

Transforming Healthcare with Telemedicine Solutions based on the Internet of Things (IoT)

Dell* and Intel use IoT technologies to help telemedicine providers improve security, device interoperability, treatment decision making via analytics, solution scalability, and access convenience.



Evolving towards
information-driven
healthcare

Executive Summary

The healthcare industry is searching for new ways to increase efficiency, especially in light of rapidly aging populations;¹ skyrocketing chronic conditions as people live longer;² and a global shortage of medical professionals.³ These factors, along with others, are escalating costs and increasing worker stress in already strained healthcare systems around the globe. Providing relief in many care situations, telemedicine solutions are being used to remotely diagnose and treat patients in order to significantly reduce travel, cost, and time.

Telemedicine solutions, like applications in many other industries, are benefiting from the rise of the Internet of Things (IoT), which brings a multitude of physical objects into the connected world via the Internet. "With remote monitoring, the IoT has great potential to improve the health of patients with chronic illnesses and attack a major cause of rising healthcare costs,"⁴ according to the McKinsey Global Institute.

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This paper describes IoT technologies from Dell and Intel that enable telemedicine applications to deliver improved security and privacy, greater medical device interoperability, better treatment decision making via analytics, and faster scalability, among other things. In particular, building blocks used to develop freestanding medical stations and in-home remote monitoring are covered.

Key Business Objectives

Improve patient outcomes while reducing readmissions and costs.

Business Challenge

For telemedicine solution providers, reducing the cost per user and maintaining high service levels often requires reaching a critical mass of patients, physicians, medical devices, etc. However, achieving ambitious growth plans can be challenging, especially for a small startup with limited resources.

This was the case for HealthSpot*, a small telehealth company looking to deploy and support 10,000 stations across the U.S. over a few years. This effort would require a large organization, so HealthSpot sought out the Dell* OEM Solutions team as a partner to help them reach their goals. The team helped HealthSpot bring their intellectual property to market while taking advantage of Dell's global supply chain for distribution and support.

Dell also helped VSee* develop an architecture that could be deployed en masse to support its HIPAA-secured video and webChat solution, an example of how IoT will have a profound impact on healthcare.

[Watch video.](#)

Solution Benefits

Through the use of IoT technologies from Dell and Intel, telemedicine solutions provide benefits in many areas, including:

- **Improved Security and Privacy**
The solutions can help strengthen a healthcare provider's security posture by providing a comprehensive picture of where data is, how it is used, and who is accessing it. These capabilities can go a long way to maintaining the integrity of patient records, preventing negative press, and avoiding substantial fines and penalties.
- **Greater Medical Device Interoperability**
The IoT enables devices to more easily and securely share information, as in a vital sign monitor communicating with a home medical station (for dispensing prescriptions) in order to ensure medication compliance and adherence.
- **Better Treatment Decision Making via Analytics**
Big data analytics is helping to improve research and treatment for Parkinson's disease by detecting patterns in patient data collected from wearable technologies used to monitor symptoms. This effort is an important step in enabling researchers and physicians to measure the progression of the disease and to speed progress toward breakthroughs in drug development.⁵
- **Faster Scalability**
Healthcare providers can quickly achieve global scale with Dell OEM Solutions that provide managed services (e.g., fulfillment and support), increased capacity to meet the demands of large customers, and reduced time-to-market, all while eliminating the need to quickly grow a large staff.

