Envisioning Internet of Things in Indian Context

Design Research Seminar | Report

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Approval Sheet

The research seminar titled '**Internet of Things in Indian Context**' by Kaustubh Limaye, is approved for partial fulfilment of the requirement for the degree of 'Master of Design' in Interaction Design.

Guide

Co-Guide

Date

Abstract

Currently we use internet for various purposes through computers and mobile phones. The next step for internet is digitally connecting our daily things to each other and to us. This trend is called as Internet of Things. It emerged as a creative application of RFID technology.

The aim of this project is to carry out a preliminary research study for identifying potential of IoT in India. As IoT products originated in west, their development is based on underlying assumptions which may not be valid in Indian context. As a part of this project, we studied the current state of IoT field and conceptualised IoT applications specific to India. We used these concepts as an ice breaker to have conversation with users in order to understand their concerns and inclinations. Finally, it helped us in coming up directions for further research and refining designed concepts.

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1 Introduction

Bill Verplank, who coined the term “Interaction Design”, once said in his interview that the day is not far when everything, we interact with, will have computer inside it or on it. Well, that day is not far. The trend of Internet of Things (IoT) is spreading rapidly and many IoT products are hitting the market. IoT is a futuristic vision of internet in which our daily things along with computers and mobiles will have capacity to connect to internet. This will result into enhancing overall intelligence of devices and allow them to work collaboratively.

However, in India, the internet and mobile computing technologies are still in the process of penetrating the masses, the IoT products are yet receive popularity. The current IoT products are driven by the assumptions, made in western context, which may not be valid in Indian scenario. Hence, there is need to take a step back and recheck the applicability of underlying assumptions.

The aim of this project was to understand the cultural issues related to implementation of IoT in India and to come up with directions for designing IoT products. Finally, using these direction we conceptualised few IoT products and evaluated their validity by taking user feedback.

The report is majorly divided into two sections. The first section showcases our literature study and review of existing products performed together along with colleague - Sanket Kulkarni. In this section we compile together - definitions, characteristics, visions, challenges of IoT in the current scenario in the field. Moreover, in this section, we propose new dimensions for categorising IoT applications. Also, we perform a review of existing IoT products in the market and map them to the newly proposed categorisation model. The second section describes the IoT concepts produced single handedly and user feedbacks on them. Finally, report gives specifying design directions and future scope of research work.

2 Research Process

As IoT field has undergone huge developments from research as well as commercial products perspective in last two decades, it was necessary to assess the current state of IoT field. The secondary research involved reading papers, articles, and case studies in order to identifying common trends.

In typical design project process, user studies are conducted before generating concepts. The needs gaps found in user studies are tried to solve in the phase of ideation. In such projects, researchers generally have vague idea about the problem area. However, in this project, problem area is not fixed. The main focus of conducting user studies is to surface concerns related to the usage of IoT for solving the problems faced by them in the context. Secondly, user studies aimed at surfacing other problems where users find usage of IoT relevant. Hence, in our opinion, it was not important exactly which problem is tackled. Moreover, understanding and responding to IoT scenario without any concrete examples or case studies, would be difficult for users.

The researchers, who were already familiar with Indian context, were having broad awareness about the problems faced by target users. Hence, based on knowledge of already known problems in chosen application domain, many concepts were generated first. These concept were used for initiating conversation with users in order to get concrete feedback from them. Using participatory design methods, we conducted co-creation sessions with users to solve context specific problems using IoT approach.

3 Literature Review

3.1 Definitions of IoT

It is hard to say whether a product comes under IoT vision or is just a smarter product. The concept of IoT is often misunderstood as its definition is continuously evolving. Decade ago, its definition considered only use of RFID tags. Now it is broader and points to intelligent and collaborative use of things.

These are some definitions of IoT, given by research communities working in this area:

Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts - European Commission [6]

A world where things can automatically communicate to computers and each other providing services to the benefit of the human kind - CASAGRAS consortium, [6]

Natural enabling architecture for the deployment of independent federated services and applications, characterized by a high degree of autonomous data capture, event transfer, network connectivity and interoperability. - Luigi Atzori et al, 2010, [6]

From anytime, anyplace connectivity for anyone, we will now have connectivity for anything - ITU [6]

3 Literature Review

3.2 Essential Characteristics of IoT

The modern definition of Internet of Things is supported by three characteristics.

Computing, Communication and Identification

It refers to technological ability of IoT products to communicate and identify each other and each other's capabilities.

Distributed Systems

IoT products should be able to work in heterogeneous environment in discrete and distributed manner.

Distributed Intelligence

It states the ability of IoT products to take semantically viable and collectively intelligent decisions in order to achieve a particular goal.

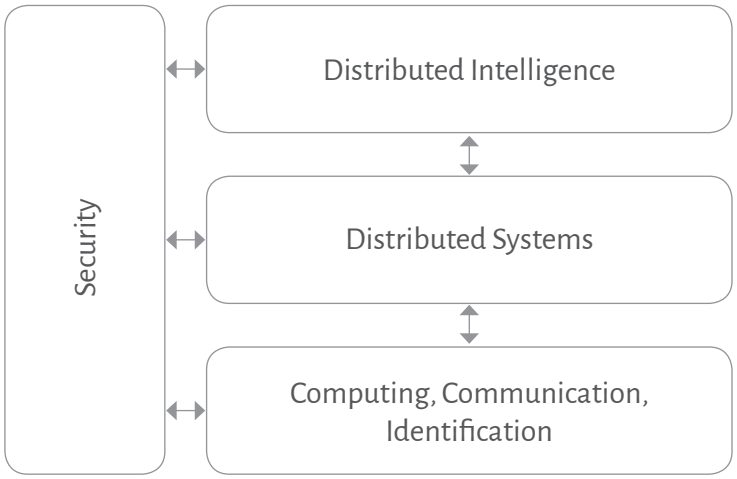


Figure: Taxonomy of Research Areas relevant to IoT [5]

3 Literature Review

3.3 Architecture

Amongst different researched architectures [1, 4], Service Oriented Architecture (SOA) is widely used architecture while implementing IoT systems [6, 11]. Conceptually, SOA is divided into five layers.

