Internet of Things and its applications in E-learning

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***Abstract*- Internet of Things (IoT) refers to technological advancements in the networking with the help of which real world objects can be connected to communicate with each other over the internet. The objects that are connected are known as 'things'. This interconnection of various things over the internet with the capability of sending and receiving information has a wide number of applications in almost every field like healthcare, business, transportation, agriculture, management and education. This paper will discuss about the Internet of Things (IoT) in general, some of its applications with particular emphasis on E-learning. Finally the paper gives a model of Smart Learning using the IoT and the gamification technique of E-Learning.**

***IndexTerms*—IoT, applications of IoT, e-learning, IoT architecture, ubiquitous learning**

I. INTRODUCTION

It has been 47 years since the first message was exchanged between two distant ARPANET computers [1]. Twenty years later, Tim Berners Leeinvented something that revolutionized the world – the World Wide Web (www). At the initial stages, www was a system which was quite efficient in terms of posting of information and its retrieval. WWW was nothing more than few static web-pages which consisted of hyperlinks to some other pages and one could get the information required by browsing and moving from one page to another. With time, this scenario changed and we saw the emergence of web 2.0. Unlike in web 1.0, a user of a website could do more than just reading the information and moving from one page to another using hyperlinks. Now, a user could interact with the website and other users of the web more freely and easily. Some of the examples of web 2.0 include applications like Facebook, YouTube, and Flickr and so on. Today we are in the age of web 3.0 also known as semantic web. In web 3.0 computers can intelligently interpret the information available on the web pages and also create and distribute the information. Till now, internet was meant to connect people with each other who could interact, share information, send messages, and even hold video conferences. But with the advent of web 3.0, apart from man-to-man and man-to-machine interactions, we have machine-to-machine interactions as well. A simple example to explain machine-to-machine interaction can be a conversation between a temperature sensor and an air conditioner. Let's suppose the temperature sensor is continuously monitoring the temperature of a room and once the temperature of a room rises above certain level, it sends a signal to an air conditioner to switch on automatically (This interaction can be an indirect one, in which a central server can act as intermediate). Now, let's suppose the temperature falls to below a minimum level, again temperature sensor sends a signal to AC but this time to turn off.IoT uses a technology known as M2M. M2M stands for machine-to-machine interaction. It can be said M2M stands for a universal link between any two real world objects.

In simple terms, IoT is an interconnection of 'things' connected over internet. The thing can be any object – a mobile phone, a laptop, a bulb, a TV, an AC, a fridge or even a plant. Any object can be converted to a 'smart object' by using certain sensors and when these smart objects connect and start communicating with each other they form internet of things (IoT). Internet of things can be defined as: *The Internet of Things (IoT) is a network of intelligently connected things with embedded sensors and actuators which can be used to gather data and even share it with other things.*

Cisco has taken the concept of Internet of Things (IoT) one step ahead [2] and they call it Internet of Everything (IoE). According to Cisco, the organizations have already experienced the Internet of Things (IoT) - the networked connection of things, soon some capabilities like context-awareness, energy independence and increased processing power is added to these things then IoT becomes IoE. This paper shall discuss in brief about this concept in the later sections. Also, according to their research, 99.4 percent of physical objects which can be a part of IoE are yet to be connected.

IoT is a revolutionary concept andit finds its applications in almost every field - healthcare, business, transportation, agriculture, management and education etc. In the following sections, this paper shall discuss about the architecture of IoT, some technologies developed and used so far, its applications in E-learning and some of the issues that need to be addressed.