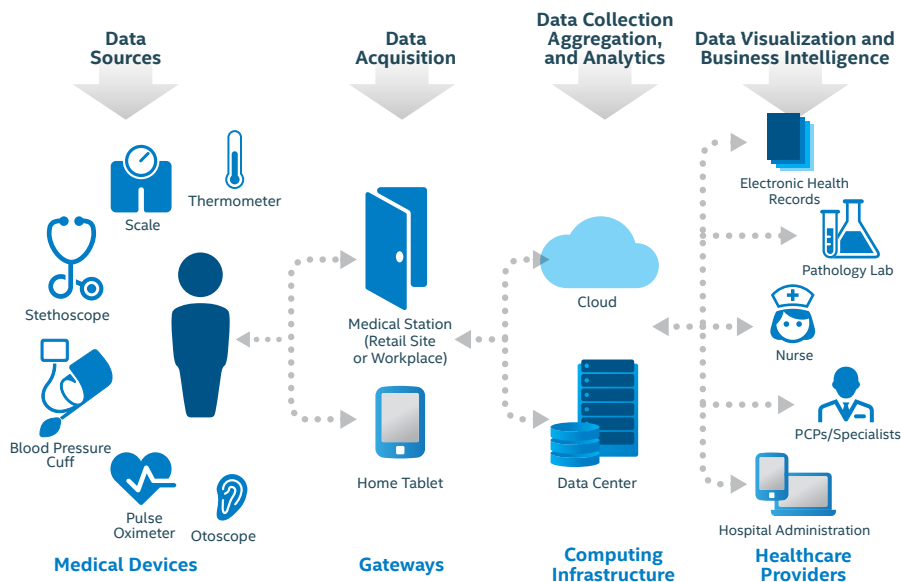


Figure 1. Simplified Telemedicine Architecture

- **More Convenient Access**

In-home telemedicine solutions can be tailored for use in extremely remote locations, like villages in Africa, India, and Central America, by equipping tablets with satellite communications and a small solar panel for power.

- **Creation of New Business Models and Partner Relationships**

The Intel® Mashery™ API Management platform allows telemedicine solution providers to open up new revenue streams by providing secure, controlled access to the IoT infrastructure to third party providers of healthcare services and applications.

Solution Overview

Telemedicine solutions based on IoT technologies allow healthcare professionals to securely communicate with patients over the Internet using the simplified architecture shown in Figure 1.

The solution can be deployed in a variety of ways, such as with a medical station for workplace or retail locations, or a dedicated tablet in the home.

Key Components

The main ingredients of a telemedicine solution are described in the following:

- **Medical Devices** are sources of medical data, measuring patient vital signs, sometimes with the aid of a healthcare assistant working at a medical station.
- **Gateways** acquire, normalize, and send data from medical devices to cloud or data center infrastructure over a secure connection.
- **Computing Infrastructure**, consisting of servers, storage, and application software, perform a wide array of operations on medical data, including collection, aggregation, and analytics.
- **Healthcare Providers** use tools to visualize medical data and generate business intelligence, such as “outcomes per dollar spent.”

Gateways acquire, normalize, and send data from medical devices to cloud or data center infrastructure over a secure connection.

Data Analytics and Business Intelligence

Healthcare businesses, including telemedicine, can produce better patient outcomes and be more profitable when medical data is used to increase understanding, insights, and action. This starts with aggregating, organizing, cataloguing, and structuring medical data to facilitate population-based queries, research, and analysis, which in turn leads to more-informed business and clinical decisions.⁶

Telemedicine, combined with data analytics, has great potential for reducing the hospital readmission rate for chronically ill patients, such as those with CHF.

The ability to gain new understanding through data analytics and business intelligence is illustrated in Figure 2, which shows examples of potential insights gained from increasing levels of data analytics. At the most basic level, spreadsheets and pivot tables are used to summarize operational data in ways that answer relatively simple questions. With more effort, information from multiple data bases is integrated, consolidated, and correlated, leading to answers to more complex questions. More sophisticated data analytics tools, like Hadoop*, can be introduced to bring in unstructured data sources, like research reports, allowing predictive analytics to be performed. At the highest level, cognitive analysis can be used to answer human behavioral questions regarding patient sentiment, loyalty, and retention, among other things.

