Annexure 1: Focused Projects in IoT and Intelligent System

IoT Cloud

1. Data Management and Privacy of data in Cloud Computing

1.A. Title: Privacy of data in Cloud Computing

Project Summary: The cloud service enables a virtual area of computation. Data are uploaded in the cloud and the cloud computes on the data. The main concern is about the privacy of the data. Is is possible to compute on the data without interpreting the value of the data. There are two concepts of privacy of data in the cloud. Firstly, users upload encrypted data and cloud must compute on the encrypted data. There are many applications of computing on encrypted data. For example, medical institutes have private and sensitive data. However, other institutions like drug culture institute may want to access the data. The cloud must provide the computation service where the privacy of the data remains secret. Secondly, user secretly shares the private data among n-servers. The cloud contains of n nodes can compute on the data where t<n nodes cooperates. An example is in the electronic voting, where the cast of the vote should not be under ones' custody. The votes are shared among a set of custodians. If a quorum of custodian cooperates the votes can be computed. However, the privacy of the voters remain secret.

1.B Title: Data Management for IoT based Applications

Project Summary: IoT generated data is rapidly growing, dynamic and diversified in nature [1]. Handling and management of such data requires to adopt distinct strategies, with respect to processing (locally or remotely executed), delivery format (raw data or aggregated information), and sharing options (through low latency network) [2]. Data generated from IoT are dynamic, time sensitive, diversified and continuous in nature and such types of data are considered as a stream (data stream) rather than static snapshots. Proper Data Stream Management (DSM) are required to develop for processing and analysis of such data streams. However, data streams have several exceptional characteristics, which make them difficult to model. Firstly, a data stream is usually defined as an unbounded sequence of values continuously appended, each of which carries a time stamp that typically indicates when it has been produced. Secondly, as the device types, structures, data transmission modes and network communication methods are different, the formats, codes and syntax of the IoT generated data exhibit obvious heterogeneity [3]. Further, rapid changing of underlying contextual information of data streams, generated in diverse domains, has serious consequences in deriving useful decisions from complex real time applications. Finally, a fixed or flexible finite partition, called window, are made from this continuous unbounded sequence while streams have to be stored or retrieved from databases. A context-driven streaming data management will helpful towards collecting, store and proper analysis of IoT network generated data (See Figure 1).

A context-driven streaming data management will be deployed towards collecting, store and proper analysis of IoT network generated data. Contextualization will efficiently deals with generic semantics towards modelling of variety of data streams, resources producing those data streams and other network related facets. On the other hand, traditional mode of transmitting data continuously over low latency network would prevent from effective bandwidth usage, and lead to unacceptable data loss and delay. A possible solution to tune the IoT paradigm properly for varied applications is to reduce the amount of data to be transmitted, by resorting to Complex Event Processing (CEP) based data transmission. This can be achieved by implementing processing tasks to aggregate data based on suitable ontology and provide a compact representation of the relevant information.

Typical IoT generated data characteristics includes, (i) Rapidly evolved, high volume, heterogeneous, streaming and geographically-dispersed, real-time, (ii) Devices in IoT environment varied by type, generated data, location and time. Challenges exist in effective modelling of such data. Typical research questions includes,

- How to provide common semantic descriptions for varied data-streams generated from different devices of IoT?
- How to manage complex metadata that describes "Things" in addition to the data that is generated by "Things" in a decentralized, efficient easy-to-access manner?
- How to represent evolving and dynamic contextual information related to IoT generated heterogeneous data streams?
- How to capture Complex Event Processing (CEP) mechanism suitably using common set of descriptions that varied with different IoT environment?

Research Objectives:

- Event driven sensor data extraction mechanism in Smart system
- Modelling context-sensitive, stream based and loosely structured IoT generated data.
- Devising efficient mechanisms for collection, storing and analysis of IoT generated data.
- Enhancement of the capability by filtering and classifying data automatically at the edge.

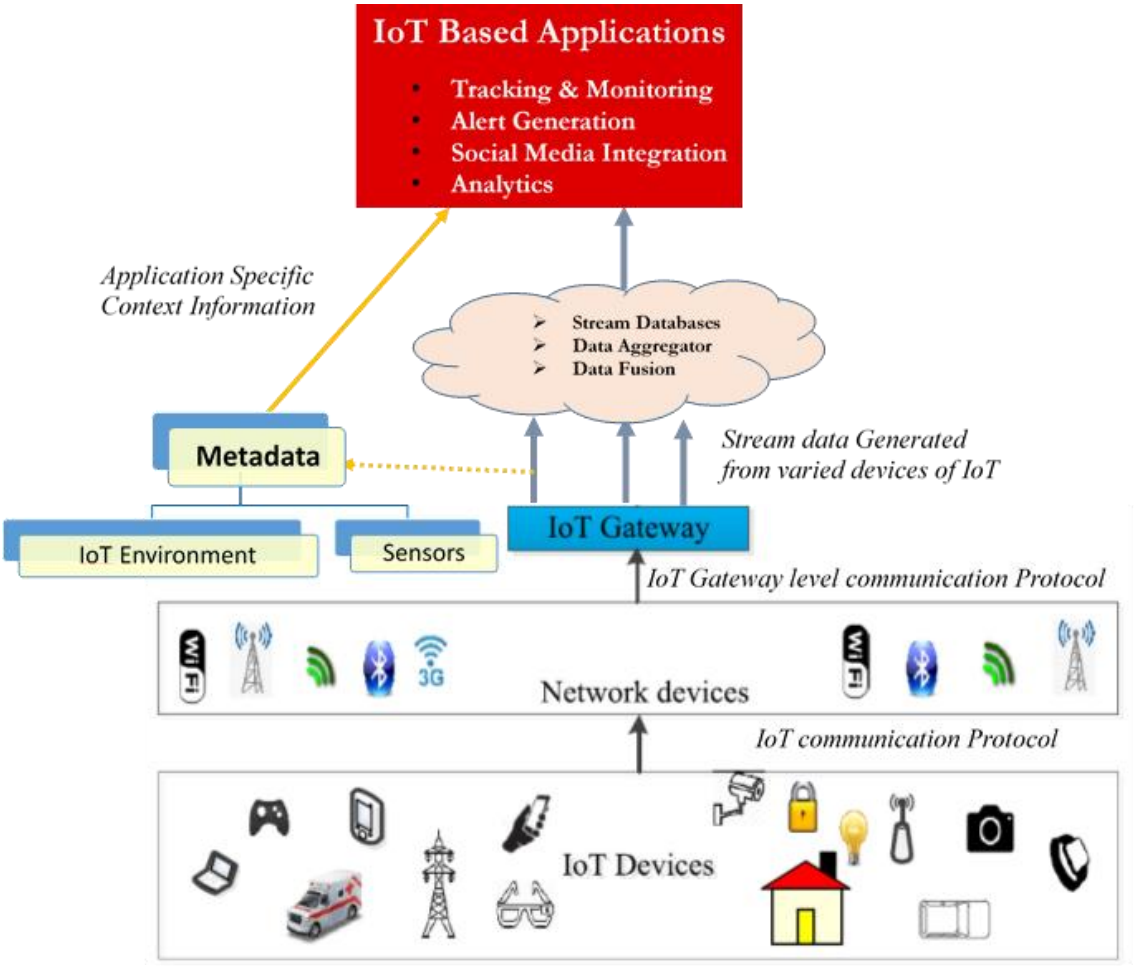


Figure 1: Typical Data acquisition framework for IoT based system

Research Task (Broadly)

- Meta – Information modelling for Sensor Resources and sensor generation data to preserve the categorization and cataloguing information based on sensor and event types
- Modelling context sensitive and Stream based IoT data over IoT-Gateway infrastructure -- This includes modelling of context sensitive, event driven streaming data and identification of functional dependencies among structured data and unstructured data generated for a particular system.
- Study on Context based near real time information retrieval mechanism and view materialization.

- Situation based decision making for data aggregation and data fusion for IoT generated data.

References

[1] Peter Krensky, "Data Management for The Internet of Things", Technical Report, Aberdeen Group, MA, USA, February, 2015

[2] S. Spinsante, E. Gambi, L. Montanini and L. Raffaeli, "Data Management in Ambient Assisted Living Platforms Approaching IoT: A Case Study," 2015 IEEE Globecom Workshops (GCWkshps), San Diego, CA, pp. 1-7, 2015.

[3] Ming Taoa, Kaoru Otab, MianxiongDongb, "Ontology-based data semantic management and application in IoT- and cloud-enabled smart homes", Journal of Future Generation Computer Systems, Elsevier, Available Online November 19, 2016.

Team Member: Jaydeep Howlader**,** Prasenjit Choudhury, Anirban Sarkar

Equipment: Cloud installation with adequate resources. Additional Funding is not essential but common cloud installation will be used

IoT Middleware

2. A Multi Agent Based Proactive Framework for IoT Middleware with context-awareness and dynamic team formation

2.A. Title: A Multi Agent Based Proactive Framework for IoT

Internet of Things (IoT) is a broad concept. In general, IoT refers to a global infrastructure ofnetworked physical things interconnected through Internet [14,15]. The central perspective is that, within the coming years, billions of resources, such as cars, lamps, foods, factory machinery and almost every object will be connected to the Internet and share information about themselves and their environments. IoT will make it possible to develop a variety of application scenarios, such as smart homes and cities, e-health, environmental monitoring and many others. Smart traffic management is an example of a smart city application, which aims at providing intelligent transportation through real-time traffic information and path optimization [16,17]. Here we consider a typical ad hoc IoT segment where the devices are considered to be autonomous and heterogeneous in terms of capability and usage. The various services available in the network, as a whole, can be combined and assimilated to create a typical service oriented computing platform. This scenario can be viewed (as shown in Figure 1a) as Internet of services laid down over a segment of Internet of things. To make the proactive framework an agent module is installed in each node (as shown in Figure 1b) in the network. To maintain an equilibrium over the network an efficient service oriented middleware is required.

