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LAY A HAND ON IOT WITH SAP LEONARDO

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Abstract

Internet of Things (IoT) is an exhortation defining next generation networks. Though it is an emerging field pertaining to a little over a decade and a lustrum old, it has already started penetrating in a layman's life in one way or the other. The technology is dynamic and self-adapting and surprises masses with its increasing applications. This paper will provide a bird view insight on IoT design methodology through case studies on designing of an IoT system for monitoring Wind Turbine failure and contactless health monitoring system and cold chain delivery of vaccine/medicines. As IoT is technology independent, understanding of mapping of functional groups (of the system to be automated) to operational view is enviable. SAP Leonardo is used for prototype automation, benefitting its micro-services which in turn enable to leverage future facing technologies.

Keywords. Body sensor networks, Internet of Things, Wind energy, Cold Chain, Automation, SAP Leonardo.

INTRODUCTION

The term **I**nternet **o**f **T**hings (IoT) was nomenclature by Kevin Ashton in 1999, although its existence in our lives dates back to much before. IoT empowers simple physical objects of the living world to be virtually intelligent objects [1]. In simple acoustic words, IoT refers to the 'things' connected via 'Internet'. Here, the things refer to both alive and non-alive physical objects, which can be connected via Internet through the sensors placed on it. These sensors capture all the minute details of the object or objects under its way, generate the data and communicate it to the server via Internet for the analysis. The volume of IoT has increased and penetrated in our daily lives with the multiplicatively exponential network of physical objects around us. Due to this increased involvement and presence, it spreads over wide variety of application areas [21][24][25]. Table 1 depicts the timeline of IoT. The vast expanse of timeline shows the exponential advancement whereas the application areas surmounts the possibilities one can think is achievable from this technology. The current scenario aims at connecting not only things, but intelligently connecting People, Things and Businesses. SAP Leonardo is an innovative platform provided by SAP for streamlining businesses, processes and people. It was launched in June 2017.

SAP Leonardo is an umbrella term that engulfs evolving technologies such as IoT, Machine Learning, Big Data, Blockchain and S/4HANA for predictive capabilities. It is a leading platform of contemporary technologies which is focused on design thinking ("creative ideas and solutions to resolve use cases" [5]) to tackle any kind of business requirements and challenges associated with them. It is not only a bunch of ace technologies, but also

encapsulates a methodological approach to unearth the premises available through these technologies. It is capable of providing robust solutions for designing of various IoT applications. Environment & Energy, Health & Lifestyle are two revolutionary resources for controlling human life. As the humanity is progressing, it has become crucial to maintain a balance between the two and between the growing materialistic needs of human race, so as to keep them alive in prosperity.

This paper discusses the solution for detection of failure in one of the eco-friendly sources for the power generation, i.e. wind turbine failure. This involves methodical study and detection of probable failure circumstances under multiple conditions such as environmental, topographical, chaotic installations, etc. In order to address these key concerns, SAP Leonardo is implemented to detect and carry out automated actions with the goal of reduction in maintenance cost and increase in efficiency by reducing machine downtime. It also discusses the solution for contactless hospital visits and cold chain delivery of vaccines and medicines.

The paper is organized into six sections. Section 2 outlines the designing of an IoT system. Section 3 discusses the preliminaries for both the use cases along with their problem definition. Section 4 details the related work for both the use cases with their IoT solution through SAP Leonardo in Section 5. Finally, section 6 concludes the paper.

Table 1 Genesis of IOT [2][3]

Time Stamp	Achievements
1990	Presenters at the Interop Networking conference control a Sunbeam Deluxe Toaster via the Internet.
1993	The U.S. Government allows civilians to use GPS.
1996	G.M. releases its Onstar service.
1998	A water fountain was built by Mark Weiser which was synched with changes in the stock market.
1999	The phrase “Internet of Things” was coined by Kevin Ashton.
2000	The first Internet-connected refrigerator was launched by LG.
2007	Fitbit was launched by James Park and Eric Friedman.
2008	Cisco believed that there were more connected devices than populace.
2009	Google tests self-driving car models Toyota Prius on the streets of California. Remote Monitoring was introduced at St. Jude Medical with the aid of wireless pacemaker.
2010	Tony Fadell and Matt Rogers leave Apple to found Nest.
2013	Google launches short-lived Glass. IoT group was formed by Intel. Amazon introduced delivery services using drones.
2014	Quantity of mobile devices and machines surpassed the world populace.

