A FRAMEWORK ARCHITECTURAL DEVELOPMENT OF AN AUTOMATED IOT BASED QOS SUPPORTED FOR ELDERLY PEOPLE - IOPA

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Abstract: Research in field of IoT have always been a demand specifically towards QoS and data aggregation primarily due to implementation in scientific and application domains. Though various QoS schemes had demonstrated on session management in IOT and data aggregation, survey discusses on simulated approach. This paper discusses on design and development of IoT framework network which should be capable of supporting QoS using an adaptive route management approach. The scheme supports variable data management and route establishment. IOPA has been designed using ATmega microcontrollers over environmental sensors. Data transfer is established using adaptive route discovery and management approaches. Experiment is conducted using real time models and compared with existing schemes.

***Index Terms* - IOPA, QoS, IoT, route management, microcontroller, sensors**

I. INTRODUCTION

IOTs (Wireless Sensor Networks) [2][12] are being deployed as inter-networking multiple sensor device which are largely deployed on an open and remotely uncontrolled environment which should include multi-tasking capabilities such as environment sensing[3], communicate wirelessly and data transmission (including data collection procedures, environmental data dissemination and data processing) [1][4]. These sensor devices lie scattered in an unattended environment (i.e., open field) deployed at remote locations which are situated far from the user location.

Sensors being modified to current technological need as low-power based ICs circuits [11][16], supported over wireless communications being enabled with low-cost design, miniature model, light weight, and enabling intelligence based on body aware systems are on demand. Such sensor nodes or kits or devices are capable of sensing, processing within the device, and communicating among device to device can be embedded into wireless personal or body area networks (WPANs or WBANs) [20] for health monitoring based on vital signs.

Increase in deployment of IOT [14][15] nodes had been witnessed in research as prototype formats in multiple scenarios as applications in real world. Such type of large-scale IOT application deployments are phenomenal in survey and implementation. Research has also witnessed most critical aspects of QoS issues [17] such as lack of reliability in wireless communication, scalability, security.This paper builds upon contributions of earlier research surveys [10] [18] as well aims at establishing a QoS architectural framework for analyzing design approaches of IOPA as health care and monitoring kit. The paper also identifies the core requirements of IoT testbeds based on real time experimental pragmatic scenarios.

The rest of the paper is classified as follows, with Section 2, which introduces the set of core requirements for IoT testbeds which help to understand the pragmatic deployment of IoT design and survey approach. Section 3, elaborates on the architectural and functionality aspects of IOPA and its hardware implementation. Section 4, discusses on design practices of IOPA - IoT testbeds. In Section 5, IOPA is evaluated over IoT health care sensors and its performance is evaluated. Section 6 concludes with possible need for future researches.

1.1 IOPA : Design Aspects

The design factors and challenges for design and development of IOPA over IoT holds on data depletion, QoS management, robustness over dynamic environment and highly scalable to numerous sensor devices. Few additional suggestions to the primary challenges are summarized as follows:

[i] reduction of an active traffic load intensity over multiple IoT devices involves data communication minimization over defined wireless channel which includes data aggregation, communicate of the network state along with summaries actual data transmitted.

[ii] maximize the intensity of packet loss along with network life time and support towards achieving adaptive QoS.

[iii] scalability can be improved by organizing network in a hierarchical clustered approach which utilizes localized interaction among sensor devices over localized algorithms among sensor device, at the same time robustness to changes in environment. The algorithms can be improved through self-learning and organization which also includes self-healing, self adaptives over the configuration setup.

Design of an elderly support mobile health care and monitoring system [1][7][13], proposed as IOPA, supports design of a device for dynamic monitoring of the elderly people. This device can be invoked as an automatic alarm for anywhere, anytime services such as handling emergency situations as well playing the role of living assistant [7]. IOPA also supports personal health management and information system, which permits health experts to view and update the current and log reports of elderly people. The device set threshold values for sensors and manage experts remotely, which is an essential part for any monitoring model of elderly[5] people. Report includes medical guidance methods which include communication platform and medical knowledge set which can serve as the real - time medical guidance for the elderly.

