

The background image features a hand reaching out to interact with a complex digital interface. The interface is composed of numerous glowing blue lines, circles, and dots, creating a sense of a global network or data flow. Overlaid on this network are various white icons: a heart with a pulse line, a stethoscope, a smartphone, a cloud, a Wi-Fi symbol, and several human figures. The overall color palette is dominated by deep blues and teals, with bright white highlights from the digital elements.

CYIENT

**INTERNET OF THINGS (IOT)
for Improved Healthcare
Outcomes**

CONTENTS

1. Introduction	01
<hr/>	
2. Facilitating Healthcare Monitoring	03
<hr/>	
3. The Future of IoT in Healthcare	04
<hr/>	
4. Privacy and Data Security	07
<hr/>	
5. Use Cases	11
<hr/>	
6. Summary	14
<hr/>	
7. About the Authors	15
<hr/>	



1. Introduction

The Internet of Things (IoT), which brings together information technology and operational technology, is an ecosystem that comprises sensor-enabled devices connected to an IT system to solve specific business challenges. IoT serves as a catalyst for the healthcare industry and plays a critical role across the range of healthcare monitoring applications. Networked sensor devices, either worn on the body or embedded in living environments, enable the gathering of rich information for both patient evaluation and asset management. IoT devices and systems have made remote monitoring in the healthcare sector possible. They have unleashed the potential to keep patients safe and healthy and empower physicians to deliver superlative care.

IoT has also increased patient engagement and satisfaction as interactions with doctors have become more accessible and efficient, especially in these pandemic times. Furthermore, remote monitoring of patient health has proven effective in reducing the length of hospital stays required and patient re-admissions within 30 days. IoT has therefore had a significant impact on reducing healthcare costs and improving treatment outcomes.

IoT is undoubtedly transforming the healthcare industry by redefining the way devices and people interact in healthcare service delivery. IoT has applications in healthcare that benefit patients, families, physicians, hospitals, and payors (insurance companies). It also presents certain challenges that need solutions.



1.1 IoT for Patients

Devices in the form of wearables such as fitness bands and other wirelessly connected devices such as blood pressure and heart rate monitoring cuffs and glucometers give patients access to personalized attention. These devices can be tuned to flag calorie count, exercise check, appointments, blood pressure variations, and much more.

IoT has changed people's lives, especially of elderly patients, by enabling constant tracking of health conditions. This has a significant impact on people living alone and their families. In the event of any disturbance or change in the routine activities of a person, the alerts mechanism sends signals to family members and concerned health providers.

1.2 IoT for Physicians

By using wearables and other home monitoring equipment embedded with IoT, physicians can track patient health more effectively. They can track patients' adherence to treatment plans or need for immediate medical attention.

IoT enables healthcare professionals to be more watchful and connect with the patients proactively. Data collected from IoT devices can help physicians identify the best treatment process for patients and reach expected outcomes.

1.3 IoT for Hospitals

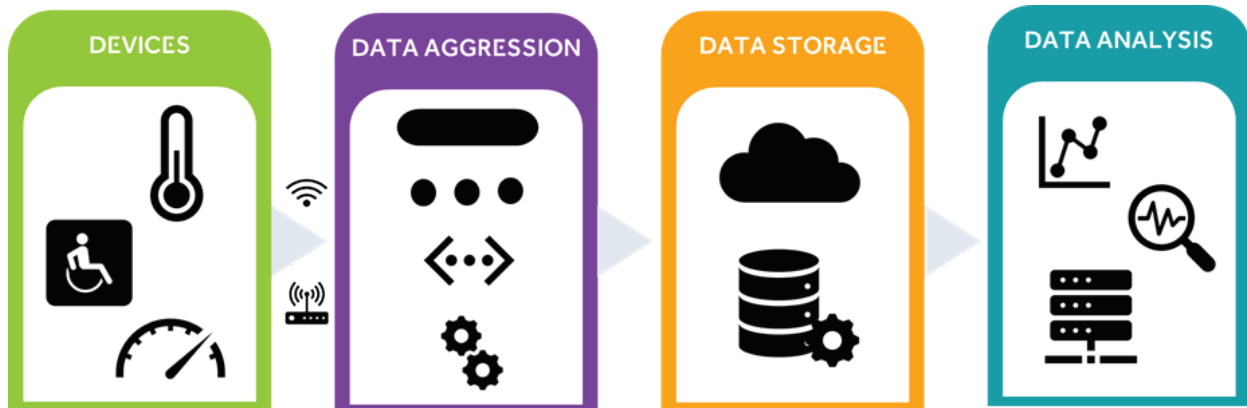
In addition to monitoring patient health, there are many other areas where IoT devices are beneficial in hospitals. IoT devices tagged with sensors are used to track the real-time location of medical equipment such as wheelchairs, defibrillators, nebulizers, oxygen pumps, and other monitoring equipment. Deployment of the medical staff at different locations can also be analyzed in real time.

