software platform options may deliver similar features and benefits.

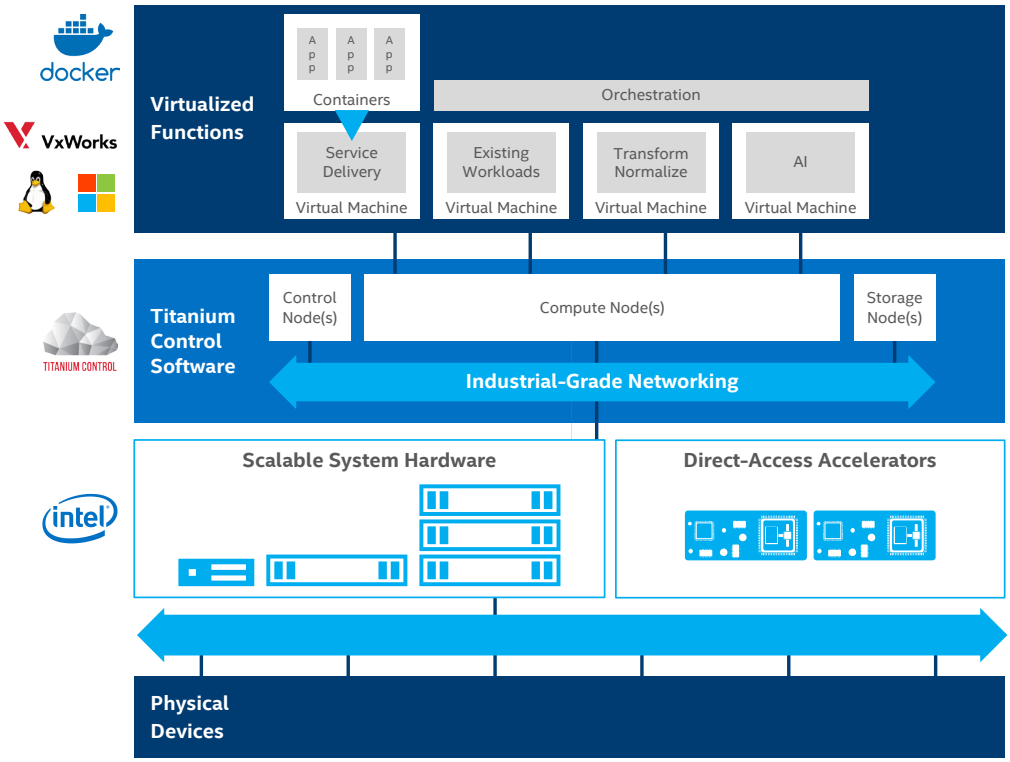

Figure 2. New Edge Computing — Platform Stack Detail

This new edge platform can provide nearly limitless reconfigurability, allowing organizations to better support and adapt to changing operational and care delivery needs while also lowering costs and improving ROI through reuse and repurposing, and resulting in increased longevity of existing IT infrastructure. This approach also provides a path to workload consolidation where the totality of medical devices and systems are more flexible and kept current more easily than an array of single purpose devices.

