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Chandramouli is a serial Entrepreneur who has co-founded MoboDexter Group companies & ViewFindAR that does information Technology products & services in CAMS domain.

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## Introduction

Internet of Things (IoT) is a path breaking new technology wave that is affecting our daily lives in ways unimaginable before. With Sensors, Cloud and Analytics, we are now able to provide solutions which were otherwise impossible. We are also able to give customers, strategic insights into their lives like never before.

Internet of Things is revolutionizing the healthcare industry; this white paper helps you to look at holistic view on opportunities, challenges and the way ahead. It also helps you to understand the role of IoT platforms in realizing these opportunities and some of the open issues which must be addressed by platform developers in creating a bigger impact.

Let us look at typical services a healthcare organization must provide. At a high level we can visualize the healthcare services broadly into two categories

- A. Healthcare provider services and
- B. Patient care services.

Healthcare provider services primarily focus on improving patient experience by effectively utilizing the various resources. The organization focus is primarily on

1. Improving patient experience.
2. Effective utilization of medical equipment, test equipment and various other assets.

Patient care services are more connected with emotional caring, respect and compassion. The focus areas include

3. Continuous monitoring of patient health condition.
4. Remote healthcare management.
5. Early diagnosis/screening of diseases.

There is an opportunity to improve each of these services and transform the industry using connected IoT solutions.

With the rapid increase of number of smart medical devices, extensive use and availability of mobile phones and constant demand for better healthcare the need for better interconnectivity technology and better solutions is growing. Besides less people want to visit hospital, they want to track state of their health using handheld devices remotely.

IoT will not only help us to connect existing medical devices and technologies together, it will also enable remote control, remote monitoring and even create a new ecosystem of smart hospitals.

## Problem space

A closure look at some of the problems customers are facing while availing these services helps us to understand the opportunities in a better way.

### Patient experience

- Increasingly long waiting times for doctor consultation.
- Inability to locate right nursing stations and sample collection centers.

### Asset management

- Inability to provide timely assistance because of inefficient management of medical equipment, test equipment and various other assets.
- Minimizing duplicate inventory and rental equipments.

### Continuous monitoring of patient health condition

- Lack of required staff and increased inflow of patients making it difficult to enable continuous monitoring of vital health parameters like heart rate, BP, blood sugar etc.

### Remote healthcare management

- Lack of effective monitoring of compliance to prescribed treatment resulting in treatment failure not being detected early. For many diseases Patients who fail treatment continue to be infectious, spreading disease to others and running increased risks of morbidity and mortality.

### Early diagnosis/screening of diseases.

- For example India accounts for almost 25% of world's pneumonia child deaths. Not being able to do early diagnosis is a cause of concern.
- Lack of lab free assessment methods in screening diseases like cognitive impairment. Based on the research data (Journal of American Medical Association) 75% of cognitive decline cases go unnoticed and many such cases are only diagnosed when cognitive impairment reaches moderate or advanced stage. Cognitive decline significantly affects patients ability to function as independent members of society.

## The Opportunity

With the increasing adaptation of accessing digital services using handheld devices, IoT technology enablers (like sensors, smart tags, gateways, and cloud, analytics and mobile applications) can help healthcare service providers in effectively addressing the above problems.

### Patient Experience

- ✓ Automatic authentication using smart tags.
- ✓ Enabling indoor navigation and guiding through various labs using beacons.
- ✓ Scheduling appointments based on doctors availability.
- ✓ Automatic allocation of wheel chairs based on patient request.

### Asset Management

- ✓ Using smart tags on medical equipments, test equipment and other assets to locate assign and move from one location to another.
- ✓ Significant reduction in duplicate inventory and rental equipment using asset tracking.