	Nest was purchased by Google for $3.2 billion, and the company has revealed a self-driving car prototype as well as work on diabetic contact lenses that can test glucose.
	The Industrial Internet Consortium (IIC) was founded by AT&T, Cisco, GE, IBM, and Intel to develop IoT standards.
	Amazon releases Echo to Prime members.
2015	Samsung acquires SmartThing.
	Amazon releases Echo more broadly.
	Mattel announces Wi-Fi Barbie.
	The FAA approves crop-dusting drones.
	Moocall sells sensors that alert ranchers when a cow is about to give birth.
2016	GM empowers Lyft by investing $500 million.
	Jasper was bought by Cisco.
	Homekit was released by Apple.
	Google Home was released by Alphabet.
2017	G.M. and Lyft plan to test self-driving cabs.
2018	Cisco forecasted that there are 10 billion connected devices, i.e. 1.4 for each person.
2020	Cisco has forecasted more than 50 billion mobile connected devices, while Intel says 200 billion.
	Gartner has estimated that 80% of all new automobiles will possess data connectivity.
2021	BMW, Volvo and Ford claims that they will have fully autonomous cars.

IOT SYSTEM AND ITS DESIGNING

Internet of Things (IoT) automates our daily routine by connecting devices and other components with each other over the web. The Internet of Things (IoT) is a network of physical items that are equipped with sensors, software, and network connectivity to collect and exchange data [22]. It enables remote sensing and control of items using current network infrastructure.

Applications of IoT span a wide range of domains [4][22] as depicted in Figure 1.

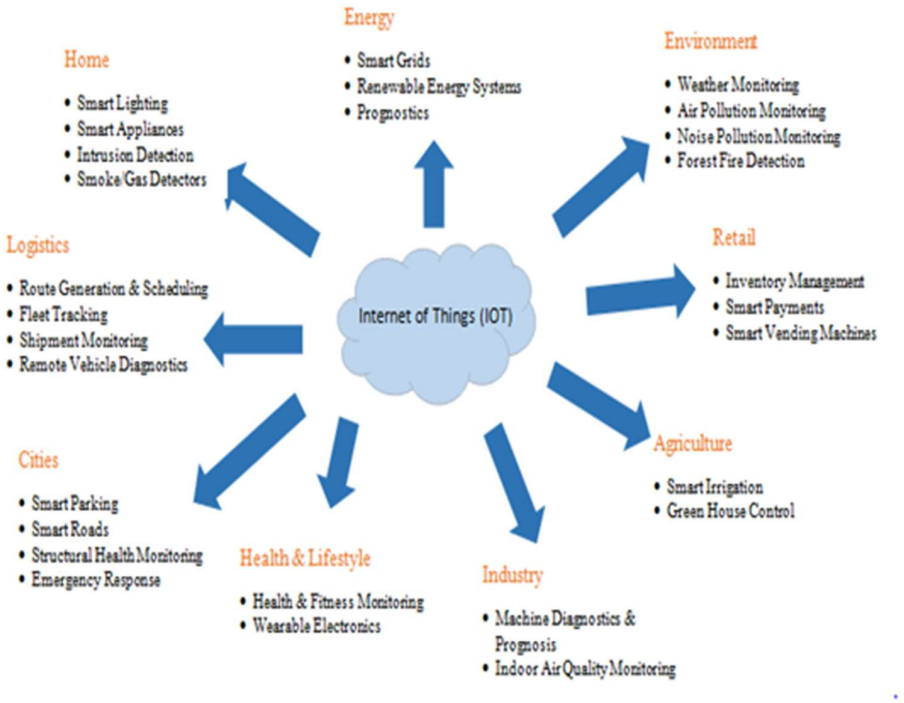

Figure 1. Application Areas of IoT [4]

Designing a robust IoT system involves a process. Figure 2 gives the detailed steps which should be addressed while conceptualizing an IOT system [4].