Data Analytics Example

In the U.S., congestive heart failure (CHF) is the most common reason for hospital readmission among beneficiaries of fee-for-service Medicare plans.⁷ Readmission is considered a second hospital admission within a short period of time (usually within 30 days) from hospital discharge and has been considered both costly

and an indication of poor healthcare quality delivery.⁸

Telemedicine, combined with data analytics, has great potential for reducing the hospital readmission rate for chronically ill patients, such as those with CHF. Today, telemedicine provides a cost-effective way to monitor patients for high blood pressure and weight gain (due to water retention), two important indicators of whether a patient should be readmitted to a hospital. In the future, data analytics will be used to generate new insights into patient conditions by correlating a wider range of data sources, such as:

- **Medications:** are drugs taken for other ailments causing a problem?
- **Sleep:** when is the patient going to bed and for how long?
- **Exercise:** is the patient moving around enough?
- **Diet:** are certain foods advantageous?
- **Patient Database:** how is the patient doing compared to others?

Data analytics allows researchers to “tease out the data” in order to uncover cause and effect relationships that could play a large role in improving patient outcomes.

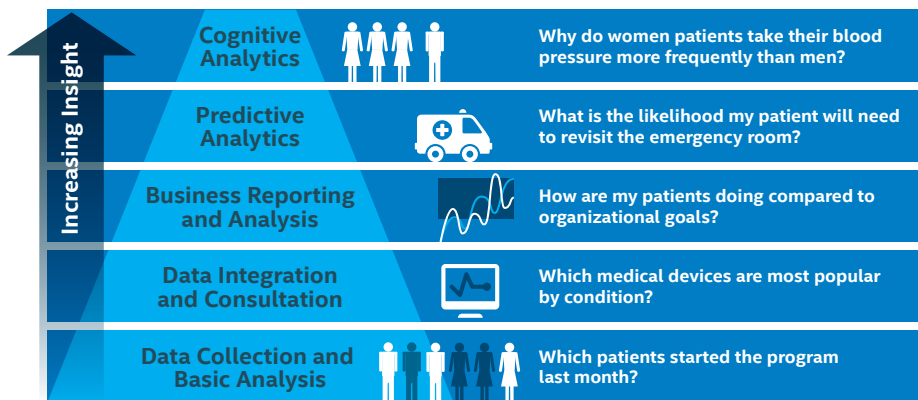


Figure 2. Examples of Insights Learned through Data Analytics and Business Intelligence



Figure 3. HealthSpot* Medical Station

Usage Models

The following covers an example of two telemedicine usage models that help improve access to healthcare.

1. Medical Stations

[HealthSpot](#) delivers and supports freestanding medical stations (Figure 3) that offer an alternative to time-consuming and expensive emergency room visits. The stations are designed for retail sites, workplaces, and, in particular, pharmacies, because patients can receive treatment and get their prescriptions at the same location.

Equipped with a two-way, high-definition video screen, the stations enable patients to interact directly with remote physicians. Patients inside the station can be weighed on a built-in scale and have vitals checked by a thermometer, otoscope, magnascope, blood pressure cuff, stethoscope, or other medical device. Medical information and images are transmitted electronically and securely to the physician, who can make a diagnosis and write a prescription.

HealthSpot uses Dell desktop PCs, laptops, and servers featuring Intel® processors, and works with Dell OEM Solutions to deploy and support thousands of medical stations at retail sites.

2. In-Home Monitoring

The in-home VideoDoc* solution from [Health Net Connect*](#) enables healthcare professionals to conduct extremely cost-effective, virtual house calls to check in on patients. Those benefiting from

close monitoring include elderly patients who have been recently discharged from the hospital but remain seriously ill, high-risk pregnant women on bed rest, and heart-transplant candidates suffering cardiomyopathy (enlarged heart).

The solution is designed from a physician point-of-view, and as such, the user interface (Figure 4) is designed to be as intuitive as possible. Physicians simply click on buttons on the left side of the screen to access the different modules. The skins and buttons are configurable; for instance, one button could take the provider to the patient data center, another start a video conference, and a third might control the bedside 360 degree camera.

Patients receive a package from their hospital or other clinical services provider containing a Dell Venue* 11 Pro tablet with an Intel® Atom™ processor Z3770, touch screen, built-in video camera, microphone, and speaker. The patient terminal is as easy to use as an ATM. When patients are taking readings at home, they will simply click on a large easy-to-read button to upload their data.



