

# The Internet-of-Things

## A revolutionary digital tool for the healthcare industry

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The global healthcare industry is starting its transformation due to the demand for high-quality care, the pressure of healthcare costs, and the patient profile shift toward patients who are more informed, empowered, and who ultimately turn out to be partners of healthcare providers rather than being passive observers of their own health journey.

The global population is growing while healthcare budgets are dwindling and the burden of chronic diseases is rapidly increasing worldwide. All these challenges are putting pressure on doctors, healthcare providers, and governments to look for new technologies so that they can continue providing high-quality healthcare while reducing costs.

Like the banking and retail sectors, healthcare has made its first steps into the digital era, thereby changing the way medicine is practiced. This industry, where mindsets and regulations are slow to change, has been overhauled by the digitalization of data and the incredible development of new technologies and apps to enable access to data anywhere and at anytime.

This infrastructure includes existing and involving internet and network developments. It will offer specific object-identification, sensor, and connection capability as the basis for the development of independent cooperative services and applications. These will be characterized by a high degree of autonomous data capture, event transfer, network connectivity, and interoperability.”<sup>1</sup>

**How can the Internet-of-Things (IoT) be defined for the healthcare sector?**

The Internet-of-Things (IoT) is understood to be “a global network infrastructure, linking physical and virtual objects through the exploitation of data capture and communication capabilities.

Applied to healthcare systems, the IoT—also called the Internet-of-Medical-Things (IoMT)—is defined as a network of medical devices that connect directly with each other to capture, share, and monitor vital data automatically through a secure service layer (SSL) that connects to a central command and control server in the cloud. ➔



1 [ec.europa.eu/information\\_society/newsroom/cf/dae/document.cfm?doc\\_id=1753](http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=1753)



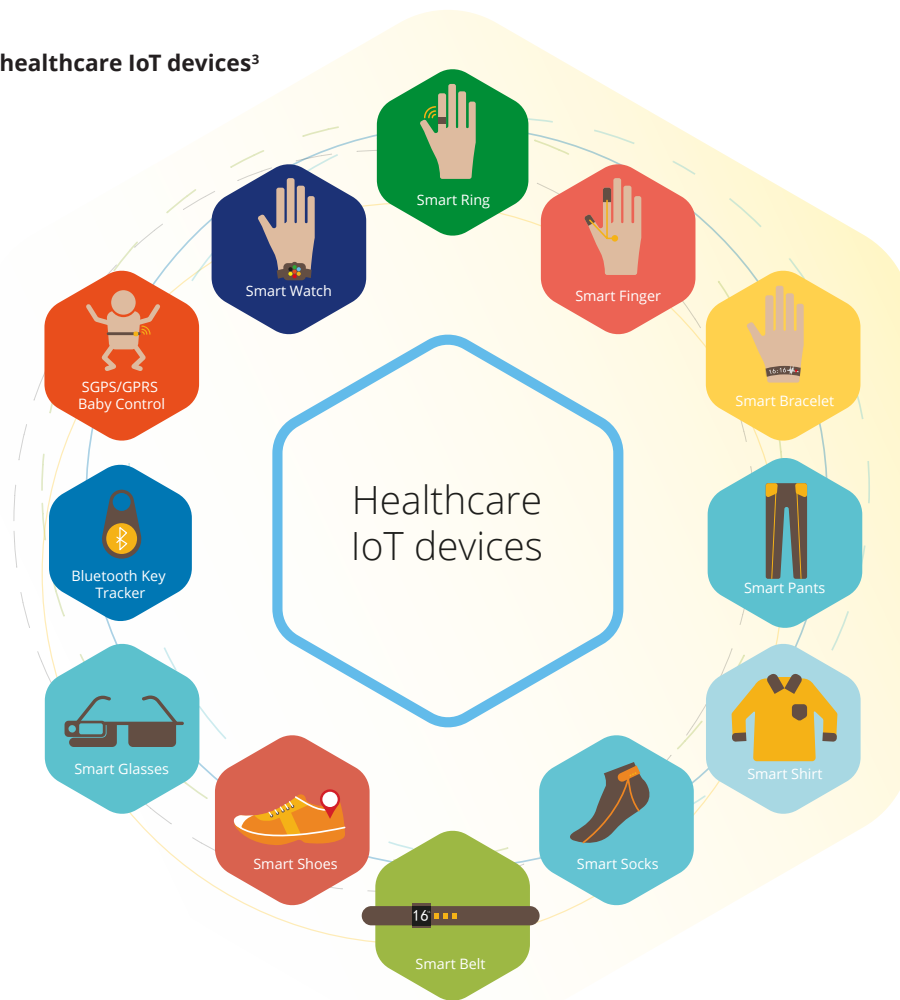
In recent decades, the wider availability of broadband internet, the decreasing cost of connecting, the integration “by design” of Wi-Fi capabilities and sensors into devices, and the strong penetration of smartphones have created the perfect basis for the development of the IoT to skyrocket.