The spread of infections is a significant concern for patients in hospitals. IoT-enabled hygiene monitoring devices help in preventing patients from getting infected. IoT devices also help in asset management such as pharmacy inventory control and environmental monitoring—for instance, checking refrigerator temperature, humidity, and temperature control.

2. Facilitating Healthcare Monitoring

Critical care system monitoring using Cyient IoT gateways/devices 5400/3300/1200

IoT products open up immense opportunities, and the vast amount of data generated by these connected devices can potentially transform the healthcare industry.



IoT has a four-step architecture that is connected such that data is captured or processed at one stage and yields the value to the next stage. Integrated values in the process bring intuitions and deliver dynamic business prospects. The steps are described below.

Step 01

Deployment of interconnected devices that include sensors, actuators, monitors, detectors, camera systems, etc. These devices collect data.

Step 02

Data received from sensors and other devices is in analog form, which needs to be aggregated and converted to digital for further data processing.

Step 03

Once the data is digitized and aggregated, it is pre-processed, standardized, and moved to the data center or cloud.

Step 04

Final data is managed and analyzed at the required level. Advanced analytics, applied to this data, brings actionable business insights for effective decision-making.

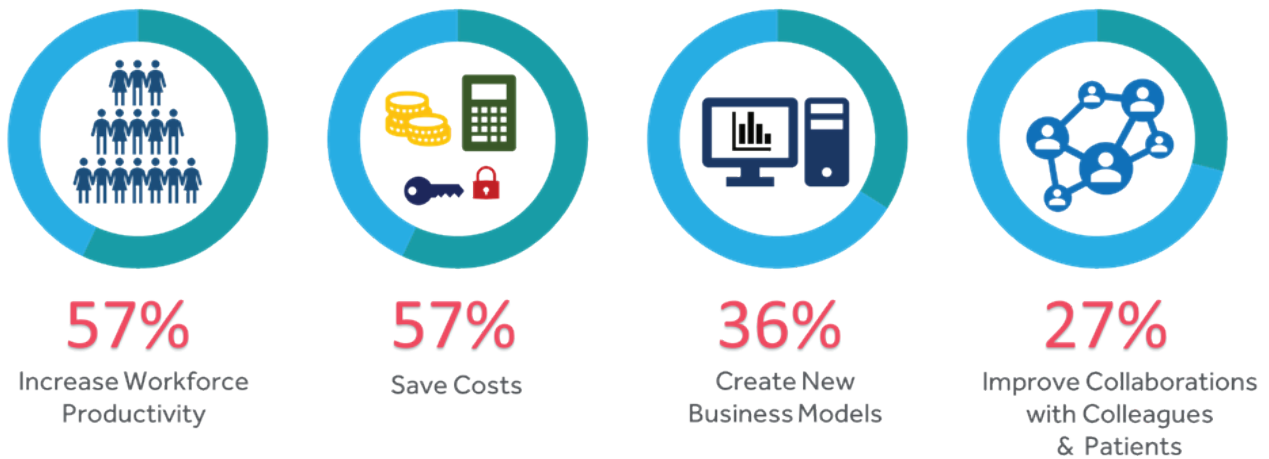
IoT is redefining healthcare by ensuring better care, improved treatment outcomes and reduced costs for patients, enhanced processes and workflows, improved performance, and patient experience.

3. The Future of IoT in Healthcare

Many IoT healthcare companies are working on new ways to use this technology to advantage in the medical world. Despite IoT's challenges and limitations, the technology's applications are swiftly growing. The need for IoT in healthcare is enormous, and it can help the industry immensely. IoT can reach every patient across the world and connect doctors with patients. There is no denying that IoT has already made a considerable impact and is set to grow further.

It is only a matter of time when the medical industry will be run mainly through IoT technology, resulting in faster and more affordable treatment for patients.