II. LITERATURE REVIEW

In this section some of the earlier works on the subjects are quoted. According to Cisco [6], the organizations have already experienced the Internet of Things (IoT) - the networked connection of things, soon some capabilities like context-awareness, energy independence and increased processing power is added to these things then IoT becomes IoE. Also, according to their research, 99.4 percent of physical objects which can be a part of IoE are yet to be connected. The whitepaper concludes by saying, "There is tremendous value in connecting the unconnected with intelligent networks across education. This paper demonstrates IoE's potential impact on making education more relevant, engaging and motivating learners, and enabling faster time to mastery. However, to realize the benefits from connecting people, processes, data, and things, reliable connectivity and continuous access must be guaranteed. Additionally for IoE to be accepted, both policymakers and educators must be well-prepared not only to exploit, but also to understand potential risks." According to GSMA [7], "IoT will enable life enhancing services" and in the

978-1-5090-6218-8/17/$31.00 ©2017 IEEE

same paper, regarding the role of IoT in education it they say, "In education, mobile-enabled solutions will tailor the learning process to each student's needs, improving overall proficiency levels, while linking virtual and physical classrooms to make learning more convenient and accessible." According toRu Xue et al. [8], "IOT might serve as backbone for ubiquitous learning environment, and enable smart environments to recognize and identify objects, and retrieve information from the internet to facilitate their adaptive functionality. A learner may gain the knowledge not only by connecting to the learning contents via networks by using desktop computers or wireless handheld devices such as PDAs (Personal Digital Assistant) and mobile phones, but also by communicating to the microprocessors (e.g. RFID – Radio Frequency Identification) embedded in devices." In a research by Jorge Gomez et al [9], two groups 25 students each were enrolled in a similar course. But one group was taught using traditional methods and other using interactive system of internet of things. After conducting various tests and analysis they concluded that, "InternetofObjects,appliedasatooltosupporttheteaching process, improves student academic performance."

III. Applications Of IoT

Table 1: Applications of IoT

Healthcare	Patient monitoring, Doctor tracking, Real-time patient health monitoring.
Retail & Logistic	Supply Chain Control, Intelligent Shopping Applications, Smart Product Management.
Smart Transportation	Smart transportation through real-time dynamic on-demand traffic information and shortest-time travel path optimization.
Smart Home	Energy Use, Water Use, Remote Control Applications, Intrusion Detection Systems.
Environmental Monitoring	Air Pollution, Noise Monitoring, Waterways, Industry Monitoring.
Agriculture	Green Houses, Compost, Irrigation Management, Soil Moisture Management.

IoT is a revolutionary concept andit finds its applications in almost every field - healthcare, business, transportation, agriculture, management and education etc.

Following are few applications of IoT:

- Healthcare: Patient monitoring, Doctor tracking, Personnel tracking, Real-time patient health status monitoring, Predictive expertise information to assist doctors and practitioners.
- Retail & Logistic: Supply Chain Control, Intelligent Shopping Applications, Smart Product Management, Item Tracking, Fleet Tracking.
- Smart Transportation: Smart transportation through real-time dynamic on-demand traffic information and shortest-time travel path optimization.
- Smart Home: Energy Use, Water Use, Remote Control Applications, Intrusion Detection Systems.
- Environmental Monitoring: Air Pollution, Noise Monitoring, Waterways, Industry Monitoring.
- Agriculture: Green Houses, Compost, Irrigation Management, Soil Moisture Management.

IV. Relation between IoT and E-Learning

E-learning refers to the mode of learning that takes place 'electronically' and usually involves the use of internet. E-learning makes the learning process more efficient for students as well as teachers. E-learning makes learning more interactive and hence fruitful. Until now e-learning has been limited to virtual classrooms, video lectures and animations, online tutorials and study materials. But the introduction of IoT in E-learning can really help to transform education. Following points show how IoT can transform education.

- There are certain IoT products available in the market which can have a great impact on E-Learning examples being smartboards and digital highlighters [3].Scanmarker[4] is a digital highlighter that can scan any printed text and transfer it to your device making the note-taking process incredibly fast and easy.
- RFID chips can be used to track any physical object, even plants and animals and gather the information about these objects, store it in the cloud. This information can be later analyzed to draw various conclusions. This can be very helpful to researchers.
- QR codes are becoming fairly popular nowadays. These codes can be embedded in books to access any additional resources or students can embed them in their offline work which can be linked to an online portfolio of the project. [5]
- IoT devices are the way towards creativity and for students of young age, this is an excellent opportunity for understanding, controlling and building such systems themselves.

