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MIOT (MEDICAL INTERNET OF THINGS): HOW IT IS REVOLUTIONIZING HEALTHCARE WITH ITS POTENTIAL AND SHORTCOMINGS

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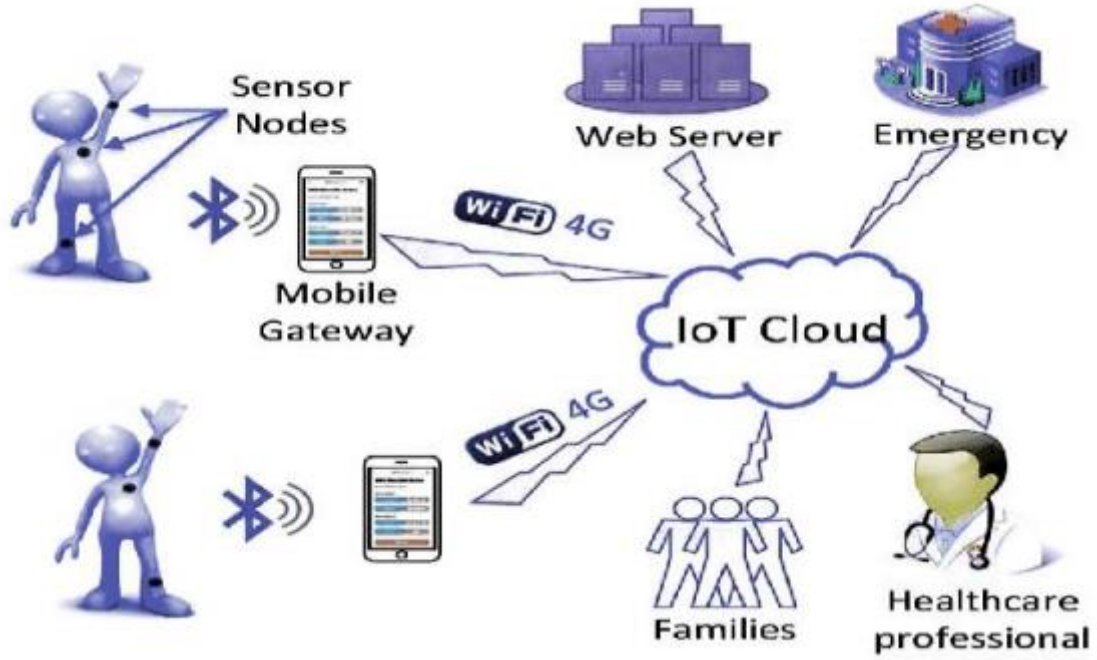
ABSTRACT
The IoMT is an amalgamation of medical devices and applications that can connect to health care information technology systems using networking technologies. It can reduce unnecessary hospital visits and the burden on health care systems by connecting patients to their physicians and allowing the transfer of medical data over a secure network. According to Frost & Sullivan analysis, the global IoMT market was worth $22.5 billion in 2016; it is expected to reach $72.02 billion by 2021, at a compound annual growth rate of 26.2%.

The IoMT market consists of smart devices, such as wearables and medical/vital monitors, strictly for health care use on the body, in the home, or in community, clinic or hospital settings; and associated real-time location, telehealth and other services.

Objective: *The main objective of this paper is to acquaint the readers in lucid language of what MIoT actually is, how it can change the future of healthcare. Like everything else, MIOT too has a flipside which also discussed in this paper.*

Keywords: *Medical Internet of Things, Healthcare, Technology*



INTRODUCTION
The healthcare industry is in a state of great despair. Healthcare services are costlier than ever, global population is aging and the number of chronic diseases are on a rise. What we are approaching is a world where basic healthcare would become out of reach to most people, a large section of society would go unproductive owing to old age and people would be more prone to chronic disease.

While technology can't stop the population from ageing or eradicate chronic diseases at once, it can at least make healthcare easier on a pocket and in term of accessibility. Medical diagnostic consumes a large part of hospital bills. Technology can move the routines of medical checks from a hospital (hospital-centric) to the patient's home (home-centric). The right diagnosis will also lessen the need of hospitalization.