Objects Layer

At this layer, objects represent different devices and sensor networks. This layer presents objects at ground level. Objects sense data and perform activities using actuators. Objects using non-compatible technologies can exist together at this layer thereby enabling heterogeneous environment.

Object Abstraction Layer

At this layer, heterogeneity of objects is encapsulated. Objects can be accessed using a common language and procedures.

Service Management Layer

At this layer, one or more functionalities provided by individual objects are combined and offered as services. A service catalogue or repository is maintained at this layer in order to list objects and services provided by them.

Service Composition Layer

At this layer, only visible resources are services not objects. Multiple unit services can be combined into complex services and workflows. Additionally, this layer keeps catalogue of services which are currently available.

Application Layer

At this layer, application utilise exposed services and workflows to perform context specific activities.

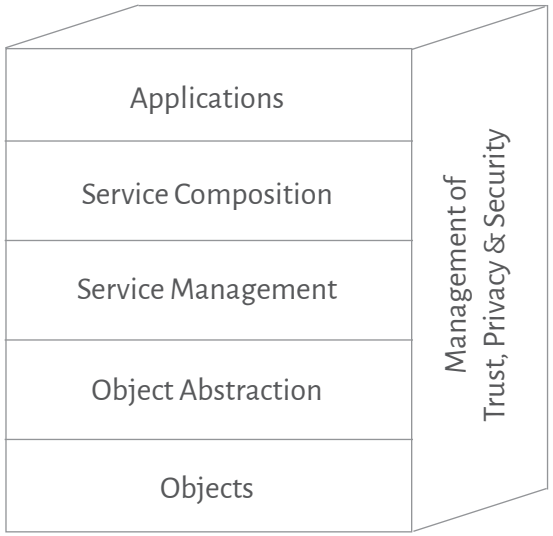


Figure: SOA-based architecture for the IoT middleware, [6]

3 Literature Review

3.4 Visions

Researchers from various domains have approached internet of things with different perspectives. The three essential visions , suggested by Luigi Atzori et al [6], which must be studied include thing oriented vision, internet oriented vision and semantic oriented vision.

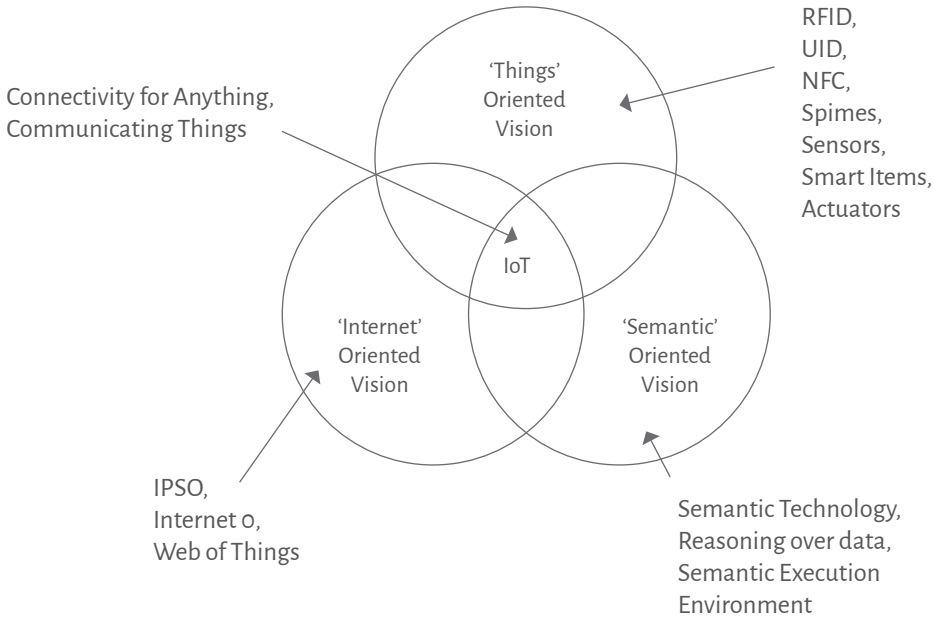


Figure: Visions of IoT [6]

3 Literature Review

3.5 Thing Oriented Vision

As its name suggests, thing oriented vision focuses on enhancing the intelligence of things. It emphasizes on creating and enhancing technologies and strategies in order to make things capable of handling IoT scenario. It means building things which are context aware and can work collaboratively with other things.

The RFID technology brought the preliminary invention in context awareness technology [2]. Consequently, thing based vision of IoT has come from the RFID research community. The term "Internet of Things" was coined by Kevin Ashton while explaining application of RIFD tags for supply chain management [2].The initial applications of RFID tags were implemented in smaller environments and offered narrow range of functionalities, wherein things were connected through intranet. Applying RFID technology in bigger environments and broader contexts like supply chain management and university campuses [3], researchers realized the need of connecting RFID tagged things through internet. Need of connecting things through internet, raised the issues of assigning unique identification. The EPC (Electronic Product Code) standard was introduced to give unique identification to each RFID tag across world which is now followed by almost all RFID manufacturers[5]. However, in a heterogeneous scenario wherein things and sensors, which do not use RFID technology (do not use EPC standard), want to be part of network, the issues of standardisation of communication, addressing and identification mechanisms became more complex. Additionally, even though EPC framework considers future scalability of RFID technology, it is not capable of handling billions of non-RFID things and sensor networks which will be connected through internet in the future.

Hence, even though Thing oriented vision started to with application of RFID tags, it now has to consider the broader issues of standardisation of heterogeneous IoT environment.

An extensive thing oriented vision pictures a scenario in which anything can be tracked though space and time throughout its lifetime (concept of "Spime"). Anything will be able connect to anything through wireless technologies. They will have enough memory and processing capabilities for temporary storage of the sensed data, authentication and collaborative decision making.