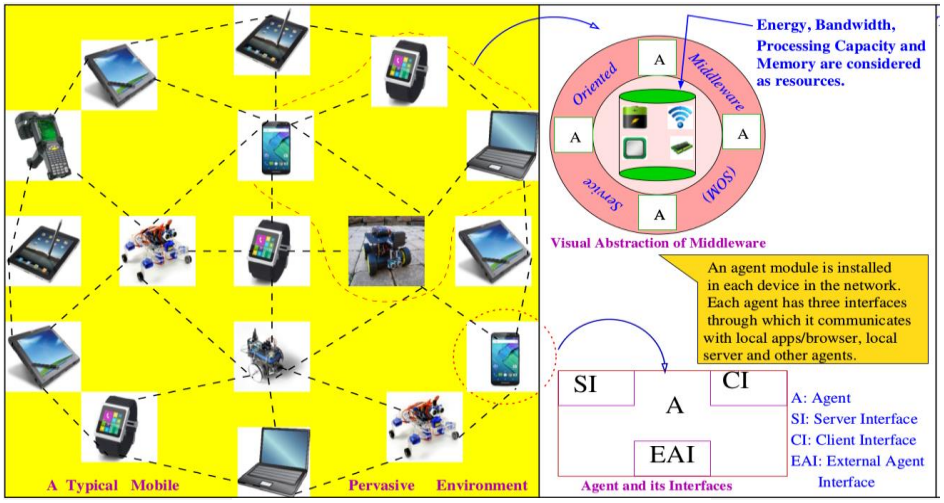


Figure 1: A Typical Automated IoT Scenario

Objectives:

The research work focuses to design a proactive and scalable multi-agent based Service Oriented Middleware (SoM) that meets the quality of service (QoS) requirements of the service consumers with minimal resources usage in the system. With the emergence of IoT enabled application/services the traffic pattern to the Internet has changed significantly and the traditional service oriented middleware (SoM) solutions are not enough to support the current scenarios.

In order to address this inefficiency, significant amount of middleware solutions are introduced by the researchers. Most of the solutions are based on the traditional service oriented architecture(SOA)/ Cloud where all the service provider register their services in a dedicated UDDI and the service broker (intermediate agent between consumer and provider) takes the responsibility to advertise and discover the services in the network. But very few of them emphasised on the performance issues of the middleware and resource utilisation of the network. In summary, our research objective is to design a Multi-Agent based proactive SoM framework for a typical IoT scenarios and the middleware should enclosed the functionality such as:

- Service Discovery
- Server Selection
- Service Replication
- Service Migration

Methodology:

- First we have to determine the basic functionality (such as service discovery, server selection, service replication, service migration etc.) of each agent in the framework as shown in figure 2a.
- To meet the real time constraints of the consumer and to reduce the overhead in the network, optimization techniques based on distributed algorithms will be proposed.
- System performance (in terms of average service response and completion time, network resource utilisation) will be evaluated through mathematical modeling.
- Prototype of the system will be emulated/implemented in an open source tool (like JADE).

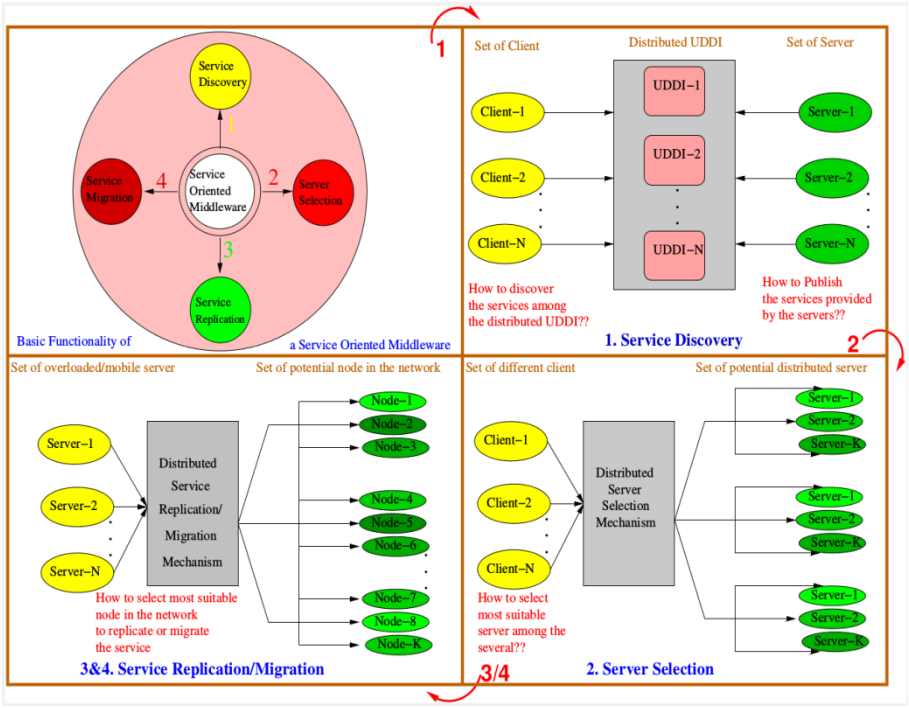


Figure 2: Methodology of our proposed middleware

Details of Equipment & Budget with Justifications

Sl. No.	*Name of the Equipment*	*Brief Specification*	*Unit Cost (Lakhs)*	*Qty (No.)*	*Total Cost (Lakhs)*	*Justifications*
1	Workstation	Xeon Processor, 64 GB RAM, 4 TB HDD	2.5	2	5	For high computation
2	UPS	6 KVA Online UPS, 1hr backup	1.5	1	1.5	For power backup
Total					6.5	

2.B. Title: Multi Agent Based Team formation for Distributed Environment

Current wireless network technologies facilitate rapid deployment of advanced software applications on sensors as well as smart mobile devices. In such networks, devices are autonomous, mobile and resource-constrained, and network topology is typically not prescribed. In this project, we address the problem of collaborative task execution in highly dynamic and unpredictable environments. We examine a disaster recovery case study. The case study concerns a scenario where software agents assist a set of persons and robots which aim to manage a disaster area. Agents are deployed on mobile devices and robots and in fire-fighters and rescuers suits (one agent per robot or rescuer suit) and establish an ad-hoc network. The nodes of the network are a set of mobile communication devices located in areas considered dangerous for humans (falling debris, explosions, rock-slides etc.) as well as human rescuers who are located primarily in less risky areas are responsible for the evacuation of the injured. The agents deployed on these nodes have the ability to monitor the environment, to find neighbouring agents, to communicate with them and to share their position details with those agents (e.g., using Bluetooth technology).

We assume that the agents can obtain data on temperature, radiations and the similar in their proximity by using external sensors. Additionally, agents can use satellite data to localize the tasks.

Each agent should react and perform a set of actions, including assessing the situation and communicating with others in order to assist human rescuers in their tasks. The rescuers do not necessarily have all the knowledge about the distribution, resources and availability of the other rescuers. Some rescue tasks require collaboration among humans, robots and agents. In addition, tasks evolve over time and agent availability varies, thus affecting the stability of groups during task execution. Coalition formation is an appropriate means for such collaboration. A coalition is defined as a set of agents which choose to act temporarily together to achieve their goals after the agreement on the cooperation conditions.

Objectives:
In this project, we mainly focus on cases where distributed group formation is required when agents are self-interested and autonomous. Our aim is to propose and formalize a coalition formation mechanism which ensures robustness and persistence of committed coalitions when facing dynamic changes, resource availability and task scope. The reliability and quality goals must be met despite inherent non-determinism in the environment.

Current coalition formation protocols which enable the dynamic restructuring of the coalitions, when an unexpected event occurs, revisit and revise the coalition agreements even if it is only one agent of the coalition which becomes unavailable. This leads to performing another step of negotiation and coalition formation process to re-construct the affected coalitions. However, with the dynamics of the ad-hoc networks the underlying assumptions of such mechanisms are not realistic, firstly, because in the context of time-critical tasks the additional time spent on renegotiation may not be afforded, and secondly, because of inconsistency with the functioning of ad-hoc networks, and in particular unpredictable connectivity and availability of network nodes. Hence, new coordination methods to manage the dynamic of the tasks, the stability of coalitions and the deployment infrastructure become an imperative when new technologies (laptop, personal digital assistant, wireless fidelity, sensor ...) which are characterized by their ad-hoc and their mobile behaviours are used. It is planned to divide the project objectives into two different modules which are as follows:

Module - 1:

a) Conduct a comprehensive survey of related literature and publish a well-documented report focused on identifying limitations of distributed group formation when agents are self-interested and autonomous, dynamic restructuring of the coalitions and dynamics of the ad-hoc networks.
b) Design of agents which are embedded in the wireless network nodes (one agent per node).
c) Design of an adaptive and dynamic coalition formation mechanism which deals with the time and the resource constraints.
d) Design and implementation of the mechanism to make these agents able to act in a heterogeneous and competitive ways where the tasks change dynamically (e.g. fire extinction, finding survivors, etc.)