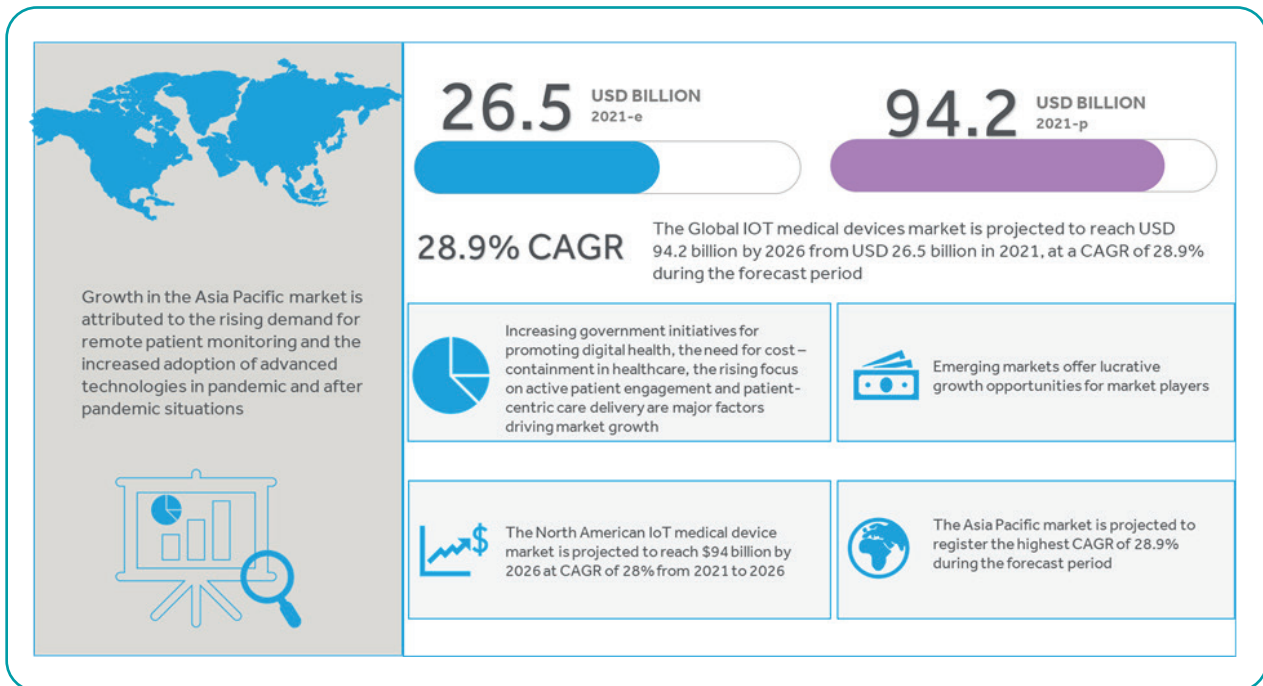
The scope of IoT in healthcare is depicted below:



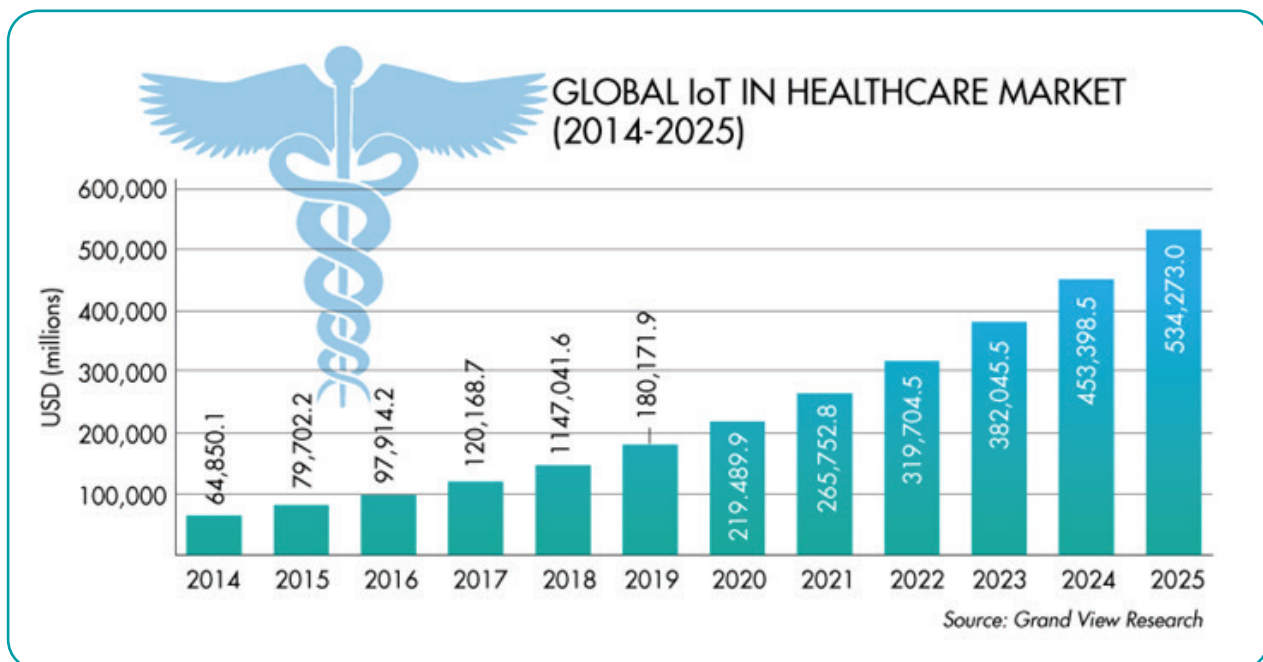
3.1 Estimated Healthcare IoT Device Installations (Global)

Smart, connected devices find increasingly application within the walls of medical institutions. There are over 100 million healthcare IoT devices installed worldwide.