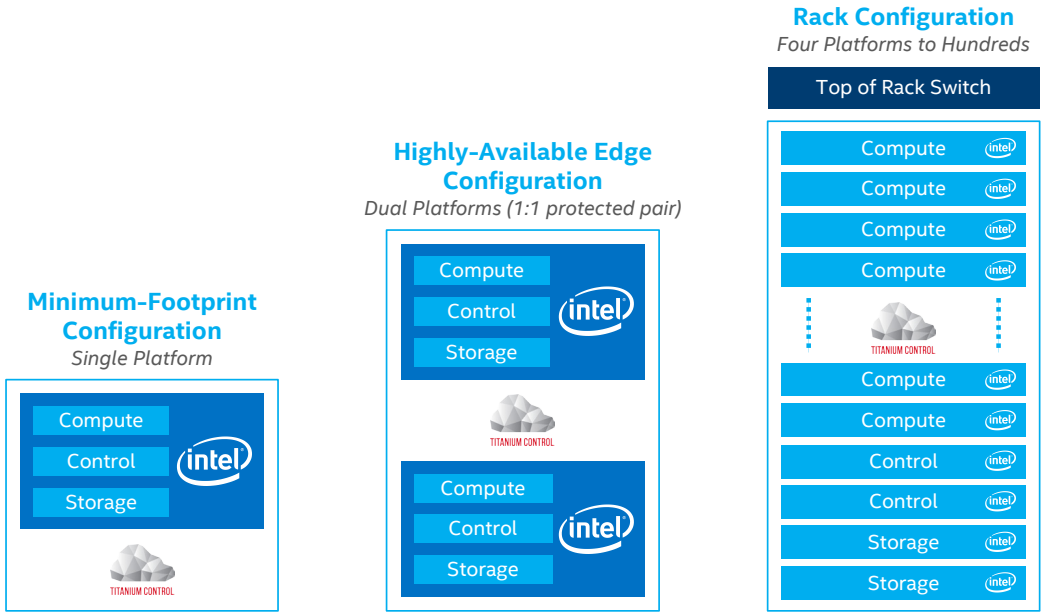

Figure 3. New Edge Computing — Scalable to Multi-Element

As with all healthcare data, security at the edge is particularly important. Intel® solutions extend a secure chain of trust from physical hardware to application deployment, delivering new ways to transform and secure care delivery at the edge through targeted and dynamic firewalls and anti-malware, host protection, secure VM deployments, transport layer security to protect management operations, and perimeter protection on external operations, administration, and management.

In addition to requisite hardware performance, scalability, manageability, and security, this new merged stack can support many uses: diagnostic devices and applications, clinical patient monitoring and assessment, predictive maintenance services, and inventory and asset management. To help illustrate this new edge computing concept, a few healthcare use case examples are offered here.

New Edge Computing in Action — Use Case Examples

The following examples leverage Wind River Titanium Control's out-of-the-box features to achieve the agility, responsiveness, and reliability cited. Other implementations are possible.

Asset Management

A significant problem in the healthcare environment—particularly in hospitals—is keeping track of the massive inventories of everything from medical instruments to medications. Typically, these inventories are manually updated and prone to human error.

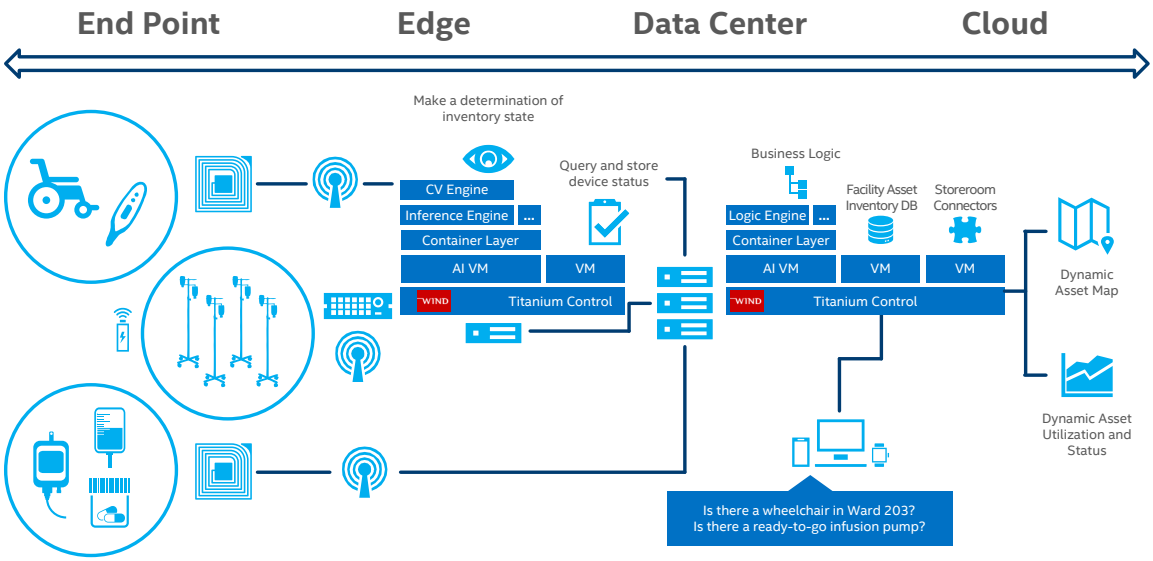

Figure 4. New Edge Computing — Asset Management Example

A new edge computing configuration tracks inventory through RFID tagging to construct a real-time store room that can be centralized and managed virtually, with a Dynamic Asset Map that gives updates on asset utilization and status. The result is a seamless and comprehensive inventory management experience spanning endpoint to edge to data center to cloud that is more easily maintained and updated to reflect status and better support operations.