Module - 2:

a) Conduct a comprehensive survey of formation and maintenance of stable coalitions under the time and the resource constraints.
b) Implementation of the agents to be functional under dynamics of the network topology.
c) Study and design of the approaches to predict stable coalitions before task execution.

Methodology:

- First we have to determine the basic functionality (such as service discovery, server selection, service replication, service migration etc.) of each agent in the framework.
- To meet the real time constraints of the consumer and to reduce the overhead in the network, optimization techniques based on distributed algorithms will be proposed.
- System performance (in terms of average service response and completion time, network resource utilisation) will be evaluated through mathematical modeling.

- Prototype of the system will be emulated/implemented in an open source tool (like JADE).

Details of Equipment & Budget with Justifications

Sl. No.	*Name of the Equipment*	*Brief Specification*	*Unit Cost (Lakhs)*	*Qty (No.)*	*Total Cost (Lakhs)*	*Justifications*
1	Workstation	Xeon Processor, 64 GB RAM, 4 TB HDD	2.5	2	5	For high computation
2	UPS	6 KVA Online UPS, 1hr backup	1.5	1	1.5	For power backup
3	NAS (Network Area Storage)	Minimum 50 TB.	15	1	15	For large volume Data storage
Total					21.5	

Team member: Animesh Dutta, Subhrabrata Choudhury

Equipment: As Listed.

IoT Network & Communication

3. Title: 5G mm Wave Channel Models for Smart Vehicles

Description: The vision of Internet-of-Things (IoT) is a digital society of new generation that encompasses every node, every node which can compute, store, and communicate. In this regard, connected vehicles are expected to play a vital role in tomorrow's information and communication technology infrastructure in smart cities.

So far, the related research has been dominantly focused toward the design and development of wireless links for vehicle-to-vehicle and vehicle-to-infrastructure scenarios. For a comprehensive realization of the connected vehicles dream, it is also important to consider the links inside a vehicle. Intra-vehicular wireless communication helps in increasing fuel efficiency by reducing the overall wiring harness and in simplifying the manufacture and maintenance of vehicles. Typical modern-day car houses hundreds of sensors connected to an on-board unit (OBU) for monitoring safety, diagnostics, and convenience. The OBU can also provide last-hop wireless connectivity to personal electronic gadgets (smart-phone, tablet, laptop, etc.), opening up a plethora of new possibilities. On one hand, it will be possible to obtain user-defined real-time multimedia streaming for navigational or recreational purposes. On the other hand, locating people and devices would trigger new applications such as smart airbag control or profile restriction of handheld devices.

However, these demands can only be met if the wireless technology provides a high bandwidth and assists in precise localization. Millimeter wave (mmWave) has established itself as a preferred technology for high-data-rate short-range low-power communication with centimeter-level localization accuracy. With recent announcements for 5G spectrum in the 60 GHz band, there has been an upsurge of interest in this unlicensed band. The 60 GHz mmWave band is being investigated for communication between vehicles or for communication inside a vehicle.

Objectives

The expected output of the current work is in the form of statistical channel models derived from the extensive measurement campaigns. The models would be useful in assessing performance of

conventional communication systems and comparing them with novel, yet-to-be-launched techniques. In general, this would accelerate the development of 5G mmWave technologies.

The project would help in finding answers to some key questions regarding wideband propagation in the millimeter wave regime. Although the context is global, there are certain national level interests involved as well. For example, our developed model may serve as a reference for propagation in hot and humid tropical countries. Such quantum of works finally accumulate in strengthening activities of wireless planning and coordination wing and facilitate Indian participation in the standardization conference WRC-19 or at the ITU-R regional bodies like Asia-Pacific telecommunity. The project is thus a small step towards the bold ambition that India, through organizations like global ICT standardization forum for India, will be empowered to claim a front-row seat in 5G standardization.

Details of Equipment & Budget with Justifications

Sl. No.	*Name of the Equipment*	*Brief Specification*	*Unit Cost (Lakhs)*	*Qty (No.)*	*Total Cost (Lakhs)*	*Justifications*
1	Vector Network Analyzer	4 port VNA 10MHz to 67 GHz	150	1	150	Studying millimeter wave propagation inside the passenger compartment of a car

Revenue Aspect: Companies developing RF circuits can get their design prototype tested. Central and state funded research labs can use the facility. Faculty from other Institutes can use the facility for measurement characterization.

Team Member

Aniruddha Chandra, Assistant Professor, ECE Department, NIT Durgapur

Equipment: As Listed (Proposed in the Central Research Facilities).

4. Title: Measurement of Radiation and Interference Characteristics of RF Devices for IoT Application

Description: In IoT applications, the interoperability of the devices depends on tether less connectivity among the entities. To ensure this, the RF front end devices should be well calibrated and tested for faithful transmission and reception. This is as important as the back-end software and embedded systems that has to be reliable. The functioning of the entire system therefore depends on satisfactory design of RF devices that are integral part of the IoT systems. Further, it must be mentioned that the devices should not cause interference with other devices. Hence, interference measurements must be done on the devices.

Challenges:

The efficacy of the measurement depends on skill of RF and microwave measurements that need to be performed for characterization of the RF devices.

Objectives:

- To determine the radiation characteristics of the RF front end devices developed for IoT application.
- To measure interference issues that can be generated due to the device with other devices or shielding the device from possible RF interference sources.

Details of Equipment & Budget with Justifications:

Sl No	*equipment /Software*	*Unit*	*Price*	*Justification*
01	EM Radiation Measurement Set-up up to 60 GHz.	1	80 Lakhs	To test the radiation characteristics of the RF module in a shielded environment of electromagnetic interference

Team member: Sujit K Mandal, Rowdra Ghatak and Gautam K Mahanti

Equipment: As Listed (Proposed in the Central Research Facilities)

5. **Title:** Development of SDN testbed for research in IoT based Intelligent Systems

The unprecedented growth of connected devices, drastic changes in application usage pattern and emergence of Internet of Things together acted as the main driving force towards the development Software Defined Network(SDN). SDN elegantly separates the data plane activities from control plane activities and making the forwarding processes in the individual data plane devices becomes simple. Moreover, the applications can directly coordinate with control plane to share the past usage statistics and estimated future demands. These two-fold benefit makes it very suitable for managing the networks intelligently under complex, semi-adhoc, highly heterogeneous and multi-context network scenarios. However, conventional centralized SDN structure for Campus scenario is not suitable for optimally managing the resources under such a complex experimental scenario as described above. Under this project, we want to investigate various distributed coordination-based algorithms (including DCOP) within multiple autonomous SDN controller agents. This federated management setting can act as a testbed for SDN research, IoT sub-system deployment, federated robotic applications and fine grained elastic cloud solutions.

Objectives:

- Developing algorithms and coordination strategies for a federation of SDN controller to achieve global performance optimization.
- Testing new strategies for performance evaluation.
- Testing IoT subsystem performance and mult-context superposed IoT systems like smart City.
- Testing performance and agility fine grained elastic clouds (including on demand edge and fog computing strategies).
- Control platform for 5G and higher research.
- This will partially act as Institute level core, edge and access network.

Equipment:

Sl. No.	Equipment	Specification		
1	Core switch	Openflow compliant, 24 ports, with 12 no. of 40GbE and 12 no. of 10 GbE with SFS. Quantity:02	50,00,000 (2X2500000)	To serve as the Institute level core network switch with redundancy and an experimental testbed for SDN based network control.
2	Edge switch	Openflow compliant 24 ports with 4 no. 10GbE and 20 no of GbE, all with SFS. Unit price: 5,00,000	40,00,000	Institute level aggregation switches for some academic blocks and to be used as part of SDN experimentation testbed.

		Quantity: 08		
3	Access switch	Openflow compliant 24 port with 04 no of GbE with SFS and 20 ports with 1 GbE. Unit price: 01 Lakh Quantity: 30	30,00,000	To provide access to Institute level users and to perform experiments on SDN based management.
4	Wireless access points/switch/routers	dual band MIMO wireless router with 4+ antenna 600+ Mbps. Unit price: 8000 Quantity: 120	9,60,000	SDN controlling testbed for mobile wireless devices and users.
5	Cabling , Fiber, accessories	standard	1040000	Connectivity
6	One experimental 5G BTS setup	Low range with precise beamforming facilities	10,00,000	In campus 5G support for experimentation only
		Toatal	1.5 crores	

Team Member: Sumit Kundu, Suvomoy Changder, Subhrabrata Choudhury, Sajal Mukhopadyay, Suvrojit Das, Animesh Dutta, Aniruddha Chandra, Sarit Maitra

Equipment: As Listed.

6. Visible Light Communication for IoT

Description: High data rate in range of terabit/second can be achieved using license free visible light spectrum so network layer of IoT based devices can be desinged using visible light. Visible Light Communication (VLC) integrated with the emerging technology of Internet-of-Things (IoT) opens up to wide range of indoor applications. So VLC can be use for various applications like intelligent traffic control system, underwater communication system, indoor communication etc. To activate this communication system, we need to modify or enable IEEE-802.15.7 protocol stack but increasing data rate and communication distance become challenging factors. Our objective is to design an efficient and effective transmitter-receiver module so that it can communicate within considerable distance with high data rate.