There is even a separate umbrella term to name the ecosystem of connected healthcare services and the system of manufactured products—the Internet of Medical Things (IoMT). It enables machine-to-machine interaction and real-time data streaming between an almost infinite range of medical devices. When equipped with sensors, IoMT devices can vary from prostheses and implants to medical equipment (e.g., stretchers) and home-use medical devices (e.g., blood pressure cuffs). The global IoT medical devices market is projected to reach \$94.2 billion by 2026 from \$26.5 billion in 2021, at a CAGR of 28.9% as seen in the statistical projections in the infographic below.



IoT applications in medicine appeared 20 years ago, and even back then, its potential to enhance the quality of services and reduce costs for patients was clearly evident. In 2020, Gartner Analytics included IoT in healthcare as one of the world's top technology trends.



An important indicator of success is the robust growth of the healthcare IoT market, which is projected to achieve \$534.3 billion by 2025 as shown in the chart above. Moreover, 60% of healthcare vendors are implementing IoT solutions at scale.

3.2 Advantages and Challenges of IoT in Healthcare

IoT offers significant advantages in healthcare.

- **Improved treatment:** IoT enables physicians to make evidence-based informed decisions and brings absolute transparency.
- **Faster disease diagnosis:** Continuous patient monitoring and real-time data help diagnose diseases early or even before the condition develops, based on symptoms.
- **Proactive treatment:** Continuous health monitoring opens the doors for proactive medical treatment.
- **Drugs and equipment management:** Management of drugs and medical equipment is a significant challenge in the healthcare industry. Through connected devices, these are managed and utilized efficiently with reduced costs.
- **Error reduction:** Data generated through IoT devices helps in effective decision-making and ensures smooth healthcare operations with reduced errors, waste, and system costs.
- **Cost reduction:** IoT enables real-time patient monitoring, thus significantly cutting down costs of visits to doctors, hospital stays, and re-admissions.

A serious challenge, however, is that IoT-enabled connected devices capture a vast amount of data, including sensitive information, giving rise to concerns about data security.

Access to confidential data of patients by third-parties can lead to other social complications.



4. Privacy and Data Security

IoT is a system of interrelated computing devices. One of the significant concerns of such a system is data security. Unauthorized access leads to unintended use, which can become a personal threat for patients and bring negative publicity to the enterprise. The reliability of connectivity is another crucial factor for better use of IoT in patient healthcare. It means there is always some risk of a cyber-attack. Security measures have improved drastically in the past few years; however, cybercriminals have also evolved.

IoT devices need comprehensive security protocols to protect vulnerable data such as health and patient data and private healthcare information. The massive data transferred and stored regularly can be hacked and used against the patient and the doctor. Hackers can create fake IDs to buy drugs and medicine that can be misused. However, a solution to this issue lies in following the compliance set up by the government for healthcare application development in the country's Multiple Devices and Protocol Integration.

Everyone owns a different device, and this difference in devices causes problems in technology performance. The Internet of Medical Things has yet to find a solution regarding the compatibility of different devices with the IoT network. The connectivity of various devices slows down the entire process of data transfer, analysis, and retrieval.



4.1 Overloading and Inaccuracy

Storing patient data means keeping a humungous amount of data. Even with the Internet of Medical Things, the vast volumes of information are becoming challenging for doctors to manage. If this continues, decision-making could be affected, putting many lives in danger. The more devices that are connected to the network, the greater the quantity of inflowing data.