Imaging Workflow

Ultrasound exams have become an increasingly popular first-pass diagnostic tool. They're safe, don't emit radiation, and can be used repetitively with no ill effects. However, ultrasound exams require a high degree of training and expertise to perform an exam correctly and make an accurate diagnosis. Hospitals are looking for ways to use technology to reduce their reliance on the human expertise necessary to perform an ultrasound exam.

This imaging workflow solution automates and streamlines the ultrasound exam process. It offers reliable triggered image capture, feedback on whether the procedure was performed correctly, and highlights image areas for follow up—all making it easier for the provider to perform a simple and successful exam.

A deep learning software toolkit deployed on top of the hardware allows for the system to adapt as it performs more procedures, eventually paving the way for deeper AI applications.

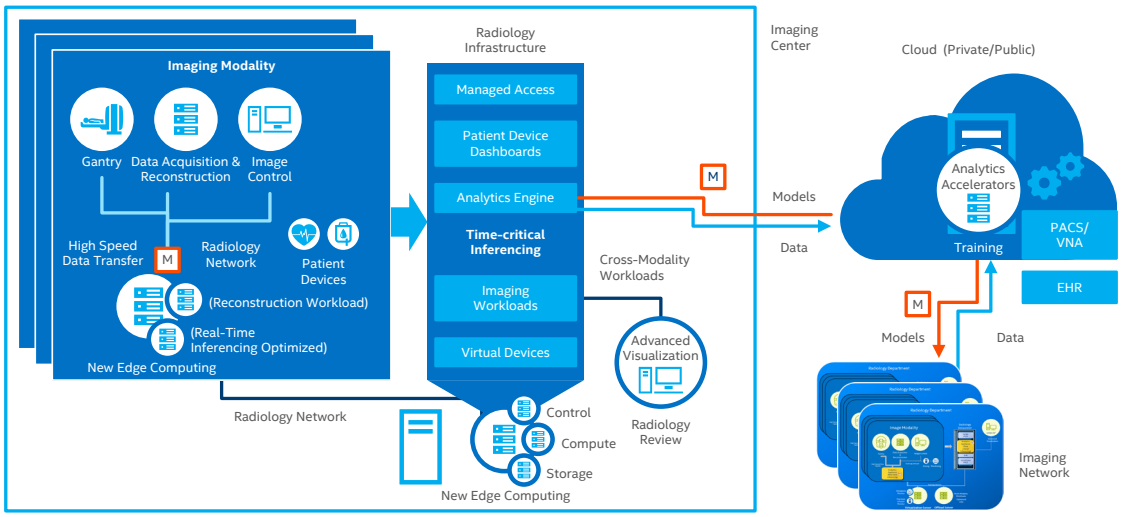

Figure 5. New Edge Computing — A Conceptual Radiology Deployment

Smart Alarm/Dashboards for Patient Monitoring

A key problem with many legacy medical devices is that they don't talk to each other, resulting in an explosion of device alarms. For years, these devices have performed specific functions, operating as isolated islands each having a part of the overall patient context.

