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Monitoring Health Using IOT Based Infrastructure

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ABSTRACT: This paper presents the design and implementation of a health monitoring system using the Internet of Things (IoT). In present days, with the expansion of innovations, specialists are always looking for innovative electronic devices for easier identification of irregularities within the body. IoT-enabled technologies enable the possibility of developing novel and noninvasive clinical support systems. This paper presents a health care monitoring system. In particular, patients, high blood pressure patients, diabetic patients, etc., in a rural area in a developing country, such as India, do not have instant access to health or emergency clinics for testing. Buying individual instruments or continuous visitation to hospitals is also expensive for the regular population. The system we developed will measure a patient's body temperature, heartbeat, and oxygen saturation (SpO2) levels in the blood and send the data to a mobile application using Bluetooth. The mobile application was created via the Massachusetts Institute of Technology (MIT) inventor app and will receive the data from the device over Bluetooth. The physical, logical, and application layers are the three layers that make up the system. The logical layer processes the data collected by the sensors in the physical layer. Media access management and intersensor communications are handled by the logical layer. Depending on the logical layer's processed data, the application layer makes decisions. The main objective is to increase affordability for regular people. Besides sustainability in the context of finance, patients will have easy access to personal healthcare. This paper presents an IoT-based system that will simplify the utilization of an otherwise complicated medical device at a minimum cost while sitting at home. A 95 percent confidence interval with a 5 percent maximum relative error is applied to all measurements related to determining the patient's health parameters. The use of these devices as support tools by the general public in a certain situation could have a big impact on their own lives.

KEYWORDS: health, monitoring, IoT, devices, patients, infrastructure, hospitals, public, media, MIT, instruments

I. INTRODUCTION

Improving the patient experience, increasing the number of positive healthcare outcomes, and reducing the costs associated with day-to-day operations are goals shared by healthcare administrators and facilities managers alike. New technologies have been the obvious contributors to improving these efforts for years – be it through a new medical procedure or a digital upgrade to a filing system or staffing roster. Now, developments in technology that contribute to the Internet of Things (IoT) are introducing some extremely interesting innovations for healthcare providers. [1]

Healthcare IoT applications utilizing the tracking and sensing of devices have increasingly become more affordable and more precise. These developments bring with them the promise of a next level of quality in terms of patient experience and operational efficiency provided through connected healthcare facilities[2]. Improved patient monitoring will allow for a safer and less intrusive check-in regimen during overnight stays. The tracking of critical assets – such as storing medicines in individual rooms while maintaining a security audit and cold chain – brings both increased operational efficiencies and quicker care to patients. Implementing data-backed approaches to employee scheduling[3] presents benefits to staff and improves their ability to provide care for individual patients. Of course, the world of IoT also comes with risks that rightfully leave those in IT departments wary[4]. With HIPAA requirements in place, IoT in healthcare introduces several unique security and confidentiality components that must be taken seriously and planned for well in advance. To introduce an IoT application at the scale of a hospital, a healthcare campus, or entire healthcare system, requires flawless execution in terms of secure connectivity and edge computing[5]. That "edge" component is critical. It provides the computing power to effectively process data near the source and allows an IoT task to execute

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without delay. [6] This need for reliability and security can be challenging – and expensive – especially if healthcare providers attempt to design, develop and deploy their own solutions. Healthcare facilities are not alone in facing the challenge of occupying buildings that are ill-equipped for in-house development and deployment of an edge-capable system. It is these factors – the complexity, risk, connectivity, and cost – that have historically been barriers to the adoption of IoT in the healthcare space.[7] However, solutions are now available thanks to a secure and scalable edge architecture model: the utilization of edge-capable wireless gateways that bring IoT applications under a single access point, provide the necessary compute power for IoT, and connect devices to cloud providers seamlessly and securely. Furthermore, the proliferation of Bluetooth Low Energy 5 (BLE) has made the connectivity of devices far more cost effective – both in terms of the actual devices and in the required power draw. The result is sensors, asset tags,[8] and gateways that are affordable enough – and managed well enough – to be deployed at scale. Here are a few examples of what this looks like in practice, as well as instances where the industry is seeing success, momentum and innovation with IoT in healthcare. [9]