4.2 Data Accuracy and Overload

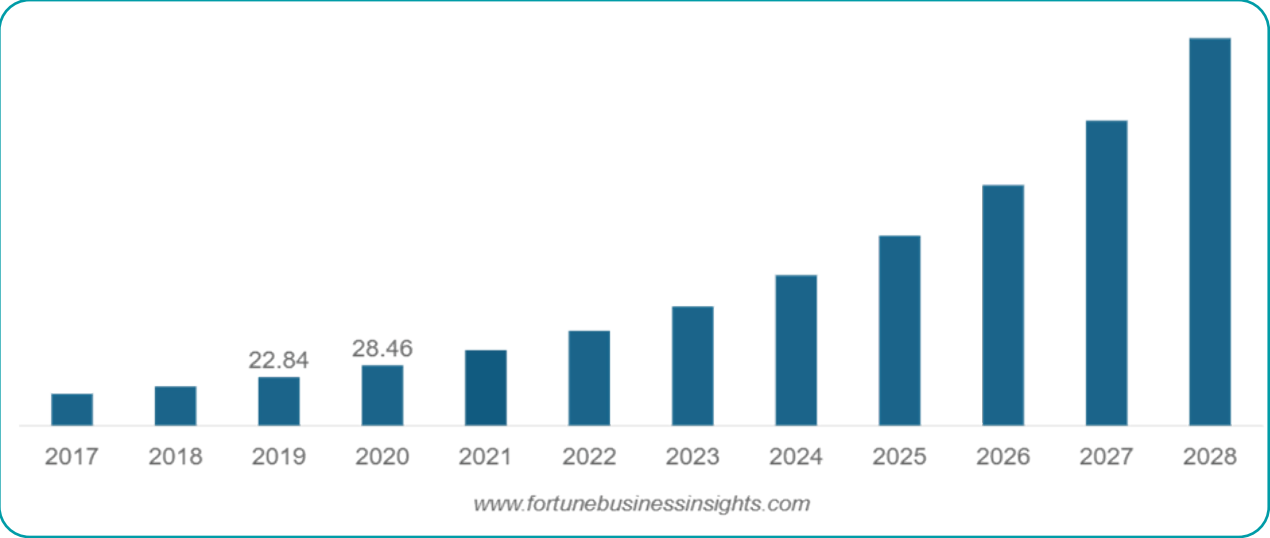
IoT devices record large data sets and, in a perfect world, give doctors valuable insights into patient treatment. The problem with a vast amount of data collection is determining what data is essential and how to navigate the data. As most IoT devices collect data to provide insights, data overload will become a legitimate problem.

4.3 RoI for IoT in Healthcare

Global IoT for healthcare is projected to grow from \$89.07 billion in 2021 to \$446.52 billion in 2028 at a CAGR of 25.9%.



Asia Pacific IoT Healthcare Market Size, 2017-2028 (USD Billion)



The Voice of the Enterprise Survey (data represented in the figure below Figure), which was fielded in June and July 2020, questioned 135 healthcare operational technology professionals about how they use medical IoT and their plans for future investment.

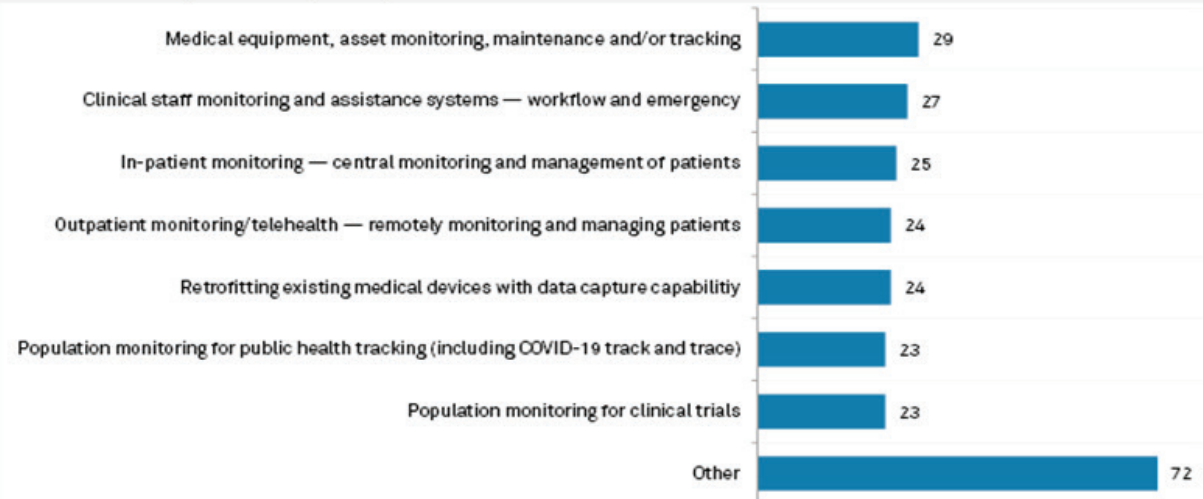
IoT includes devices that can collect information and share it with other networks or devices. The most popular application of this technology is to monitor patients, used by 39% of survey respondents, with about 19% saying they expect to implement in-patient monitoring tools in the next two years.

Monitoring medical equipment assets ranked as the second-most popular reason for implementing IoT technology, with 35.6% of respondents noting that they had made this investment and 22.3% planning to invest over the next two years. Asset monitoring includes maintaining medical equipment such as MRI scanners and X-ray machines, and optimizing the use of medical devices.