II. LITERATURE SURVEY

Primary research component considered in this paper is analysis on QoS aspects related to implementation of IOT network for applications such as support for elderly health care, health assistant and primary healthcare devices where patients' health monitoring and related activity status should help in decision making for related actions or alerts. This paper discusses on signal localization algorithm collected from sensor data where Received Signal Strength Indicator (RSSI) is considered as the primary indicator. The authors suggested that signal localization algorithm proves that monitoring of patient's health shows better performance in a environments such as hospitals or health care clinics. [18] discusses on IoT based home implemented healthcare application. The primary aspect behind this research work lies towards analysis of home based networking working model of healthcare monitoring system which needs reliable communication, efficient power, and bandwidth. The IoT based design of sensor network for applications such as support for health, collect heart activity data, and transmit data over 802.15.4 network nodes is discussed [14]. The issues related to analysis and implementation of IoT is discussed.

This paper works on related device hardware and operational software for representative system, which supports research aspects towards time synchronization, power management and chip signal processing. Specific research areas which are to be addressed may be related to routing of QoS over wireless networks, interface standardization and device interoperability. Based on sensory data obtained from clinical and ambulatory settings the system can support towards understanding the limitations of device as well applications of the IoT technology based upon the in-depth study.

Approaches in relation to continuous and real-time monitoring of health [10] discussed about a smart shirt which incorporates ECG sensor and works upon collection of acceleration signals. Smart shirt being designed incorporates conductive fabric materials which collects the body signal using electrodes, where such data analyzes the health data monitoring over frequent period intervals of time. This work focuses on the observed and measured data being transmitted over IoT network which involves remote monitoring and health support. Reference [2] focuses on design of micro Subscription Management System (μSMS) developed as a middleware and suggested as an event-based service model. This approach proposes the design constraints of IoT network in terms of limited resource availability, device efficiency, scalability of sensors, low power consumption of device. This approach works on implementing a dynamic memory kernel over variable payload multiplexing related to service based events and managing better services. The observed approach suggests that application of service yields best results for e-health applications.

2.1 Significance of the Study

Need for consistent monitoring and maintenance of health care among patients and elderly people lead to the demand on change in traditional monitoring approaches among chronic disease patients and alert on acute events. The demand on need to capture transient abnormal events reliably [8] and detecting life threatening disorders normally go un-detected since it happens only infrequently. Stress on better diagnosis [9] and support on treatment with monitoring [19] are possible through communication systems enabled with IOT or WBANs. Such approaches demonstrates better results for monitoring of patients over surgery, rehabilitation scenarios, daily assessment of life activities among elderly people or people observed as suffering from cognitive disorders like Parkinson's, Alzheimer, or similar diseases.

A case study for health care and gathering patient's data is carried out to satisfy the following objectives:

[a] To enable physicians or experts to consistently monitor specific health aspects of patient or elderly members through sensor based device wearable kit.

[b] To gather patient's data and develop knowledge repository by employing a supervised learning approaches towards disease prediction and suggestive approaches.

[c] To integrate patient's history and provide support through monitoring with effective diagnosis approach.

The objective of this research work is to design and develop approach to monitor and aggregate data for a health monitoring system that comprise of a compact body worn device (embedded on a garment) over a patient, as a network connected over web server and mobile network with internet.

The primary objective of IOPA ,

(a) To survey and analyze on existing approaches to provide consistent QoS aspects over service differentiable IoT networks

(b) To support in minimizing packet loss and delay using both real time and simulated approaches.

(c) Handling Erroneous data (aggregated data may have missing values or errors in certain packets) Accuracy of information sent to end user would be better.

(d) Providing optimized decision making for health care support

The primary focus of IOPA kit is focused towards data maintenance and handling effective decision making among large networks, IOPA can be defined as a IoT MOTE with the following properties as suggested in Table 1.

Program Flash Memory	:	32 KB (16K x 16K)
Flash Memory	:	32kbytes
EPROM	:	1 KB
SRAM	:	2 KB
Number of IO	:	14 slots
Data Rate	:	512kbits/s

Table 1. Properties of IOPA

Two major supporting functionality of IOPA are data aggregation [11] and data management factors [14] for variable services along with health care based decision making. IOPA controls the data gathering and analysis through functionality of interrupt handler, where the device collect external environmental parameters [8] using health supported sensors, process them through processing units, and support in data management and decision making though optimized swarm optimization algorithm such as ACO (ant colony optimization) for analysis.