Challenges: The work proposed following challenges (i) implementation of CSMA/CA in logical link control of Data link layer (ii) implementation of OFDM to achieving data rate 96 Mb/s or above high data rate (iv) achieving the considerable communication distance between transmitter and receiver using multiple LEDs. (iv) Design reliable and efficient data tranceiver.

Objectives:

(i) Development a robust transceiver circuit.

(ii) Implement different access mechanism like WiFi using visible light

(iii)Implement FODM to achive high data rate

(iv) Implement CSMA/CA mechanism using visible light

(v)Implement IEEE 802.15.7 protocol stack for reliable communication.

(vi) Implement FODM to achive high data rate

Team Member: Mousumi Saha, Dr. Sujoy Saha

Details of Equipment & Budget with Justifications:

Sl No.	Equipment	Specification	Total (approx.))	Justification
1	LiFi/VLC (6 nos.)	802.15.7 Protocol stack enabled device and/or components for prototype development	4,20,000 (each 70,000/-	5G enabling technologies
2	Variable Voltage source (2units), CRO (1units)	Variable Voltage source: DC Outputs 0 -30 V/ 2 A, 5 V/ 2 A & 0 ± 15 V Dual Tracking /1 Amp CRO:analog band width 100 MHz, analog channel 2, sample rate 1GSa/s,Vertical range: 500 μV/div ~ 10 V/div8-inch WVGA (800×480), 256-level intensity grading display	2,00,000 (each voltage regulator25,000/-) (each CRO-1,50,000/-)	Regulated voltage to Microcontroller and Microcomputer
3	Microcontroller with accessories (6 units)	1GHz ARM® Cortex-A9, and an ARM Cortex-M4 I/O real-time co-processor that can run up to 200Mhz. RAM 1GB or higher, Arduino-Compatible through the standard Arduino Pins layout and compatible with Arduino shields. 32 extended GPIOs (A9 dedicated), Wi-Fi 802.11 b/g/n,Direct Mode SmartConfig and Bluetooth 4.0	60,000 (each 10,000/-)	sensor integration
Total			6,80,000	

IoT Applications

7. IoT and Healthcare - Cloud Assisted Wireless Body Area Network System for Health Care Applications

Accessibility to the healthcare system in India is abysmally *limited*. The economically weaker and marginalized sections of people, particularly those living in remote villages of India have very limited and often no access to proper healthcare services. Tremendous shortage of trained manpower (e.g., medical professionals, nurses) and huge cost for setting up state-of-the-art facilities in remote areas

are two major hindrances that deny even the basic healthcare services for 80% of our citizens. This project aims to comfort millions of ailing citizens who cannot even tell a Doctor about their discomfort, and disease [NRHM-2010][PWC-2007]. Although overturning the entire scenario is a long-term issue that requires major policy change and priority shift, the situation can significantly be improved with the use of cutting-edge technologies such as sensors and wireless mobile technologies.
In a country like India, quite contrary to popular belief, Internet and cell-phones have reached in places where clean, drinking water is yet an illusion. Technologists rightfully claim that "mobile era" has started in India and mobile technology is penetrating rural India at a rapid pace than ever. Latest Census data (Housing and House Listing Report, Census 2011) released in March 2012 revealed that half of rural India now uses a mobile phone (while about one third has access to a proper toilet). It can therefore be expected that essential contents and services can be delivered using mobile phones to foster inclusive growth in India and digitally empowering the citizens across all cross-sections of the society, both urban and rural. For example, mobile technology can be used to deliver low-cost healthcare services *to the rural patients*, *to the patients on the move*, and *to the medically vulnerable patients (including elderly) living at or traveling to remote locations*. To add further benefits to healthcare services, sensors can be placed on the patient's body to monitor vital clinical parameters and thus can be wirelessly communicated to a caregiver (doctor or nurse) at a remote location; the collected data can help determine the medical condition of the patient. However, such remote healthcare services also pose major technical challenges.

- First, such services must be provisioned on-demand in a pervasive manner with substantially low response time.
- Second, provisioning for these services will involve handling huge volume of data efficiently in real time and in a secured manner.
- Finally, the quality of service (QoS) requirements for delivering remote healthcare services must be maintained at desired level.

In order to meet up the above requirements, a sensor network based cloud infrastructure for provisioning healthcare services would be beneficial. The cloud infrastructure will be integrated with mobile and sensor technologies to create a *low-cost, low-response time, on-demand, and secure* service provisioning framework. The major goal of this work is to create a framework by integrating all the proposed technologies. The proposed cellular and sensor-cloud based healthcare solution targets to extract the present socio-economic setup and to bridge patients with doctors.
Team member: Anirban Sarkar

7.A. **Title:** Cloud Assisted Wireless Body Area Network System for Health Care Applications

Description: The aging population, stressful daily life and high cost of health care have triggered the introduction of novel technology to current health care practices. For example, recent advances in electronics have introduced small and intelligent (bio-) medical sensors which allow to monitor of the patient's health continuously across the clock. These sensors need to send their data to an external medical server where it can be analyzed and stored. Wired connection for this purpose incurs a high cost for deployment and maintenance. But same can be done using wireless interface. The use of a wireless interface enables an easier application but in cost efficient manner. The patient experiences a greater physical mobility and is no longer compelled to stay in a hospital. This is the referred as M-health or Mobile health. Wireless body area network (WBAN) is an example of wireless connection where remote health monitoring is provided in a ubiquitous manner. In WBAN, medical sensors are placed on a patient's body. These nodes sense physical signals, and subsequently transform the same into digital readings. Providing on-demand service in WBAN is also a challenging task. Acquring the data from multiple WBANs and then integrate it with the cloud server to support seamless health service is an important issue in M-health. Raw data the from patient can be transmitted to cloud server for analyzing via middleware. Health data analytics analyze the data and send the notification via the middleware if they detect irregularity.

Objectives:

- Development of Wireless body area networks (WBANs) comprising of multiple body sensor devices.
- Development of a middleware to link WBANs to a cloud server.
- Development of interference free routing for transmitting the data from WBANs to cloud server.
- Designing energy efficient routing protocol to improve the longivity of the sensors.

- Data analysics and database design for monitoring of patients healthcare.
- Location tracking and health mangement issues

Details of Equipment and Budget with Justification

Sl No	Equipment/Software	Unit	Price	Justification
1	Cognitive Radio		3,00,000	5G Implementations or Future Communication
2	Tmote Sky	10	1,00,000 (each 10,000/-)	Sensor platform for fault tolerance and development
3	Blood glucose sensor	4	20,000 (each 5,000/-)	Measure sugar level
4	Temperature sensor	4	20,000 (each 5,000/-)	Measure temperature of body
5	Movement sensor	4	20,000 (each 5,000/-)	Measure movement
6	Breathing sensor for respiration	4	20,000 (each 5,000/-)	Measure breath and respiration
7	Blood pressure sensor	4	20,000 (each 5,000/-)	Measure blood pressure
8	Wearable Sensors	5	3,50,000/-	
		Total	**8,50,000 Lakhs**	

7.B. Title: IoT based cognitive and adaptive learning system (ICALS)

ICALS is an integrated system of devices and neuro-tools consisting of Electroencephalography (EEG) sensor, Eye-tracking sensor, Emotion measurement, Mouse tracking, Galvanic skin response (GSR) sensor, Heart pulse rate sensor and surveys. This system is used for research in Psychology, Neuroscience, Education and Consumer Research.

Eye-tracking:

Eye tracking is an enormously informative research tool. It is a technique that can measure eye movements with high accuracy and precision providing unique insights into cognitive processes and attentional states. In other words, what we notice and how we look at them can reveal a great deal about how we process the visual world. It is well established that the study of gaze can lead directly to important insights about visual attention with respect to interfaces and images and the tasks and the activities which engage us. There are, however, other aspects of experience and perception that are more elusive to capture in gaze behaviour. And that's where biometrics comes in. Adding an additional data stream to eye tracking can provide more dimensions of information and thus support richer and more nuanced findings. It can also make conclusions stronger.

Brain Signal Capturing:

The electroencephalogram (EEG) is the depiction of the electrical activity occurring at the surface of the brain. This activity appears on the screen of the EEG machine as waveforms of varying frequency and amplitude measured in voltage (specifically micro-voltages).

EEG waveforms are generally classified according to their frequency, amplitude, and shape, as well as the sites on the scalp at which they are recorded. The most familiar classification uses EEG waveform frequency (e.g., alpha, beta, theta, and delta). This data is used to determine attention and meditation level of human subject.