The IoT is not new, but has been gaining more attention and traction lately in some industries, such as energy, mobility, and healthcare. The development of the IoT in the healthcare market has had a significant impact on the healthcare sector as a whole and has been particularly valuable in remote clinical monitoring, chronic disease management, preventive care, assisted living for elderly people, and personal fitness monitoring. The IoT has changed the game within the healthcare industry by lowering costs, improving efficiency, and bringing the focus back to quality patient care.

Internet-connected devices have been introduced to patients in various forms. The diversity of the sensors can be related to the nature of stimuli to which they respond (e.g., physiological vital signs such as heart beat or blood pressure and body movements), and to their location on the body (clothing, subcutaneous implant, wearable devices such as smart watch and glasses, etc.). These devices have the ability to meet patients’ needs by transferring information in real-time to the patients’ smartphones, computers, or other wireless devices and have the potential to influence their behaviors. Sensors allow patients to self-monitor, track, and assess physiological parameters, while also providing interfaces and a dashboard for caregivers<sup>2</sup> (Figure 1). Many of these measures, whose monitoring can be vital for some patients, usually require follow-up interaction with a healthcare professional. This opens a window of opportunity for smarter devices to deliver more valuable data and reduces the need for direct patient-physician interaction. For instance, some hospitals have begun implementing “smart beds”

2 <http://archpublichealth.biomedcentral.com/articles/10.1186/2049-3258-72-28>

Figure 1: Diversity of healthcare IoT devices<sup>3</sup>



that can capture vital sign information for better health management, detect when a bed is occupied, and detect when a patient is attempting to get up in order to prevent falls. It can also adjust itself to ensure appropriate pressure and support is provided to the patient without the manual interaction of nurses.<sup>4</sup>

### IoT healthcare market

The global IoT healthcare market is expected to record considerable growth. It was valued at US\$60.4 billion in 2014, and is estimated to reach US\$136.8 billion by 2021, registering a CAGR of 12.5 percent over the forecast period.<sup>5</sup> In particular, the wearable tech market is expected to be worth US\$34 billion in 2020, representing 411 million smart wearables sold. Wrist-based devices, such as smartwatches and

fitness trackers, represent 50 percent of the estimated sales.<sup>6</sup>

The IoT healthcare market can be viewed from two different angles: the connected component itself or the application of the IoT in the healthcare sector.<sup>7</sup>

Successful implementation of the IoT in remote monitoring of diabetes and asthma patients, coupled with high penetration of fitness and wellness devices, has created strong demand for the Internet-of-Things in the healthcare industry. The remote patient monitoring market saw a big jump last year, with 7.1 million patients in 2016 enrolled in some form of digital health program featuring connected medical devices, and using patients' own mobile devices as a core part of their care plan.<sup>8</sup> ➔

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3 <http://electronicdesign.com/iot/future-digital-health>

4 [http://bamlabs.com/downloads/01\\_theSmartbed.pdf](http://bamlabs.com/downloads/01_theSmartbed.pdf)

5 [www.todaysmedicaldevelopments.com/article/iot-internet-of-things-healthcare-medical-111716/](http://www.todaysmedicaldevelopments.com/article/iot-internet-of-things-healthcare-medical-111716/)

6 [www.forbes.com/sites/paullamkin/2016/02/17/wearable-tech-market-to-be-worth-34-billion-by-2020/#26201e2d3cb5](http://www.forbes.com/sites/paullamkin/2016/02/17/wearable-tech-market-to-be-worth-34-billion-by-2020/#26201e2d3cb5)

7 [www.slideshare.net/alliedmarketresearch/internet-of-things-healthcare-market-the-industry-set-to-grow-positively](http://www.slideshare.net/alliedmarketresearch/internet-of-things-healthcare-market-the-industry-set-to-grow-positively)

8 [www.berginsight.com/ReportPDF/ProductSheet/bi-mhealth8-ps.pdf](http://www.berginsight.com/ReportPDF/ProductSheet/bi-mhealth8-ps.pdf)