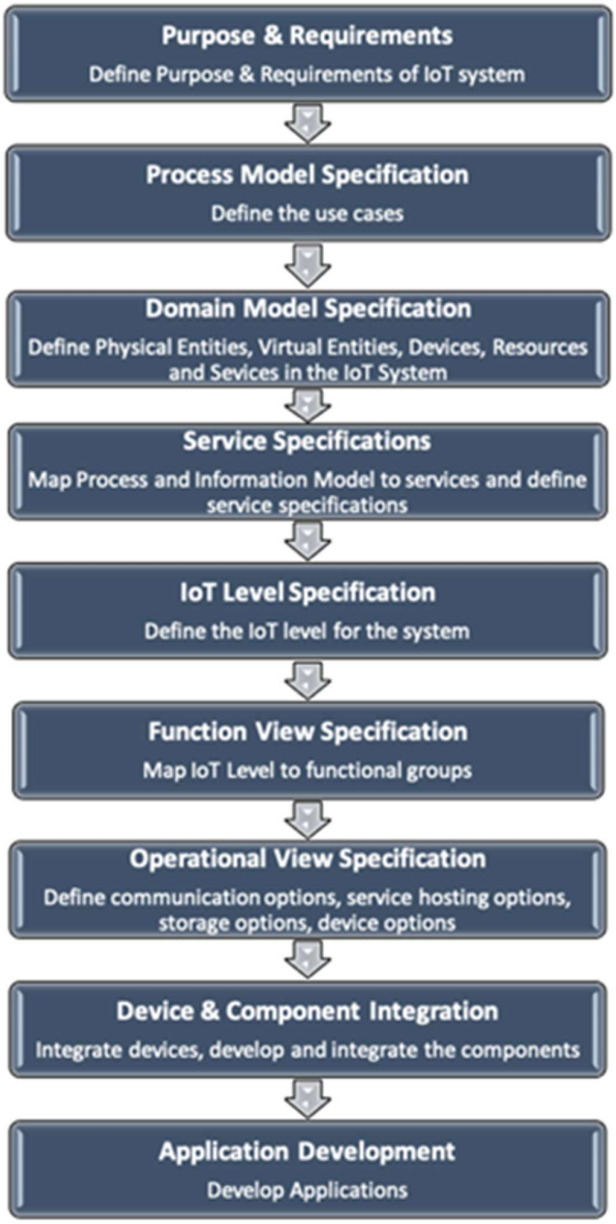

Figure 2. Design Process of an IOT System [4]

PRELIMINARIES

3.1 Environment and Energy

As the advancement in technology is coming, so are the techniques being developed to keep a check on our basic blocks. IoT is playing a vital role in this. IoT-based weather monitoring systems can collect data from the attached sensors, such as humidity, temperature, pressure, UV levels, etc. and send it to cloud-based applications and storage back-ends. The data collected is analyzed and weather alerts can then be sent to the concerned department or people. On the similar lines, air pollution monitoring systems have been developed to detect the emission of harmful gases such as CO_2, CO, NO, NO_2, etc. by industries and vehicles

using gaseous and meteorological sensors. The collected data can then be utilized to take informed decisions on pollution control approaches [23]. Similarly, IoT based solutions coupled with artificial neural networks and multi-criteria decision making can help in detection of forest fire or river floods too.

Energy systems (power plants, smart grids, wind turbines etc.) have numerous critical components that need to function in correspondence of each other so that the system can function properly. Due to variability in the output from energy sources such as solar and wind, stability and reliability issues can creep in. An IoT based system can overcome these problems and simply cut off the overproduction.

3.2 Health and Lifestyle

It is rightly said by Theo Veltman [20], the innovation manager for the City of Amsterdam, that there is no need for technology to exist if it cannot assist its users in achieving happiness, in April 2018 in a summit organized in London.

Our life has greatly impacted with the invention of smart devices. With so many smart devices around us, IoT has created a great impact on our day to day activities. In the healthcare industry, before the era of IoT, interaction of patients and doctors was restricted to only face to face visits in clinics and hospitals. It would be counted as a difficult situation if a specific doctor to whom the patient is consulting moves out of the city or country, there was no provision available with the doctor through which he can monitor the health condition of his patient and suggest proper medication.

IoT has made remote monitoring in the healthcare sector possible. It has extended the scope of keeping patients healthy from remote locations as well. Level of satisfaction of patients has risen to a great extent because of more interaction with the doctors from the comfort of their home. The system is cheaper and effective, as visiting and staying in hospital cost has become negligible.

IoT is undoubtedly transforming the healthcare industry by redefining the space of devices and people interaction in delivering healthcare solutions. IoT has applications in healthcare that benefit patients, families, physicians, hospitals and insurance companies.

3.3 Use Cases needing smart IoT Solutions

3.3.1 Wind Energy

Winds with a power of 2 X 1013 W are present. Though this represents a modest part of incident solar energy, it is greater than the world's total energy consumption rate [6]. Only 1% of potential wind power is predicted to be equivalent to 2 X 1011 W, or around 3% of current global energy usage.

Harnessing the wind energy is an excellent substitution of conventional fossil fuels for generating power as the latter lead in undesirable climatic changes. If it is used for

electricity generation, its thermal equivalent would account for about 8% to 9% of the total. Although technical and economic issues limit the appeal of this extraordinary energy source, the potential extracted from wind power utilising a Wind Turbine is enormous.

The Indian government has developed and implemented a unique wind energy initiative. Wind power potential in India is estimated to be around 20,000 MW on a conservative basis. Currently, the country has a total wind power capacity of roughly 2002 MW, with plans to add further capacity in the next years [6]. Although windmills are used to generate electricity in many nations, including areas of India, wind energy is better suited to pumping water for irrigation due to the high variation in wind power density over time and location. Windmills have been tested in India for pumping water for drinking, fodder crop irrigation, forest nurseries, and agro-forestry plantings.

The question arises for dependable, secure and advantageous operation of wind turbines which draws upon a plenty of Engineered Safety Solutions (ESS). This entails a thorough work and credentials of plausible failure scenarios using multi-criteria decision making involving typographical, environmental and haphazard installations, etc.