PROPOSED WORK

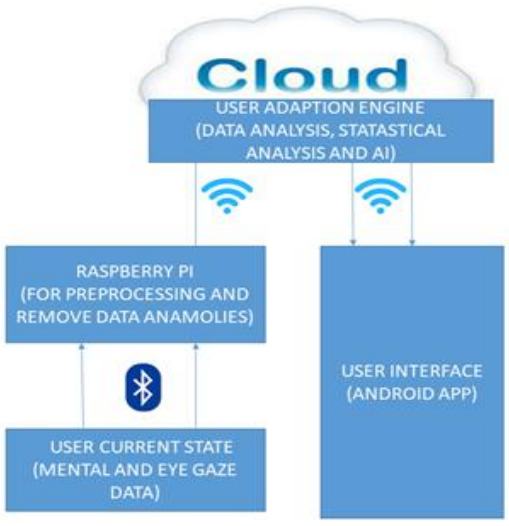
Real Time Adaptive Learning Management System (A-LMS)

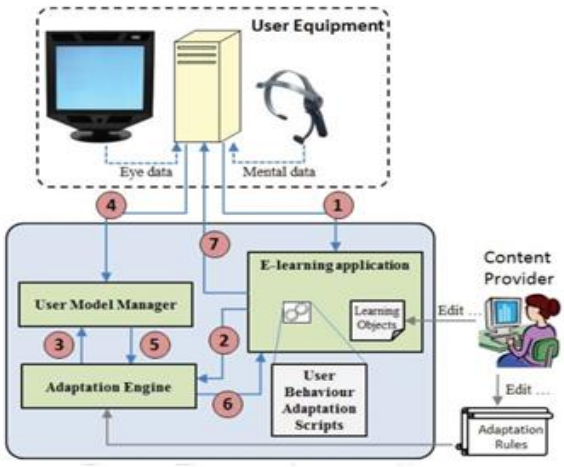
Technology to make physiological measurements related to attention and cognitive load is becoming more affordable. A solution based on combining the exploitation of dynamic user information gathered through such technology with a rule-based strategy for adaptation of e-learning Web applications has been proposed. This LMS system if conceived can dynamically adapt to students' behaviour in order to improve the learning process.

The proposed system will be a Real Time Adaptive Learning system on an Android App or Web based. The content will be dynamic and will be personalised with the User Learning traits. For example: while learning a topic say Integration by substitution method, if the system find that user have difficulty in Differentiation part, then the system will Automatically Recognize and will Recommend there to first get Read the required part (not full).

Eye tracking can capture interesting insights about student learning behaviour and teaching methods in a broad range of educational situations. The data from an eye tracker can reveal different learning strategies for researchers to better understand student cognitive workload. The Eye-tracker can precisely indicate, when reading a document, which areas are of interest to the reader. As the user goes through the documents we can get a content presentation and style preference of the user using ICALS Suite. Depending on how fast or slow a person reads through the sections of documents, it's possible to estimate the learning needs of that user. With enough users using such system documents can be clustered with tags of various learning persona. All this information can be used to determine user context accurately when they try to look for new information in search engine and give them better, **personalised** results.

Also, the current Attention level (Brain waves from prefrontal cortex) is read by the EEG device corresponding to the content on Eye Gaze of the user. This will give better insight of the User Cognitive State for the content which will give an unbiased feedback to the Learning Management system.





Challenges to the Work:

1) To get the User Brain wave data and to process it using efficient Algorithm to get the User Attention/ Concertation.
2) To get the Eye gaze data of the user.

3) To efficiently integrate and process the data to get the overall cognitive state at a time.
4) To pre-process the data and to compress it for faster syncing with the cloud.
5) To design a Real-time based Adaption Engine.
6) To optimize the Adaption Engine for better time complexity.
7) To smoothly deliver the Adapted content to the User.
8) To decrease the overall latency of the proposed system.
9) Expanding the ideas to study patterns of specific areas for finding optimal utilizations of the Resources.

Hardware Required:

This is the current market cost and may vary accordingly during purchase.

Device	Unit Cost (Rs.)	Quantity	Total Cost (Rs.)
EMOTIV Insight 5 Channel Mobile EEG	30000	2	60000
Eye Tracker	25000	2	50000
Software package (Integration tools and Licence)	120000		120000
Arduino Uno R3	1500	3	4500
Raspberry Pi 3 Model B	3500	3	10500
ESP 8266 Wifi	1500	3	4500
System Integration/ Connections and Development	30000		30000
RFID READER	15000	4	60000
RFID PROGRAMMER	20000	1	20000
RFID TAG	200	25	5000
ARDUINO UNO R3	1500	6	9000
RASPBERRY PI 3 MODEL B	3500	3	10500
WIFI(ESP 8266)	1400	6	8400
3G MODULE FOR RASPBERRY PI	6000	3	18000
SHARED VPS (1 YEAR)	10000	1	10000
INTEGRATION TOOLS AND SOFTWARES	50000		50000
		TOTAL	**4,66,900**

Team Members: Prasenjit Choudhury, Sanghita Bhattacharjee, Anirban Sarkar

Equipment: As Listed.

8. Title: An early warning system for to prevent sudden interruptions in electrical power supply in smart cities using distributed interconnected smart system

Project Summary: India has come up from the age of scarcity in electrical energy into the age of reliable and quality electrical supply. Presently many interruptions in electrical supply are mainly due to sudden insulation failures of the electrical apparatus, which are now-a-days causing deep impact in economy and society. Any weakness in insulation causes partial discharge (PD), with time these partial discharges become stronger and more frequent. Therefore monitoring of PD activity inside electrical utilities such as substations can provide early indication of failure, and thereby preventive action can be taken. There are many distributed components in any substation, such as transformers, bushings, insulators, circuit breakers, isolators, capacitor banks, and surge arresters. Continuous monitoring of PDs through various existing dedicated component specific PD sensors cannot be

justified from economic point of view. Moreover, PDs are very uncertain phenomena, at inception phase it occur suddenly, may be at certain time of the day, load condition, or may be seasonal.
Therefore, main objective is to develop partial discharge (PD) source detection and localization system capable of monitoring an entire power system utility continuously with less numbers of suitable designed non-contact sensors.

This can be achieved through experimental investigation on radiated impulsive UHF signal from various PD sources, which will help to design of suitable bandwidth antenna and associated signal conditioning. Moreover, application of advanced digital signal processing techniques will provide scope to identify PD source/sources, it will also provide the opportunities to separate other noises occurred due to pulsating interferences. Previous researchers observed that, due to multiple reflections time domain signature of the impulse waveforms received at various antenna get changed, however the basic frequency domain based signature of a particular PD source could be less variant.

The proposed UHF sensors/antennas will be mounted around the periphery of power system utility, therefore it can be easily installed in an existing power system utility without any interruption of supply and can identify PD source at very early stage, and expected to have much higher sensitivity than the modern thermography technique. Moreover, an unsupervised intelligent system will be developed for detection of multiple PD sources rather applying some supervised model, which require prior training data. These individual intelligent systems may be installed in the critical and sensitive power transmission and distribution systems, which are distributed over a region. These systems will the connected through internet for remote monitoring, collective decision making, and taking preventive action

OBJECTIVE: The main objective is to develop a partial discharge monitoring system for an entire power system utility using multiple non-contact type ultra-high-frequency (UHF) sensors, mounted around the periphery of the electrical installations.

Equipment Required:

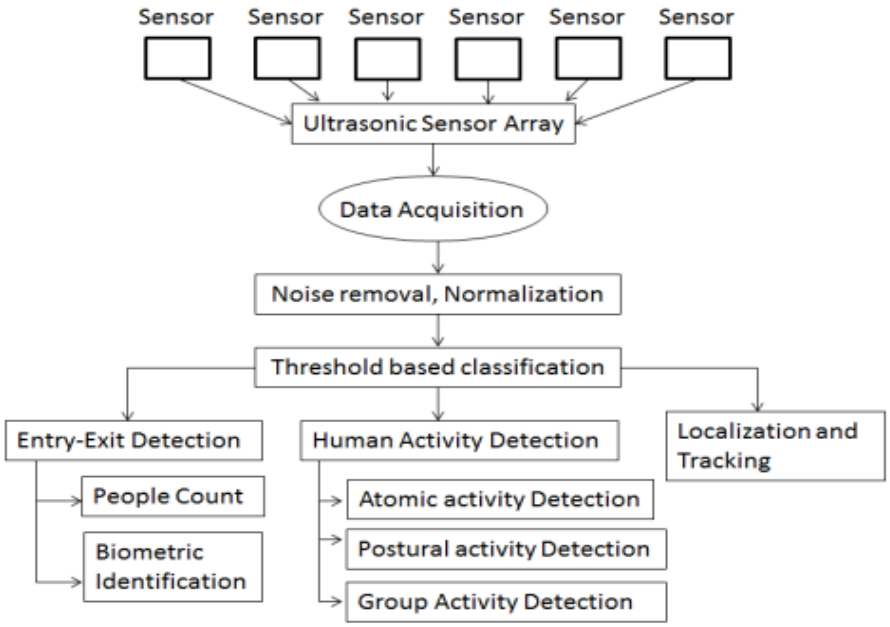
Sl. No.	Name	Cost	Justification
1	UHF Sensor and associated signal conditioning and amplification unit	3.5 Lakhs for 4 quantity	The sensors will be used for detection of faults in electrical apparatus
2	Computation facility	Shared with the common facility	
3	IoT and Microcontroller Platform	Will be shared from the common facility	
4	Data Acquisition System and Software	12 Lakhs	For acquiring analog data, LabVIEW Software, the same module and software will also be used M Tech and B Tech laboratory. The LabView software may be common part of the IoT facility
Total: 15.50 lakhs			

Team Member: Chiranib Koley

Equipment: As Listed.