## By components

### System & Software



Network Layer



Database Layer



Analytics Layer



### Devices



Implantable  
Sensor Devices



Wearable  
Devices



## By applications

Patient  
Monitoring



Clinical  
Operations  
& Workflow  
optimization



Clinical Imaging



Fitness and  
Wellness  
Measurement



Drug  
Development



### The IoT opens up opportunities for the healthcare industry

The IoT has the potential to reinvent the healthcare industry. It has the potential to transform traditional paper-based healthcare treatment through access to real-time patient data and remote patient monitoring. The emergence of this digital healthcare technology has delivered solutions to tackle the increasing need for better diagnostics and more personalized therapeutic tools. The IoT plays a significant role in a broad range of healthcare applications, from managing chronic diseases to preventing disease, but it also works as a fitness and wellness tracker for athletes.

### The IoT is changing the business model in the healthcare industry; patients and providers both stand to benefit from the IoT for multiple reasons<sup>9</sup>:



#### Decreased Costs

Taking advantage of development in the connectivity of healthcare solutions allows healthcare providers to monitor patients in real time based on the collection, recording, and analysis of comprehensive information using sensors. In particular, hospitalized patients whose physiological status requires close attention can be constantly monitored using IoT-driven, non-invasive monitoring. In this way, the IoT simultaneously improves the quality of care through constant attention and cuts down the cost of care by eliminating the need for a caregiver to actively engage in data collection by checking the patient's vital signs at regular intervals.



#### Improved Outcomes of Treatment

The IoT provides healthcare professionals with access to real-time information that enables them to make informed decisions and provide treatment that is efficient and evidence-based.



#### Improved Disease Management

When patients are continuously monitored and caregivers are able to access real-time data, diseases can be treated before serious complications occur. It enables preventive care, allows early diagnosis, and gives insight into the efficiency of the prescribed therapy for the patient's health.



#### Remote monitoring of chronic diseases

Access to healthcare infrastructure and effective treatments can be complicated for populations living in remote regions. Small and powerful wireless solutions connected through the IoT now make it possible for these patients to have access to health monitoring. These solutions can be used to securely capture patient health data using a variety of sensors, analyze it, and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations.



#### Enhanced Patient Experience

The connectivity of the healthcare system through the IoT places emphasis on the patients and on their needs. Patients are now able to take control of their own health, to self-monitor, and to communicate whenever necessary with the healthcare providers. This is leading to a new type of physician-patient relationship in which the patient becomes a partner to set up appropriate (or even proactive) treatments, improve the accuracy of the diagnosis, and facilitate a timely intervention by physicians.



#### Improved Drug Management

The creation and management of drugs is a major expense in the healthcare industry. Forbes reported the average cost to develop an approved drug at US\$4 billion.<sup>10</sup> IoT devices and processes may prove helpful in better managing these costs—especially those related to drug supply chain management. RFID tags are already being added to medication containers to ensure producers, consumers, and regulators have greater confidence in the drug supply chain. The next step is to implant the RFID technology into the medication itself to be able to confirm its authenticity and reveal provenance information such as manufacturing location, dosage, packaging images, expiration date, supply chain data, and lot or batch number.<sup>11</sup>

The IoT certainly opens the door to many opportunities but also gives way to many challenges that must be tackled in order to allow the entire community to take advantage of the services offered by the IoT in the healthcare sector.

9 <https://www.ibm.com/blogs/internet-of-things/6-benefits-of-iot-for-healthcare/>

10 <https://www.forbes.com/sites/matthewherper/2012/02/10/the-truly-staggering-cost-of-inventing-new-drugs/#18f8a99a4a94>

11 <http://www.cio.com/article/2981481/healthcare/how-the-internet-of-things-is-changing-healthcare-and-transportation.html>

The IoT is transforming how healthcare providers deliver treatment to their patients and how patients are taking control of their own health and their data.

### The expansion and adoption of the IoT may be limited by some challenges

The IoT is growing rapidly; in the coming years, the medical sector is expected to witness the widespread adoption of the IoT and the sky-rocketing development of new eHealth IoT devices and applications. The number of connected devices expected to be in use by the year 2020 has been estimated at 30.7 billion<sup>12</sup> With so many devices collecting vast amounts of data in new ways, it is nearly impossible to fully prepare for every possible threat or fault.<sup>13</sup> Healthcare providers, manufacturers, governments, and users must identify the areas of potential failure to apply fixes in order to fully and securely explore the opportunities offered by the IoT.