Figure 4. Health Net Connect* VideoDoc* Terminal

Technologies

This section describes the technology ingredients available to deploy telemedicine solutions like the two previously described.

Gateways for Data Acquisition

Gateways used in telemedicine may take many forms, including a desktop PC built into a medical station or a dedicated tablet used in the home. They interface with patients, medical devices, and enterprise or cloud-based infrastructure, and integrate technologies and protocols for networking, embedded control, enterprise-grade security, and device manageability. Two examples are:

Medical Stations

Built for security and manageability, the [Dell Latitude* E6440 Laptop](#) and [OptiPlex* XE2 Desktop PC](#) can guard medical data with industry-leading endpoint security solutions that include the most comprehensive encryption, strong authentication, and malware protection. Service providers can easily manage their Latitude fleet with exceptional integrated management capabilities that include Intel® vPro™ technology and exclusive automated tools that plug into Microsoft* System Center and Dell KACE. With high-performance options, such as the Intel® Core™ i7 processor, 64-bit graphics processing, and fast boot with solid-state drive (SSD), the Latitude E6440 satisfies the demanding compute, graphics, and networking requirements of medical stations.



Figure 5. Dell* Venue* 11 Pro tablet

In-Home Tablets

Designed for easy integration with an array of peripherals, like medical devices, the [Dell Venue 11 Pro](#) tablet provides constant connectivity with dual-band 2x2 Wi-Fi, Bluetooth* 4.0, and mobile broadband⁹ options. Pictured in Figure 5, its stunningly bright 10.8-inch, high-definition (HD) display with wide-angle viewing and wireless video technology¹⁰ makes teleconferencing and data sharing easy to implement. Built with a dual-core Intel® Core™ i5 processor, this tablet delivers the power of a laptop and the experience of a desktop.

Computing Infrastructure

Figure 6 shows the modules comprising a comprehensive data analytics solution for telemedicine providers working with small to large data sets. It supports data acquisition, aggregation, and analytics workloads for various types of medical data and enables data mining and visualization capabilities for generating business intelligence.

The following section describes available products for hardware infrastructure, management, integration, business intelligence and data discovery, and advanced analytics.

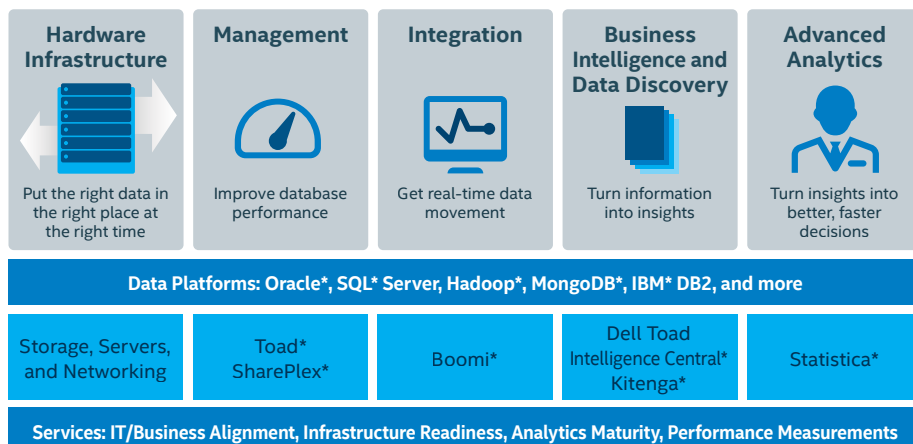


Figure 6. Comprehensive Data Analytics Solution

Hardware Infrastructure

The [Dell In-Memory Appliance for Cloudera Enterprise*](#) is designed to enable users to ingest, store, analyze, and build insights from big data. To deliver fast analytics and stream processing, the appliance is bundled with Cloudera Enterprise, which includes Apache* Spark. Cloudera Enterprise allows telemedicine providers to implement powerful end-to-end analytic workflows, comprising batch data processing, interactive query, navigated search, deep data mining, and stream processing, all from a single common platform.