3 Literature Review

3.5.1 Key enabling technologies

RFID

Radio Frequency Identifier is a circuit in which electricity gets induced due to radio waves, propagated by RFID readers. Upon electricity induction, RFID uses same energy to respond back to reader by emitting a radio wave encoded with its identifier. RFID tags can be active or passive. Active RFID tags are powered by a battery. Passive RFID tags are powered through radio waves sent by RFID reader.

WSN

Wireless sensor networks are circuits which transmit data collected by sensors through wireless communication like Bluetooth and Wi-Fi [6]. In WSN, there can be multiple discretely located sensors. In such scenario, data is collected at central nodes which have storage capability, called as sinks. Each discretely located sensor in WSN is powered by a separate battery. The range of data transmission of WSN depends on the technology used by it. Generally, WSNs use Wi-Fi and hence can transmit data over long distance.

RSN

RFID Sensor networks are WSNs which are powered by RFID technology [6]. RSNs harvest power from the radio waves emitted by RFID reader and use this power not only to sense data as well as to transmit it back to reader. The research in the area of RSN is still in its infancy.

	Processing	Sensing	Power	Range
RFID	No	No	Harvested	10 m
WSN	Yes	Yes	Battery	100 m
RSN	Yes	Yes	Harvested	3 m

Figure: Comparison between RFID, WSN and RSN , [6]

3 Literature Review

3.5.2 Challenges

Authentication Challenges

Currently existing security provisions use encryption algorithms to authenticate devices. In order to implement these algorithms, device needs high processing power. IoT devices are low energy devices with limited processing power. Device may not have enough processing capacity to run encryption and decryption algorithms to provide advanced security.

Data Integrity Challenges [6]

The passwords used by IoT devices to protect data are short in size (due to their limited processing ability). This poses a high security threat on the integrity of data transmitted by IoT devices.

3 Literature Review

3.6 Internet Oriented Vision

Internet based vision focuses on communication issues of connecting all things using IP address. Currently most widely used transport layer protocols like TCP are not capable of handling the tremendous amount of traffic that will be generated in futuristic IoT scenario. The length of IP address is not capable of giving unique identifier to everything in the future. Considering the billions of things which will be connected to internet, there is need to redesign the internet architecture and protocols so that new architecture will not only be capable of handling network traffic but also be supportive to exiting systems.

Internet Protocol for Smart Objects (IPSO) is an alliance of more than 500 tech companies working on restructuring and standardisation of IP address and protocols. IPSO plans to use light weight IP stack protocol in the view of 6LoWPAN (IPv6 over low power wireless Personal Area Networks). This assures capability of IP to handle huge number of communicating devices over internet [6].

Also, Web of Things is a standard being developed. It allows embedded devices to provide their services on websites. [9]

3 Literature Review

3.6.1 Challenges

Security Challenges

Security for IoT is a major challenge. In a heterogeneous scenario, it becomes difficult to decide roles of devices in terms of security as devices work at different levels of IoT architecture. Additionally, resource constrained IoT devices are not capable of implementing advanced security mechanisms.

Standardisation Challenges

Many research communities have taken efforts in establishing standards for IoT. Some of these standards like EPC and IP are followed world-wide. However, there is no comprehensive framework which supports heterogeneous devices. Hence, there is need to design all-inclusive standardisation framework. An ideal standardisation framework should fulfil following needs:

. Scalable in terms of number of devices which can be connected and identified. [1]

. Supports interoperability. It means framework should enable devices implemented using heterogeneous communication technologies to work together. [1]

. Support simultaneous mobility of sensors and things [6]. · Support multiple device discovery algorithms [1]

Addressing and Networking Challenges

The prime challenge related to addressing and networking is inability of current protocols to handle IoT scenario [6]. Current protocols needs to redesigned in order to handle

. The huge amount of traffic that will be generated in IoT scenario

· Transport of high amount of data that will be generated in IoT scenario [9]

· Better Fault tolerance [9]

· Better Quality of Service support [6]

3 Literature Review

3.7 Semantic Oriented Vision

Semantic Oriented Vision asks for meaningful reasoning over collected data and analysis. Even though IoT systems will be able to capture all types of micro data and work collaboratively, IoT systems should be able to take decisions and provide insights which are relevant and meaningful in the working context.

Aspects of IoT related to how to represent, prioritise, order and organize the information comes under semantic vision.

3.7.1 Challenges

Privacy Challenges [5, 6]
IoT devices capture lot of person's private information. There is chance that person is not aware about what information is being collected about him/her and how it is being used. Hence, the distribution of generated information needs to be controlled.

Digital Forgetting [6]
The information collected about person should be deleted after it is used. Retaining information without reason and consent is not ethical.

Political Challenges
The management and use of data generated by IoT devices raises many political concerns. Some of these concerns are:

There still exists lot of confusion regarding the ownership of data generated by IoT. Data of substantial commercial or social value can be used without owner's consent. IoT will also generate lot of public data, then it becomes a concern who is entitled to use such data and for what purpose. It is still not clear that who will govern IoT systems. What is the role of government in controlling unethical use of IoT? Hence, there is need of a strong and effective ethical and legal framework to handle such issues.

Social Challenges
It is certain that IoT will facilitate our lives and will make it more comfortable. However, this is only one side of coin. The other side includes the negative impacts or side-effects of IoT on our lives.

With so many smart devices around us, the real freedom and privacy that we will have in the future is questionable. IoT things may not operate as we would desire. They will choose what is best for us by analysing our behavioural patterns.

In this regard, interaction designers has a big role to play. They need identify the boundary for IoT systems to limit their interference in our social lives.

In this project, we wish to focus on exploring semantics aspects and constraints in the Indian context for IoT applications.