A new paradigm, known as the Internet of Things (IoT), has an extensive applicability in numerous areas, including healthcare. The full application of this paradigm in healthcare area is a mutual hope because it allows

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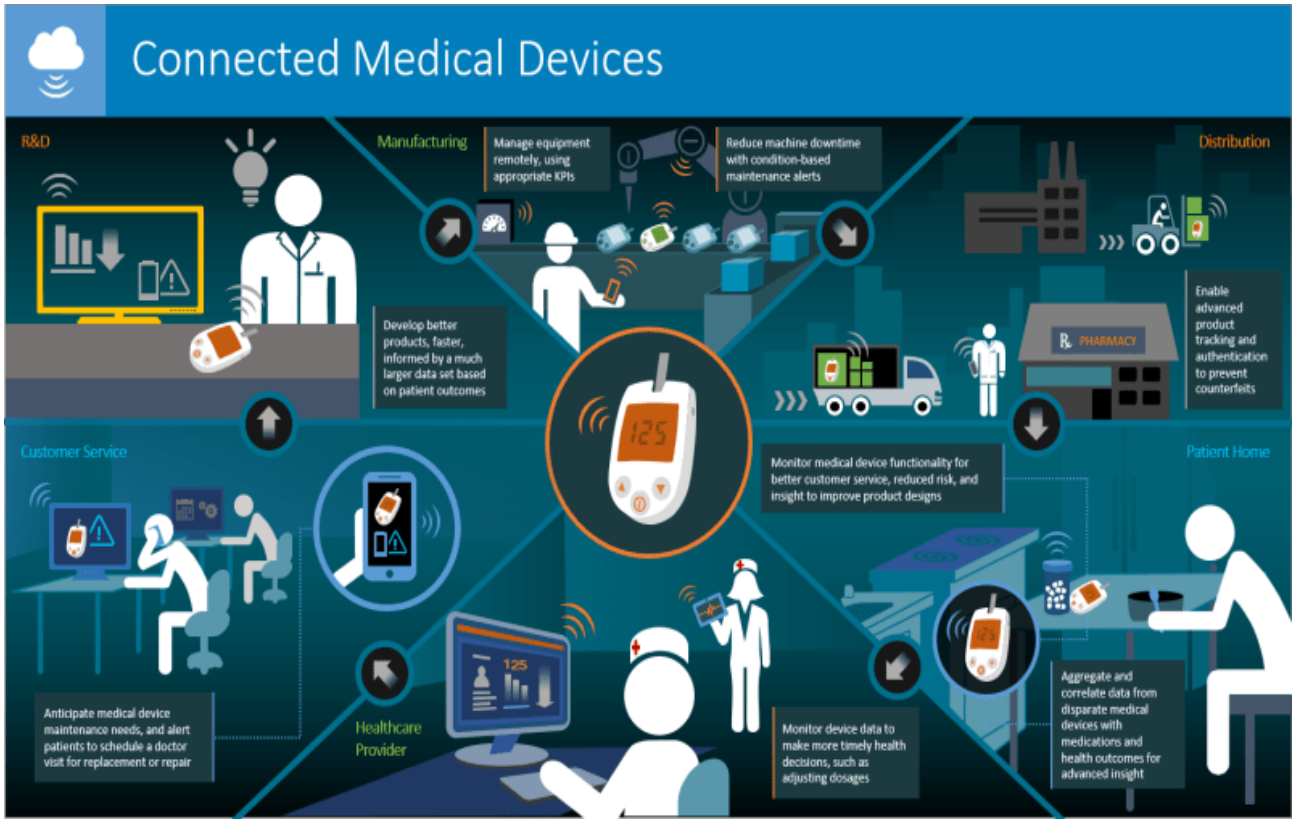
medical centers to function more competently and patients to obtain better treatment. With the use of this technology-based healthcare method, there are unparalleled benefits which could improve the quality and efficiency of treatments and accordingly improve the health of the patients.

While IoT-based medical technology applications are still in a nascent stage, recent research in sensor, networks, cloud, mobility, and the big data domain is witnessing significant activity towards developing maximum IP coverage by companies.

Although the development of telemetric devices was first commenced in 1970 with a patent filed by both Warner–Lambert and Pacemakers Diagnostics clinic of America to disclose the telemetry, actual patent filing activities grew robustly after 1989, with the integration of biosensors into existing systems in order to capture dynamic physiological data and transmit it through wireless networks. The Internet-based medical device and remote healthcare assistance segments first flourished in the US due to the country's major market share in conventional medical devices. Remote location-enabled technologies were rapidly adapted in the market due to their widespread clinical acceptance and healthcare policies. Due to this, major corporations opted to protect their inventions in North America, followed by Europe.

