Integration of Service Oriented WSN and IoT for E-Commerce

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Abstract – Wireless sensor networks (WSN) generate huge volume of the heterogeneous data that can be made open source and linked for the different Enterprise IT applications. In order to use the services and data generated by the sensors, it should be in the standardized format. This homogeneity of defining the data and services is provided by the new emerging technology known as Internet of things. It has the power of Resource Description Framework, which links URIs and thus provides easy access from different sources to users through Internet. In this paper, we have studied different technologies that are using for integration of Service Oriented WSN and IoT for E-Commerce. Paper also discussed the current issues and challenges of the integration. By studying E-Commerce scenario, we also propose mathematical formulation of the problem for healthy transportation between seller and receiver.

Keywords – Wireless Sensor Networks, Service Oriented Architecture, Internet of Things, Resource Description Framework, Middleware, E-Commerce, Ontology, SPARQL.

NOMENCLATURE

APIs- Application Programming Interfaces
EIC- Enterprise Integration Component
HTTP- Hypertext Transfer Protocol
IoT- Internet of Things
RDF- Resource Description Framework
SPARQL- SPARQL Protocol and RDF Query Language
SOA- Service Oriented Architecture
SOP- Service Oriented Paradigm
URI- Uniform Resource Identifier
USDL- Unified Service Description Language
WSN- Wireless Sensor Network

I. INTRODUCTION

Today's world is inundated with sensors in various applications. They are integrated with different devices like mobile phones, Wireless Sensor Network's (WSNs). Their widespread deployment shows its significant involvement in financial and technical perspective with the importance of the data, it collects for high value proposition applications. It provides new economic opportunity for worldwide profitability. WSNs can be turned into the networks which are interoperable, open, ubiquitous and multipurpose infrastructures with the aid of Service Oriented Architecture (SOA) [1].

A. Problem associated with current Internet

The Internet is getting aged at the same time conflicting from the rationale of its original creation; as consequence of this, severe problems like rigidity, layering, etc., are being faced [2]. The concept of layering was instigated to give an abstract view to designer, but J. Crowcroft et al., clearly showed in their paper that layering is harmful [3]. In the work of Philippe et al. showed that the rigidity can worsen the communication performance [4] together [1]. One of the idyllic ways of solving these issues could be modification of existing protocol or changing protocol interaction or introducing a new protocol to satisfy requirements.

B. Service Oriented WSN

SOA is a method for arranging software components into a collection of intractable services. It's a promising design handling necessity of loosely coupled, standard protocol free distributed computing [5] [6]. SOA divides the entire system into three essential roles: Service User, Service Broker, Service Provider as shown in Fig.1. The broker provides appropriate service based on user requirements. It acts like a middleware and removes direct dependencies between all layers. The SOA has been assumed as fine candidate to develop efficient, scalable, open, inter-operable & customizable WSN applications. By packaging application functionality into set of modular services, programmer can start the state execution flow by basically connecting the apt services. Programming job becomes simpler since capabilities of sensor nodes are abstracted and termed as services and applications are created based on service requests subjected to the network. Besides, XML format is awfully verbose and its processing utilizes considerable sum of memory & time and bandwidth utilization is relatively elevated for Wireless Sensor Networks. System should comprise a service & device discovery protocols so that sensor nodes should be made competent of hosting services, broadcast them in network and discover novel services [1]. Service composition plays vital role in systems which plan to work with heterogeneous devices produced by cluster of sensors. Therefore service composition procedure can be exercised for creation of such clusters. Nonetheless, sensor nodes are typically quite limited in resources (processing-power, memory-size, and battery-power). Since majority of SOA solutions depend on middleware resource rich devices to bridge gap between outside world & WSNs, therefore this resource-restricted nature of sensor nodes influences negatively the proposed SOA solutions [1].

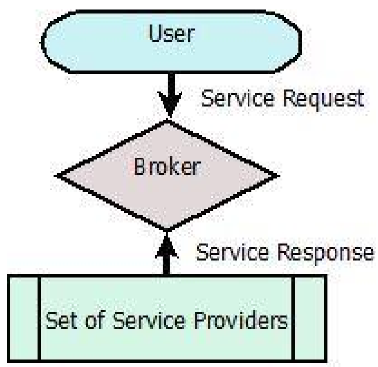

Fig.1.Service oriented view

C. Domain oriented model for IoT

Before Today, the gap between sensors (and actuator) in IoT (Internet of Things) and Business Systems of the Enterprise world is still a reality. As the term suggests Internet of Things means, the 'thing' is the most important concept in the domain oriented model that is called 'Physical Entity'. This physical device has a sensor attached with it to monitor it and the actuator will react on the observations of the sensors. To distinguish between different 'Physical Entity' in the environment a hierarchy is needed that would be able to define the role of the attached sensor with its specification, after sensing the action being performed with (actuator) with its location and other information's. This information called resources that associated with 'Physical Entity' and thus make it suitable to bridging the gap between physical and digital world [7]. One example of this hierarchy has been shown with the Fig. 2. Any time a user can invokes a service, which access any of those resources associated with it. Summing up, the interaction of the user with the 'Physical Entity' can be mapped to the digital environment by some standard language that provided by the IoT specifications, describes in the next section.