With the rise of cloud based technologies along with data mining and big data analytics, the future of IoT seems to be promising and with it, the applications it is going to provide. Thus, the above discussed points are just some of the numerous possibilities in which IoT can benefit E-Learning, technological advancements coupled with imagination are the only limits!

V. Types Of E-Learning Techniques

E-learning is currently implemented using various techniques and technologies. Some technologies have been specifically developed for the same while others canbe used as successful E-learning tools like Games. Some Technologies used in E-learning are:

1. Communication Technologies like e-mail, SMS, social Network and forums.
2. Some special software that are developed to increase e-learning experience. For Example, a software that adds whiteboard to video conference calls, on-screen sharing etc.
3. Content Management System (CMS) and Databases are effectively used for E-learning. These are used to store course content, conduct online exams and generate test reports.
4. Online Quiz, Instructional Videos and Podcasts.

Since various e-learning techniques have been mentioned, it is worthy to note that the most effective e-learning technique is the Gamification. Gamification is different from playing Games. It is the process of applying the game-design thinking to non-gaming applications. What does that mean? It simply means that the learning process is made more interactive just like playing a game is. Next section proposes an E-Learning architecture that is based on Gamification technique and leverages the power IoT.

VI. Making Education Smart and Engaging

Before coming to the actual architecture, let's first discuss about the benefits of Gamification in E-learning.

1. Gamification can impart high levels of engagement. The learners experience the fun during game while learning. This leads to increase recall and retention. Hence, provides a better learning experience.
2. Gamification provides a better learning environment. It can be used to provide a safe alternatives to real life situations facilitating a better knowledge retention.
3. The learners get to know about their weaknesses instantly. This helps them to work on them, hence increasing the engagement.
4. While playing games, we receive virtual benefits in form of points, leaderboard listings, etc. These work as motivating factors to play the game more and more. Gamification can do the same to learning. It makes learning more and more addictive!

Using the Internet of Things (IoT) concepts in E-learning and applying Gamification concepts will make the education smart, available and engaging.

Zhu et al. [11] have included a research framework for smart education. According to this framework, smart education has three important elements: Smart Learning Environments, Smart Pedagogies and Smart Learners.

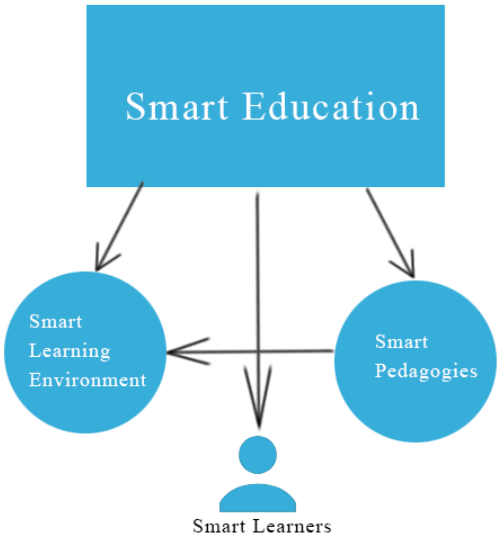

Figure 1: Smart Education Framework

Smart Learning Environments: Smart Learning Environment unlike the conventional learning environment provides the learners access to resources and learning systems in a ubiquitous manner i.e., learning can be done at any time and at any place. Such environments even provide tools to analyze the best place and the best time for the learner to study. Smart Learning Environment is more effective and 'engaging'.

Various hardware and software technologies can be used for the implementation of such learning environments. An interactive whiteboard, a tablet, mobile phone, smart classroom objects like smart table, an e-bag etc. are some of the examples for the hardware category. Software components can include learning systems and tools, online resources, messaging, social network and blog resources, analytical and virtualization tools.

Smart Pedagogies: The conventional methods of pedagogy are not valid in this era. With the incorporation of IoT in the Education, pedagogical issues are obvious to rise. This makes the educators and the researchers work on development of new methods of pedagogy that help learners gain knowledge more effectively and efficiently.