3 Literature Review

3.8 Categorisation of Application Domains

In the field of Internet of Things, researchers have mentioned many application areas [3, 5, 6]. Most of them have tried to categorise based on the type of domain. However, these categorisation are not able to define clear boundaries. Many IoT applications fall into multiple categorisations. As IoT systems are expected to work across multiple domains, one needs to understand that there are many other dimensions involved while designing IoT system. Finding generic categorisation dimensions can help researchers and products makers in taking an informed decision while choosing an application domain.

We tried to gather list of application areas. Using affinity mapping and bottom-up approach we came up with three dimensions of IoT categorisation that are ownership, geography and domains.

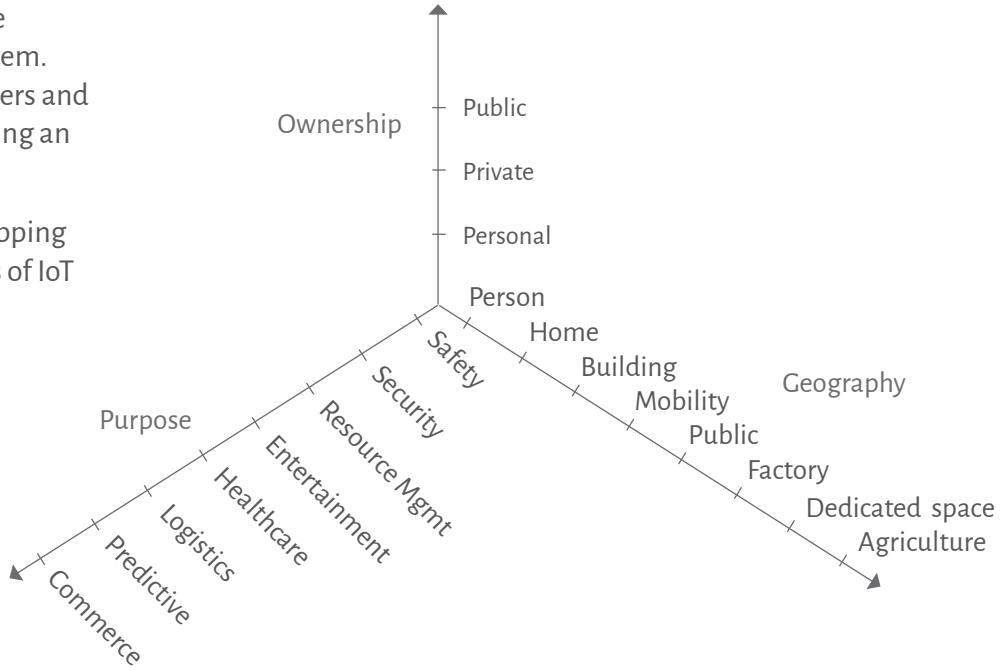


Figure: Dimensions of Categorisation

3 Literature Review

3.8.1 Proposed Dimensions

Ownership

In ownership dimension, we define three levels that are personal, private and public. As its name suggests, products under personal dimension will be owned by a single individual. He/ she might not like to share with anyone. Products under private categorisation are owned by group of people. Applications designed for home or private organization will be considered under this level. Products under personal and private level need to provide means of identification as well as authentication. Products at public level are accessible by everyone. Generally, such products will be government owned e.g. IoT applications in city bus. Products at private and public level have to consider multi- user scenario while designing.

Geography

This dimension deals with scope of IoT products in terms of geographical area. Levels in this dimension start from a person level, home level till the city level. These geographical levels actually represent the nested threshold spaces for human. Our concerns and perspectives in different thresholds are different. To illustrate, we praise our city while debating with a person from other city. However, both of us will praise our state while debating against person from another state. Various IoT applications are designed to cater different geographies or in other words different threshold spaces.

Purpose

These are different application specific contexts like healthcare, security and entertainment. To illustrate, a healthcare application can be designed for different ownership and geographical dimensions. Another example, a healthcare IoT application with private ownership in a factory has to be designed differently than a healthcare IoT application for family (private) inside home.

3 Literature Review

3.8.2 Categorisation Map

	Person	Home	Building	Mobility	Public Space	Office/Business	Factory	Dedicated Environment	Agriculture
Safety	• Disaster Management	• Disaster Management • Environmental Monitoring	• Disaster Management • Environmental Monitoring	• Disaster Management • Environmental Monitoring	• Disaster Management • Environmental Monitoring	• Disaster Management • Environmental Monitoring • Employee Safety	• Disaster Management • Environmental Monitoring • Employee Safety	• Disaster Management • Environmental Monitoring • Surveillence	• Disaster Management • Environmental Monitoring • Surveillence
Security	• Losses and Thefts	• Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Hospital Patient Survaillence • Losses and Thefts • Perimeter access control	• Survaillence • Losses and Thefts • Perimeter access control
Resource Management	• Personal Trends • Historial Queries • Search Engine for Things	• Light & Temperature Control • Resedential E-Meters • Enhanced Game Room • Augmented Maps • Search Engine for Things	• Light & Temperature Control	• Light & Temperature Control • Smart Parking • Traffic Control • Assisted Driving • Robot Taxi	• Light & Temperature Control • Smart roads • Noise urban Maps • Electromagnetic Field levels • Waste Management • Smart Steet Lights • Potable water monitoring • Air Pollution • Earth Quake early detection • Chemical leakage detection in rivers • Meterological Applications • City Information Model • Augmented Maps • Search Engine for Things	• Light & Temperature Control • Smart Marketting • Flow Optimization • Real Time Inventory • Asset Tracking • Search Engine for Things	• Light & Temperature Control • Tank level monitoring • Silos stock calculation • Industrial Control • Augmented Maps • Search Engine for Things	• Light & Temperature Control • Smart Museum • Search Engine for Things	• Light & Temperature Control • Wine Quality Control • Green Houses • Meterological Applications • Smart Compost
Entertainment	• Infotainment • Social Applications	• Infotainment	• Infotainment	• Infotainment	• Infotainment	• Infotainment	• Infotainment	• Infotainment	
HealthCare	• Drug Tracking • Elderly Fall Detection	• Ambient Assisted living						• Ambient Assisted living • Hospital Medical Fridges	
Logistics			• Fleet monitoring • Item Monitoring • Ambulance Telemetry • Drug Tracking			• Supply Chain Control	• Supply Chain Control • Smart Product Management	• Hospital Asset Tracking	• Supply Chain Control
Predictive Maintenance		• Repairing & Maintenance	• Repairing & MaintenanceW		• Repairing & Maintenance • Meterological Applications	• Repairing & Maintenance	• Repairing & Maintenance	• Repairing & Maintenance	

3 Literature Review

3.9 Existing Products Review

We choose 36 products to review from wide range of available products. Products were chosen based on their popularity and variety in terms of application areas and strategies.