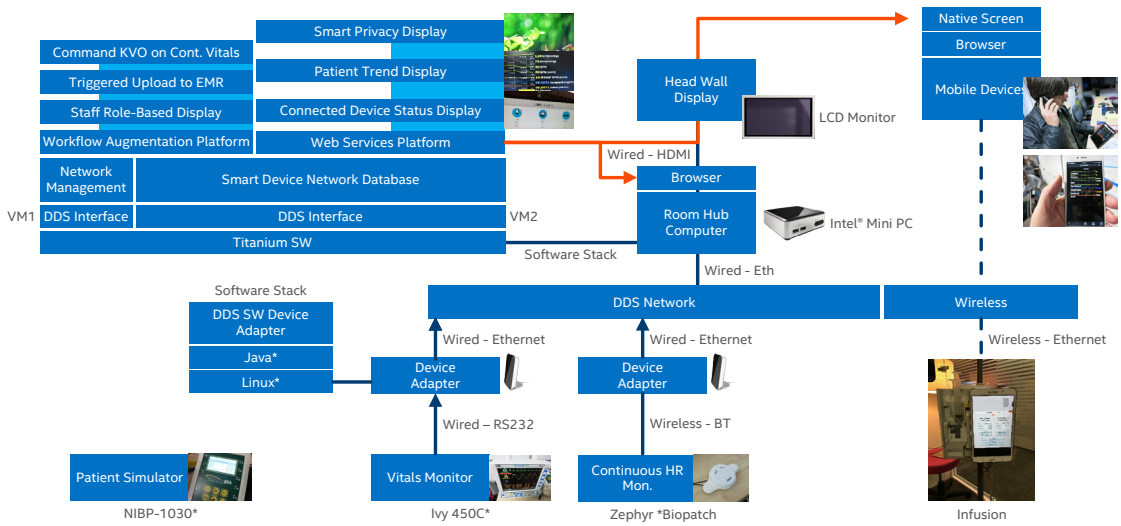

Figure 6. New Edge Computing Smart Alarm/Dashboards Example

Using a new edge computing model, the value of combined data streams is nearly limitless. Software functionalities can be refined and enhanced over time and can easily be managed across a suite of devices.

For example, a smarter alarm system[1] can be created, by using data from the two different monitors, that verifies patient heart rate across both devices before sounding an alarm. It can also conduct a first layer of diligence by distinguishing machine error from an actual patient crisis, or create centralized display units covering multiple devices which can be updated and customized based on provider requirements.

Many other solution possibilities exist across the healthcare spectrum, creating a more connected patient, provider, and hospital with clinical, operational, and IT applications:

Clinical Applications

- Patient Health Monitoring
- Medical Data Analytics
- Fall Prevention – Video Analysis

Operations Applications

- Asset Tracking and Workflow Optimization
- Predictive Maintenance
- Environmental Controls
- Eliminate Device Duplication
- Automated Documentation
- Alarm Management

IT Applications

- Secure Legacy Device Network Interfaces
- Enable Device Inventory and Status Reporting
- Manage Updates and Time Bases Across Devices

Building Blocks for Edge Computing Solutions from Intel

Intel has a broad product portfolio that can be used to develop edge computing solutions. These solutions are built on a standards-based architecture to ensure interoperability for a wide range of systems and devices, to facilitate wide application development, and to simplify services deployment.

