IoT Based Sensor Networks:
Architectural Optimization of a Large Scale Cloud Based System

Name: Indrajit S Acharyya   **Supervisors: Prof. Adnan Al-Anbuky and Dr. Sivakumar Sivaramakrishnan**

Sensor Network and Smart Environment Research Centre (SeNSe), Auckland University of Technology, New Zealand

Introduction

Research work on 6LoWPAN-based IoT-sensor networks and cloud computing has gained enormous interest and widespread attention within the sensor network domain. Through a standard interface such as 6LoWPAN/IPv6 (Internet Protocol version 6), the combination of 'Cloud computing' and PSC can serve as an efficient infrastructural framework for WSN-IoT integration and Big Data management [1-4].

A system architecture of PSC governed by remote server or the cloud over the internet is proposed, with SDN/softwarization being the actuators. The PSC end-devices capture/sense environmental data and escalate it to the IoT-based cloud infrastructure which acts as the sink for the entire PSC network data. This PSC data so accumulated is used for data analysis. The organization has the potential for facilitating the dynamic interaction between the PSC and the remote management software including the virtual sensor cloud. The proposed research work intends to achieve the objective of better control of operation of PSCs via such dynamic interaction so as to get it to react to the dynamics of the monitored phenomena.

IoT-WSN Applications

Fig.1. Smart Farming.

Fig.2. Smart Agriculture.

Fig.3. Smart City.

Fig.4. Shared Spaces.

Research Questions

❑ For a typical large scale PSC (governed by a remote cloud through the IoT) to be vastly flexible in adapting to service requirements,

- how could implementation of the concept of WSN softwarization/ virtualization at the cloud level enhance flexibility of network engagement with the physical world?
- how and to what extent would implementation of an multi-SDN controllers at the cloud level and/or SDN-based solution at the WSN level impact and flexibility of the system architecture of the PSC?

Research Objectives

❑ To develop an organization for closing the loop between the PSC and cloud resources represented by the VSC via implementation of WSN softwarization within cloud services to remotely influence PSC dynamics so as to increase architectural flexibility.

❑ To utilize the concepts of SDN/softwarization to expand the degree of freedom available for control of the contextual data flow at both the upper communication layers (e.g. adaption) as well as the lower protocol layers of the PSC and study the effects of its implementation.

❑ To establish an optimal architectural organization, via physical experimentation, with respect to following:

a) Dynamic PSC cluster formation (How to group the end devices?)
b) PSC granularity
c) Which level would be the ideal position for softwarization capability to reside? At the cloud level? At the IoT-Gateway level? Or both?
d) IoT Clusterhead rotation

Proposed Conceptual Approach

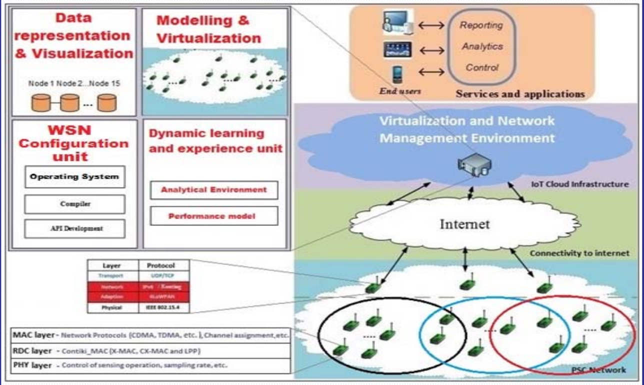
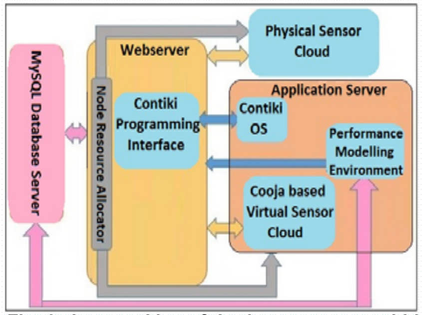


Fig. 5. IoT Cloud server and sensor network architecture.