Major issues of concern when it comes to failure of Wind Turbines or increasing their effectiveness are:

- Slacking of the bolts may lead to ejection of the blade.
- Fissures near the roots of the blade may damage the veracity of the machine.
- Failure of speed controllers can result in high impact blade collisions leading to tower collapse.
- Reduction in Maintenance cost.
- Minimizing the machine down time to upscale the productivity.
- Orders should be placed immediately in lieu of shortage in inventory.

To address all these issues, a complete IOT solution is required which can capture real time data from the sensors at one place and process the associated applications and business transactions at the other. It should signal immediately, if any failure happens or it is better if it can forecast any mis-happenings due to break down of turbine tower or an oil leakage. For the same, the proposed system should also be able to do pattern analysis for a better forecast. The system should also automatically look for shortage of any spare parts and be able to place an order to the vendor directly.

3.3.2 Cold Chain and Remote Patient Monitoring System

The cold chain is a mechanism for preserving vaccinations in good form. The vaccination supply chain, or the immunisation supply chain, is another name for it. From the point of manufacture to the point of administration, the cold chain is made up of a number of linkages that are meant to maintain vaccinations within WHO-recommended temperature limits.

WHO has defined a set of temperatures for cold storage at various points in the chain with defined time duration. WHO cold chain has a starting point located at the manufacturer site, which needs to be maintained till Vaccinator, one such chain is shown in Figure 3 Recommendation for some vaccine cold chain temperature is provided by WHO shown in Table 2 Beside the information given in Table 2, it is suggested that: (i) Diluents should not freeze, (ii) storage temperature is maintained between +2**°C** to +8**°C**, if diluents and vaccine are packed together. (iii) Vaccines having a lyophilized-liquid combination should never freeze [17].

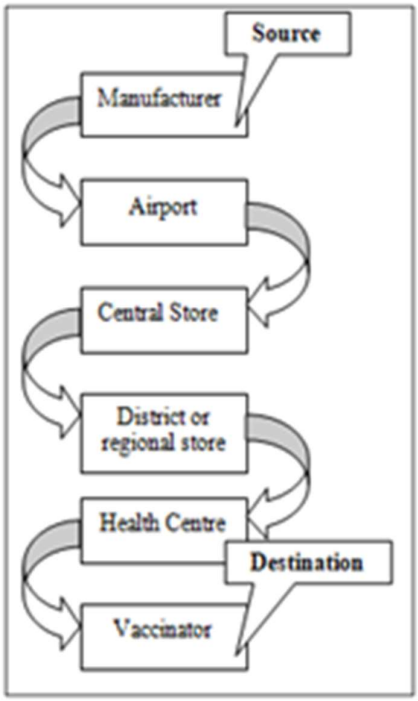

Figure 3. Clod Chain [17]

Table 2. Recommended Temperature level [17]

Level	**Recommended Time Duration**	**Recommended Temperature (in °C)**	**Type of Vaccine**
National	(up to 6 months)	+8 to +2	Liquid, Lyophil
National	(up to 6 months)	-15 to -25	All OPVs, Lyophil (acceptable)
Sub- national	(up to 3 months)	+8 to +2	Liquid, Lyophill
Sub- national	(up to 3 months)	-15 to -25	All OPVs, Lyophil (acceptable)
District	Up to 1 months	+8 to +2	Liquid, Lyophil, All OPVs
Service	Up to 1 months	+8 to +2	Liquid, Lyophil, All OPVs

For maintenance of cold chain different equipment are employed at different levels namely cold or freezer rooms, refrigerators (Electric or Solar or Bottled Gas), cold boxes, refrigerated trucks for transportation, refrigerator with water pack freezing/ cooling compartment, vaccine carriers, foam pad, water packs, etc. All of the above mentioned equipment has specific temperature maintenance roles, at different levels. With these equipments, we have a set of devices required for continuous temperature track. Some of the temperature track devices are Vaccine Vial Monitors (VVMs), electronic temperature loggers, electronic freeze indicators, integrated digital thermometers, Stem thermometers, and digital thermometers.

Out of above mentioned devices Vaccine Vial Monitor (VVM) is the only device that regularly escorts vaccines during the entire supply chain. It is a chemical indicator which changes color if temperature fluctuates beyond the threshold temperature range. Besides, the temperature checks some vaccines need to protect from humidity and heat as well. So, a mechanism is needed to handle these environmental issues.

Various problems occur because of cold chain malfunctioning. Some of them are listed below:

- Degradation of vaccine effectiveness.
- Vaccines need to be thrown away
- If a temperature mistake vaccine is administered, it won't provide effective protection and patients might need to get revaccinated.

Cold chain problems lead to the wastage of 25% of vaccines [18]. Annual loss of approx US$34.1 billion is estimated because of inappropriate cold chain management [19].

Hence, a robust system is required which monitors temperature, humidity, heat and other environmental parameters throughout the cold chain. If some problem occurs in any device/ equipment whether it's a storage or temperature recording system, transport facility issue, etc., it should be notified timely. Beside this a system is needed to maintain cold chain between the distributer- pharmacy and pharmacy- patients which is an integral part of contactless medical system.