Philips, GE Healthcare, and Medtronic are the leading players in IoMT technology. Philips primarily offers cardiac monitoring, remote patient communication devices, and sensor-related products, whereas GE and Medtronic focus on cloud-based technologies in existing monitoring devices, implants, and cardiac pacemakers. Siemens and IBM, two other players in the value chain, extend solutions in upper layers, which enable data analytics and cloud-based services to biometric data obtained from physical devices and sensors.



Exciting Applications of IoT in healthcare

The rise of IoT is exciting for everybody due to its different scope of use in various sectors. In Healthcare it has several applications. IoT in healthcare helps in:

•Reducing emergency room wait time

•Tracking patients, staff, and inventory

•Enhancing drug management

•Ensuring availability of critical hardware

IoT has also introduced several wearables & devices which has made lives of patients comfortable. These devices are as follows.

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1. Hearables
Hearables are new-age hearing aids which have completely transformed the way people who suffered hearing loss interact with the world. Nowadays, hearables are compatible with Bluetooth which syncs your smartphone with it.

It allows you to filter, equalize and add layered features to real-world sounds. Doppler Labs is the most suitable example of it.

2. Ingestible sensors
Ingestible sensors are genuinely a modern-science marvel. These are pill-sized sensors which monitor the medication in our body and warns us if it detects any irregularities in our bodies.

These sensors can be a boon for a diabetic patient as it would help in curbing symptoms and provide with an early warning for diseases. Proteus Digital Health is one such example.

3. Moodables
Moodables are mood enhancing devices which help in improving our mood throughout the day. It may sound like science fiction, but it's not far from reality.

Thync and Halo Neurosciences are already working on it and has made tremendous progress. Moodables are head-mounted wearables that send low-intensity current to the brain which elevates our mood.

4. Computer vision technology
Computer vision technology along with AI has given rise to drone technology which aims to mimic visual perception and hence decision making based on it.

Drones like Skydio use computer vision technology to detect obstacles and to navigate around them. This technology can also be used for visually impaired people to navigate efficiently.

5. Healthcare charting
IoT devices such as Audemix reduce much manual work which a doctor has to do during patient charting. It is powered by voice commands and captures the patient's data. It makes the patient's data readily accessible for review. It saves around doctors' work by 15 hours per week.

6. Cancer treatment
In June 2018, data was presented at the ASCO Annual Meeting from a randomized clinical trial of 357 patients receiving treatment for head and neck cancer. The trial used a Bluetooth-enabled weight scale and blood pressure cuff, together with a symptom-tracking app, to send updates to patients' physicians on symptoms and responses to treatment every weekday.

The patients who used this smart monitoring system, known as CYCORE, experienced less severe symptoms related to both the cancer and its treatment when compared to a control group of patients who carried on with regular weekly physician visits (with no additional monitoring).The study demonstrates the potential benefits of smart technology when it comes to improving patient contact with physicians, and monitoring of patients' conditions, in a way that causes minimal interference with their daily lives.

7. Smart continuous glucose monitoring (CGM) and insulin pens
Diabetes has proven to be a fertile ground for the development of smart devices, as a condition that affects roughly one in ten adults, and one that requires continual monitoring and administration of treatment.

A Continuous Glucose Monitor (CGM) is a device that helps diabetics to continuously monitor their blood glucose levels for several days at a time, by taking readings at regular intervals. The first CGM system was approved by the US Food and Drug Administration (FDA) in 1999, and in recent years, a number of smart CGMs have hit the market.

Smart CGMs like Eversense and Freestyle Libre send data on blood glucose levels to an app on iPhone, Android or Apple Watch, allowing the wearer to easily check their information and detect trends. The FreeStyle LibreLink app also allows for remote monitoring by caregivers, which could include the parents of diabetic children or the relatives of elderly patients.

Another smart device currently improving the lives of diabetes patients is the smart insulin pen. Smart insulin pens – or pen caps – like Gocap, InPen and Esysta have the ability to automatically record the time, amount and type of insulin injected in a dose, and recommend the correct type of insulin injection at the right time. The devices interact with a smartphone app that can store long-term data, help diabetes patients calculate their

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insulin dose, and even (in the case of the Gocap) allow patients to record their meals and blood sugar levels, to see how their food and insulin intake are affecting their blood sugar.