Which of the following IoT use cases does your organization plan to implement within the next two years?

Healthcare respondents (n=130)



As of July 17, 2020.

Source: 451 Research's Voice of the Enterprise: IoT, The OT Perspective 2020

The vast majority of respondents across the board had reaped benefits from implementing healthcare IoT technologies. As much as 98.1% saw a positive or very positive return on investment, or ROI, for in-patient monitoring technologies, while 97.2% saw a similar return for their supply chain monitoring and management IoT.

Technologies for population monitoring for clinical trials, medical equipment asset monitoring, and location-based services such as wayfinding had the highest "very positive" responses at 54.2%, 45.8%, and 45.8%, respectively.

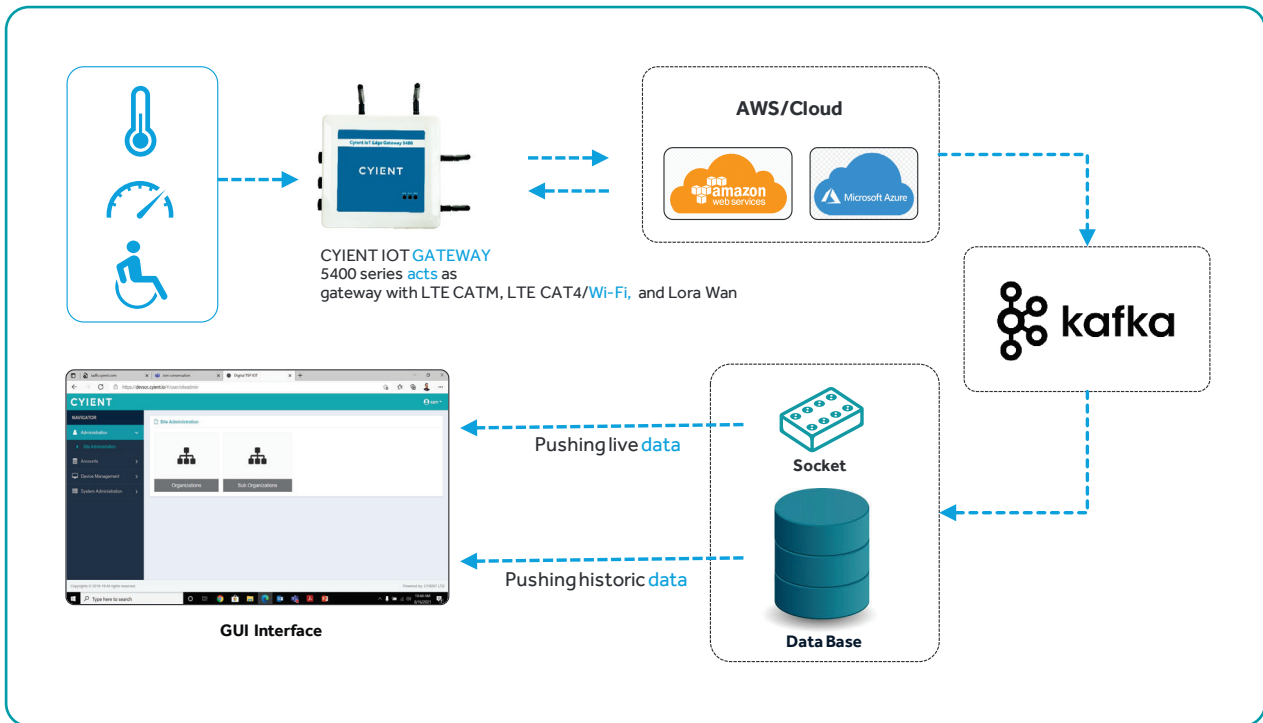
Overall, more than 95% of respondents indicated that they had implemented at least one healthcare IoT use case. The positive responses to ROI in those use cases suggest that IoT is already an essential element of healthcare spending and will likely become more critical.



