AAU PhD Degree

Tentative Detailed Plan of Research

Title:

Design of Internet of Things Architecture for RPC areas

PhD Candidate

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AALBORG UNIVERSITET

11 Month Provisional PhD Study Plan

Doctoral Programme:	**Wireless communication**
Project title:	**Design of Internet of Things Architecture for RPC areas**
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Date of enrolment	**15 Nov 2009**
Expected date of Completion:	**14 Nov 2012**
Signature	
Signature	**Mrs. DipashreeMilindBhalerao]**
Date	**/ 07 / 2011**

Study plan approved

Date	**Supervisor**	**Prof. Ramjee Prasad**
Date	**Co-Supervisor**	**Prof. Ole Brun Madsen**
Date	**Head of Department**	**Prof. Børge Lindberg**
Date	**Head of Doctoral Programme**	**Prof. GertFrølund Pedersen**

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Design of Internet of Things Architecture for RPC areas

1. Summary

1.1 Key motivation

Development of people with education and providing the medical assistance for saving life in rural, poor and catastrophic areas is very much important. It is good to be a significant part of such a network architecture design, which is useful to each and every one in the world. Internet of Things (IoT) would be of living and nonliving things networked together with many different communication networks and many technical and non-technical challenges.

Most of the time catastrophes are a natural calamity. Other catastrophes can be created because of problem in hardware of software working. The loss of communication systems made rescue and relief operations rather difficult costing many lives unnecessarily. To come out of these problems, communication must be there.

After analyzing all the challenges and understanding the importance of this topic, it was decided to finalize the subject as "Design of Internet of things architecture for interoperable heterogeneous networks with special focus on Rural, Poor and Catastrophic area". This architecture will be a solution for placing smart objects in farms, catastrophic areas or other places which are required to be connected to IoT. Architecture will integrate all types of smart objects based on device adaptability, heterogeneity, scalability, security, data volumes and discovery mechanisms. Indirectly it will take care of tracking and tracing of all objects, finding faults, controlling power, giving alarms and may more services. Most of the farms are in rural remote areas. As the population in RPC areas count for more than two third of the world population, it exposes an increasing global problem in the digital divide in addition to the socio-economical divide.

1.2 Significance

Although the main objective of this new network architecture is to connect each & every place with all things together, the real fact is that RPC areas are not easily seen as part of this network due to their low or nonexistent connectivity, economical constraints or conditions due to catastrophic events. The developed IoT architecture will help in agricultural development with which economy of India is based. Farms are monitored with sensor networks for different reasons like water content in soil, chemical content in soil, quality of

the farm products and for many more reasons. The same information will be put up on the net. Once the network architecture is successful in providing connectivity at remote rural area, development of farmers also will take place. Architecture will help in improving better living standards with e-learning, e-medicine, agricultural development and saving life of many people from catastrophic areas. As the work is conducted under the Global ICT standardization Forum for India (GISFI) initiative, special attention will be made to the contribution of results in the international standardization activities.

1.3 Methodology

Analysis of the project indicates that long distances, broken and heterogeneous networks which lead to huge non refundable, recursive investments are the main problems for providing the Internet in RPC areas. Architecture shall take into account requirement of very long distance coverage with heterogeneous networks as a prerequisite. Application software will be developed for sensors or active objects from farms, from catastrophic area (according to type of catastrophe) and from other applications related with rural, poor and catastrophic area. Object events help in generation, integration, and filtering, storing number of business processes related with application. They also help in monitoring and controlling these business cases.

Actual experiments, simulation models and software development will be applied in the research. Field study of some RPC areas will be used to acquire more detailed information as input and to verify the viability of the proposed architecture. A new more scientific approach is expected to identify and classify RPC areas from an ICT point of view in order to create an improved decision support base for the various actors in the overall global evolution of the ICT world.