The solution delivers performance-packed computing with the [Intel® Xeon® processor E5-2600 product family](#) and up to 24 dual in-line memory modules (DIMMs). Built with 22-nanometer process technology and up to 12 cores per processor, the Intel® Xeon® processor enables super-fast processing for compute-intensive tasks.

Management

[Dell Toad*](#) can be used to normalize data across disparate data sets to facilitate accurate data analysis. In telemedicine, Toad could ensure “body temperature” is the same type of data (text) throughout the solution: medical devices, insurance records, patient and doctor terminals, and enterprise databases.

[Dell Toad SharePlex*](#) enables high-performance replication and data integration for databases. The software provides access to a real-time copy of production data with zero impact on online transaction processing (OLTP) system availability and performance, ensuring business continuity and helping meet database operational goals.

Integration

[Dell Boomi*](#) allows telemedicine providers of all sizes, IT resources, and budgets to sync data between their mission critical applications without the costs associated with acquiring or maintaining software, appliances, or custom code. Results include faster deployments, significant reduction of data errors over manual data entry, and substantial cost savings over traditional integration solutions.

Business Intelligence and Data Discovery

[Dell Toad Intelligence Central*](#) is a set of data reporting tools that provides a centralized repository for up-to-date information, making data provisioning more efficient.

[Dell Kitenga*](#) is an analytics suite providing integrated information modeling and visualization capabilities in a big data search and business analytics platform. Combining technologies such as Hadoop for scalability and performance, Lucene/SOLR search, Mahout machine learning, 3D information modeling, and advanced Natural Language Processing, Kitenga is a fully integrated, configurable, cloud-enabled software platform that can be deployed in minutes.

Advanced Analytics

[Dell Statistica*](#) facilitates data mining, predictive analytics, and analysis of structured and unstructured data.

Services Creation and Management

Using IoT technologies to build telemedicine solutions can make it easier for providers to generate additional revenue from opening up their infrastructure to third-party solution providers. Imagine a medical

device manufacturer launches a revolutionary sensor that can detect heart failure hours in advance but needs a platform to support the new device. In response, a telemedicine provider hosts the device on its infrastructure - as a Platform as a Service (PaaS) - for a fee.

The PaaS offering, including services creation, management, and payment, could be implemented with application programming interfaces (APIs), which lower the barrier to entry for connectedness and enable secure communication from medical devices to telemedicine applications located just about anywhere. In the example, a patient using the new sensor would trigger the gateway to access an API used to transmit the data to the telemedicine provider, medical device manufacturer, or whoever is supporting this particular service. With the API, a wide variety of functions could be implemented, such as user authentication, software updates, security, and payment.

In other cases, applications using IoT technologies and API management are being developed to support self-care or remote patient monitoring (RPM). These solutions provide patients and citizens with information around their medical and treatment history, care plans, prescriptions, data from wearables, implants, and other healthcare monitors, and so on. It will even be possible for the patients to link their medical records to information from external health and fitness services using the Open APIs that those services offer.

Such solutions are made possible by the [Intel Mashery API Management platform](#), which greatly simplifies the effort to manage communications between medical devices, cloud analytics platforms, and telemedicine

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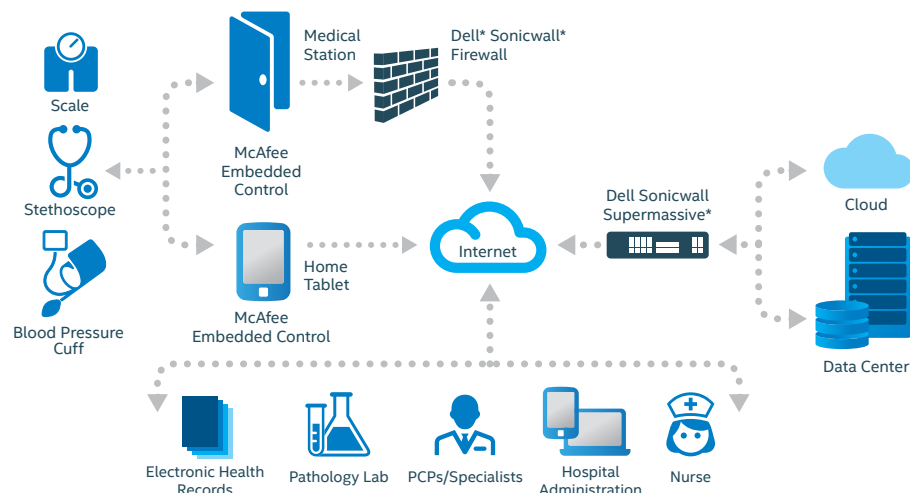