Patient monitoring

BLE-based sensors – for measurements such as temperature or other vital signs – offer real advantages in patient monitoring. The devices are sophisticated enough that they can transmit data by the second, allowing for more visibility into a patient's status – even as in-person check-ins are conducted less frequently[10]. Wireless capabilities are critical as well. Using BLE means a longer battery life and a more effective wireless connection. This results in patients who can be more mobile and monitored outside of their hospital rooms. In turn, this results in a more comfortable experience for the patient, as it eliminates a constant, tethered connection to wired bedside devices[11]. With HIPAA as an additional consideration, confidentiality components must be designed into the network. For example, using techniques such as MAC-address rotation allows facilities to collect employee or patient-level data without it being tied to an individual. This means that even in the event of a security breach, the information can't be connected to a single person. [12]

This form of advanced, confidential and real-time patient monitoring is one of the most in-demand IoT applications in healthcare today. Healthcare providers, such as elder-care facilities and in-patient hospitals, are installing gateways in every patient room and in common areas to provide safer, less intrusive, and more flexible monitoring. [13]

Tracking key assets

Keeping track of important and expensive equipment, such as oxygen tanks or wheelchairs, may not be a new concept in healthcare, but the reduction in the cost of tracking tags and monitoring solutions means loss prevention is being extended in terms of what can be inventoried and tracked. Utilizing wireless IoT gateways allows for coverage to be extended all the way to the perimeter of a campus.[14] This provides for real-time location of an asset and an alarm to be triggered if an asset enters a geographically restricted area. Key assets, such as medicines or medical devices, can also be tracked by implementing locks with a credential system and an audit trail. Cold-chain management for medicines and vaccines can also be deployed at scale. The costs for sensors have been reduced to the point that individual containers can now be affordably temperature tracked as they move about a facility. When the cost and effectiveness of perishable treatments is at stake,[15] this becomes a critical need as it brings additional confidence in the service a facility provides. There are some key considerations for this type of IoT deployment, such as what level of accuracy is required and what level of cost and performance trade-offs must be balanced. For that reason, a best practice is to implement a flexible gateway infrastructure where all types of IoT applications can be installed and configurations can more easily be changed as necessary. [16]

Staff scheduling & optimization

Scheduling has long been a hot category in healthcare as providers seek optimization of staff hours with patient care. However, seeking out accurate information as to how worker skills relate to task times has always been a challenge. Self-reporting of how time is used can often be estimated in a way that results in half-baked assumptions for schedulers. The ability to cost-effectively gather real-time data about staff location significantly alters this equation. By understanding where staff are located during a day, and what areas require certain levels of attention, IoT applications can offer new options for optimizing staff scheduling. In turn, this can help improve both staff utilization and patient care. [17]

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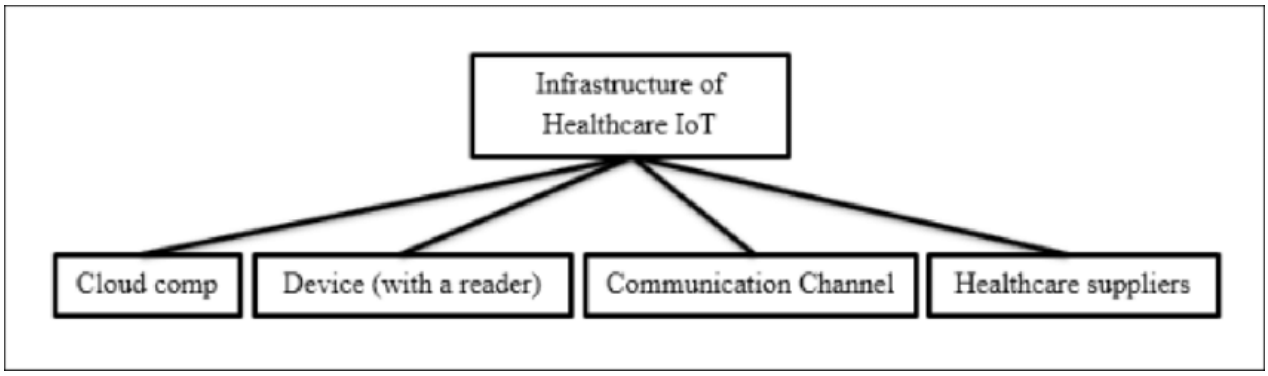
Always considering security

In each of these use cases, security remains paramount. We previously looked at one strategy of ensuring confidentiality for patients – the rotation of MAC addresses – but key considerations must go into each level of network design[18]. Utilizing providers – both on the application and hardware side – that provide constant security patches and support is a must. Also make sure they have developed systems and safeguards to protect both from digital attacks as well as physical ones. An individual removing a gateway from a wall, or a sensor from a device, should not be able to access any data being transferred or any security keys being stored. [19]