1.4 Expected outcome of PhD study

With new approach rural farms, catastrophic events, and other applications will be connected to the world through IoT. Power utilization will be implemented efficiently according to conditions. This will lead to fewer failures in connectivity. Environment monitoring will become easier. It will become easy to know when Catastrophe is going to occur and take prior actions through IOT as well as separately if required.

2. The scientific content of the PhD project:

2.1 Background

Internet of Things (IoT) [1] is characterized by ubiquitous, pervasive, seamless networks. The Strategic Research roadmap is provided by European Commission [2]. This future or global network should have a generic architecture which will complete the requirements of upcoming heterogeneous networks, changing service requirements and will absorb all present ones. The new architecture shall support all the future requirements for ubiquitous, seamless, pervasive and expandable networks. EPC (Electronic Product Code) standard global model is already defined. But still there is a need of enhanced global IoT Architecture. Architecture shall be a foundation of the network, on which many networks can be erected. The tables (1 and 2) presents an analysis of research papers as well as CERP- IoT research projects (Cluster of European Research Projects on the Internet of Things) based on six architecture metrics as scalability, heterogeneous interoperability, security and privacy ,discovery mechanisms, data volume and device adaptability . The table has analyzed the different aspects of global architecture design.

2.2 State-of-the-art for the PhD project

There are approximately 100,000 billion of objects to be connected to the Internet [3]. In the present Internet connections figure, billions or trillions of other new connections will be added. These new connections are nothing but Virtual or physical Things or objects.

Different approaches for architecture designs are available. To name a few, service oriented architecture [4], resource oriented architecture (Web of Things) [5], EPC global architecture [6] and many more are available. SOA concept lies on an ontology-based mediator component, which is capable of composing queries to any combination of relevant logistics data sources. Wrapper components handle the transformation to and from the relevant data sources in a rule-based fashion. SOA and WoT are using top to bottom approach. Web of Things (WoT) architecture is based on the RESTful principles, which leads to the evolvability, scalability for popular success of the Web. Popular Web technologies (e.g., Ajax, Ruby, HTML, JavaScript, PHP) can be used to build applications involving smart things. Users can enhance very basic Web mechanisms (e.g. caching, searching, browsing, Bookmarking and linking) to interact with devices for sharing their information.

Table I: important features from paper and EU projects architecture

paper Ref. No	Architectural metric	Building blocks	IoT special features covered	Challenge	Applications
7	Scalability	Unit IoTmodule, global IoT Module	1.Ubiquitous, systematic hierarchy to connect entire world using IoT with security, safety, freedom, and restrictions at each level, 2.Standardization	1.Designing such architecture itself is a challenge-	Industrial, Environmental, Societal
8	Heterogeneous interoperability	Mobile device as a reader, wireless internet	1.Tracking and tracing 2. Safety	security	Cooking ,washing
9	Heterogeneous interoperability	Wireless sensor network, cellular network, Internet	1. RRM algorithm to provide Internet connectivity to all sensor nodes within WSN and some scattered nodes in CN covering heterogeneity. 2.RRM achieves capacity gain over the WSN and CN access and spectrum	1.For All type of networks in IoT Such algorithm can be found out	Telecommunication applications in selecting access technique and spectrum
10	Heterogeneous interoperability	Different types of RFIDs	1.Address mapping problem of variety of RFIDs at MAC layer is considered with new suggested protocol General Identity Protocol (GIP)	1. To check the computational complexity. 2. To reduce the length of header, add security, improve QOS performance.	In all IoTapplications
11	Device adaptability	WSN, wired or wireless Internet as per requirement	1.Intelligence is provided with different types of contexts	1. Achieving self capabilities	Intelligent power grid
12	Web of things, resource oriented	Web services, smart objects	1.Web based search for things information, enterprise services, business intelligence, easy implementation of applications	1.Providing web pages for all things, speed of operation, service discovery	Web based services, energy monitoring and control systems
CERP projects					
13 Cute-Loop	Heterogeneous interoperability, security and trust, device adaptability, service oriented and event driven architectures and more		1. Decentralized intelligence is provided. 2. Supports features for all types of architectures mentioned. 3. Services on heterogeneous sensor, GPS or RFID readers. 4. Key elements for frame work Network devices enabled services (NDEI).	1.Decoupling, heterogeneity, 2.Distribution and decentralization, 3.Connectivity, scalability and cost and Trust	Food chain and craftsmen business world
14 SMART	Service oriented architecture and many more	RFID integrated	Shelf inventory tracking, smart recall, promotional management, dynamic pricing system, Case and item level tagging, innovative consumer applications, promotion management system.	1.Redability, data management and aggregation 2.Consumer privacy, health corners, organisational impact and support	supply chain services in retail Industry.
15 TRACER	Service oriented architecture more	RFID, client server architecture, Web Services	1. Any standard can be used for identifiers and network operations.	1.Tag readability, technical and financial 2.Cross company transparency	Entry level solution package for very small industry or users who require lightweight tracking.
ASPIRE - 16 HYDRA- 17	Heterogeneous interoperability and more	Middleware, JMX management module	1.Implements EPC standards 2. Business events generator with filters. 3.connector application 4.Actuators, IDE	1. Different layers communication architecture from different business contexts. 2. Middleware design for a reducing a high entry cost for RFID/Sensor technology adopters, SMEs.	Logistics, textile apparel, cold chain Management, and process management
18 STOLPAN	Heterogeneous interoperability SOA, and more	Mobile RFID reader, NFC, service, distributed wireless and wired devices	1. Implemented tracking and tracing for individual small scale company level, without connecting it to internet.	1. Challenges are standardization in heterogeneous interoperability, business and logistic models.	Applications related with smart mobile and smart things