RELATED WORK

4.1 Wind Energy

There is much advancement in the field of wind energy, yet some pitfalls do exists. There are various solutions to optimize it. One such innovative idea is being followed by 'Invenergy'. It is getting the benefit of IoT software to optimize its wind energy assets. It follows a 60-days pilot to prove two use cases. Two of the main use cases revolved around reducing lost production and reducing unscheduled downtime. The pilots aimed that operators comprising the 24/7 Invenergy Control Center uses NarrativeWave, so that automation could be achieved, thus saving time and manual labour. It also accelerated the

RTS (return-to-service time) of the wind turbines, thus reducing the downtime by almost 50% [7]. It provided a user friendly toolkit, allowing companies to enhance their productivity without the increased incurring cost. It leads companies to become self-operating,

NarrativeWave is one of the first solutions available targeted on enabling domain experts, stated Johnny Dobbins, client engineering director at the Software Experts. Our industry-leading partners are working to bridge the gap between their data and SMEs while lowering the expenses of data science and engineering to produce meaningful insights [7].

In another article the prospects of IoT has been discussed by the virtue of which we can do various tasks sitting remotely and even automate things to work on their own. This can also be very vitally used to virtually reduce the distance between a wind farm and the control centre and its attendants in order to facilitate them to adjust settings, buttons, software(s), tools or apparatus from far away [8]. IoT provides remote controlling for monitoring and regulating operations related to turbines to the wind-farm operators. Sometimes failures may also occur in remotely located systems that might lead to intermittent generation of power, eventually leading to reduced efficiency and enhanced downtime of the system and expenses. IoT can be used efficiently to use distributed systems and solve the above mentioned scenario. "The industrial Internet of Things refers to a more enhanced capacity to access data and information from connected machines, sensors, and controllers." It can gather, exchange, monitor, analyse, and act on data in order to make intelligent decisions, operate, and change with little to no human intervention" [9].

Yet there are a few left out problems like while solving the problems like reducing downtime, giving remote access, making automated systems etc. avoiding the fact that ultimately these wind farms will be left situated at some distant locations, due to which reliability of the tools and the system becomes critical. Superfluous maintenance impediments can be caused due to the delays and error in the transmission [10].

There is yet another prominent factor which should be taken into consideration for designing IoT based solutions for wind energy. This factor is the environmental inputs required for the wind turbines, which accede to the atmosphere’s usual unpredictability. This unpredictability leads to the problems in the distribution of energy, particularly when the production of the solar or the wind energy is too high or too low. If the energy produced will be too high, the excess will be wasted and if it is too low then, there will raise a need to knock off more and more power sources for fossil fuel. IoT induced techniques comes as a big relief by providing an almost ideal system which is capable of forecasting and managing systems by peeping raised or decreased energy demands [11]. It helps in storing energy when it is available in access, thus utilizing it when the generated energy is scarce. This again can be done by the aid of IoT. It is of particular use in case of distributed systems. It permits dissimilar gears and equipments to act as a single entity by letting them to communicate. Where a single and centralized energy storage system may be too expensive, an efficient, distributed system may be feasible for the same purpose [12].

An example of such a solution is a project presently running by Steffes Corporation in Hawai. This pilot project has led to the experimentation by placing IoT enabled hot water heaters in about 500 homes, which acts as a measure to store thermal energy, when the energy is found to be in excess [8]. Allowing the efficient matchup between supply when the availability is in excess and demand is scarce is observed. Another project is being carried out by Tesla Powerwall. A battery is installed that powers residences by putting it together with the solar plant. It stores the excessive energy produced by the solar plant during the daytime. The Powerwall [9], further behaves as a buffer amid the home's solar system and the power grid. As is the case of the hot water heater, the Powerwall allows the synchronization of energy demand and supply to the grid operators forming an efficient and optimized system. This leads to reduction of wastage.

4.2 Cold Chain and Remote Patient Monitoring System

In this pandemic time, monitoring of patient health critical parameters at home or in hospital is a challenging task. Various techniques are devised to realize remote patient health monitoring [26][27]. A monitoring system for discharged patients in pandemic situations is projected by Ahmad et al. [13]. They are monitoring the patient's health condition by collecting health data from patients through a survey form which they need to fill daily. Patients' with some abnormal readings are advised for physician meetings through phone or video call. In another article by Taiwo et al. [14], a smart healthcare support system is used during the quarantine period for remote patient monitoring. They have proposed a health monitoring system, through which patients can get doctors advice while staying at home. Also, an android mobile application is built for better and efficient patients-doctors communication.