The review of products was done which includes critical analysis of product's functionalities, interaction design strategies and user interface against Indian context. Findings from first part gave us overall insights about conflicting assumption.

3.9.1 List of Reviewed Products

Tennis Racquet
Sense
Smart Car
Dog collar
Toothbrush
Baby Onesie
Beddit
Oven
LG HomeChat system
Mobiplug
AllJoyn
SmartThings
Electric Imp
FitBit
EVRYTHNG
Belkin Wemo
Securifi Almond+
IFTTT
MagicCast
Freescale
Broadcom's WICED™ Sense Kit
UP
Nike+ FuelBand SE
Nest
Lab of Things
Wulian Smart Home-wireless LED Dimmer
IoT Monitor
Cooey
Spark Core
IOT Series
Netatmo June
Misfit Shine Activity Tracker
The Health Patch
Sensoria
Smart wear
Philips Hue

3 Literature Review

3.9.2 Conflicting Assumptions

Most of the products are personal products and assume that it will only be used by same user. However, in Indian scenario, where sharing is inherent part of tradition, sharing of IoT products in multi-user scenario need to be addressed.

Most of the products showcase the analysis of data using different types of graphs. However, it is uncertain in India whether users, who are illiterate or semi-literate, will be able to understand them and draw some meaningful insights.

Almost all products assume, there is availability of smartphones, wi-fi router and high speed internet which may not valid in India. While designing IoT products for India, it is necessary to consider resource-constrained environments.

In India, people are more concerned about the return value while investing into anything. Almost all products are very costly and address problems which one may not find important. Hence, it is uncertain that people will buy products whose return gains are not significant.

It is wrong to assume that people will buy new IoT products to replace existing products. For India, to create low-cost products, one strategy could be to create add on products which convert existing products into IoT products.

4 Scoping Down

4.1 Application Domain

After studying existing application domains through different dimensions, it was decided to work on the Internet of Things applications for Indian Schools. It was decided to not limit the application purpose to a specific one in Indian Schools, as it would help to discover concerns and priorities of users in the school. It was decided to consider the ownership of the IoT products as private, which means, the products are owned by the school and collectively used by the users.

4.2 Target Users

For the selected domain, Indian schools, the target users were teachers and the administrative staff working in schools, that were well acquainted with the use of smartphones. Focus was more on the teachers.

The teachers have a lot of responsibilities which range from enabling learning to administrative tasks like attendance management, crowd management, ensuring discipline and so on. As they are overloaded with a lot of tasks that are carried out in parallel, ideating for such an user helps in uncovering the concerns and priorities in the Indian school context, well.

5 User Studies

5.1 Methodology

Concepts were generated for use of IoT in Indian schools based on prior insights about the context, which was the Indian Schools. These concepts were used as an icebreaker for the conversing with the users to achieve a greater goal, which was to determine user concerns and priorities in their environment. Also, feedbacks for each concept was recorded. Additionally, users were triggered to brainstorm more ideas / areas of IoT applications in school context related to each researcher generated concept. Thus, users participated in a co-creation activity. After the co-creation activity, users were made to perform a card sorting act with the ideas on the table to gain insights related to a system design. Later, users were asked to rank all the concepts/ideas on the table.

5.2 Goals

· To generate ideas in the context of Indian Schools.

· To evaluate generated ideas in terms of desirability.

· To determine the concerns of users in their environment.

· To co-create new ideas/areas of IoT application.

· To determine the connection within ideas seen by users for a systemic design.

5.3 Plan

1. Give a feeling of ownership of project to the user
2. Explain individual idea
3. Take qualitative feedback
4. Contextualise on the problem to surface their concern with respect to the idea
5. Co-create one or more ideas/areas of IOT application
6. Repeat step 2 to step 5 until all ideas are done.
7. Write down old and new ideas on chits
8. Let user sort the ideas to see connections within ideas
9. Let user rank all the ideas

5 User Studies

5.4 Overview

Many ideas were generated that demonstrated use of Internet of Things in the various activities of the school. These ideas were taken to the users where they expressed their thoughts about the idea as well as helped in brainstorming more ideas and application areas. Also, the users ranked all the ideas on the table and card-sorted the ideas. In all five users were interviewed at the Kendriya Vidyalaya school at inside the IIT Bombay campus. The users were all teachers in the school ranging from primary to junior college teachers.

In total there were six concepts that were taken to the users. Following section explains each concept that was taken to the user with the help of the targetted problem and the proposed solution. Along with it, the feedback of each idea and co-created ideas are also put together.

5 User Studies

Student Logistics

Problem

Parents and teacher worry about kids whereabouts when away from home/school.