Sensor device Name	IOPA
Microcontroller	ATmega 328
Transceiver	IEEE 802.15.4
Data Memory	10KB RAM
External Memory	EPROM
Transfer Data Rate	100Kbps–256 Kbps
Communication Range	10-25feet

Table 2. IOPA – Components

IOPA adopts the stack architecture structure where each device is equipped with sensory interface setup which can interface multiple sensors such as temperature, EKG, EMG, motion sensors and bodysweat and moisture which are highly sensitive to variable environments.

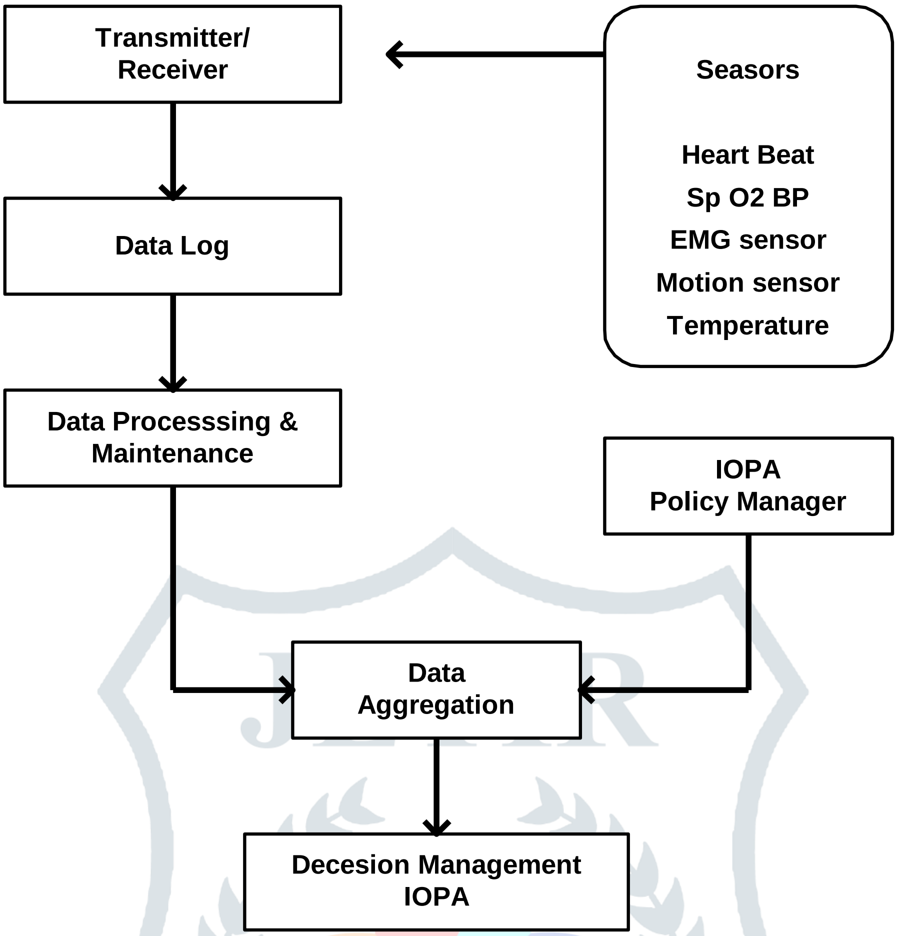

Fig. 1 IOPA functionality model and flow diagram

IOPA is developed using ATmega 328 microcontroller (Table 2), which is considered as simple, cheap and effective microcontroller for industry specific applications. It can operate at a low voltage of 5V for simple applications. IoT nodes are heterogeneous, hence multiple sensors are built along with the kit to actuate and partake in completing an event as per need of service in use. The trans-receiver adopts a data transmission rate of 256kbps at 2.4GHz whose transmission range is 50m within an indoor environment and 100m in outdoor scenario. The experimentally gathered data have to be temporally stored on the wireless sensor board before being collected and used for decision making /analysis. IOPA can also be fixed on to 1 MB external flash, which stores the data and buffering the process. The experimental test bed is explained using the organizational setup and test procedures.