Partnering for success

To effectively implement these solutions, healthcare facilities should look to an edge infrastructure partner that understands the desired IoT applications and can bring them together onto a unified and secure gateway[20]. The flexibility of allowing multiple applications to run through a single access point is critical when installing and managing devices at scale. It also ensures the system exists as a cost-effective model throughout the life of the installation. Edge solution providers and application developers must also approach such installations as a partnership, as opposed to a sale.[21] Long term support, potentially through a subscription model, providing constant and consistent security updates is critical. These "as-a-service" subscriptions ensure you have assistance in monitoring the system and replacing the devices if the technology becomes obsolete or fails. That said, make sure you are not being locked into a closed technology or an infrastructure tied to exclusive partnerships[22]. Open platforms are important to ensuring the long-term success as your needs shift or the scale of your deployment changes. These partnerships reduce the complexity and risk associated with Healthcare IoT. They empower facilities and providers to make the promise of IoT a reality. The result is healthier patients, more effective staff, and more efficient healthcare operations.[23]



II. DISCUSSION

Monitoring your beloved ones becomes a difficult task in the modern day life. Keeping track of the health status of the your patient at home is a difficult task. Specially old age patients should be periodically monitored and their loved ones need to be informed about their health status from time to time while at work. So we propose an innovative system that automated this task with ease. Our system puts forward a smart patient health tracking system that uses Sensors to track patient health and uses internet to inform their loved ones in case of any issues. Our system uses temperature as well as heartbeat sensing to keep track of patient health. The sensors are connected to a microcontroller to track the status which is in turn interfaced to an lcd display as well as wifi connection in order to transmit alerts. If system detects any abrupt changes in patient heartbeat or body temperature, the system automatically alerts the user about the patients status over IOT and also shows details of heartbeat and temperature of patient live over the internet. Thus IOT based patient health tracking system effectively uses internet to monitor patient health stats and save lives on time.[24]

The monitoring system consists of various sensors such as temperature, strain gauge and wind speed which provide the current information through data fusion. Data fusion is the process of combining various data sources to produce more consistent, accurate, and useful information than that provided by any individual data source.

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The obtained data is then analysed through suitable software and stored. The reports are prepared and alarmed about the current condition.[25]

Benefits:

The following are the benefits of monitoring the structure

1. Identification of the defect and its position during the service of the structure
2. Constant monitoring of hidden and remotely located cracks or flaws present in the structure.
3. Online monitoring and early warning of the health of the structure
4. Improved safety and better maintenance management
5. Analysis of the present health status of the structure
6. Prediction of remaining useful life the structure based on the present condition.[26]

Structural Health Monitoring:

Structural Health Monitoring [SHM] is the monitoring of the present status of any civil structure. It ensures the integrity and safety of the structure and provides information about the current condition. It is achieved by monitoring the structure regularly.The monitoring of structure usually deals with providing information about the deterioration of health of the structure and its evolution if it is prone to a kind of damage. It even helps in estimating the deteriorating performance of any ageing civil infrastructure.[27]

The parameters which affect the health status of the structures are as follows

1. Static and dynamic loads on the structure
2. Environmental issues such as changing wind speed, temperature, and humidity.

Emerging Areas:

Following are the sectors and areas of adopting SHM Techniques

1. Power
2. Process industry
3. Mass Transit
4. Mining Machinery
5. Oil and Gas Pipelines
6. Aerospace
7. Dams, Bridges and Underpasses[28]

Applications:

The following structures that have been monitored using SHM Technique in recent years

1. Large Bridges
2. Hi-Tech Buildings
3. Tallest Concrete Tower
4. Tallest Steel Towers
5. Flyovers in cities and across Highways

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Health Monitoring of Machinery:

Health monitoring in machinery is the process that deals with the collection, study and analysis of relevant data collected using a wide array of coupled sensors during the service life of machines or equipment.It is a non-destructive and continuous method of identifying and quantifying the worsening status of the machine to predict the necessity of repair and maintenance.[29]

Role of IoT in Health Monitoring:

In recent years, the Internet of Things (IoT) has been used as a monitoring and assessment tool to track the current condition of structure or machine or equipment. This tool collects, analyses, and transfers the various data parameters related to the service condition of the equipment, structure, or machine.This ultimately leads to optimization of cost as per its repair and maintenance of the machine is concerned. It even reduces the related manpower as well. In addition, the life of the machinery can be extended by early detection or identification of the issues and their corrective measure.[30]