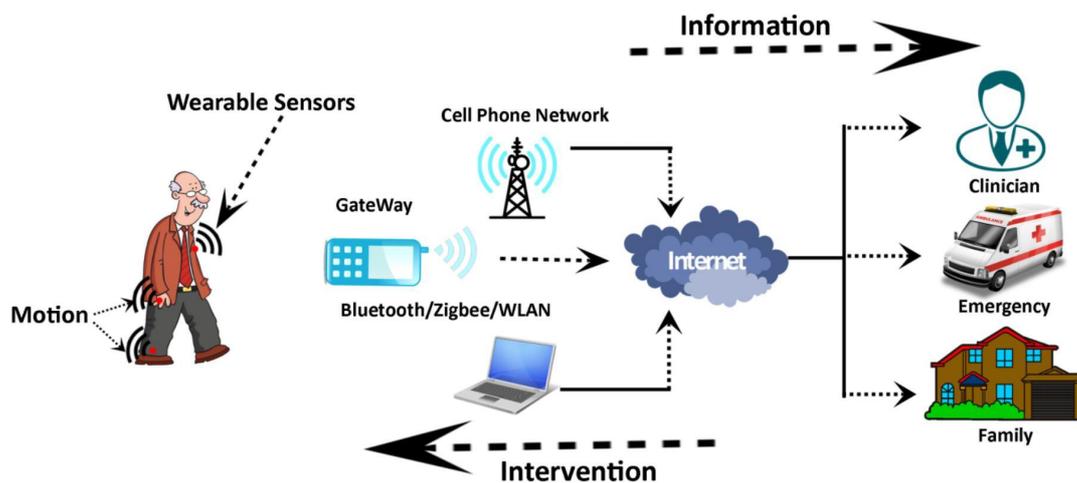
## The Opportunity

### Continuous monitoring

- ✓ Of vital parameters to assess patient's conditions using wearable sensors. For example a number of risk factors related to an individual's lifestyle can contribute to the development of chronic diseases (eg. cardiovascular diseases, chronic respiratory diseases and diabetes). As the individual start mitigating these risks the need for continuous monitoring increases.

### Remote Health Monitoring

- ✓ Vital parameter monitoring using wearable sensors.
- ✓ Recovery monitoring of diseases like Knee replacement surgery using wearable sensors like accelerometers, gyroscopes and force sensor to measure gait parameters.



**IoT in Remote Health Monitoring**

## The Opportunity

### Early diagnosis/screening of diseases.

- ✓ Cognitive decline can be diagnosed with automatic assessment through electronic observation of object usage in smart home scenarios; speech based and gesture based technologies; artificial intelligence and machine learning algorithms.

### Alerts / warning messages.

Generating alerts/warning messages to concerned people and doing in depth analysis on pattern of diseases, spread etc localized within specific regions by

- ✓ Storing the data on the secured cloud.
- ✓ Analyzing the data using analytical models and machine learning algorithms.

Realizing these opportunities improves the quality and safety of patient care, reduce inefficiencies and wastage, and enable better management and administration of the hospital environment.

- Reduction in mortality rates.
- Reduction in spreading of diseases to others.
- Reduced clinic visits, and hospital admissions.
- Reduced length of stay in hospitals.

## Challenges

Definitely in realizing the opportunities discussed above using IoT technologies there are many challenges to address. Some of these are listed below.

### 1. Interoperability

- a. A variety of devices from different vendors located in homes and clinics require to be connected to a cloud to store the data. The data must be aggregated in a local environment using gateways before it gets stored in the cloud. There is a need for standard based communication between devices and gateway and between gateway and cloud.

### 2. Data security

- a. The sensor data must be only be made visible to authorized persons. Policies to share data with authorized persons must be strictly followed.

### 3. Data Integration

- a. The data from multiple sources must be integrated before deriving possible clues. For example in addition to current sensor data, access to patient history is also important to analyze a symptom.

### 4. Integration of different technologies

- a. Support for voice processing, hand writing and gesture recognition engines. For example speech data to be collected for respiratory disease analysis, hand gestures to be collected for cognitive processing of a patient.

### 5. Domain expertise

- a. To build intelligence systems it is very important to build the decision trees, rule based engines by using expertise from trained physicians/doctors.
- b. And more importantly the effectiveness of the entire systems must be evaluated which requires domain expertise.

### 6. Data quality

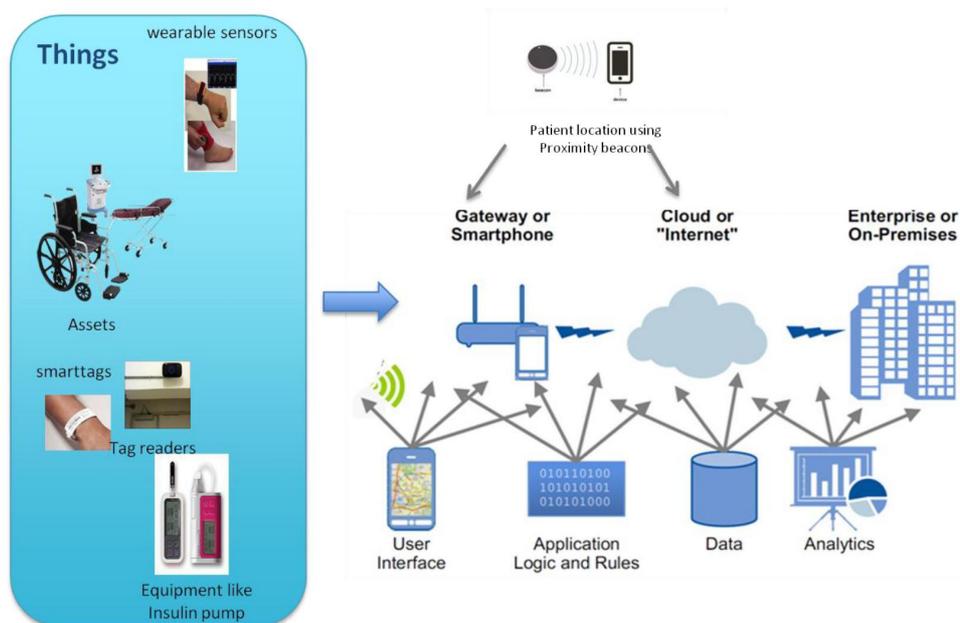
- a. The accuracy and availability of sensor data requires a holistic system view covering aspects like calibrating the data, and annotate data with some measure of confidence.