Observational study on Remote Patient Monitoring for New York city is presented by Tabacof et al. [15]. An impressive model for remote patient monitoring is proposed by Naik et al. [16]. They have installed closed-circuit television (CCTV) cameras for remote monitoring of ICU, and exploited the Smartphone functionalities to keep a check on patient health conditions. They have set up a remote mobile health monitoring system, where patient health essential parameters (temperature, respiratory rate, SpO_2, ECG, blood pressure, heart rate, CO_2) are visualized over Smartphone from a remote location.

IOT SOLUTION USING SAP LEONARDO

5.1 Wind Energy

SAP Leonardo along with S/4 Digital Core resides on S/4 HANA and has strong capabilities to read real-time data from the sensors on the Wind Turbine and processing it against the concerned business application. It facilitates instant notifications and alert messages to the users on occurring of any alarming event. On occurrence of any issue, where a spare part needs to be replaced, it will automatically check for it in Warehouse Management Component of S/4 Digital Core. A Pick Transfer Order is generated if the availability is there in the warehouse, and the nearest technician is informed by raising a

work order based on the coordinates of his or her distance from the tower by tracking through GPS. Alternatively, Leonardo raises the Purchase Order in case of shortage or absence of the spare parts to the concerned vendor(s).

SAP (System Applications and Products in Data Processing) Suite is the leading ERP Platform across the industry and Leonardo gives the power of automation for IoT. A possible prototype suggesting a IOT solution for the Wind Turbine failure problem discussed. As the dashboard, created through prototyping model of SAP Leonardo suggests, the administrator can manage every minute detail related to each and every Wind Turbine through a click. Any emergency alarm can be raised and corresponding situation can be handled in a more managed, efficient and timely manner. Screenshot depicted in Figure 4 is designed using

https://standard.build.me/prototype/editors/api/public/v2/prototypes/5c0b9f7f9b3b78010c08adea/snapshots/latest/artifacts/index.html#/Page1