5. Use Cases

5.1 Hospital Facilities Monitoring

Hospital Facilities Monitoring with Cyient IoT Solution Accelerator-Cyient IOT Gateway and SW Platform



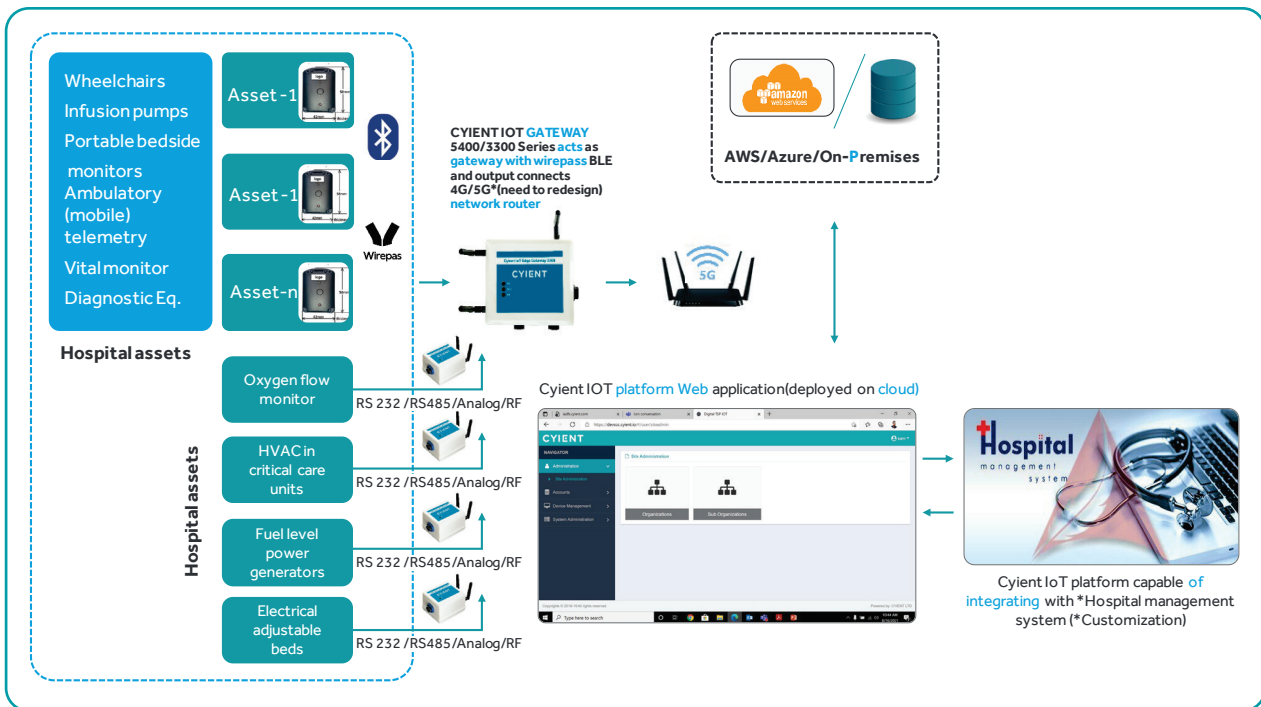
Oxygen supply level and flow, power generation facilities, heating, ventilation, and air conditioning (HVAC), waste management facilities, etc., are connected to the Cyient IoT gateway/devices. The IoT gateway pushes the data to the cloud (AWS/Azure). The real-time data is displayed on the Cyient IoT application dashboard, and the data is stored in the cloud. Cyient's IoT application helps to configure and connect the Cyient IoT gateways. Users can access the information in the IoT application dashboard based on their user roles.

This can also be integrated with enterprise applications such as hospital management systems for central remote monitoring.



5.2 Hospital Asset Monitoring

Hospital Asset Monitoring Using Cyient IoT Devices with BLE Tags/Sub1-GHz RF Nodes with Cyient IOT Edge Gateway Devices and SW Platform



Hospital equipment is expensive and easily goes missing. Studies have found that hospitals will purchase 10%-20% more equipment than necessary because staff often have difficulty locating and using assets.

Bluetooth low Energy based asset tracking uses Bluetooth tags attached to electric wheelchairs, electric beds, portable monitors, infusion pumps, portable ECG equipment, and other pieces of critical equipment, enabling hospital staff members to locate and track assets in real time. Each time a doctor or nurse needs a particular tool, they can check a dedicated app and see where the equipment is located. Business outcome-oriented asset management solutions are not only about availability in real time, but more importantly, they translate all the collected location data into insightful reports, helping to understand the flow of assets, identify areas that are under and over-equipped, or assets that are misplaced, and help make data-driven decisions on equipment purchases and placement.

Note: Cyient gateways support 4G/5G cellular communication over private networks and have been tested successfully in Band 7 (dl_freq=2680.000 MHz ul_freq=2560.000 MHz).

5.3 Patient Health Monitoring

Patient Health Monitoring in Real Time

Real-time patient health monitoring includes bedside devices and mobile telemetry monitors that send data over wireless networks/Private LTE 4G/5G. The data is then routed through IoT gateways/hubs to a central database.

This real-time and historical data is accessed by support staff and doctors for patient diagnostics.

Cyient IoT gateways are built for industrial applications. They can be customized for the hospital environment and provide ease of monitoring for facilities, hospital assets, and patient data monitoring applications playing the role of hubs and gateways.