9. Title: HumanSense: An IoT enabled smart-home testbed for human activity recognition.

Description: Human activity recognition is an important parameter for realizing smart home design. It becomes more significant as people spend almost 90% of their time in indoors. The advancement in sensor technologies has been instrumental in creating interactive and smart-responsive environment. Identification of human activities is a necessary contributor for success of these environments. Activities performed by individuals are the combination of different set of actions and movements. Deploying significant number of sensors in a wireless sensor network will collect information regarding the change of state in its surroundings. This information's in case of individuals can be interpreted as a change in activity. Based on sensor technology many applications have been designed. This low-power, low-cost, high-capacity, miniature sensors can be used to solve real life problems by identifying human activities. For example, in case of security and surveillance, human activity recognition techniques can be used to identify threats from terrorist attacks. As the average age is increasing in developed and developing countries, activity recognition can be used for protecting aged people from accidental injuries. For patients, in hospital or in-house, these can be used for remote monitoring. Designing energy efficient home or office will have significant use of human activity recognition techniques.



Architecture of Human sense

Challenges:

- The definition of physical activities: develop a clear understanding of the definition of the activities under investigation and their specific characteristics.
- Selection of attributes and sensors: the selection of the attributes to be measured and the sensors that measure it plays an important role in recognition performance.
- Sensor inaccuracy: the sensor data play an important role in the overall recognition results.
- Sensor placement: the wrong placement or orientation of sensors could be causing a problem or effect the recognition performance.
- Resource constraints: power consumption is the main factor affecting the size of the battery and sensor nodes.
- Usability: the systems should be easier to deploy and more efficient to use.
- Privacy: sensitive user information should be not invading users' private life.
- Multiple residents: More than one resident can be present in the same environment.

Objective:

- Designing a non-invasive, non-intrusive system for monitoring human activity using array of heterogeneous sensors.
- Developing method for sensor based human identification mechanism for identifying individuals
- Designing technique for recognizing human activities such as standing, sitting, fall, bending, jump etc.
- Designing sensor based technique for locating and tracking individual in indoor
- Developing technique for recognizing group activities using machine learning based models

Hardware Required

Sl No.	Equipment	Specification	Total (approx.))	Justification
1	Proximity Sensor with Accessories (Jumper wires, Power module) (20 units)	Small and light: 0.870" x 0.785" x 0.645" (4.3 g) Long range detection: 0 – 6.45 m (21.2 ft) No dead zone (detections from 0 to 6" are output as 6") Resolution of 1" (2.5 cm) Low typical current consumption: 2 mA Runs on 2.5 – 5.5 V 42 kHz or higher ultrasonic sensor 20 Hz reading rate Free-run or triggered operation Three interfaces (all are active simultaneously)	2,00,000 (each 10,000/-)	Sensing for different human activities
2	Microcontroller with accessories (5 units)	1GHz ARM® Cortex-A9, and an ARM Cortex-M4 I/O real-time co-processor that can run up to 200Mhz. RAM 1GB or higher, Arduino-Compatible through the standard Arduino Pins layout and compatible with Arduino shields. 32 extended GPIOs (A9 dedicated), Wi-Fi 802.11 b/g/n,Direct Mode SmartConfig and Bluetooth 4.0	50,000 (each 10,000/-)	sensor integration
3.	LoRA Module (2 Units)	Freq. 865-867 Mhz (ISM), Data Rate: 20 Kbps or Higher	2,50,000 (1,25,000 each)	Energy aware long distance communication
4.	High Computing SBC with Accessories (10 Units)	Single board Computers UP board with Apollo Lake Intel Celeron Dual Core N3350 up to 2.4 GHZ, on board 4 GB DDR4, 32 GB eMMC	2,00,000 (20,000 each)	Edge Computing devices
5.	Power Monitor (2 Units)	High Voltage Power Monitor (HVPM) supports a main channel output voltage range of 0.8V to 13.5V and up to 6A continuous current	2,00,000 (1 Lakh Each)	Precise energy estimation
Total			9.0L	

Project Members: Sujoy Saha, Mousumi Saha, Subrata Nandi

Equipment: As Listed.

10. Title: Fine-grained Indoor/Outdoor Environment Pollution Map using Low Cost Sensors

Description: Air quality is an important facet of environmental health. Populations in both the developed and developing countries have a significant health burden due to airborne pollutants. Enormous increase in industrialization and unplanned urbanization has caused depletion of natural resources, and at the same time release of harmful pollutants in the environment. The World Health Organization (WHO) estimates that the indoor air pollution causes almost two million premature deaths annually (mostly in developing countries), and that half of these deaths are due to pneumonia in children under the age of five years. Outdoor air pollution is estimated to contribute to 6.7% of all deaths worldwide. Therefore, there is an inevitable necessity to make people aware of the air quality of their surroundings. Existing air quality monitoring stations are insufficient (although accurate) with respect to the area that they are supposed to cover. The collected data often are not available to common people and are difficult to interpret even if available. Hence, in modern context, it is necessary to augment environment sensing by developing tools for fine-grained, real-time air quality monitoring, so as to allow appropriate and timely decisions even at a personalized level.

There has been real-life as well as research-level initiatives [1-8] to develop systems to measure air quality. Monitoring air quality as well as controlling pollution levels has several non-trivial challenges for developing countries like India. Urban air quality changes non-linearly with time and location and depends on many factors including meteorological components, land use, traffic pattern, human mobility, and so on. Due to unavailability of sufficient authenticate data; it is hard to model the aforesaid additional factors as component of air quality. Work places in developing countries suffer by polluted environment as well, due to overcrowded rooms, improper ventilation and poor infrastructure. People in these work places could suffer from health issues due to prolonged exposure to such environment. So, inferring fine-grained real-time air quality of an arbitrary location either indoor or outdoor and forecasting using sparse monitoring stations becomes critical. Considering above, an integrated ICT-based solution using low-cost air quality monitoring devices for inference and forecasting is much needed.

From the above observations, the proposed work goals to design and to implement an integrated ICT-based solution for Environment monitoring. The proposed framework will address the following issues related to the Indoor and Outdoor environment: (I) Design and development of Environment Monitoring Devices (EMD) using low-cost sensors (II) Defining suitable multi-hop calibration techniques for sensors (III) Smart deployment of static EMDs in the given area, which are being augmented with publicly-deployed mobile stations to effectively cover larger area with relatively less number of devices. (IV) Collection of large-scale environment data through the above-mentioned deployment. (V) Based on collected data, intelligent algorithms will be designed for estimation and forecasting of air quality indices through suitable pollution modeling. (VI) Indoor room profiling for pollution aware working environment and break-time recommendation. (VII) trigger alert through social media to make the citizens aware of the real-time environmental conditions.

Challenges:

We are proposing research group has enough research capacity in the field which can eminently be found from our past research publications. In addition, our collaborating team from CMERI has long lasting R&D expertise in various fields of science and technology, including computer science.

Recently published reports by various international organizations such as the Organization for Economic Cooperation and Development (OECD), World Health Organization (WHO), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP), and the World Bank analyses trends in environmental and natural resource issues over the coming decades. One of the issues is urbanization; The urban/rural population split is changing rapidly. Thirty years ago, about 38 percent of the world's population lived in cities. By 2008, more than 50 percent (3.3 billion people) did. A third of urban dwellers (more than one billion people) now live in slum areas that lack basic social services. By 2030, 60 percent of the world's

population (almost five billion people) are projected to live in urban areas, and most of this growth will be concentrated in smaller cities in developing countries and in megacities of unprecedented size in Southern and Eastern Asia. Globally, the urban area expanded by 171 percent between 1950 and 2000 and will increase by another 150 percent by 2030.

Information and communication technologies(ITCs) are playing a key and rising role in environmental management and monitoring. The International Telecommunication Union (ITU, 2008) has identified six main applications of ICTs in environment: observation, analysis, planning, management and protection, mitigation and capacity building. The developing countries face a

number of challenges in using 6 ICTs for environmental monitoring and sustainability. They have problems with limited infrastructure, low institutional capacity, low capacity to integrate scientific data into decision and policy making, and limited capacity to implement policy recommendations. Thus, the current proposal has decent opportunity in near future.

Objectives:

- To develop communication-enabled (3G+WiFi) Environment Monitoring Devices with relatively low-cost sensors for sensing air pollutants (PM 1/2.5/10, CO, SO_2, NO_2, humidity, temperature, etc.) to quantify indoor and outdoor air quality; the sensors are to be calibrated using multi-hop sensor calibration technique(s).
- To design a framework for optimization of budget requirement for placement of static (high-end and robust sensing devices) and public mobile stations (with intelligent low-cost devices) monitoring stations.
- Design and implement algorithms for fine-grained prediction and forecasting of indoor and outdoor environment.
- To develop Smartphone App-based recommender system to help the people in informed decision making in terms of finding less-pollution zones and pollution-aware indoor program scheduling (such preparing class routines in a school/college) with suitable break interval(s), so that the ventilation system of the room/building could be improved.

Team Members: Sujoy Saha, Mousumi Saha, Subrata Nandi.