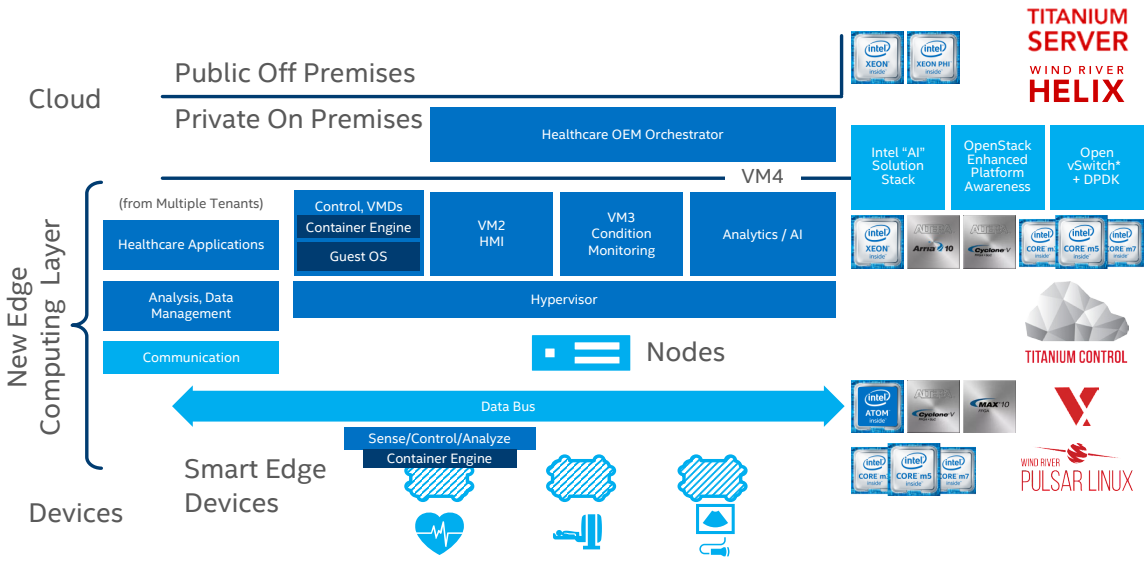

Figure 7. New Edge Computing —Intel® Ingredients

Key enabling elements include:

- *Processors:* Intel Atom® processors, 8th Generation Intel® Core™ processors, Intel® Xeon® Scalable processors
- *Accelerators:* Intel® Optane™ Memory; Intel® Stratix® 10 and Intel® Arria® 10 FPGA; Intel® Movidius™
- *Software:* Wind River Titanium Control supporting real-time analytics capabilities, mission-critical reliability, and virtualization and containerization; The OpenStack* Cloud Platform; Akraino Edge Stack
- *Analytics:* Deep Learning Deployment Toolkit for analytics across real-time patient data; Data Analytics Acceleration Library to speed up existing and newly deployed algorithms
- *AI Technology:* Intel® Nervana™ Platform, including productivity tools, IA-optimized DL frameworks, and IA optimization libraries
- *Security:* Hardware features including Protected Boot (Hardware Root of Trust, Secure Boot, UEFI 2.3.1+, Operating System Guard); Device Identification (Intel® Enhanced Privacy ID, RSA Key pair + TSI Service); Protected Storage (Trusted Platform Module (TPM), Intel® Platform Trust Technology (Intel® PTT), eMMC Flash); Trusted Execution Environment (Intel® Software Guard Extensions (Intel® SGX), TrustLite, VTx); Built-In Crypto Engines (DAL, CSME, Innovation Engine, Secure Element, Intel® AES-NI)
- *Networking and Communications:* Intel® Ethernet Converged Network Adapters with hardware optimization and offload for the rapid provisioning of networks; Intel Ethernet Optics and Cables

A Vibrant Ecosystem Drives Solutions Innovation

In looking at the state of technology in healthcare today, we see a broad spectrum of uses and applications and differing levels of deployment. Some providers and institutions are just now starting to get connected. Some are making use of IoTG technologies but are relying on single-purpose deployment. Others are proactively looking towards the edge computing solutions of the future. Intel is there across the entire range of customer needs and potential use cases.

Intel nurtures an ecosystem of innovative hardware and software partners, easing solution development with pre-built, qualified and reliable building blocks and reference designs, and a well-defined foundation for device connectivity and cloud-to-edge data management. This means partners can focus on building value-added, differentiated solutions that better address the needs of their customers.

Intel builds solutions from the ground up, connecting the unconnected and standardizing the framework through which devices operate, interact, access and exchange data, and speak to one another. With all devices having the same fundamental view of the world, each one can be as connected as the developer chooses. Partners benefit from reduced development cost and time to market, while providers can more easily deploy systems that accommodate new devices within the ecosystem.

The move to edge computing and a newly agile, reliable, and responsive platform architecture eases the deployment of intelligence wherever it's needed, offering a product ecosystem that customers ultimately want to invest in. The flexibility and versatility of our solutions give manufacturers the ability to add value over time by leveraging the latest advances while adding innovation of their own.

Giving Your Healthcare Solutions a New Edge

Intel provides healthcare technology solutions that increasingly connect and optimize care delivery, setting new standards in technology speed, precision, agility, reliability, and responsiveness.

From innovations that change how devices, providers, and patients interact, to optimizing existing edge technologies so that healthcare applications and services can be run on a single common platform, the scope of possibility reaches across the entire healthcare continuum.

To find out more about how Intel's edge computing solutions can help enhance provider organization performance and transform patient care, contact an Intel Field Sales representative or visit https://www.intel.com/content/www/us/en/healthcare-it/transforming-healthcare.html?wapkw=iot+health.

[1] Some of the potential use cases for the Intel technology described in this material may be regulated by the FDA or similar regulatory agencies.

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