8. Closed-loop (automated) insulin delivery

One of the most fascinating areas in IoT medicine is the open-source initiative OpenAPS, which stands for Open Artificial Pancreas System. OpenAPS is a type of closed-loop insulin delivery system, which differs from a CGM in that as well as gauging the amount of glucose in a patient's bloodstream, it also delivers insulin – thus "closing the loop".

OpenAPS was started in 2015 by Dana Lewis and her husband Scott Leibrand, who hacked Dana's CGM and her insulin pump in order to automate the delivery of insulin into her system. Using the data feed from the CGM and a Raspberry Pi computer, their own software completes the loop and continuously alters the amount of insulin Dana's pump delivers.

Automating insulin delivery offers a number of benefits that can change the lives of diabetics. By monitoring an individual's blood glucose levels and automatically adjusting the amount of insulin delivered into their system, the APS helps to keep blood glucose within a safe range, preventing extreme highs and lows (otherwise known as hyperglycemia – excessively high glucose – and hypoglycemia – excessively low glucose).

The automatic delivery of insulin also allows diabetics to sleep through the night without the danger of their blood sugar dropping (also known as night-time hypoglycemia).

Although OpenAPS is not an "out of the box" solution and requires people to be willing to build their own system, it is attracting a growing community of diabetics who are using its free and open-source technology to hack their insulin delivery.

The OpenAPS community aren't the only ones to have had this idea. In 2013, Bryan Mazlish, a father with a wife and young son who both have Type 1 Diabetes, created the first automated and cloud-connected closed-loop artificial pancreas device. In 2014, he founded SmartLoop Labs – now known as Bigfoot Biomedical – to scale and commercialize the development of an automated insulin delivery system based on his invention.

9. Connected inhalers

Like diabetes, asthma is a condition that impacts the lives of hundreds of millions of people across the world. Smart technology is beginning to give them increased insight into and control over their symptoms and treatment, thanks to connected inhalers.

The biggest producer of smart inhaler technology is Propeller Health. Rather than producing entire inhalers, Propeller has created a sensor that attaches to an inhaler or Bluetooth spirometer. It connects up to an app and helps people with asthma and COPD (Chronic Obstructive Pulmonary Disease, which includes emphysema and chronic bronchitis) understand what might be causing their symptoms, track uses of rescue medication, and also provides allergen forecasts.

One of the benefits of using a connected inhaler is improved adherence – in other words, medication is taken more consistently and more often. The Propeller sensor generates reports on inhaler use that can be shared with a patient's doctor, and show whether they are using it as often as is prescribed. For patients, this provides motivation and also clarity, showing how the use of their inhaler is directly improving their condition.

10.Connected contact lenses

Medical smart contact lenses are an ambitious application of the Internet of Things in a healthcare context. While the concept has a great deal of potential, so far, the science hasn't always managed to live up to expectations.

In 2014, Google Life Sciences (now known as Verily, a subsidiary of Google's parent company Alphabet) announced it would be developing a smart contact lens that could measure tear glucose and provide an early warning system for diabetics to alert them when their blood glucose levels had dropped or risen beyond a certain threshold. It partnered with Alcon, the eye care division of pharmaceutical company Novartis, for the project.

However, the project attracted a great deal of skepticism from researchers who believed that the idea of measuring blood glucose levels via tears wasn't scientifically sound – and ultimately, they were proven correct. After a lengthy period with no real news about project developments, in November 2018 Verily confirmed that the project was being shelved.

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But other medical applications for smart contact lenses might prove more successful. Verily is still working on two smart lens programs with Alcon, which aim to treat presbyopia (long-sightedness caused by a loss of elasticity in the lens of an eye) and cataract surgery recovery.

11.The Apple Watch app that monitors depression

Wearable technology doesn't always have to be designed with a medical use in mind to have healthcare benefits. Takeda Pharmaceuticals U.S.A. and Cognition Kit Limited, a platform for measuring cognitive health, collaborated in 2017 to explore the use of an Apple Watch app for monitoring and assessing patients with Major Depressive Disorder (MDD).

The results from the exploratory study were presented in November 2017 at pharma and biotech conference CNS Summit.

The study found a very high level of compliance with the app, which participants used daily to monitor their mood and cognition. The app's daily assessments were also found to correspond with more in-depth and objective cognition tests and patient-reported outcomes, showing that cognitive tests delivered via an app can still be robust and reliable.