Remote Server Organization



Application server – hosts Contiki OS, network simulators & analytical software

Web server – uses REST APIs to communicate with users

Database server – implements MySQL as the RDBMS

Fig. 6. Interworking of the 3 components within the remote server [5].

Abbreviations

- o **IoT** - Internet of Things
- o **WSN** - Wireless Sensor Networks
- o **SDN** - Software Defined Networking
- o **PSC** - Physical Sensor Cloud
- o **VSC** - Virtual Sensor Cloud

Future Work

The future of this research work will include:

❑ Formulation of an analytical model and system re-implementation (PSC & VSC)

❑ Cloud software organization development for interaction between PSC and VSC.

❑ Data collection and analysis to compare pre and post softwarized scenarios

❑ Refinement of SDN model for reimplementation on PSC

References

[1]N. Chandrakant, A. Bijil, P. Puneeth, P. Deepa Shenoy, and K. Venugopal, "WSN Integrated Cloud Computing for N-Care System (NCS) Using Middleware Services," *International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN*, pp. 2278-3075.

[2]M. A. Hossain, "A survey on sensor-cloud: architecture, applications, and approaches," *International Journal of Distributed Sensor Networks*, vol. 2013, 2013.

[3]H.-I. WANG, "Constructing the Green Campus within the Internet of Things Architecture," 2014.

[4]R. Piyare, S. Park, S. Y. Maeng, S. H. Park, S. C. Oh, S. G. Choi, *et al.*, "Integrating Wireless Sensor Network into Cloud services for real-time data collection," in *ICT Convergence (ICTC), 2013 International Conference on*, 2013, pp. 752-756.

[5] S. Ezdiani, I. S. Acharyya, S. Sivakumar and A. Al-Anbuky, "An IoT Environment for WSN Adaptive QoS," *2015 IEEE International Conference on Data Science and Data Intensive Systems*, Sydney, NSW, 2015, pp. 586-593. doi: 10.1109/DSDIS.2015.28

[6] I. S. Acharyya and A. Al-Anbuky (Forthcoming), "Towards Wireless Sensor Network Softwarization" *2016 IEEE International Workshop on SDN and IoT,* June 6, 2016, Seoul, South Korea.

NETWORK STACK (COMM. LAYERS)	SOFTWARE CONTROL AVAILABLE FOR FLEXIBILITY [6]
APPLICATION	Implementation of HTTP or CoAP
TRANSPORT	Packet sequencing
NETWORK	Packet routing, implementation of IPv6 or RPL (Routing Protocol for Low-Power and Lossy Networks) protocols and enabling either unicast, multicast or broadcast addressing for the network.
ADAPTION	Header compression, Fragmentation and reassembly, etc.
MAC	Implementation of Network protocol (TDMA, CSMA), addressing and retransmission of lost packets, etc.
RADIO DUTY CYCLING	Setting of sleep period of nodes, Time of packet transmission, RDC layers available are ContikiMAC, X-MAC, CX-MAC, LPP, and NullRDC, etc.
PHYSICAL/RADIO (PHY)	Setting the sampling rate, RF Channel allocation, node address

Modeling Environment & Preliminary Results

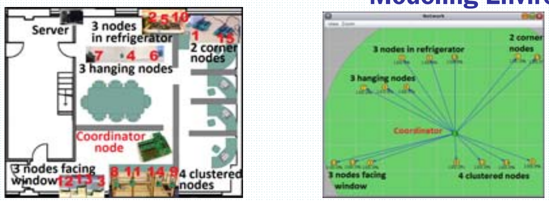


Fig. 7. System implementation (PSC and VSC)

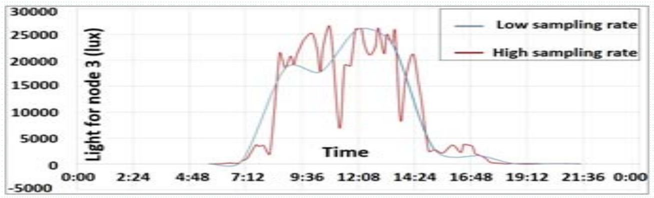


Fig. 8. Impact of sampling rate on accuracy post reconfiguration.

Fig. 9. PSC dataflow representation form database webserver.