Tech Insight: Internet of Medical Things

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In previous *Tech Insights* and *Enterprise Design Patterns* (EDPs), we introduced the Internet of Things (IoT), the various technological devices that connect to the internet, including wearable technology, self-driving cars, home appliances, and much more. The Internet of Medical Things (IoMT) is a subset of IoT, from which several submarkets of the technology have evolved. IoMT enables virtually any medical device to collect, analyze, and send data across the web. This *Tech Insight* explores how IoMT is used, including its benefits, risks, and risk mitigation; and how the Department of Veterans Affairs (VA) uses the technology to improve services for our nation's Veterans.

Overview of IoMT

For thousands of years, medical devices were standalone units, with the earliest known device dating back to 7000 B.C. Recent technological advancements, however, now enable us to control and monitor medical devices from vast distances through internet connectivity. Medical equipment and healthcare products, ranging from heart monitors to hospital beds, and even medication,[1] can be monitored. Real-time access to shared data is provided to all those with a legitimate "need-to-know," such as physicians and other healthcare professionals.

Uses for IoMT Devices

As might be expected, hospitals and clinics are the biggest users of IoMT devices for patient monitoring, but those users responsible for maintaining IoMT devices are also integral to the quality of care provided to patients. Magnetic resonance imaging (MRIs), X-ray machines,

[1] "IoT: Smart Pill and the Future of Medicine," https://www.qulix.com/about/blog/iot-smart-pill-and-the-future-of-medicine/

computed tomography (CT) scanners, and other equipment can be remotely monitored for performance issues. Companies such as General Electric (GE), Siemens, and Philips use IoMT for remote diagnostics, predictive maintenance, and performance upgrades of these imaging products. Before hospital staff notice a problem, the manufacturer or service vendor can detect issues that need to be corrected. This not only enables them to maintain equipment in a more timely and efficient manner, but since it eliminates the transportation and labor expenses of traditional on-site maintenance, it is considerably less costly.

Recently, there has been an increase in the use of medical devices in patients' homes and on their person. These IoMT devices are resources for a branch of medicine referred to as telemedicine. Healthcare services are extended beyond the walls of the hospital, with IoMT devices linked to remote patient monitoring (RPM) through the internet. RPM allows patients who suffer from chronic disease to avoid frequent visits to their care units. Heart patients and diabetics also benefit from RPM technology through remote monitoring of their heart activity and glucose levels; automatic alerts notify healthcare professionals when a medical problem exists.

Finally, virtual home assistants are valuable additions to the homes of many elderly patients. These intelligent devices interact with patients, remind them to take medications, and are accessed remotely by family and/or medical professionals. Advances in biosensor technology make possible the use of wearable smart devices that monitor the user's health. Whether the device is embedded in apparel, attached to the skin, or implanted, on-the-body IoMT sensors give patients the protection they need with a close watch on their health conditions.

IoMT Examples

Globally, by 2020, as many as 30 million IoMT devices[2] will be in use. These include the following innovative devices:

- "Smart" wound dressing that automates the delivery of painkillers, antibiotics, and tissue regenerating medicines
- Clothing and bedding that can alert caregivers to the needs of bedridden patients
- Bluetooth-enabled gloves that help some stroke patients recover cognitive function faster
- Electroencephalogram (EEG)[3]-enhanced earbuds[4] and headbands that improve pain management

[2] Source: "Healthcare: 5 Digital Trends for 2019 and Beyond," 2018, at https://stfalcon.com/en/blog/post/healthcare-digital-trends
[3] Defined by the Mayo Clinic as "a test that detects electrical activity in your brain using small, metal discs (electrodes) attached to your scalp," https://www.mayoclinic.org/tests-procedures/eeg/about/pac-20393875
[4] Source: "5 Real-Time & Remote Patient Monitoring Trends" at https://www.mpo-mag.com/contents/view_online-exclusives/2018-08-22/5-real-time-remote-patient-monitoring-trends/7970

- Ingestible sensors[5] that track when a patient has taken their prescribed pill and sends information to a smartphone application so that patients and their doctors can monitor adherence
- Implantable blood-glucose monitoring systems and blood-glucose monitoring contact lenses that send updates to smartphone applications that alert patients, their health care providers, or a combination of the two, if levels are not in a normal range
- Cameras that patients can swallow that eliminates the need for uncomfortable endoscopic procedures

While ease of access and better-quality medical care are primary benefits, medical facilities can track the gamut of medical apparatuses as part of their IoMT strategy; this leads to a greater array of niche IoMT devices, such as those that track clothing, bedding, and pharmaceuticals.