Solution

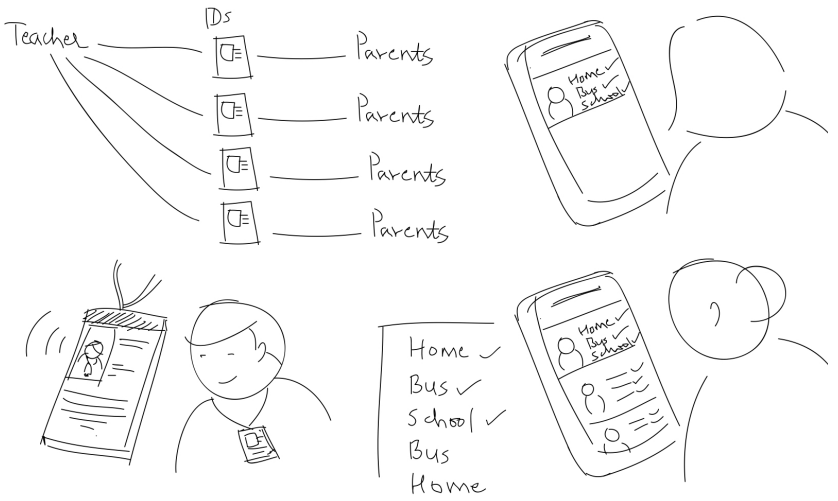
This concept involves the use of a smart ID card which is carried by the kid at all times. Trackers are placed at strategic locations like at the door step of kid's home, door frame of the school bus, at the main gate of the school campus and so on. Trackers are connected to the internet which update information abou the latest location of the particular smart ID. A mobile application connected to the internet helps in finding out the current status or the latest tracked location of the smart ID, which in turn informs the user, that is, the teacher or the parent about the whereabouts of the kid. Based on the type of user, mobile application displays information of one or multiple kids.

Feedback

Users were happy about the effort that could be reduced if the idea was implemented. Users raised concerns about the smart ID becoming more valuable than the kid. Also, users mentioned that school would repel from the idea if the smart ID was costly. Moreover, users suggested using webcam along with this idea in school to track kids. One of the user suggested to have a Smart ID irrespective of the school that could be owned by the kid for the whole of his/her schooling period.

Co-created Ideas

Users suggested use of this idea for attendance taking which is a time consuming task every period. Also, use of this idea for solving the bunking problem prevalent in many schools.



5 User Studies

Picnic Management - Kid Radar

Problem

Teacher finds it stressful to manage kids when taken on a picnic.

Solution

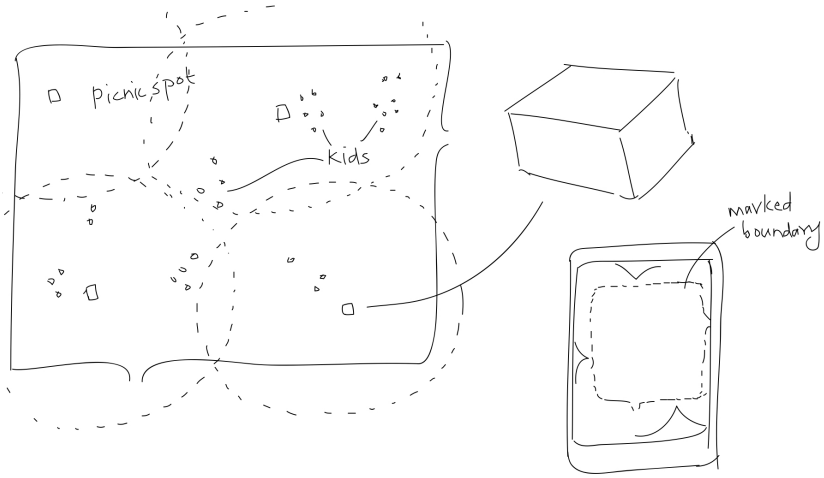
This concept involves use of a mobile deployable device that helps in sensing the presence of certain smart things in a particular radius. The device being connected to the internet can be accessed using a mobile application to know the movement of smart things in the radius. Multiple such devices can be deployed to cover a larger area. The smart things that are sensed by the device are carried by the kid at all times. Various number of things could be given smartness that a kid carries while on a picnic, like shoes, uniform, identity card, belt, and so on.

Feedback

Almost all users liked this idea as it could reduce management effort during outtings. They mentioned about the frequent outtings of the school. They suggested use of alternate smart tags that would be detected by the mobile deployable device like shoes, uniform, belt, socks and so on. Users expressed their concerns about the reliability on technology for safety and security of the children. They felt it would not really make them stress free.

Co-created Ideas

Users suggested use of this inside school premises to track child location. Also combining the previous idea with this idea, user suggested to help in the bunking issue.



5 User Studies

Chalk Duster Resource Management

Problem
Time is wasted in getting chalk/duster in place after a period begins.

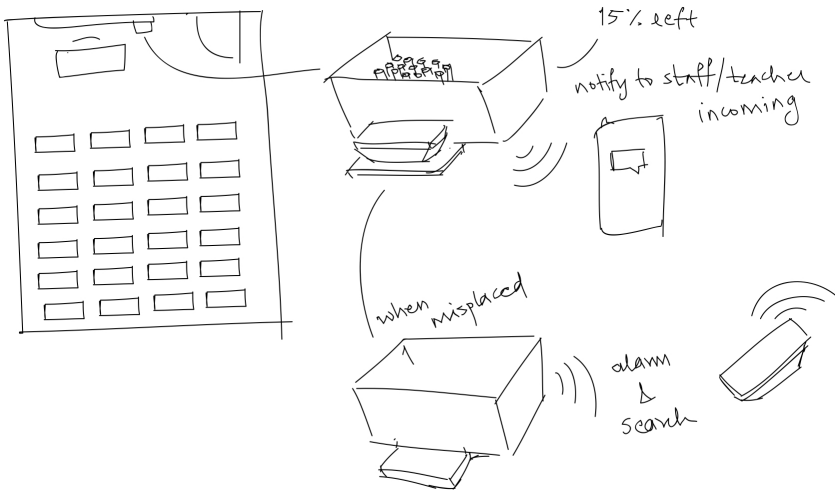
Solution
This concept has two parts - managing chalks and managing the duster. For managing the chalks, the chalk box is made smarter. The chalk box can sense and notify if the number of chalks in the box have gone below a preset threshold. Notification is sent to the school staff or the teacher, who refills the chalks before the next period begins. This saves time for the teacher. For managing the duster, the duster is equipped with a receiver and a speaker which can be remotely triggered to ring through a control on the chalk box. The duster when misplaced in the classroom can be located based on the triggered sound.