Figure 7. Data Protection Solutions

players. The Intel® Mashery™ Developer Services can also be used to manage the business relationships between the different players in the telemedicine value chain.

Security

Security solutions from Intel, Dell, and Dell SonicWALL* can protect gateways and data centers, while sustaining performance and simplifying management. The solution shown in Figure 7 can secure access from virtually any endpoint and protect against viruses, spam, phishing, and other attacks with multiple threat-detection techniques.

Gateway

[McAfee Embedded Control](#) maintains the integrity of devices, gateways, and servers by allowing only authorized code to run and only authorized changes to be made. It automatically creates a dynamic whitelist of the “authorized code” on the system. Once the whitelist is created and enabled, the system is locked down to the known good baseline and no program or code outside the authorized set can run.

Network

The [Dell SonicWALL Family of Firewalls](#) tightly integrates intrusion prevention, malware protection, and application intelligence and control with real-time visualization. The Dell SonicWALL deep packet inspection engine scans 100 percent of traffic and massively scales to meet the needs of the most high-performance networks.

Cloud and Enterprise Data Center

[Dell SonicWALL SuperMassive* 9000 Network Security Appliance Series](#) is a next-generation firewall (NGFW) that detects and blocks the most sophisticated threats with minimal latency for every network connection, delivering deep security for the enterprise at multi-gigabit speeds.

IoT Tenets

The IoT building blocks from Dell and Intel are designed to provide security and interoperability from medical devices to data centers or Internet clouds in keeping with five key tenets defined by Intel:

- **World-class security** as the foundation
 - The solution protects data from medical devices with state-of-the-art security products.

- **Automated discovery and provisioning of edge devices** to ease deployment

- Gateways (e.g., tablets and medical stations) support a wide range of network protocols, including USB, that can be used to connect medical devices in Plug and Play fashion.

- **Data normalization** through protocol abstraction to improve interoperability

- Gateways can aggregate data received via various communication protocols before sending it to the cloud.

- **Broad analytics infrastructure** from edge to cloud to realize customer value

- Dell supplies a comprehensive set of data analytics and business intelligence software that can be used to turn data into actionable insights.

- **Infrastructure** to monetize hardware, software, and data management from edge to cloud

- Intel Mashery API Management provides the tools needed to realize new revenue-generating service creation and management in telemedicine.

Summary

Big data analytics and Internet of Things technologies provide the critical backbone to enable telemedicine providers to improve security, device interoperability, treatment decision making, solution scalability, and access convenience. The readily-available ingredients presented in this paper map out a solution capable of making telemedicine providers more profitable and competitive. Dell and Intel are working to drive a data revolution in healthcare that can help improve patient outcomes and increase medical provider efficiency.

Moving Forward

Dell believes that any organization can start implementing IoT technologies in its own manufacturing facilities. By starting with relatively small projects – perhaps just by analyzing a single process – organizations can build capabilities that result in a competitive edge.

Dell also believes it is time to get past the hype and help connect what matters for IoT.

Everyone is talking about IoT, but what is it exactly? Put simply, it is what the Internet is evolving towards: a world in which just about everything has an Internet address and can generate data for tracking, analysis, and action. And that data will change healthcare as the world knows it. The industry will go from guessing to knowing about how best to improve healthcare, patient outcomes, government regulations, and much more.

With so much potential, it is understandable that IoT and telemedicine, in particular, are surrounded by hype. But there are also immediate opportunities.