Risks of IoMT

With a plethora of IoMT devices connected to the internet, there are risks involved. Cybersecurity is a crucial concern. In 2016, a cybersecurity risk occurred in the United Kingdom (UK) because no encryption was built into the network that processed data between the sensor and the base server of the Owlet infant heart monitor.[6]

Another example of cybersecurity vulnerability existed In August 2017. The US Food and Drug Administration (FDA) issued a recall of 465,000 radiofrequency-enabled implantable pacemakers. It was found that hackers could use commercially available equipment to access the pacemakers and change the programming to harm the patient by depleting the battery or ordering dangerous pacing. Additionally, glucose monitors and insulin or medication delivery systems were at risk, with hackers capable of changing readouts and adjusting dosages from up to a half-mile away.

The key to mitigating these risks is keeping firmware and software updated. Developers are constantly working to identify and correct issues that can be exploited by hackers and other malicious sources. By keeping antivirus and other preventative software applications current, these devices can run more efficiently and securely over networks. This is the same principle as having automatic updates on home computers, laptops, and mobile devices.

Not all risks are related to cybersecurity. There are medical risks of rejection of implanted devices and physical harm to patients. If an IoT device does not operate as planned, technology companies could be liable for resulting injuries, or even the death of a user or patient. For example, if a doctor prescribes a pill with an ingestible chip to verify compliance for a patient with a memory impairment, and a flaw prevents the transmitter

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[5] Source: "10 examples of the Internet of Things in Healthcare" at https://econsultancy.com/internet-of-things-healthcare/

[6] "Comprehensive Guide to IoMT Cybersecurity – Risks, Safeguards, and What We Protect," https://www.alpinesecurity.com/blog/comprehensive-guide-to-iomt-cybersecurity

from sending compliance data to the physician, the doctor may not receive alerts that the patient is not taking the medication. If the patient's condition worsens and the patient needs expensive surgery, the firm that made the connected pill may be liable for failure to transmit compliance data in a timely fashion.

IoMT at VA

VA Medical Centers have doubled down on "value-based" care and "patient outcomes." With these ideals, it is only natural that IoMT is employed within Veteran healthcare. In addition to its telehealth program, VA has employed the use of wireless infusion pumps[7] in many facilities. Veterans with hearing impairments can acquire hearing aids with Bluetooth connectivity that they can pair with their smartphones. There even exists the ability to provide a total hip arthroplasty;[8] it is enabled by using an IoMT-enabled drill that simultaneously receives patient vitals, while regulating its rotational speed, thereby mitigating damage to the bone tissue.

For diabetics, foot and leg health is important. Therefore, VA has partnered with the firm, Podimetrics, to develop a new type of sensor that detects foot ulcers in diabetes patients. The Podimetrics Mat™ works by scanning the foot and finding signs of elevated temperatures and sending that information to the Podimetrics team for analysis.

To add to these kinds of benefits, VA is working to expand its current use of IoMT devices to increase the quality of care for the country's 20.4 million Veterans.

Conclusion

Given the vast applications of the IoMT, the possibilities are seemingly endless. The prospect of diagnosing and treating illnesses without the need for invasive procedures reduces discomfort, recovery time, and cost. Medical facilities can track supplies without the need for a physical inventory to be performed.

The adoption of IoMT devices has increased so significantly that providers are struggling to keep pace with new technologies. By 2020, the market is predicted to become saturated;[9] however, technologies are ever-evolving. Part of that evolution applies to cybersecurity, keeping patients safe from malicious attacks. The other part is about making devices that are easier to use and more accessible.

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[7] Defined by the Food and Drug Administration (FDA) as "a medical device that delivers fluids into a patient's body in a controlled manner, either through the use of interconnected servers or via a standalone drug library-based medication delivery system." https://www.fda.gov/medicaldevices/productsandmedicalprocedures/generalhospitaldevicesandsupplies/infusion pumps/defa ult.htm [accessed 4/5/2017].

[8] Defined by Up to Date as "a surgical procedure that replaces the hip joint with artificial parts". https://www.uptodate.com/contents/total-hip-replacement-arthroplasty-beyond-the-basics

[9] "Wearable Hardware Design for the Internet of Medical Things (IoMT)", Fayez Qureshi & Sridhar Krishnan, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6263646/

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