Table II: Number of features covered in above architectures

									CuteLoop	SMART	TRACER	ASPIRE Hydra	STOLPLAN
Paper ref no.	5	6	7	8	9	10	11	12	13	14	15	16-17	18
Scalability	✓											✓	
Het. Interoperability		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Discovery mechanisms								✓	✓				
Data volume								✓	✓				
Security and privacy						✓		✓	✓			✓	
Device adaptability					✓	✓		✓	✓	✓	✓	✓	✓

Above analysis indicates that there is a need of generalized architecture which will cover mentioned six metrics. Also none of the architectures have taken into account the power requirement.

2.3 Project's objectives

Objectives of the PhD subject are:

1. To design the IoT service oriented architecture with heterogeneous interoperable features.
2. To provide a means of providing indication before catastrophe will occur.
3. To define rural, poor and catastrophic areas from ICT point of view

2.4 Key Method

The IOT network architecture designing methodology will be as follows:

a. Geological survey of actual location will be carried out for placing nodes, base stations, etc.

b. Requirement analysis for IoT architecture will be carried out.

c. Fix up the technology/methodology for covering long distances of remote rural areas for providing connectivity.

d. Design Network architecture for IOT (figure I) with special focus on rural, poor and catastrophic areas. With the help of simulator NS2, analysis will be made for data, devices, services and networks heterogeneous interoperability for different parameters.