Feedback

The users did not like the idea much as they felt it was over use of technology for not so critical activity. More than the chalk idea, they liked the duster idea. Also, they mentioned using markers and white board, which meant doing away with chalks at all.

Co-created Ideas

Users suggested to use this idea for more critical and meaningful activities like notebook/workbook tracking, as they are often misplaced in the school premises. Also they suggested the duster idea could be used for library book management. Another premise is the exam department in school which finds it difficult to keep track of the number of answer sheets issued as students are found cheating with old stored answer sheets. Also, users suggested to use this idea in the laboratory to safeguard the equipments and chemicals.



5 User Studies

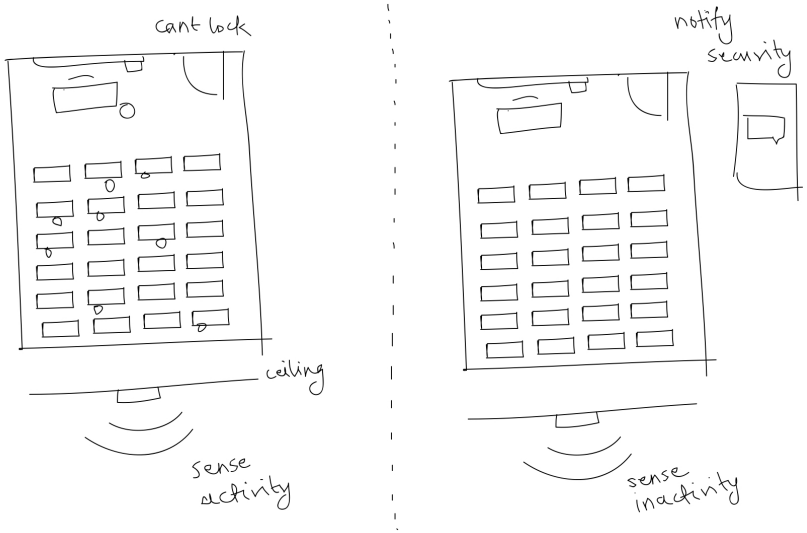
Smart Door

Problem
Teacher/Students get locked in room as a prank/by mistake.

Solution
The classroom is equipped with an activity sensor and a remote locking mechanism on the door. The activity sensor collaborating with the locking mechanism makes the door smarter. The door is coded to not get locked when there is any activity sensed in the room. Similarly, when the sensor senses no activity in the classroom for a particular amount of time, it sends out notification to the concerned person who comes and locks the classroom. Also, such a notification helps the concerned person ensure that no one is left back in the classroom.

Feedback
Users felt this idea would be helpful in reducing mischiefs in school. Also, they said it would be more useful in the primary section of the school. Users said it would help make the job of the watchman easier as it would be easy to know if anyone is left behind.

Co-created Ideas
Users suggested adding access profiles along with the idea. Access profiles on the door will allow only the people having permissions to enter the room.



5 User Studies

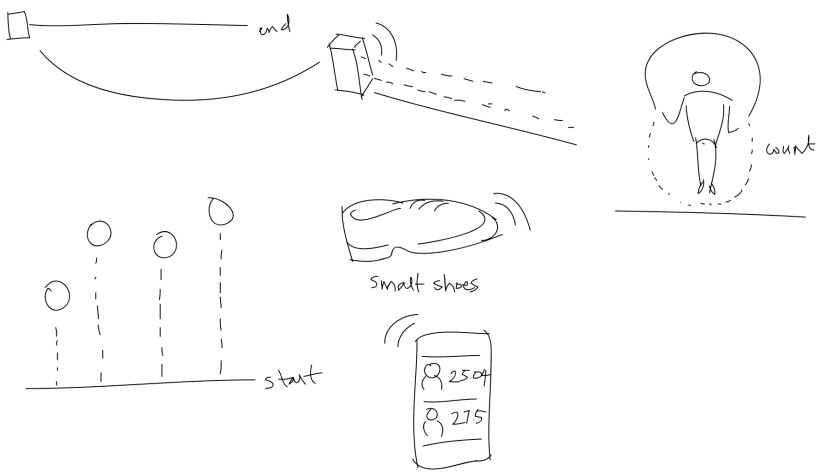
Physical Training Management Tool

Problem
Teacher finds it difficult to do performance analytical tasks in a PT class with students.

Solution
In this concept, it uses a bunch of interconnected smart things that are together used to provide the set of analytics which increases the motivation towards physical training. The set of smart things include a smart shoe that helps in mapping bodily movements. The other smart device used is a portable mobile device that includes a infrared sensor which also has network connectivity. This device helps in triggering the timer off when the shoe crosses the infrared wave created by the mobile device. This mobile device is kept at the finishing line. This can be used for running related events. Moreover just the smart shoe could also be used for tracking progress of events like skipping.

Feedback
Users said that this idea would be helpful to prepare and train for interschool tournaments. They expressed a concern about the number of sports that could be monitored and managed. Also, they queried about the ownership of the equipment like smart shoe. Will the school own the shoe, and how many in how many different sizes?

Co-created Ideas
Users suggested managing the sports equipment along with this idea. Another idea that was co-created was to use monitoring and tracking the readings of various experiments conducted by children in the lab. Monitoring the results will make them do the experiment well to achieve the desired result.