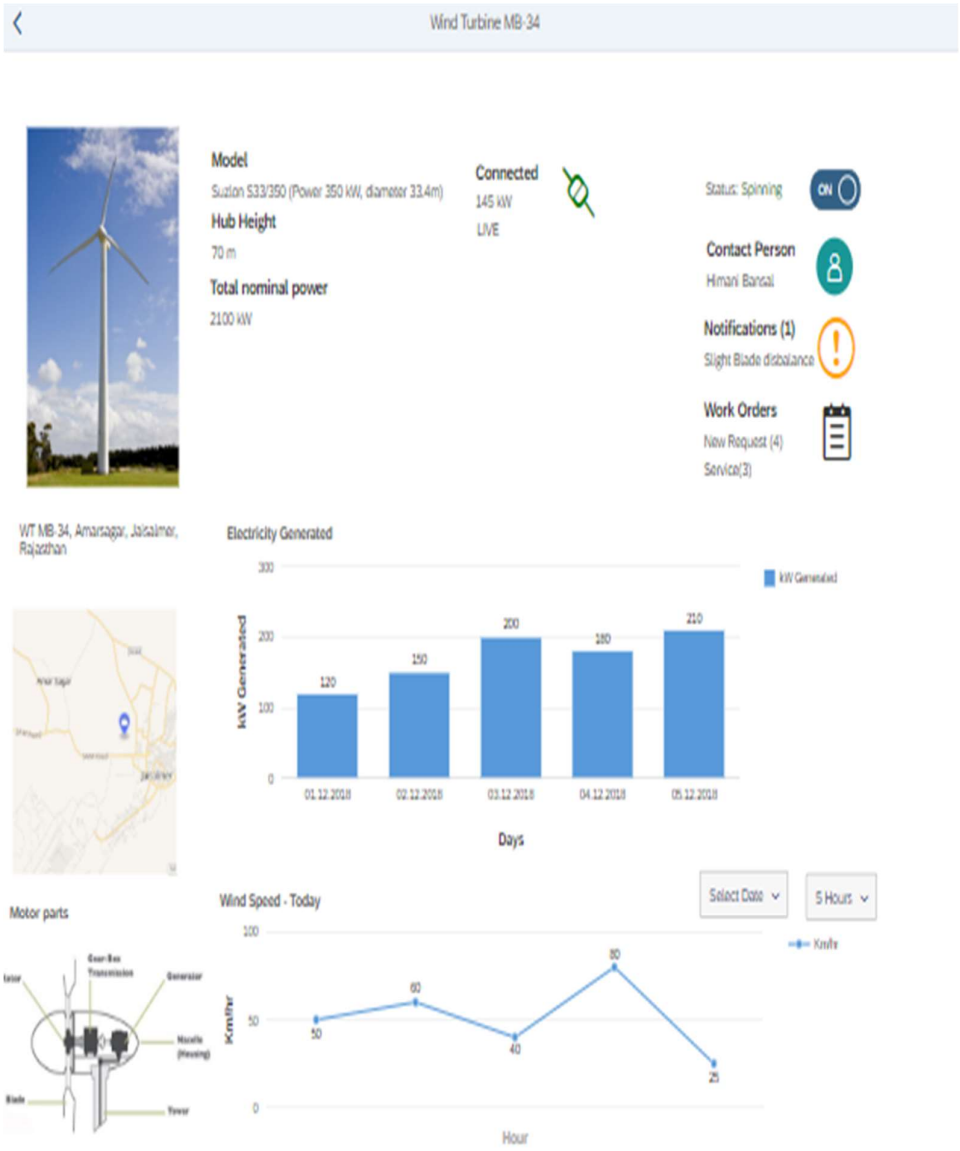

Figure 4. Proposed IOT Solution using SAP Leonardo

5.2 Cold Chain and Remote Patient Monitoring System

After analyzing the medical condition of the patient, the medical practitioner will prescribe him/ her some medication, which may involve some vaccination/ injections as well. As most of the vaccine and some medicines need to be kept at defined temperature (maintain the cold chain) and other environmental conditions such as light exposure, humidity, etc. Temperature can be controlled by use of a cold box, ice packs, use of a refrigerator, measuring temperature once or twice a day, etc. The system used for storing vaccines in good condition (temperature-controlled environment) is called the cold chain. Cold chain is an unbroken or an uninterrupted series of refrigerated production, storage and distribution activities. It is sometimes referred to as the vaccine supply chain, or the immunization supply chain.

To this end, a remote patient monitoring system with safe delivery of medicine and vaccines is proposed for contactless medication and processing of health issues during home quarantine. Besides this, said system is designed on SAP Leonardo along with S/4 Digital Core resides on S/4 HANA and has strong capabilities to read real-time data from the sensors. The system is designed in two parts (a) sensors on the vehicle and the box containing intensive medicine/ vaccine as shown in Figure 5, and (b) sensor on the patient body for continuous extraction of health data as shown in Figure 6.

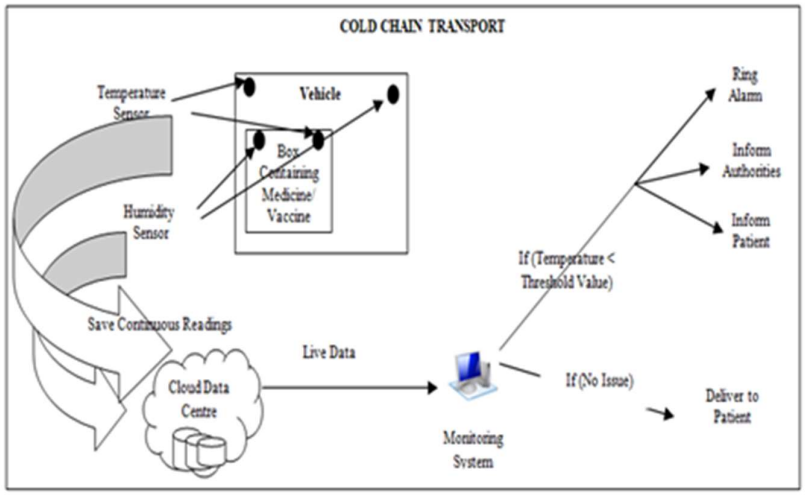

Figure 5. Continuous Extraction of Vaccination/ Medication data

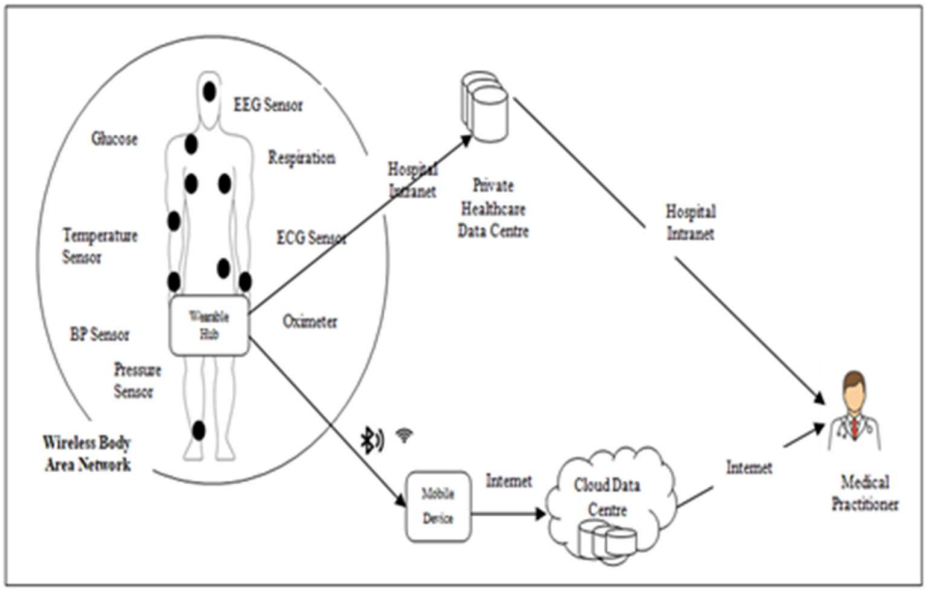

Figure 6. Continuous Extraction of health data from patient's body

It facilitates instant notifications and alert messages to the users on the occurrence of any alarming event. On occurrence of any issue, where a need to check the appliance or any sensor needs to be replaced, it will automatically check for it in Warehouse Management Component