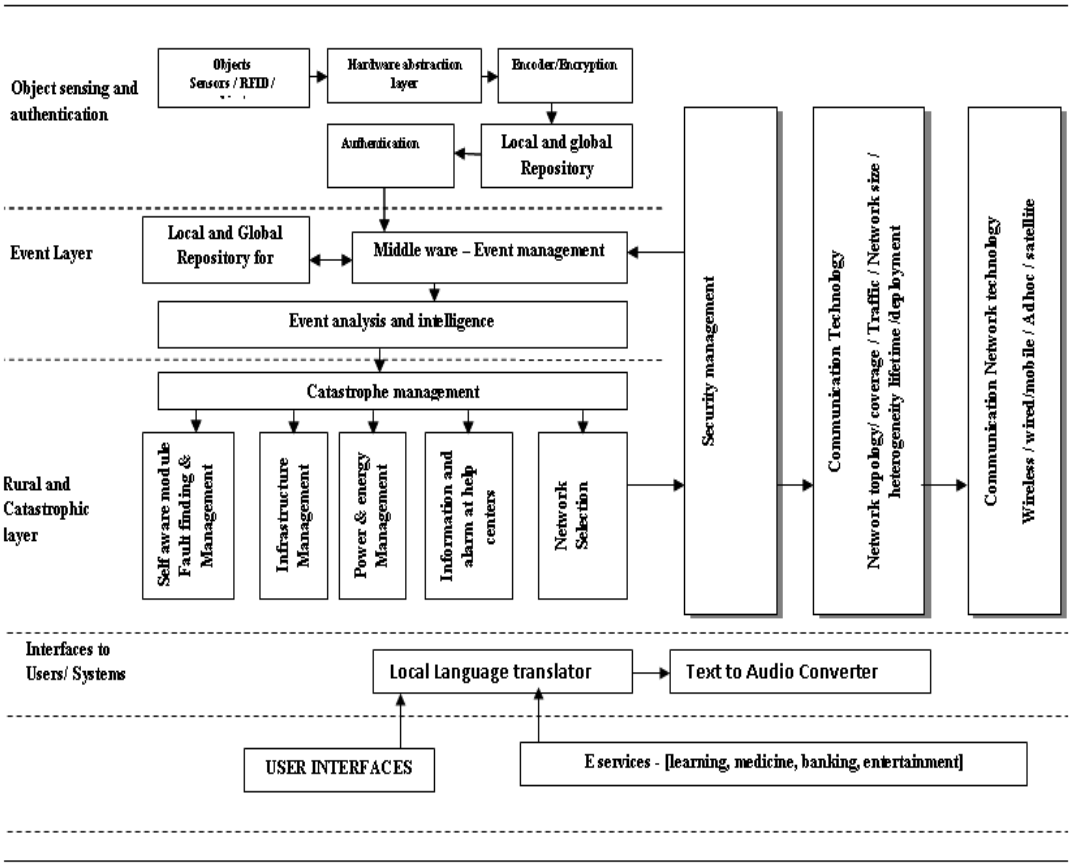
e. Develop a package (protocol) for generating event based heterogeneous interoperable services for rural and catastrophic areas. Events specially related with

rural and catastrophic areas like infrastructure, fault finding, power and alarm shall be taken into account.

f. To define RPC areas from ICT point of view, mathematical model based on Okumura hatta [19] model and quality of service model is suggested.

The network architecture in (figure I) is developed based on RPC requirement analysis and Cluster of European Research projects (CERP) and individual research papers state of the art.

Figure I: Suggested IoT Network Architecture for rural and catastrophic area



Scenario 1: General Aspects of the Locality

The Sunderban is the world's largest mangrove forest area, with an area of about 30.000 sq. km. One third lies in West Bengal, India and the rest in Bangladesh. The whole area consist of island surrounded by a network of large and small rivers and canals watered by the river Ganges and the tide from the ocean as a giant delta system.

Half of the Indian side of the Sunderban is inhabited with approximately 4 million people with an average income of 10,000 – 12,000 Indian Rupees per year/family. The other half is a

forest reserved area, which plays a vital role environmentally for the whole area. This we can take as a best scenario for the connectivity.

The area represents all three aspects of an RPC area, although only 100 km from Kolkata. It is remote due to lack of infrastructure in term of general infrastructure like roads, water supply and electricity as well as lack of access to ICT infrastructure. It is poor due to overpopulation and very low income. The area is time after time flooded in connection with cyclones, due to the low altitude and was hurt by earthquakes in connection with the tsunami a few years back.

Scenario-2

In India, 70 percent area is rural and most of it is poor. Areas near major cities also have problems in communication. Sinhgad is a fort near Pune city, in Maharashtra state. It is approximately 50km from Pune. One side of it has connectivity, but other side doesn't. It is poor and most of it is agricultural area. It can be thought of as a scenario for project. Lack of connectivity is because of very low income of people.