5 User Studies

Infotainment using Tablets

Problem

Teacher uses mundane techniques to teach subjects like programming, history, geography and so on

Solution

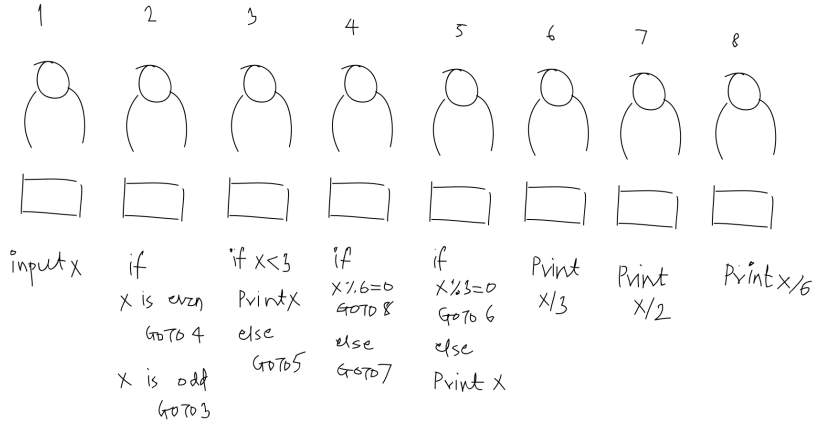
In this concept, it uses multiple tablets which are part of a network to make meaningful interactions in order to teach a particular subject. Each tablet could be given to a child or a group of children in the classroom specific to the activity that is to be carried out using the tablets. Content specific to subjects can be built to use the network capabilities of the tablets and enhance the learning within the children. The example used to demonstrate this enhancement involves teaching conditional flow in programming through the network of tablets. Each tablet is held by a child which reads out and performs the command given to him/her by the tablet. Based on the input by the child, the class could predict the next person to operate. It can be fun task with certain gamified elements.

Feedback

dsf Users expressed a general positive feeling about the idea. They said they could relate to the idea better if it was about the subject they teach. Also, a few users suggested to use the class projector along with the tablets to get the whole class together in the fun and learn activity.

Co-created Ideas

Users suggested use of tablets to conduct instant quizzes in the class. Tablets could be used for keep the pace of slow learners in classroom. Also, tablets could be used to conduct collaborative activities among the kids. Tablets could be used for teaching comparative analysis, where different content is displayed on different tablets and the kids are supposed to interact and analyse. Tablets could be used for teaching communication theory concepts based on 'Chinese whispers'.



5 User Studies

5.6 Card Sorting Findings

As mentioned previously, the co-creation and feedback session was followed by a card sorting activity for all the ideas/application areas on the table. Card sorting activity was performed by three users in two groups consisting two users and one user respectively. The findings of the activity are as follows -

Summary

With a system design perspective, tracking and resource management ideas can be linked together to form a system that offers an array of benefits to the school.

The heading of 'Tablet' is about grouping ideas/application areas which can be implemented using the tablets and supporting infrastructure in the school. From the system design point of view, it is not communicating much.

The heading of 'Door' is a very specific grouping related to the ideas around the physical doors of classes in school. For system design point of view, it does not communicate much either.

Session 1 results

Tablet	Door	Tracking	
Infotainment	Access profile	**Important things**	**Students**
Live quiz on map	Smart Door	Books	Logistics
Explaning communication		Notebooks	Kid radar
Comparative Study		Chalk/Duster	

Session 2 results

Tracking	Resource Management	Tablet
Smart Door	Exam department	Infotainment
Student	Answer sheets	Quiz
Logistics	Chemistry lab chemicals	
Library books	Lab equipment	
Kid radar	Shared printer resources	
Bunking	Chalk/Duster	

5 User Studies

5.7 Rankings

The card sorting activity was followed by a ranking activity for all the ideas/application areas on the table. This activity was also performed by three users in two groups consisting two users and one user respectively. The findings of the activity are as follows -

Session 1 results

The ideas/application areas were ranked as follows -

1. Access profile for entering in classrooms. Against theft
2. Live quiz on a map. Tablet. collaborative activity
3. Tracking of books. Lost and found
4. Student Logistics
5. Kid radar inside school classrooms, corridors and washrooms
6. Collaborative learning on tablets. Comparative study
7. Picnic Management
8. Smart Door
9. Infotainment with tablets
10. Explaining communication through tablets
11. Chalk/Duster management

Session 2 Results

The ideas/application areas were ranked as follows -

1. Tracker for kids to check if bunking or no
2. Picnic management
3. Library book management
4. Student logistics, Smart ID
5. Shared printer resource management
6. Chalk and duster management
7. Chemistry labs, dangerous chemical usage tracking and control
8. Smart Door
9. Exam dept. Accountability of answer sheets
10. MCQs using tablets.
11. Live Quiz using tablets

Summary

From the rankings, we can make a judgement about which of the problem areas are more important for the users. Overall, tracking related ideas are ranked higher followed by resource management related ideas.

6 Conclusion

From the study, it can said that the concepts and ideas shown to the users were low fidelity which resulted in little or no clarity about the usefulness or the shortcomings of the concepts.

Users showed preference towards products which are cost-effective, multi-purpose and have high return value. Hence, a system design perspective towards IoT products is a must. A IoT system would provide solutions to multiple problems with a common set of hardware.

As understood from the studies, in a school environment, the problems can be classified under two categories - management, teaching/learning. Both the categories being fairly large, interconnections can be found between two categories. Hence, both have to be tackled simultaneously.

A participatory design approach towards uncovering user problems may not be the most fruitful approach. A school environment being fairly complex with multiple users and hence, a detailed user study involving contextual inquiries with all kind of users involved would reveal the deeper problems.

Before starting to design IoT product, the scope should be defined in terms of three dimensions that are ownership, geography and specific application domain. In case of multiuser scenario, it necessary to understand hierarchy of responsibility and users willingness to share responsibilities.

In order to optimise the IoT system, a quantitative study approach would be more meaningful. In such an approach, various variables in a school environment are recorded for a specified period of time. Performing analytical operations on this data would reveal co-relations between variables. Further it would lead to minimal set of variables that need to recorded to trigger certain actions. A minimal set of variables in turn lead to minimising the infrastructure costs as it involves lesser sensors. Thus, cost effectiveness, which is an important factor for IoT in India can be tackled.

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