Dell believes IoT and telemedicine technologies can deliver significant benefits today, such as reducing costs, accelerating innovation, and improving patient outcomes. To realize these

benefits, telemedicine providers must help their customers with three critical challenges:

1. Define an IoT strategy tied to specific, measurable organizational goals.
2. Develop a telehealth architecture that will: handle a flood of real-time data from sensors, machines, and endpoints; create insight; and take action.
3. Keep IoT/telehealth data secure and private, even as it flows from endpoints to clouds to the data center.

Dell Services is available to provide support and leadership as desired throughout a project. Dell Services can help develop an overall technology strategy and provide program management. They can concentrate on specific pieces of a solution, such as business intelligence and analytics, to help aggregate, consolidate, integrate, and derive insights from data. They can help design a cloud solution – and deliver the right elastic platform from partner or Dell components that are secure and optimized for any environment. Dell Services has a team dedicated to developing custom mobile applications to deliver insights to a company's team members, who are best positioned to act on the information.

The industry will go from guessing to knowing about how best to improve healthcare, patient outcomes, government regulations, and much more.

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Resources

[Intel® Internet of Things Solutions Alliance](#)

Members of the Intel® Internet of Things Solutions Alliance provide the hardware, software, firmware, tools, and systems integration that developers need to take a leading role in IoT.

[Intel® IoT Gateway Development Kits](#)

Intel® IoT Gateway development kits enable solution providers to quickly develop, prototype, and deploy intelligent gateways. Available for purchase from several vendors, the kits also maintain interoperability between new intelligent infrastructure and legacy systems, including sensors and data center servers.

For more information about Dell solutions for healthcare, visit www.dell.com/healthcare.

For more information about Intel® solutions for IoT, visit www.intel.com/iot.



Dell is a Premier member of the [Intel® Internet of Things Solutions Alliance](#). From modular components to market-ready systems, Intel and the 250+ global member companies of the Alliance provide scalable, interoperable solutions that accelerate deployment of intelligent devices and end-to-end analytics. Close collaboration with Intel and each other enables Alliance members to innovate with the latest technologies, helping developers deliver first-in-market solutions.

¹ Source: Mark W. Frazier, "No Country for Old Age," February 18, 2013 www.nytimes.com/2013/02/19/opinion/no-country-for-old-age.html?_r=0.

² Source: Kaiser Health News, "Chronic Disease Expert: U.S. Health Care System Needs To Treat 'Whole Person'," kaiserhealthnews.org/orig-chronic-disease/.

³ Source: World Health Organization, "Global health workforce shortage to reach 12.9 million in coming decades," November 11, 2013, www.who.int/mediacentre/news/releases/2013/health-workforce-shortage/en.

⁴ Source: McKinsey Global Institute, "Disruptive technologies: Advances that will transform life, business, and the global economy," May, 2013, pg. 6, http://www.mckinsey.com/insights/business_technology/disruptive_technologies.

⁵ Source: Intel Newsroom, "The Michael J. Fox Foundation and Intel Join Forces to Improve Parkinson's Disease Monitoring and Treatment through Advanced Technologies," August 13, 2014, http://newsroom.intel.com/community/intel_newsroom/blog/2014/08/13/the-michael-j-fox-foundation-and-intel-join-forces-to-improve-parkinsons-disease-monitoring-and-treatment-through-advanced-technologies.

⁶ Source: Paul Horstmeier, "Why Your Healthcare Business Intelligence Strategy Can't Win without a Data Warehouse," <https://www.healthcatalyst.com/category/data-warehouse>, <http://www.ahrq.gov/news/newsletters/research-activities/13jun/0613RA20.html>

⁷ Source: Agency for Healthcare Research and Quality, "Certain medical conditions and Medicaid insurance predict hospital readmission for congestive heart failure,"

⁸ Source: Hao Wang, Biomedcentral, "Using the LACE index to predict hospital readmissions in congestive heart failure patients," www.biomedcentral.com/1471-2261/14/97.

⁹ Subject to service provider's broadband subscription and coverage area; additional charges apply.

¹⁰ Requires a compatible Media Adapter and cable (sold separately) and an HDMI or composite AV-enabled display.

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