#### The major healthcare IoT-related challenges are described in different areas:

##### Data privacy and security issues

The driver behind all the development of devices and sensors is the data that is generated. Healthcare devices and applications are expected to deal with vital private information such as personal healthcare data, including genetics. The area of IoT healthcare, which is connected to global information networks that are accessible anytime, anywhere, may be targeted by hacking in a world where data is the new gold. Protecting captured health data from illicit access is crucial. Information security, privacy, and data protection should systematically be addressed at the design stage when creating sensors and devices. Also, IoT devices do not always have enough computing power to implement all the relevant security layers.<sup>14</sup> The adoption of the IoT in the healthcare industry requires stringent policies, and technical security measures should be introduced to share health data with authorized users, organizations, and applications.

##### Unadapted reimbursement model

Healthcare reimbursement systems are still in a “fee-for-service” configuration, meaning that the only way that physicians get paid is to have face-to-face medical visits with patients. This creates a paradox: technologies are promoted to reduce face-to-face interactions when the reimbursement system calls for the opposite. However, a slight shift is observed toward a value-based care model, which ties payments for care delivery to the quality of care provided, and rewards providers for both efficiency and effectiveness. Value-based care aims to advance the triple aim of providing better care for individuals, improving population health management strategies and reducing healthcare costs. Then, there is more incentive to use new technologies that reduce unnecessary face-to-face physician-patient interactions, which are seen as a cost center. The regulatory and reimbursement environment for connected health programs must improve for adoption rates to accelerate.<sup>15</sup>

##### Patient safety issues

IoT technology can create new safety risks if it is not designed appropriately, implemented carefully, and used thoughtfully. Data integrity errors as a result of incorrect or missing data in electronic health records (EHRs) and other health IT systems are a crucial issue in the healthcare sector that can dramatically affect patient health. Data integrity issues occurred with the use of paper medical records as well, but now, as EHRs become more interoperable and hackable, incorrect information is more readily available, more easily shared, and harder to eliminate. One patient’s data appearing in another patient’s record, missing data or delayed data delivery, and clock synchronization errors between medical devices and systems are examples of data integrity failures, as listed in the Top 10 Health Technology Hazards for 2015 report.<sup>16</sup>

12 <https://www.forbes.com/sites/louiscolombus/2016/11/27/roundup-of-internet-of-things-forecasts-and-market-estimates-2016/#7e3e3ed6292d>

13 <https://www.isaca.org/SiteCollectionDocuments/2015-risk-reward-survey/2015-it-risk-reward-barometer-report.pdf>

14 [ec.europa.eu/information\\_society/newsroom/cf/dae/document.cfm?doc\\_id=1753](http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=1753)

15 <http://revcycleintelligence.com/features/what-is-value-based-care-what-it-means-for-providers>

16 [https://www.ecri.org/EmailResources/PSRQ/Top10/2015\\_Patient\\_Safety\\_Top10.pdf](https://www.ecri.org/EmailResources/PSRQ/Top10/2015_Patient_Safety_Top10.pdf)

## Unclear IoT-related regulation

Health-related apps and devices generate huge amounts of data that can be used to monitor people's health. However, the line between medical devices and health gadgets is becoming blurred. The reliability and validity of wearable devices is not always proven, especially in the case of the fitness and lifestyle markets. Devices are marketed under the promise that they will help improve general health and fitness, but the majority of manufacturers provide no empirical evidence to support the effectiveness of their products, which most of the time are not cleared by the FDA or EMA. Also, it is unclear where the regulatory cut-off point lies for deciding which health apps and devices have to go through the regulatory process.

The IoT is transforming how healthcare providers deliver treatment to their patients and how patients are taking control of their own health and their data. Indeed, the IoT has made it possible for patients to work alongside professionals to customize their own health journey.

Patients can track and automate various aspects of health, which in turn provides more comprehensive data for healthcare professionals to prevent, treat, and diagnose medical conditions for a lower cost.

No one knows what the IoT may bring in the coming years, but one thing's for sure; more connected devices means more data. Each click and command will be an engagement that is logged. And each engagement reveals something valuable about an individual's health. Healthcare professionals will have to learn how to collect, organize, and analyze this fragmented data to provide more personalized individual care and identify trends and symptoms that can lead to some cutting-edge treatments. The biggest challenge is not going to be in using IoT devices. Rather, it will be for healthcare practitioners to make sure that these devices are secure and not misused, that data is protected, and that errors and exceptions are properly handled to guarantee patient safety. ●