According to Chatti, et al. [12], "The knowledge-pull approach to learning is based on providing learners with access to a plethora of tacit/explicit knowledge nodes and handing over control to them to select and aggregate the nodes in the way they deem fit, to enrich their personal knowledge networks".

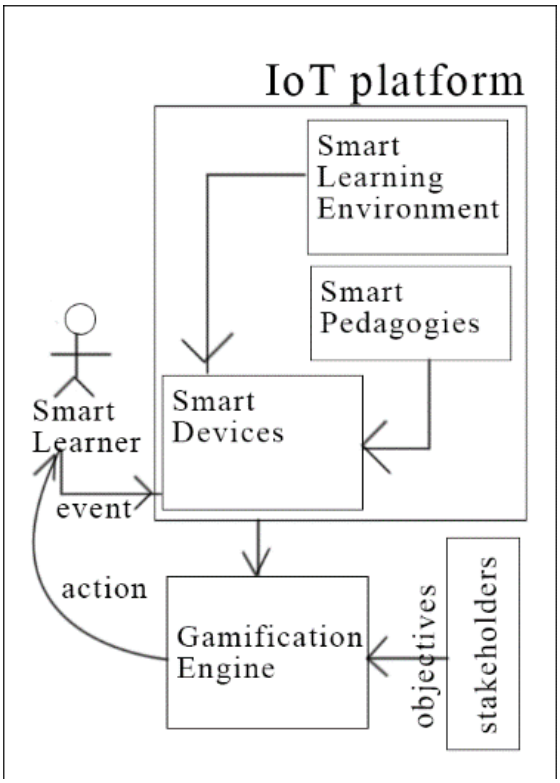

Figure 2: Model For Smart Education using Gamification

As the framework for the smart education has been already discussed, now we shall proceed to propose a model which will make learning more engaging by incorporating the Gamification technique. The model is depicted in the *Figure 2* above. This model consists of following elements:

- Smart Learners
- Smart Devices
- Smart Learning Environment
- Smart Pedagogies
- Gamification Engine
- Stakeholders

Smart Learners: Smart Learners are would be the end users of this system. They would be 'smart' because they will choose a system of learning that is totally different from a conventional one! The learners will interact with the system using smart devices.

Smart Devices: These will be the connected 'things' that would be able to respond to the user events. These things can be devices like smartphone, computer or a tablet. To make it simple, any object that belongs to the learner and is connected to the system is a smart device. It can be a smart pen or a smart bag!

Smart Learning Environments and Smart Pedagogies: Smart Learning Environments and the Smart Pedagogies have been already discussed in the section VI of this paper.

Gamification Engine: A Gamification engine is in itself a complex concept but is shown as a single block in *Figure 3*to keep the things simple. Gamification engine is a subsystem that is responsible for the gamification of the contents and making the learning experience more engaging effective. Some common gamification approaches are:

Level Based Gamification: Learners are required to complete various levels in stipulated time.

Avatar Based Gamification: This approach is characterized by creation of various learning paths, mix of questions in each path and non-availability of learning aids to make challenges tougher.

Task Allocation: A learner is given some interesting tasks to complete which make the learning a fun experience.

Reward Based: This is based on Avatar Based approach but a learner is given some benefits in the form of points or leaderboard listings which act as motivation to stay engaged and learn more.

Stake Holders: Stake holders refers to the individuals or the organization that controls the learning process. They set the objectives which lead to targeted actions. Examples of stake holders are the school management or teachers in the learner is a student of school. Stake holders can be organization heads, managers in case of learners being employees of organization and so on.

VII. Conclusion

Internet of Things (IoT) is going to expand at a very rapid rate and with it there are going to be huge advancements in every field. In the field of education, IoT will take E-learning to a next level. We can leverage the power of IoT to implement smart learning environment that facilitates better learning and greater retention rates. This advancement in education will help to produce better individuals in terms of skills and knowledge.

This paper explains the need and significance of IoT, its applications with specific focus on E-learning. The paper has also presented Gamification as one of the effective e-learning technique. Finally an education model which is both smart and engaging has been proposed.

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