While the study was only an exploratory pilot, it has demonstrated the potential for wearable tech to be used to assess the effects of depression in real-time. Like other smart medical devices that gather data, the Apple Watch app could also give patients and healthcare professionals more insight into their condition, and enable more informed conversations about care.

12.Coagulation testing

In 2016, Roche launched a Bluetooth-enabled coagulation system that allows patients to check how quickly their blood clots.

This is the first device of its kind for anticoagulated patients, with self-testing shown to help patients stay within their therapeutic range and lower the risk of stroke or bleeding.

Being able to transmit results to healthcare providers means fewer visits to the clinic. The device also allows patients to add comments to their results, reminds them to test, and flags the results in relation to the target range.

13.Apple's ResearchKit and Parkinson's Disease

In 2018, Apple added a new 'Movement Disorder API' to its open-source Research Kit API, which allows Apple Watches to monitor Parkinson's Disease symptoms.

Normally symptoms are monitored by a physician at a clinic via physical diagnostic tests, and patients are encouraged to keep a diary in order to give a broader insight into symptoms over time. The API aims to make that process automatic and continuous.

An app on a connected iPhone can present the data in a graph, giving daily and hourly breakdowns, as well as minute-by-minute symptom fluctuation.

Apple's ResearchKit has also been used in a number of different health studies, including an arthritis study carried out in partnership with GSK, and an epilepsy study that used sensors in the Apple Watch to detect the onset and duration of seizures.

Apple is keen to tout the potential for its apps to aid with medical research and care, and to that end, in 2017 it launched CareKit, an open-source framework designed to help developers to create apps for managing medical conditions. Unlike HealthKit, which is aimed more at general fitness and wellbeing, CareKit can be used to design apps with a specific medical purpose – so watch this space for more medical innovations that make use of iPhone and Apple Watch technology.

CHALLENGES

1. Data security & privacy

One of the most significant threats that IoT poses is of data security & privacy. IoT devices capture and transmit data in real-time. However, most of the IoT devices lack data protocols and standards.

In addition to that, there is significant ambiguity regarding data ownership regulation. All these factors make the data highly susceptible to cybercriminals who can hack into the system and compromise Personal Health Information (PHI) of both patients as well as doctors.

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Cybercriminals can misuse patient's data to create fake IDs to buy drugs and medical equipment which they can sell later. Hackers can also file a fraudulent Insurance claim in patient's name.

2. Integration: multiple devices & protocols

Integration of multiple devices also causes hindrance in the implementation of IoT in the healthcare sector. The reason for this hindrance is that device manufacturers haven't reached a consensus regarding communication protocols and standard.

So, even if the variety of devices are connected; the difference in their communication protocol complicates and hinders the process of data aggregation. This non-uniformity of the connected device's protocols slows down the whole process and reduces the scope of scalability of IoT in healthcare.

3. Data overload & accuracy

Data aggregation is difficult due to the use of different communication protocols & standards. However, IoT devices still record a ton of data. The data collected by IoT devices are utilized to gain vital insights.

However, the amount of data is so tremendous that deriving insights from it are becoming extremely difficult for doctors which, ultimately affects the quality of decision-making. Moreover, this concern is rising as more devices are connected which record more and more data.

4. Cost

The situation is such that it has given rise to "Medical Tourism" in which patients with critical conditions access healthcare facilities of the developing nations which costs them as less as one-tenth. IoT in healthcare as a concept is a fascinating and promising idea. IoT has not made the healthcare facilitates affordable to the common man yet. The boom in the Healthcare costs is a worrying sign for everybody especially the developed countries.

However, it hasn't solved the cost considerations as of now. To successfully implement IoT and to gain its total optimization the stakeholders must make it cost effective otherwise it will always remain out of everyone's reach except the people from the high class.

CONCLUSION

Approximately 60% of global health care organizations have already implemented Internet of Things technologies, and an additional 27% are expected to do so by 2019. Traditional health care is witnessing a paradigm shift as digital transformation puts technologically advanced and connected products in the hands of consumers and gives patients and physicians even in the poorest and most remote locations better access to health care facilities. This paper attempts to take both the pros and cons of using MIOT into scrutiny and figure out a probable balanced approach so that this remarkable field does more good than harm in the coming future.

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