of S/4 Digital Core. A Pick Transfer Order is generated if the availability is there in the warehouse, and the nearest technician is informed by raising a work order based on the coordinates of his or her distance from the tower by tracking through GPS. Alternatively, Leonardo raises the Purchase Order in case of shortage or absence of the spare parts to the concerned vendor(s).

Patient body is fitted with a variety of sensors and devices, creating BAN (Body Area Network), which produces continuous data. This data needs to be saved somewhere for analysis. Data produced by sensors are saved to either the hospital private data centre (if a patient is admitted at hospital) or to a third party cloud database via public ISP (internet service provider). Doctor will now access the records from a remote database and after analyzing the health condition of the patient, he will prescribe the medication. Thereafter, prescribed medication needs to be delivered to patients.

Once the medication is advised by the doctor, it needs to be safely delivered to the patient. So the pharmacy which is empanelled with the hospital will be notified to deliver medicine/ vaccine to the desired address. If the medicine/ vaccine is available in pharmacy inventory it would be delivered immediately. Else it would be ordered and would be delivered later as shown in Figure 7

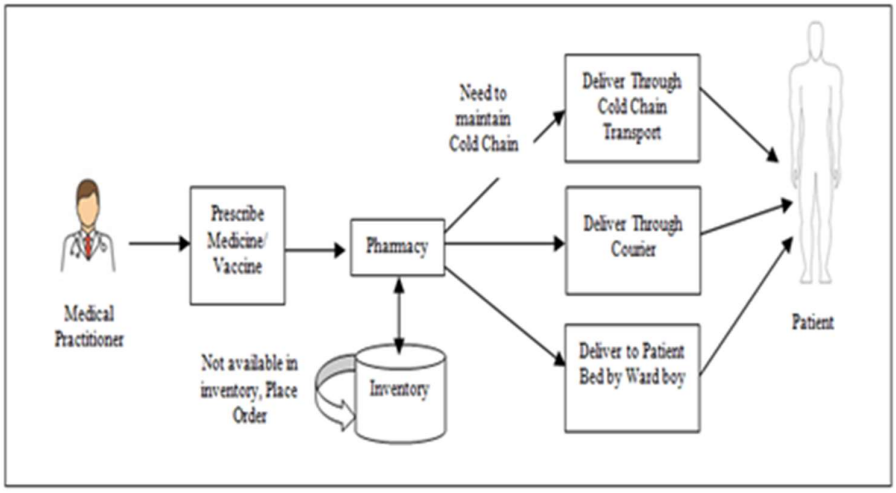

Figure 7. Delivery Monitoring System of Medication

While delivering any medicine/ vaccine if cold chain requirements arise proper mechanism should be followed for its safe delivery. As maintenance of remote patient monitoring and cold chains is difficult, here we have proposed a SAP Leonardo based system for remote patient monitoring and safe delivery of vaccines using cold chain. Proposed system for remote patient monitoring is depicted in Figure 8.

Figure 8. Proposed IoT Solution using SAP Leonardo

DISCUSSION

The Internet of Things promises a future in which every device is connected. As far as the renewable energy is concerned it states that every solar panel, wind turbine, and home meter would be connected. It will be possible to manage these remotely As a result of such a system, more precise monitoring, predictive maintenance for important equipment, resulting in reduced downtime, and more efficient energy utilisation in general would be possible.

Since, the outbreak of corona virus (COVID 19), practices such as social distancing and quarantining are need to be implemented worldwide. Due to the implementation of the above

control practices, frequent hospital visit in person are being discouraged. However, there are people who require routine monitoring of their health conditions for improved healthy living. Lot of people is on home quarantine that also requires continuous monitoring of temperature and oxygen level (SpO_2). With the recent technological advancements in the areas of Internet of Things (IoT) technology covering diverse areas like making home smart, remote patient monitoring, smart vehicles, smart city, and many more; makes the contact-based hospital visits as not a mandatory task.

SAP Leonardo provides a suite of easy implementable solutions for all such domains. The present paper discussed one such solution for Wind Turbine Management to harness Wind Energy in an uninterruptable and effective manner and a contactless solution for the cold chain problem. The authors are convinced that this technology is a boon for Energy & Environment, Health & Lifestyle industry and can eventually prove to be a boon for mankind as this is the high time that we shift to renewable energy resources for our everyday consumption and maintain a healthy sustainable lifestyle.

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