2.5 Potential significance and application of the projects expected outcome

Small contribution will be given to development of future IOT applications and technologies. Recommended network architecture shall automatically take care of fault findings (self awareness), energy saving, e-services and interfacing of smart devices. The power monitoring and controlling feature is useful in any application. It will lead to green IOT. As network devices will have intelligence, they are self aware. This will help in fast fault finding or self diagnosis Fault finding feature is helpful in recovering the problem. This will also lower the maintenance required giving system output.

Maximum rural, poor and catastrophic area will be covered with smart objects for different applications. Life of people will be saved or rescue from catastrophe will be made easier by proper alarming system. Education, medicine of rural area facilities will be provided in very economical way. Medical facilities can be availed at required time, saving life of people.

2.6 Project milestones

	Task	Year 1			Year 2					Year 3			
1	Define RPC areas												
2	Geographic and requirement analysis of field												
3	Design of IOT network architecture												
4	Deciding the communication technology												
5	Experimentation												
6	Application software development for integration of power, fault finding and other features architecture												
7	Package testing												
8	Thesis writing												
9	Paper and conferences												
10	Teaching and supervisions												

2.7 Thesis

		chapters
1		Abstract,
2		Introduction
3		State of the art IoT architecture –**Survey paper for IoT Architecture**
4		RPC area Definition
	4.1	Rural-Poor area behavioral model -**Paper**
	4.2	Catastrophic area behavioral model **(paper accepted)**
	4.3	RPC area mathematical model - **Paper**
5		Geographic and requirement analysis
6		Design of IOT network architecture - **Paper**
7		Analysis of data, devices, services and networks for heterogeneous interoperability for different parameters - **Paper**
8		Experimentation
9		Package (protocol) development for mentioned Architecture -**Paper**
10		Package (protocol) testing
11		Out puts and results
12		Result analysis
13		Paper and conferences
14		Teaching and supervisions
15		References

3 Agreement on the relationship between supervisor and student

Roles

- The student and the supervisors are together responsible for time management in the project. Time plan for the Ph.D. study should be reviewed every six months.
- Supervisor, Co-supervisor (India) will provide technical assistances and supervision.
- The student should be able to get access to lab equipment and technical assistance from both AAU and STES. In cases when advanced equipments are required, the student should make a request at least one month in advance and the supervisors should help the student as much as they can.

Type of collaboration

- Telephone conferences two times a month between the student, supervisor, the AAU co-supervisors and Indian co-supervisors. As per requirement extra meetings or communication through mail continuously will be done. Joint meeting once in a two month will be continued.
- Workshops every six months.
- Minutes will be made for telephone conferences and workshops.
- Feedback regarding the progress and quality of work will be given during the meetings, conferences and workshops.

Supervision meetings

- Most meetings are scheduled and arranged jointly by the student and the supervisors. In case of special needs, both student and supervisors can call for a meeting.
- Agenda will be provided by the student one day prior to each meeting.
- Common documents will be distributed and maintained via e-mail and/or AFS servers at AAU.
- Every year 3 months PhD Student will be in direct contact with Supervisors at AAU and telephonic and video conferencing meetings with Indian co-supervisor. Remaining 9 months PhD Student will be in direct contact with Indian Co-supervisor and Telephonic and video conferencing with AAU Supervisors.

Workplace participation

- The student is involved in group activities at AAU and STES both.
- The student will frequently meet with research group at AAU and renowned Institutes and multinational companies in India
- Group meetings at STES are usually organized once in a year.

Development plans

- Building Professional network

Writing papers

- Paper writing is on the basis of collaboration between the student and the supervisors. In most of cases, the student prepares the first draft and the supervisors give feedback and comments timely.
- The student will present his/her work at biannual workshops.

Characteristics of and expectation to the research

- Novel Ideas towards standardizations and patents

Developing the cooperation and updating the agreement

- This agreement will be evaluated every six months.