***The big winners are those who will be able to provide an end to end solution by having the right mix of platforms and good partner ecosystems.***

We are highly interested to start helping healthcare service providers to build and deploy end to end IoT solutions using our PAASMER IoT platform.

## IoT Platforms PAASMER™

MoboDexter's PAASMER™ provides the complete set of components to build an effective IoT healthcare solution as illustrated in the figure below.



PAASMER™ platform comes with following subsystems. Also PAASMER can easily integrate with compatible 3<sup>rd</sup> party subsystems if they already exist.

- **Sensors:** Integration of IoT-enabled sensors to measure various physiological parameters of a patient like Temperature, BP, Blood sugar, heart rate etc.
- **Beacons:** By integrating proximity beacons the platform enables tracking of people and things and further facilitates movement of equipment from one location to another.
- **Gateway:** The Mobo OS™ Gateway operating system, cloud hosted Web application for configuring the gateway. Mobo OS™ is designed to be flexible, modular and gateway platform agnostic. The core functionality of the OS, Connectivity, H/W interface and middleware component are built into Mobo OS™. The gateway has capability to interface with Sensors and periodically transfer the data to cloud. The gateway can also support voice processing engine and hand writing / gesture recognition engine.

## IoT Platforms PAASMER™

- **Core business logic:** To push alert / warning messages to patients and stakeholders based on the data collected from sensors and from other sources.

Advanced analytics for deriving various alert/warning messages; For screening patients with data collected for various diseases.

## Potential Usecases

Following tables illustrate some more details for the various services as we start building implementation usecases.

### Patient Experience:

#	Business Process	Details	Access/Control points
1	Patient registration	Patient arrival, registration and authentication.	Smart tags, Gateways and Mobile apps
2	Sample collection	Locating right nursing stations and sample collection centres.	Indoor navigation using proximity sensors and Apps.
3	Scheduling consultation	Automatically scheduling checkups with consultant doctor.	Gateways, Mobile apps.
4	Investigation	Based on doctors advice requesting right medical equipment and assigning staff for investigation and observations.	Smart tags, Gateways
5	Prescription	Updating digital prescription	Mobile apps.

### Asset Management:

#	Business Process	Details	Access/Control points
1	Asset tracking	Medical equipment, test equipment, IT assets, wheel chairs and high value assets etc.	Smart tags, Gateways
2	Inventory management	Medical supplies, surgical trays etc.	Smart tags, Gateways
3	Staff tracking	Tracking staff and the time spent at different places	Proximity sensors, apps.

## Potential Usecases

### Continuous monitoring:

#	Business Process	Details	Access/Control points
1	Vital parameter monitoring	Sensor data for Heart Rate, BP, Blood Sugar etc.	Sensor data aggregated at Gateway.

### Recovery monitoring of diseases:

#	Business Process	Details	Access/Control points
1	Remote data collection	Fever, chest pain, gait parameters etc.	Sensor data aggregated at Gateway.

### Early screening of diseases like Cognitive impairment.

#	Business Process	Details	Access/Control points
1	Memory, Language and visuospatial abilities	<ul style="list-style-type: none"> <li>a. Simple object naming test.</li> <li>b. A story recall test used for memory and language functioning assessment.</li> <li>c. Picture description test to assess the information content in speech, ability to recognize objects.</li> </ul>	WebUI on Gateway
2	Cognitive processing	<ul style="list-style-type: none"> <li>d. Digital clock drawing test a very well known neurocognitive test which helps in measuring elements of cognitive processing.</li> </ul>	

***Assessing these tests will help in early screening of cognitive impairments before they manifest into major disorders.***

## Way Ahead

Future of healthcare is to enable hospitals to be patient centered, optimize on administrative tasks, and improve quality of service. Once the deployments starts happening sophisticated health analytics systems will be able to monitor patient health without patient even knowing about it.

In a completely new environment known as Smart Hospital, different end systems will talk to each other to exchange information, keep track of doctor, patient location and remotely monitor state of health. Connectivity to large computational clusters allows analysis of all sorts of medical data.

If you are interested to implement this solution you can contact us at [contact@mobodexter.com](mailto:contact@mobodexter.com)

Visit us @ [www.mobodexter.com](http://www.mobodexter.com) ; [www.paasmer.co](http://www.paasmer.co)