Details of Equipment & Budget with Justifications:

Sl No.	Equipment	Specification	Total (approx.))	Justification
1.	Environment Sensor (10 units) Meteorological Sensor (2 units)	Carbon monoxide CO 1 – 1000ppm Nitrogen dioxide NO_2 0.05 – 10ppm CO_2: 0 - 10000ppm or higher SO_2:0～20ppm PM diameter0.3~1.0, 1.0~2.5、2.5~10 (um) 03: 0-1000 ppm Ozone Meteorological Sensor(Humidity, Temp, Wind Direction, Rainfall)	14,00,000 Each sensor costs (CO-10000/-NO_2-10000/-, SO_2-20000/-, PM-20000/-, CO_2-20000/-O_3-20000/-, Hum.+ Temp 5000/-) (Wind Direction, Rainfall - 2,00,000)	Fine Grained city scale pollutant data analysis using low-cost sensors
2	Microcontroller with accessories (10 units)	1GHz ARM® Cortex-A9, and an ARM Cortex-M4 I/O real-time co-processor that can run up to 200Mhz. RAM 1GB or higher, Arduino-Compatible through the standard Arduino Pins layout and compatible with Arduino shields.	1,00,000 (each 10,000/-)	sensor integration
3.	Smart phones Android enabled (20 units)	Android operating system with 2.0GHz Snapdragon 625 octa-core processor or higher, RAM: 3GB or higher, storage: 64 GB or higher, WLAN: Wi-Fi 802.11 a/b/g/n, dual-band, WiFi Direct, hotspot Bluetooth:4.2, A2DP, LE, EDR, aptX; GPS:Yes, with A-GPS, GLONASS Sensors: Fingerprint (front-mounted), accelerometer, gyro, proximity, compass, light	4,00,000 (each 20,000/-)	for crowd sourced data acquisition using IMU sensors, light sensors, gyroscope, compass related to human activity monitoring, road surface monitoring. These phones will also be used as testing/designing User Interfaces and field deployment for case studies

4.	FPGA Kit	Virtex – 7, Artix – 7	5,00,000	
5.	Vivado xPro Design Studio		10,00,000	FPGA Design synthesis, mapping, floor-planning, simulation
Total			34,00,000	

Robotics and Intelligent Systems

11.A. Title: IoRT: Internet of Robotic Things for Service Robotics Application

Description: Recently, most IoT initiatives are focused on using connected devices with simple, onboard, passive sensors to manage, monitor and optimize systems and their processes. Even though impactful, the potential of IoT solutions could be further unlocked by exploring the more advanced and transformational aspects of ubiquitous connectivity to, and communication among, smart devices. Robotic systems can aid this transformation because of their inherent ability to sense, think (compute), act (manipulate) and move around (mobility). Internet of Robotic Things (IoRT) is a new concept given by ABI Research that depicts this synergistic nature between IoT and robotics, where intelligent devices can monitor events, fuse sensor data from a variety of sources, use local and distributed intelligence to determine a best course of action, and then act to control or manipulate objects in the physical world, and in some cases while physically moving through that world. IoT-aided robotics applications will grow upon a digital ecosystem where humans, robots, and IoT nodes interact on a cooperative basis. The synergy of IoT and robotics remains largely an untapped field of future technology that has the potential to bring about drastic changes to how we live today. IoT based solutions are changing the way we tackle problems.

Objectives:

- Development of IoT based service robotics system for applications/solutions in healthcare, industry and defence

11.B. Title: Industrial IoT-based Monitoring and Control of different Processes in Steel Plants

Description: Steel making is a fairly complex process – comprising a mix of legacy system as well as state-of-the-art manufacturing machines. To make steel, iron ore is first mined from the ground. It is then smelted in blast furnaces where the impurities are removed, and carbon is added. It involves continuous monitoring the manufacturing process and take immediate or time-bound corrective actions whenever necessary. This makes the job of a plant worker highly tedious. IoT has opened up huge opportunities to enterprises to help improve upon the efficiency, reduce wastages, enable innovations and speed up their digital transformation journey – if implemented properly.

The new Industrial IoT framework generates automatic alerts for preventive maintenance of machines and sends them to remote devices with corrective measures based on large historical data analysis. The analytics platform helps generate these patterns that emerge from the Industrial IoT data that are early indicators of future failures, enabling them to implement predictive maintenance and reduce the number of scheduled service visits.

Objectives:

- Design of predictive model of different processes in steel and iron making .
- Design and development of Industrial IoT-based Monitoring and Control of different Processes in Steel Plants

Industry Collaborators:

- ISP, Burnpur.

- DSP, Durgapur

11.C. Title: IoT-based Intelligent Condition Monitoring of Additive Manufacturing Systems

Description: The new era of Industry 4.0 is demanding new tools and technologies to allow operators, managers and engineers to have a better control and monitoring of the new processes that are becoming available every day. The Internet of Things comes as a solution to integrate and provide a better use of the resources on shop floor. Moreover, industrial machines typically have limited human machine interfaces (HMI), which area not standardized.
IoT and 3D printing might look like the greatest marriage of two buzzwords in the history of technology. The internet of things, after all, unlike the internet of applications and data, takes up 3D space and uses physical materials, including the electronics that control devices and carry their data home. The ability of 3D printers to produce one-offs from CAD designs cheaply and quickly promotes experimentation and is therefore a boon to designers. It should not surprise, then, that in the past few years we've begun to see the convergence of IoT and 3D printing, with 3D printing applied to the prototyping and even manufacturing of circuitry and printed circuit boards, much of it for IoT devices.

Objectives:

- Design of expert systems of different Additive Manufacturing System in Macro, Micro scale.
- Design and development of IoT-based Intelligent Condition Monitoring Systems of Additive Manufacturing Processes

Team member: Shibendu Shekhar Roy, Sujay Saha, Dakshina Ranjan Kisku, Nanda Dulal Jana

Details of Equipment & Budget with Justifications

Sl No	*Equipment /Software*	*Unit*	*Price (In Lakhs)*	*Justification*
1	Soldering stations, Fine welding stations		3.00	Soldering electronic components
2	Wires, breadboards and other tools & accessories for working with electronic components		1.00	Making electronic circuits
3	Basic electronic components, gates, transistors, regulators etc.		1.00	Making electronic circuits
4	Motors, power hydraulic systems, gear systems		15.00	Actuators and movement of robots
5	Robot bodies (with motors and batteries) – 2/3/4 wheeled, caterpillar, 4/6/8 legged, cubelets, legs, wheels, tracks, rollers etc.		12.00	Land robot bodies for various terrains
6	Robots arms – motorized, geared, hydraulic, electromagnetic		10.00	Actuators
7	Sensors, cameras and respective mounts		30.00	Self-explanatory
8	Wireless communication systems		5.00	Control and communication of/with

				robots
9	Ranging and navigation systems		5.00	Navigation and tracking of robots
10	Microcontrollers, development boards (arduino, raspberry pi etc.), motor controllers etc.		8.00	Controlling robots and robot parts
11	Batteries and chargers		10.00	Powering robots
		Total	100 Lakhs	

12. Developing Robots for Assisted Teaching in School and smart electronic voting machine

12.A. TITLE: SMART ELECTRONIC VOTING MACHINE

Description: India is the world leader in the use of EVMs for elections. The Election Commission has conducted all elections through EVMs since 2001. In 2014, a whopping 55.38 crore people cast their votes in EVMs in the parliamentary elections. It has removed the manual counting of the votes leading to faster and error-free result processing. It consists of two units, ballot unit, which has a push button switch against the candidates and voters are pressing the switches to cast their votes. Other is the control unit storing the data in a small ROM. However, following capabilities are absent in the present EVMs.

(a) Checking the identity of the voters, which is presently done by the polling officials?
(b) Data analytics (Storing and transferring the data)

Identity of the voters is presently manually checked and data is stored in the small ROM of the EVM. Therefore, it is necessary to incorporate the activities of the polling officials inside the EVMs.

Challenges:

- In February 2004, the Karnataka High Court hailed, the electronic voting machines (EVMs) used by the Election Commission of India as 'national pride'. That pride of the largest democracy of the world is today facing the crisis of credibility. Many prominent leaders in the country have raised doubts about the reliability of EVMs.
- There are about 120 countries in the world that practice democracy. Of all those democratic countries, only about 25 have experimented with or used electronic voting machines to elect their governments. So, the EVM is not the dominant choice of the world for recording votes in elections. It is because of again the reliability of security of the system. Also, the data transfer and chance of hacking the data.

Objectives:

- *Checking of the identiy of the voters:* A camera based face-recognition system will be placed along with a finger-print detector will be placed against the each button of the EVM switches. A voter will be able to cast the vote only when finger print matches with their **aadhar data.**
- *Data Analytics: S*toring all data, starting from photograph taken to casted votes and sending report to the election commission on real time.

Details of Equipment & Budget with Justifications

Sl No	*equipment /Software*	*Unit*	*Price*	*Justification*
1	Electronic Voting Machines	02	5lacs	Acting as the base platform for the smart-EVM
2	Camera	02	1lacs	For collecting the images of voters
3	Computer	01	1lacs	For processing the images and face recognition, finger print detection
4	Electronic Components (Touch switches, LCD screen, Keypads, DDRAMs, LEDs)	02 each	1lacs	For fabrication of smart touch switches
		Total	**8 Lakhs**	

12.B. Title: Developing Indigenous Robots for Assisted Teaching in School

Descriptions: In today's' technology-driven world, it's important now more than ever to prepare students for the future. Teaching robotics to young students throughout their schooling can increase their ability to be creative and innovative thinkers and more productive members of society. Robots are increasingly being used to teach students in the classroom for a number of subjects across science, maths and language. Develop a robotic platform able to carry out certain functions of a teacher. Research shows [1] that robots are much more likely to be used as learning tools than as teachers in a classroom. Humanoid robots are being widely utilised in classrooms in many countries including, Japan and South Korea. In Singapore, admired globally for its education system, authorities are trialling the use of robotic aides to teachers in kindergartens. Two humanoid robots, Pepper and Nao, assisted teachers in a seven-month trial at two Singapore preschools last year, while technology-enabled toys such as Kibo were deployed at 160 nurseries, including Sparkletots. obots are particularly suitable for engaging with children on the autism spectrum. Children on the spectrum respond to the calm, clear, consistent interactions that robots can provided.