4. Plan for PhD courses (both general and project-related courses)

Courses	Place/ Organizer	ECTS	Joint or Project course	Status
Introduction To Internet Of Things	Nilee Prasad, AlbenaMihovska, ZhengHua Tan, Ole BrunMadsen,Aalborg	1	Project	Completed
Intellectual Property Rights	LisbethTvedLinde	2	Joint	Completed
Vehicle Communication	Tatiana Kozlova Madsen and Hans-Peter Schwefel	3	Project	Completed
Air Interface Design for Future Wireless Systems – Towards Real 4G and Cognitive Radio	Prof. RamjeePrasad, Prof. Frederikson , SuvraShekhar Das, Nicola Marchetti	4	Joint	Completed
PBL and Engineering Education Research – from research questions to research methodologies and publications.	Erik de Graaff and Anette Kolmos	4	Joint	Applied
Distributed Source Coding and Multiple Descriptions	PostDoc Jan Østergaard	3	Joint	Applied
Writing and Reviewing Scientific Papers, Fall 2	Professor JakobStoustrup	3.75	Joint	Applied
PBL In Engineering And Science – Development Of Supervisor	Professor AnetteKolmos	2	Joint	planned
Professional Communication	Professor AnetteKolmos	2.5	Joint	planned
Localization In Wireless Networks	Professor Bernard H. Fleury&HenrikSchiøler&JakobGulddahl Rasmussen & Hans-Peter Schwefel	3	Project	planned

Design choices and tradeoffs in Computer Systems	Bruce Shriver	**2**		
Subtotal (Planned)		**31**		
Total (Completed)		**10**		

*Based on the PhD Courses Catalogue and the courses available in India, this list may change

5. Plan for dissemination of knowledge and findings from the project

1. Most of the findings from the research work are going to be published in official conferences and included in the IEEE database according the standard proceedings.
2. Furthermore, depending on the quality of the future results, other ways of dissemination -as newspaper articles, seminars, etc. will be considered.
3. Depending on the solution and the application, some findings can be published as patents.

5.1 Publication plan

Conferences:

Paper Accepted:

1. Dipashree M. Bhalerao, M. Tahir Riaz, Michael Jensen, Ole Brun Madsen and RamjeePrasad,"On the New Global ICT Model"at ICACT Korea (IEEE sponsored).

Paper Submitted

1. "Internet of Things Network: An Architectural Survey"submitted at IEEE communication survey and tutorials journal.

Ready for submission (finishing is left):

1. "On the Use of the Universal Okumura-Hata Model for Defining Different ICT Areas"

Future submissions

Sr. No	Conference name	Paper Title	Date
1.	ACM/IEEE Journal for computer network	"Mathematical Modeling for Rural, Poor and Catastrophic (RPC) area" (Journal)	20/05/2011
2.	IEEE 13th International Conference on High Performance Switching and Routing IEEE HPSR 2012	"Heterogeneous Interoperability Analysis of data, devices, services and networks for IOT" (conference)	2012-01-20
3.	ACM/IEEE	"Heterogeneous Interoperability Protocol forQoS	25/2/2012

	Journal for computer network	Improvement "(Conf/Journal)	
4.	Wireless communication and networking (WCNC)	"The IOT Future Generalized architecture" (conference)	1-4-2012

5.2 Supervision of Masters Theses and Teaching–

1. Guiding and teaching Master theses (post graduation) students from communication discipline. Subject is given as visible light communication, self awareness Technology, and range improvement of wireless sensor nodes.

6 Agreements on immaterial rights to patents

The outcome of the research work will be registered for IPR and all the rights will be shared between the Aalborg University and the PhD student, following the standard procedures at AAU.

7 Plans for external collaboration

I will work along with research groups from IITs, Hydrabad, India (Under guidance of Indian supervisor).

8 Financing budget for the PhD project

CTIF, Aalborg University will provide the research facility.Expenses for tuition fee, lodging, boarding and travelling will be borne by STES, Pune.

9 Short References

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