6. Summary

IoT is revolutionizing the field of healthcare. Yet, many challenges and technological obstacles remain. Though there are downsides, things seem to be headed in the right direction for this technological innovation, as its benefits outweigh the challenges. The future of IoT in healthcare is promising, given recent events. The unfolding crisis in the industry caused by the pandemic once again proved the importance of implementing technologies like IoT, big data, and AI to enhance efficiency and improve safety in healthcare. Implementing IoT solutions right now is no longer about staying ahead of the competition; it is about making sure that we can handle crises.

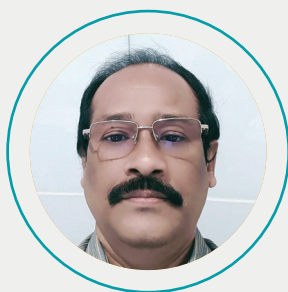
At Cyient, we have 15+ years of experience serving industries and have developed a strong knowledge of industry-specific operations and IoT systems, enabling us to merge core engineering capabilities with digital technologies. We help hospitals leverage IoT for improved healthcare service delivery by deploying gateways, and integrating APIs and enterprise software to analyze data, bring devices online, and control intelligent systems. Our teams develop hardware (gateways) that supports multiple types of inputs (sensors, actuators, computer devices, etc.) to address the requirements of various industries. We also integrate different connectivity protocols such as MQTT, CoAP, AMQP, HTTPS, etc., with middleware and software apps for healthcare professionals, hospitals, foundations, and pharmaceuticals companies. We have a rich IoT solutions portfolio that includes telehealth applications, diagnostic data analytics systems, and embedded software for smart medical devices.

For more information, please visit our website at <https://www.cyient.com/intellicyient>



About the Authors

A highly proficient technology-driven professional with 20+ years of rich experience in tech management, program management, with multidomain working knowledge in defense, medical, automotive and industrial automation. His expertise spans end-to-end HW, SW product development, product improvement/redesign, V&V, regulatory compliance, and productionization, and in tech embedded, IOT, FW applications, Web application development and integration to cloud platforms.



Lead-IOT Tech Studio
Srinivasu Parupalli

Core Expertise

- Technology management, program management, process management, and customer relations
- Budget and cost estimations and management
- End-to-end product design development and product life cycle management
- Risk management, product qualification and reliability engineering
- Regulatory compliance and testing
- System integration—embedded HW, SW, and cloud applications
- Telemetry systems, data analysis, smart and remote monitoring

Nagasai Srinivasa Rao Boppana has 8+ years of experience as a business analyst in business development, project and product management, and product director activities, and has filed for several patents. He has domain expertise in applications such as document management solutions, e-commerce, logistics, video conferencing, medical and health management, traffic enforcement (payment gateway, authentication, tracking, data management, and monitoring), and entrepreneurial experience as senior IT business analyst/product director for startup companies.



Business Analyst
Boppana Nagasai
Srinivasa Rao

Core Expertise

- Business analysis, outlining problems, opportunities, and solutions for business development
- Customer relationship management
- Ensuring that solutions are understood and address stakeholders' business requirements
- Market study, comparison study, feature analysis
- Upgrading/re-designing systems with the latest technologies

About Cyient

Cyient (Estd: 1991, NSE: CYIENT) is a leading global engineering and technology solutions company. We are a Design, Build, and Maintain partner for leading organizations worldwide. We leverage digital technologies, advanced analytics capabilities, and our domain knowledge and technical expertise, to solve complex business problems.

We partner with customers to operate as part of their extended team in ways that best suit their organization's culture and requirements. Our industry focus includes aerospace and defense, healthcare, telecommunications, rail transportation, semiconductor, geospatial, industrial, and energy. We are committed to designing tomorrow together with our stakeholders and being a culturally inclusive, socially responsible, and environmentally sustainable organization.

For more information, please visit
www.cyient.com



Contact Us

North America Headquarters

Cyient, Inc.
99 East River Drive
5th Floor
East Hartford, CT 06108
USA
T: +1 860 528 5430
F: +1 860 528 5873

Europe, Middle East, and Africa Headquarters

Cyient Europe Limited
Apex, Forbury Road,
Reading
RG1 1AX
UK
T: +44 118 3043720

Asia Pacific Headquarters

Cyient Limited
Level 1, 350 Collins Street
Melbourne, Victoria, 3000
Australia
T: +61 3 8605 4815
F: +61 3 8601 1180

Global Headquarters

Cyient Limited
Plot No. 11
Software Units Layout
Infocity, Madhapur
Hyderabad - 500081
India
T: +91 40 6764 1000
F: +91 40 2311 0352

Follow us on:  