1. *Muneeb Imtiaz Ahmad, Omar Mubin, and Joanne Orlando. 2016. Understanding Behaviours and Roles for Social and Adaptive Robots In Education: Teacher's Perspective. In Proceedings of the Fourth International Conference on Human Agent Interaction (HAI '16). ACM, New York, NY, USA, 297-304. DOI: https://doi.org/10.1145/2974804.2974829*

Challenges:

- The Cost of the Robot comercially available is so high.
- Teachers are in general unaware of robots and hence there was a technological bias associated with their opinions.
- Teacher preferred the robot to not have full autonomy and instead take on restricted roles in the classroom. The teachers also want full control over the robot. Thus, teachers are slightly reluctant to use them in the classroom.

Objectives:

- Development of smaller robots or toolkits are particularly used to teach robotics or computer science. By teaching our students the basics of robotics, we can open a whole new world to them and exciting opportunities that they wouldn't have access to otherwise.
- Development of appropriate interfacing mechanisms (software, hardware or even mobile apps), allowing the human teacher to control the robot with minimal training.

- Development of Prototype with following functionalities:

Function 1: Lesson loading and delivery (showing videos or ppt presentations over the projector while delivering the lesson)
Function 2: Assessment after each class (formative assessment)
Function 3: Marking attendance by Face recognition
Function 4: Data Analytics (storing all data in cloud, starting from attendance report, lesson delivered, and assessment scores) and sending report to the class teacher real time.

There are some humanoid / intelligent robots, which are now used for assisted teaching. Some of them are listed below with their capabilities.

Robots	SAYA	RoboThespian	Nao	ASIMO
Photo				
Developed By	Professor Hiroshi Kobayashi, The Department of Mechanical Engineering, Tokyo University of Science, Japan	Engineered Arts Ltd., UK	Aldebaran Robotics, Paris, France In 2013, it is acquired by SoftBank Mobile, Japan	Honda Robot, USA
Present Status	• It is called as the World's first robot teacher. • Tested in real classroom in 5th and 6th grader • Initiated in 2010	• Tested with sixth grader • 15 languages are supported • Can create customized motion routines • has fully articulated hands and fingers	First came in March 2008	In 1986 initiated and in early twenty first century it has born.
Degrees of Freedom (DOF)	For facial expressions 18 motors are installed. It is not mobile (can't walk)	Over 30 It is not mobile (can't walk)	It has three categories having 14, 21 or 25 DOF	34
Capabilities	• facial expressions– happiness, surprise, fear, disgust, sadness and anger • Head an Eye movement • Speech -- shout orders like "keep quiet" • Memory consists of 300 phrases and 700 words • Android type communication	• Move its arms and legs • Embedded SHORE facial recognition software allow real-time recognition and reproduction of facial expressions • 40+ faces	• Can see, speak and reacts • Can browse internet, interface with internet	• Turn light switch, open doors, carry objets, push carts • Synchronize with humans • Walking and running across different terrains • Avoid obstacles,

		installed		recognize moving objects • comprehend and respond to simple voice commands
Cost (INR)	Not available readily in the market. Approx. cost **20Lakhs**	Approx. **2.5crores**	Initial cost is **7 to 10 lacs +** Software user licences is valid for 1 year, it can be extended with 1lacs per year	Nearly **16crores**

Important Features: Two key features of such robot are as follows

(a) Structure of the prototype Humanoid Robot: We will be using Nao robot for the said purpose. One such robot will be purchased and its capabilities will be enhanced.

(b) Capability enhancement of the Humanoid robot: Lesson delivery will be done using text-to-voice converter and lesson loading will be done by zip-drive based content repository (pen drive, hard drive etc. having cloud accessibility). After the lesson is delivered, a criteria-based-assessment (MCQ) will be done and disseminated to the stakeholders after each period. Currently, it will not have Voice to-Text Search capability and hence it'll be unable to answer students' verbal queries.

Proposed functionalities:

- **Function 1:** Lesson loading and delivery (showing videos or ppt presentations over the projector while delivering the lesson)
- **Function 2:** Assessment after each class (formative assessment)
- **Function 3:** Marking attendance by Face recognition
- **Function 4:** Data Analytics (storing all data in cloud, starting from attendance report, lesson delivered, and assessment scores) and sending report to the class teacher real time.

Tentative Budget: Rs. 15.5 Lakhs

Item / Description	Purpose	Specifications	Number of Units	Total Price (INR)
Nao Robot	Acting as a mobile platform in the class	14 dof Nao Robot with three years software licence	1	13,00,000
CAMERA	• For detecting the motion of the objects • Face recognition	• The camera should be mounted on a robotic base. • Detection capability of around 100 ft range • Wifi + Bluetooth enabled • Mini HDMI • Upto 2Hours of battery life • Waterproof and shock resistant • Microsd card slot • Optical zoom between 20 – 40x. • Make: SOLOSHOT	Two	1,00,000
Computer / Laptop	For processing the videos / images.	• RAM should be above 32GB. • Good graphics quality	One	1,00,000
Smart Display	Standard	• HDTV Compatibality	One	50,000

unit / Smart LCD projector		• Video compatibility of NTSC, PAL, SECAM \xE2\x80\x8E • 3D support and compatibility. • Make: BenQ preferred		
			Total	**15,50,000**

Team members: Nirmal Baran Hui, Bibhash Sen

Device/Sensor

13. Title: E-Sec: Development of Embedded Hardware Security for IoT applications

Description: The security principles for IoT devices include important aspects such as the proper authentication and verification of the identity in order to ensure that only legitimate users are accessing the resources while any access intentions of unauthorized users are rejected. The devices, as well as users, need to be authenticated, and it is equally essential to guarantee protected procedures for authorization, confidentiality, integrity and availability. IoT devices are potential entry points to wider IoT systems. Different IoT devices, including both new connected devices and more traditional network equipment, unauthorized access to wider networks, databases, and systems can be obtained, therefore increasing an attack vector. Hence, it is critical to not only ensure confidentiality, integrity and availability, but also to take into account proper access control mechanisms – specifically identification, authentication and authorization procedures. The current trend indicates that there is an increased need and market opportunity for embedded hardware and/or software security in IoT ecosystems. Which mechanisms to implement will depend on the security requirements of the specific IoT application. Security principles can be applied in the IoT system at the device level (among other levels) through the use of embedded hardware which can ensure proper authentication and access control mechanisms. Embedded hardware may be a "secure element," or another IoT device hardware element with security functionality (such as incorporating the Trusted Execution Environment (TEE) in the microprocessor). Hardware-based secure elements can provide the high level of security required by many IoT applications.

Challenges:

- Security must be balanced with cost, implementation effort and end user convenience. There is an unavoidable give and take between the level of security and convenience provided by any solution. It is critical to strike the proper balance between required security levels, and cost or even feasibility of implementation. For example, a portion of IoT devices, such as certain sensors, may lack sufficient processing capability for advanced cryptographic operations.
- Achieving an architecture that is standardized among different devices, applications and networks is also a challenge to implementing defined security principles and standards.

Objectives:

- Development of Robust, tamper-resistant system based on PUF.
- Designing key-less cryptographic system with PUF.
- A proven, standardized means for securing communications between the device, the security-focused hardware element, and external entities such as mobile network servers and other systems interfacing to the IoT system.
- Protection against both virtual and physical attacks (such as power analysis or tampering), with appropriate up-to-date shielding techniques
- Detection of IC counterfeit issues.

Details of Equipment & Budget with Justifications

Sl No	***equipment /Software***	***Unit***	***Price***	***Justification***

01	MDK-PLUS-F-ED10: Software: MDK-ARM Microcontroller Development Kit – PLUS Edition,	10-(Ten) users Floating License	7 Lakhs	• Embedded system development of IoT applications • Designing embedded model for IoT devices.
02	ESA Keil MCB1760-ED Evaluation Board	08 unit	1 Lakhs	Debugging and verification developed system
03	ESA Segger J-Link EDU (JTAG Debug adapter/Flash Programmer)	08 unit	1 Lakhs	
04	FPGA Kit for PUF and IOT System (Intel Nino, Artix 7, Raspberry PI 0 W, PI3 board etc) and Sakura Board (2 unit)	1 unit.	9.5 Lakhs	Development of Prototype of security module for IoT systems.
		Total	**18.50 Lakhs**	

Team member: Bibhash Sen, Suchismita Roy, Mamata Dalui, Ashis Kumar Mall, Rajat Mohapatra, Jaydeep Howlader, Debasis Mitra, Suvrojit Das, Anirban Sarkar and NIrmal Baran Hui.