The health care sensors which are used in this project are

i. EMG Sensor which gathers electrical signals produced during contractions of muscle.

ii. EKG sensor, which collects electrical signals produced by the heart, (ECG biosensors).

iii. Sweat and Moisture sensors – to gather the body sweat and moisture level

iv. Motion sensor – to gather the abnormal and normal motion of a person

III. IOPA : Architecture and Functionality

IOPA mote works on software which manages an fixed array of wireless sensor network nodes fitted with wireless interface backchannel boards allowing data logging and transmission of data over multiple nodes. IOPA mote sensor test-bed supports data aggregation and addresses challenges through wireless interconnectivity as interface. The kit supports automated test-bed programming and gathers log data generated by experiments into a PC or server as persistent database. The sensor data can be retrieved as source from database, where the database maintains consistent data collected at various iterations including sensor data, time, sensor name and service adopted from test-bed.

IOPA is attached with different software components, such as

(i) Data Logger and reading sensor data

(ii) Wireless network Interface for communication

(iii) Port / USB interface for collecting the sensor data

The architecture is based on a multi-tiered protocol structure, which relies on ZigBee (Network and Application Layers) and 2.4 GHz, IEEE 802.15.4 (Physical and Data Link Layers) communication protocol standards, which serves as a network backbone for data transfer and routing phenomenon. To understand, analyze the behavior of IoT network, an application based test-bed is being developed with the objectives of implementing, assessing and validating IOPA architecture.

3.1 IOPA QoSModel Architecture

IOPA adopts variable QoS modeling architecture, where multiple IoT nodes are under limited mobility. Any IoT node can act as a source or as destination or as an intermediate node for data transmission. The intermediate forwarding node as A or B….G or H can send or receive the data received from another node (Fig. 2).