The following are the benefits of using IoT based monitoring systems

1. Reduced skilled labour
2. Improved performance and efficiency of the machinery or structure
3. Improved productivity
4. Reduced risk of failure
5. Prevention of catastrophic failure

IoT-based health monitoring is growing worldwide at a faster rate in domains such as medical and healthcare, industrial processing, agriculture, public safety, environmental monitoring, smart homes and buildings, smart grid, smart mobility, etc.It has already been widely spread in developed countries. It is due to the advancements in intelligent digital technology.[31]

III. RESULTS

The Internet of Things (IoT) covers a broad range of industrites and applications. There many IoT use cases which require:

Cloud connectivity (asset tracking, home automation, industrial automation, etc.) using technologies like WiFi or cellular networks like NB-IoT, LTE-M, GSM, etc.Long-range local networks (smart city, smart agriculture, etc.) using technologies like LoRa, Zigbee, Sigfox, etc.Short-range local networks (tracking vital health parameters using wearables, smart door locks, etc.) using technologies like BLE, NFC, ZWave, etc.While implementation specifics vary across these applications, the fundamentals of IoT infrastructure is the same.As a result, a solid understanding of IoT infrastructure is an important aspect of building reliable IoT systems across industries. In this article, to help you improve your IoT skillset, we'll take a deep dive on the topic of IoT infrastructure.[32]

Infrastructure Requirements for IoT

At a basic level, Internet of Things refers to any system of interconnected devices that have sensors and embedded processing abilities. Note that devices don't have to use the Internet. Even locally connected devices interacting and exchanging data are an IoT system.With that in mind, we can break down the IoT infrastructure required to make an IoT system into these elements.

IoT Infrastructure Element

Sensor Used for measuring physical quantities that the IoT device shares over the network

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Controller

The brain of the device; acts as a bridge between the sensor and the network and also performs onboard computations and storage[33]

Network

The technology used for exchanging data with either other devices in the system, or the Cloud

Cloud Computing, storage and gateway resources accessible over the internet

User-facing applications Mobile and web applications that allow the user to interact with the IoT system and visualize the data

Data Analytics-The tools and resources (often on the Cloud) that enable users to derive insights from the data sent by the IoT system.In addition to these basic IoT infrastructure elements, optional hubs can connect a cluster of IoT devices to the internet. And finally, an attribute spanning all these infrastructure elements is security. In the following sections, we'll take a closer look at each of these infrastructure elements. IoT Sensors-IoT sensors are vital component of enabling IoT use cases. These sensors can monitor conditions like the temperature of a room using a temperature sensor or track a vehicle via GPS. IoT sensors are usually powered by a battery or external DC power source.[34]
While most IoT systems have sensors, there can be some that don't need them. For example, if you need to control a smart light using an app, you only need an IoT controller.IoT Controller-An IoT controller is the brain of an IoT application. It acts as a bridge between the sensor and the network and often performs local computations. Today, IoT controllers are becoming more powerful in terms of storage and compute resources. This evolution is driving the popularity of edge computing, which moves storage and compute closer to data sources (e.g., IoT sensors).Like IoT sensors, controllers' use a battery or external power source.IoT Network-Next comes the 'interconnectivity' part. Without network connectivity, a device is not an IoT device but just a standalone computing device. To create an IoT system, devices must connect to other devices or the cloud.The types of connectivity vary depending on the application, ranging from cloud connectivity to short-range local connectivity (e.g., BLE). Likewise, different network communication mediums will require different IoT hardware (e.g., Bluetooth, WiFi, or LTE chips).IoT Cloud-If IoT devices communicate with the cloud, you'll need an IoT cloud platform. You can either take up the monumental tasks of provisioning your own cloud infrastructure (in which case you will need to set up a dedicated server room with UPS, fire safety, redundancy, and backups) or use a cloud service provider like AWS, Azure, GCP, or Macrometa.Cloud infrastructure for IoT applications involves not only the traditional data processing (app services, virtual machines, serverless functions, etc.) and storage (databases, cache, etc.) services, but also gateway services to gather incoming data and interact with the devices (HTTP/MQTT server, WebSocket server).Scale is an essential consideration for cloud infrastructure built for IoT applications. If you plan to grow from a handful of devices to millions of devices, your cloud infrastructure should also scale in tandem. This is one of the reasons in-house server infrastructure isn't ideal for IoT applications. IoT cloud platforms are more straightforward to scale than in-house physical server infrastructure.[32]