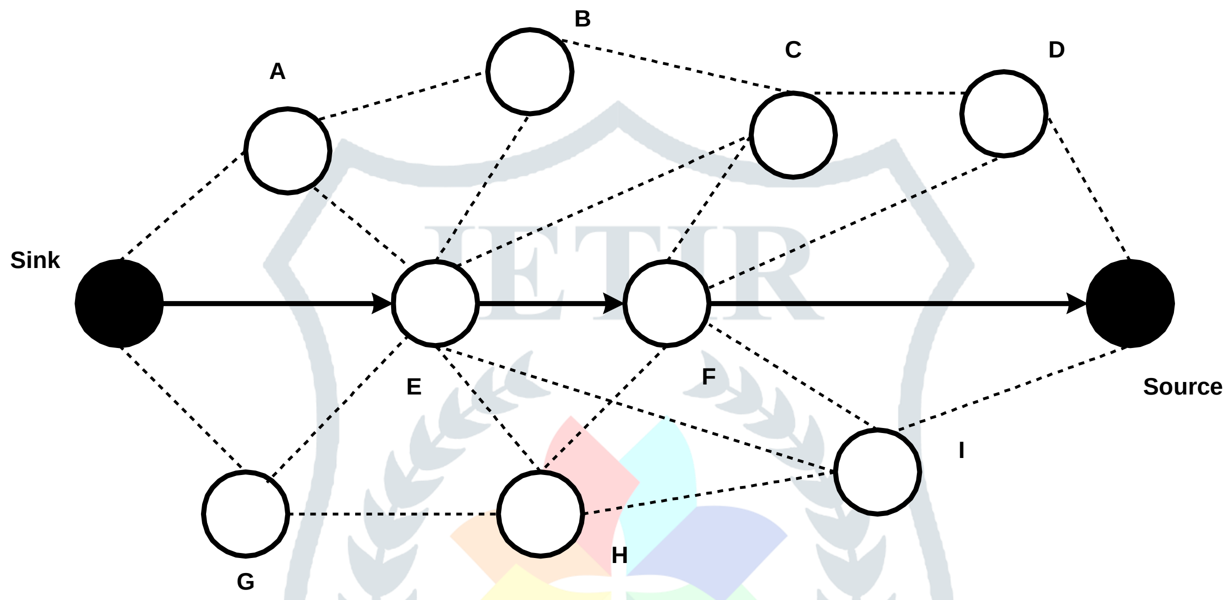

Fig. 2 QoS support with route establishment

In this case study, the IOPA works on multiple sensors such as temperature or humidity or ECG sensors with required buffer to 'hold the data' or 'transmit the data' to another IOPA node. The experimental test bed is explained using the organizational setup and test procedures. IOPA node referred to as "ni" adopts the following node configuration and route establishment process [Fig. 4].

a. Node Configuration 'ni'

Any node 'ni' can be considered to be as part of IOPA network, only if the node is accepted using the configuration procedure. An IOPA node is accepted as part of network, only when it is affixed with unique name value and static IP addressing format within its ROM.

b. Co-ordinator node CN

Any set of intermediate nodes can be defined as CN nodes or co-ordinator nodes. Fig. 3 shows nodes E and F as co-ordinator nodes. Nodes which can act as major buffering node can be taken as coordinator nodes. The coordinator nodes link route among intermediate nodes such that multiple source and receiver nodes can communicate. The coordinator nodes maintain variable buffer density such that multiple intermediate nodes do adopt upstream and down stream through coordinator nodes.

c. Route Establishment Process

When any IOPA node 'ni' receives an instruction or message, it returns an acknowledgement to its sending or upstream node. On receiving this acknowledgement, a node can confirm its route update or link with its neighboring nodes. If the node 'ni' does not respond to any instruction or message after many retries, its upstream or sending node will report the node failure to the coordinator node, then IOPA can diagnose the problem with any failure report.

d. IOPA QoS Manager

The QoS manager focuses on providing an adaptive QoS supportive route establishment approach between source and receiver. Allocation of variable buffer among intermediate nodes determine the adaptive path for data transfer. Any intermediate node 'ni' can participate in route determination along with coordinator node 'cn' between the source and receiver node. Multiple sensors gather data and transfer the data between the nodes, the data is stored in intermediate buffer of nodes selected for transfer as explained in algorithm-1 IOPA_QoS_MANAGER.

Algorithm IOPA_QOS_MANAGER

```
1. Set node[i].buffer = NULL
2. If node[i].pkt EQUAL TO node[i].recv THEN
node[i] = NULL
3. for all node[i,j]
4.    select node[i].source = node[j].buffer
5.    select node[i].link(source.node(i),node[j]) = node[i+1] // interfering constraint
else
6. if node[i].buffer == node[i].NULL then
7.    Choose a random node[i-1] of node.recv whose buffer is full
8. Schedule link (node[i],node[j]) respecting interfering constraint
9. node[j].buffer = NULL
10. node[j].buffer = FULL
11. end if
12. endif
13. If node[i].status="ACTIVE" and node[i].route_status="TRUE"
      then node[i].addroute(route[i])
   else
14.   if node[i].status="INACTIVE" and
15.    if node[i].route > node[i].congestion_value   // determine congestion metric based on route
         node[i].update_route( )             // update the selected route
       else
16.      node[i].refresh ( )                 // find another new route
```

The node which participates in route determination updates in status at intermediate intervals of time of experimental runtime. The experimental test bed is explained using the organizational setup and test procedures.

IV. PERFORMANCE EVALUATION OF QOS OVER IOPA

The performance of IOPA's QoS approach is tested using a set of health related sensors which gather the patient's data over variable period of time and send from a source to destination IOPA node. The experimental test-bed is prepared, where the IOPA kit can be deployed on a ZigBee communication kit.