IV. CONCLUSIONS

The Internet of Things is about to transform the way we live and work. And if it reaches its fullest potential, it will fundamentally change every aspect of our lives.That sort of disruption is evident in the healthcare sector, where the pen and paper has been the primary means of recording patient information for decades. But now, healthcare technology is changing in major ways.Digital healthcare applications now let patients schedule their appointments without the need to call a doctor's office and wait for a receptionist. Healthcare information technology lets doctors carry information with them anywhere they go through apps on their smartphones.And this increasing connectivity shows no signs of slowing down. In fact, it's only accelerating. The global internet of medical things (IoMT) market is expected reach $187.60 billion by future more than four times its worth in 2020 at $41.17 billion, according to Fortune Business Insights.In short, more connection means more accessible data and better healthcare for patients. Below, we've laid out a roadmap of healthcare's past, present, and future thanks to the IoT.[31]

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The Evolution of Healthcare Technology

Physicians have adapted to the demands of the workplace and adopted digital tools to keep up. These demands are being driven by evolving business models such as value-based reimbursement and virtual care, and by technologies such as electronic health records (EHRs) and precision medicine.Arguably the greatest technological leap forward in the last several decades has been the development of EHRs. Previously, hospitals had multiple systems that handled different functions, but EHRs roll all of those into a single system.Connecting technology systems that contain patient data is a key element of delivering cost-effective, high-quality care. But longstanding challenges preventing healthcare interoperability still exist because business incentives among industry players are misaligned, and patient data is spread too far and wide.Leading EHR software developers hold the key to unlocking patient data trapped in their technology systems. These companies are frequently criticized for making patient data difficult to access via other EHR products.Some 80% of clinicians agreed that their current EHR system supports better patient outcomes, according to Hewlett Packard Enterprise's May 2020 survey.But EHRs are demonized as the primary cause of clinician burnout, based on poor usability, inefficient functions, and diverting a caregiver's focus from the patient, to name a few.[30]

IoT Medical Devices

The IoT enables healthcare providers to extend their reach outside of the traditional clinical setting. Home monitoring systems allow patients and doctors to keep track of an individual's health when not in the doctor's office to prevent unnecessary and costly trips to sit down with a physician.Another IoT tool US health systems and hospitals are turning to improved outcomes and reduced costs is remote patient monitoring (RPM) technology. This type of patient care leverages connected devices with IoT sensors to offer providers a continuous stream of real-time health data such as heart rate, blood pressure, and glucose monitoring.As demand for convenience and distanced care continues, and RPM adoption will only increase post-pandemic. We estimate there will be 70.6 million RPM users in the US by 2025, up 56.5% from 2019. In three years, more than one-quarter of the US population will be regularly using a device that remotely tracks or collects their well-being or medical data for their doctors to assess.In addition to monitoring basic fitness levels, wearables such as the Apple Watch are now taking on more medical device functionality as tech companies eye a growing opportunity in the lucrative digital health market.[31]

How IoT Will Revolutionize the Healthcare Industry

The IoT is slowly starting to weave into healthcare on both the doctor and patient fronts. Ultrasounds, thermometers, glucose monitors, electrocardiograms, and more are all starting to become connected and letting patients track their health. This is crucial for those situations that require follow-up appointments with doctors.Multiple hospitals have started to utilize smart beds, which can sense the presence of a patient and automatically adjust itself to the correct angle and pressure to provide proper support without the need for a nurse to intervene.The IoT could also help transform patient care at home. Sadly, some patients don't take their medication in appropriate doses or at the correct times. Smart medication dispensers in the home could automatically upload information to the cloud and alert doctors when patients don't take their medicine. More broadly, this type of technology could let doctors know of any potentially dangerous patient behavior.[28]

IoT Healthcare Companies and Startups

Several well-known companies are leading the pack when it comes to the IoT and healthcare. These companies are clamoring to gain a major slice of the pie by developing products for specific medical applications, increasing collaborative research and development, and acquiring new startups.Microsoft, for example, has built its Microsoft Azure cloud platform to facilitate cloud-based delivery of multiple healthcare services. Additionally, Apple has worked toward turning its consumer products into portable health hubs.Apple Watch continues to advance its health features with each iteration – like its FDA-approved electrocardiogram (EKG) embedded in the Series 4, and both a menstrual health-tracking feature and a dedicated Research app added to the Series 5.

But dozens of other companies and startups are also looking to break into the space, such as:

- AliveCor

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- Proteus
- CrossChx
- Neurotech
- Sensely
- Pear Therapeutics
- Clover Health
- Babylon Health
- Genoox
- Helix
- Karius[34]

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