Accuracy in data collection :

Data Collection Time	10 secs
Sensor as nodes	Sp2O2, Temp, Humidity
Sensor calibration	+1 to -2%
Power utilization	3V DC to 9V

Operating Environment	0 – 30 C
Network Layout based on connectivity range	10-15 feet
No of nodes	5 to 10 nodes
Source, Sink in experiment	A, D

Nodes communicate with each other and possess limited mobility as a patient lying on bed or moving within a room, but not outside the campus or moving into another room. Each node establishes a communication link with the co-ordinator node which creates the adaptive route for communication. The sensor data transmitted over the network generates traffic over the route created with packet streams whose mean packet sizes possess 450 bytes (including TCP/UDP, IP headers). The data transmission over generates an approximation of 3500 to 5000 bytes of data traffic over multi-nodal network.

4.1 IOPA QoSModel Architecture

The performance analysis of IOPA routing scheme is discussed in this section. The experimental test-bed uses 10 IoT nodes implemented over limited random mobility speed and conserved over variable real time data transmitted between IoT nodes. Behaviour of IOPA routing approach and its performance analysis is observed over QoS metrics such as throughput, traffic load intensity, observed end to end delay and effective signal connectivity range.

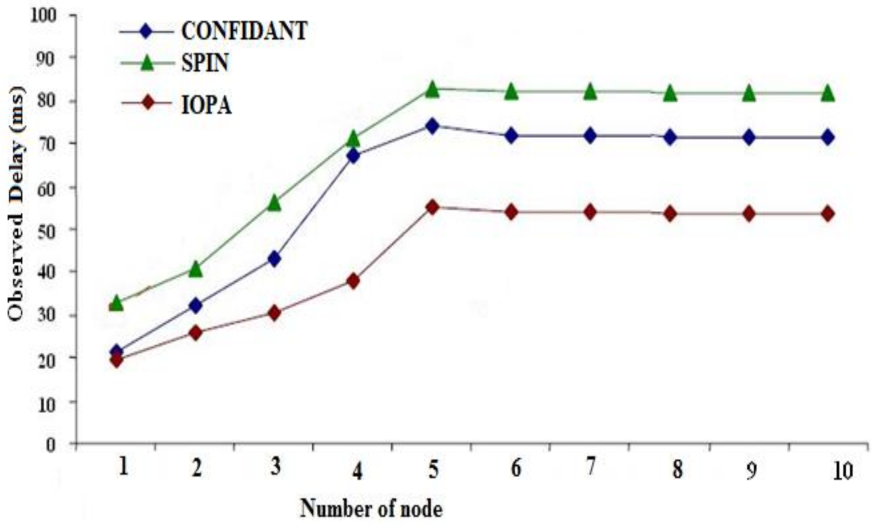

Fig.3 Observed delay of IOPA

IOPA scheme demonstrates highly reduced signal loss during session in use based on optimal route selection and establishment, where the beacon signal is also considered as a QoS metric. Compared with existing schemes SPIN and CONFIDANT, IOPA outperforms with minimal signal loss rate and hence a better neighbourhood node selection and link selection is guaranteed. Fig. 6 denotes the observed signal rate and loss rate when numerous IoT nodes participate in route establishment and communication. It can be understood from the observed delay rate that IOPA maintains a nearly average minimal delay compared to SPIN and CONFIDENT route schemes, due to adaptive node selection in route establishment. This work does not consider end to end delay due to route establishment time due to intermediate node availability.

IOPA shows an average of 57.24% of traffic intensity observed over 472ms of experimental run, compared to 538ms of LEACH and 594ms of SPIN routing schemes. IOPA was able to demonstrate a minimal time due to selection of node with better buffer capacity for coordinating in routing process.

V. CONCLUSION

The primary objective of IOPA is to support in effective QoS provisioning of IoT networks, where providing health care for patients who require consistent monitoring and diagnosis is considered a case study. This paper surveys on IoT architecture and implementation, as well provides the design strategy of IoT network for health care monitoring system. Though the primary work supports in provisioning QoS for IoT network, this work also design and develop a health care IOPA. The kit is designed based on the following society and environmental aspects. Most of elderly people do not have support for immediate medical care due to hospitals available at remote locations and immediate availability of expert physicians in near by locations. Hence such kits do have major social impact among patients and elderly people. The future work can be extended into machine learning approaches such intelligent models support in disease diagnosis and expert knowledge of system.

VI. REFERENCE

[1] Avijit Mathur, Thomas Newe, Comparison and overview of Wireless sensor network -systems for Medical Applications, , Proceedings of the 8th International Conference on Sensing Technology, Sep. 2-4, pg 272-277, 2014.

[2] Buratti, Martalo, Verdone, Ferrari, Sensor Networks with IEEE 802.15.4 Systems, Distributed Processing, MAC and Connectivity, Springer publications, 2011.

[3] Dardari, D., Conti, A., Buratti, C., Verdone, R.: Mathematical evaluation of environmental monitoring estimation error through energy-efficient Wireless Sensor Networks. IEEE Transaction on Mobile Computing 6(7), 790–803 (2007).

[4] Eugene Y. Song, Kang B. Lee, IEEE 1451.5 Standard-Based Wireless Sensor Networks, Advances in Wireless Sensors and Sensor Networks, Volume 64, Lecture Notes in Electrical Engineering, pp 243-271, 2010.

[5] Harvard, "CodeBlue: wireless sensors for medical care," 2008. [Online]. Available: http://fiji.eecs.harvard.edu/CodeBlue. [Accessed 3 January 2014.

[6] IEEE STD 1451.5-2007, Standard for a Smart Transducer Interface for Sensors and Actuators – Wireless Communication and Transducer Electronic Data Sheet (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The Institute of Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH99685, October 5 (2007)

[7] Kumar, D. Lee and H. Lee, Secure health monitoring using medical wireless sensor networks, Networked Computing and Advanced Information Management (NCM), 2010 Sixth International Conference, 16-18 Aug. 2010.

[8] Lee, K., Song, E.: A Wireless Environmental Monitoring System Based on the IEEE 1451.1 Standards. In: IMTC 2006 - Instrumentation and Measurement Technology Conference Sorrento, Italy, April 24-27 (2006).

[9] Lee, K.: IEEE 1451: A Standard in Support of Smart Transducer Networking. In: Proceedings of the 17th IEEE Instrumentation and Measurement Technology Conference, Baltimore, Maryland, May 1-4, vol. 2, pp. 525–528 (2000).

[10] Lee, K., Song, E.Y.: Object-oriented application framework for IEEE 1451.1 standard. IEEE Transactions on Instrumentation and Measurement 54(4), 1527–1533 (2005).

[11] Lewandowski, Arochena, Naguib, Chao, Garcia-Perez, Logic centered architecture for ubiquitous health monitoring, IEEE Journal of Biomedical and Health Informatics, 18, 1525-1532.

[12] Munir A, Gordon-Ross, Ranka, Multi-core embedded wireless sensor networks: Architecture and applications, IEEE Transactions on Parallel Computing, 11(7), 2011.

[13] S. Stankovic, Medical applications based on wireless sensor networks, Transactions on Internet Research, vol. IV, no. 2, pp. 19-23, 2009.

[14] Stojmenovic, Position based routing in adhoc networks, IEEE Communication Magazine, Vol 40, pg 128-134, 2002.

[15] Subhas Chandra Mukhopadhyay,Henry Leung, Advances in Wireless Sensors and Sensor Networks, Lecture Notes in Electrical Engineering, Vol 64, 2010.

[16] Sweetser, D., Sweetser, V., Nemeth-Johannes, J.: A Modular Approach to IEEE-1451.5 Wireless Sensor Development. In: Proceedings of the 2006 IEEE Sensors Applications Symposium, Houston, Texas USA, February 7-9, pp. 82–87 (2006).

[17] Verdone, R., Dardari, D., Mazzini, G., Conti, A.: Wireless sensor and actuator networks, 1st edn. Elsevier, Amsterdam 2008.

[18] Vuran MC, Akyildiz, I.F, XLP : A Cross-layer protocol for efficient communication in wireless sensor networks, IEEE Transactions on Mobile Computing, 9(11), 1578-1591.

[19] Xu L, He W, Li S, Internet of Things in industries : A Survey 2014, IEEE Transactions on Industrial Informatics, published online, 10.1109/TII.2014.2300753.

[20] Zang J, UWB systems for wireless sensor networks, Proceedings of IEEE, Vol 97, No 2, pg 313-331.