D. Service Oriented WSN with Enterprise IT and IoT

Nowadays, the Service Oriented Paradigm (SOP) is predominant in an enterprise context. Description modeling of Business processes decomposes the process into distributed process steps that can also be executed on physical devices like sensors or sensor network gateway [8]. Sensing services can be considered as a composition of small sensing devices thus having inbuilt SOA phenomena. Enterprise middle ware will perform all types of handling from service binding to execution of those distributed services. Due to technical specialty of developing software for sensors, its integration with Business becomes cumbersome task. The relevancy of an abstract level extract interaction in very large scale system such as the Web has formed until now a big challenge of the different models of services and service composition. The challenge is still intractable from human-oriented web in respect to the accuracy and machine-readable web [9]. Through this challenge, new issues of human-machine interaction to the surface given that any proposed model should respect both sides of the process, humans and machines.

Applying Linked Data principles (included IoT) for service descriptions to integrate enterprise IT system with the sensor networks makes it easier than before. There are various attempts to make service and application models for Linked Data [10]. Recently, Linked Data and Web APIs have emerged as the preferred means of exposing data and Web application functionality. In this paper, we argue that service systems should be adapted in the light of both trends. In particular we believe that i) common means for discovering and interacting with Web services and Web APIs are necessary, and that ii) we should bridge the gap between services and linked data both by supporting the publication of services as linked data and by enabling the processing of linked data by services. Integration needs following drivers for functioning.

- There should be service endpoint that has technical description of invoking the services.
- In SOA based network service repository and registry were needed to discover a particular service however in more or less static sensor network most of the logic execution can performed on the enterprise backend. In the self organizing scenario and ad-hoc network self description of services are needed.
- We have to deal with the devices that have various constraints in terms of computation, memory and communications. It will work better when the services of each of the devices are properly defined to reduce the reconfiguration and re-deployment of the sensor network.

Enterprise system provides coordination and cooperation of the work across the enterprise. To deal with these issues many researchers have proposed RDF (Resource Description Framework) for service description so that it can perform a unified specification throughout the enterprise management process. Linked Open data principle was introduced by Tim

Berners Lee in 2006 [10] that said that each real world entity can be represented by a URI, thus providing it a unique id. It is based on the standardize language called RDF which organized in the form of <Subject><Predicate><Object>, where all the triplets represent URIs except <Object> that can be a literal also. This graph continued for representing information related to seed node, For example: Fig.2 represents the information of associated with the sensor node. To query this type of data different query language has being used, called as SPARQL [11]. This concept already being utilized in many areas to serve the society and nation [12][13].
Service description can be hosted in the different device, thus it performs easy re-configurability and re-programmability in the enterprise context. Services should be properly describes including essential properties, quality parameters also the observational area that will be covered by sensor networks and also the observation schedule of the sensor network. Linked USDL (Unified Service Description Language) has the advantage of being description languages for different services which can be description of technical interface also. Fig. 3 explains sample RDF that describes different information related to a sensor using a unified Web ontology vocabularies.

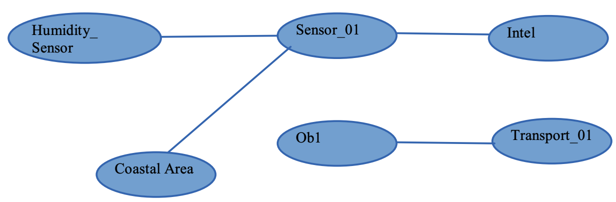

Fig.2. RDF representation of one Sensor Node

E. Concept and Terminology Used

To describe the service characteristics or properties that sensor networks are going to be performed and should be modeled so that service discovery and selection can be performed smoothly. From the Business point of view, quality of service parameters can be modeled using Linked USDL. It has advantage of being description language that goes beyond technical interface, consist of different modules which cover functional, operational and business aspects. It allows domain specific vocabularies that modeled in RDF language. RDF makes utilization of existing vocabularies easy and also flexible to make any changes related to any domain specific aspects. As explained earlier RDF is a triplet of URIs that combined information in the <S><P><O> format. Here, one URI can point out one sensor or whole sensor network. Service description and other additional information related to sensor can be on the sensor or off the sensor node or even on both. This gives opportunity to sensor to keep only minimal requirement with them self, thus allows cost reduction, usage on devices that are not HTTP enabled but use proprietary protocols. For ex. In Fig. 4 sensors can communicate to enterprise repository to get additional on-demand service related information. Also, this service description allows re-programmability and reconfiguration so that sensors can communicate with the middleware or business process model smoothly. In this paper, we are planning to integrate WSN and other building blocks of IoT (Internet of Things) in service oriented manner with Enterprise IT. Past researchers mainly focused on developing and evaluating a business modeling and service delivery framework in an integrated manner.

```
<> rdf:type usdl:ServiceDescription ;
dcterms:title "USDL service description for a
dcterms:creator :Jhon ;
owl:versionInfo "0.1";
dcterms:contributor
a foaf:Person ;
foaf:name "John";
dcterms:created "2011-09-25"^^xsd:date .
:SensorHumidityService a usdl:Service, msm:Service;
usdl:hasNature usdl:Automated;
usdl:hasServiceModel <http://research.intel.com/sensors> ;
dcterms:title "Humidity sensor service"@en;
usdl:hasProvider :SAP_SENSOR_GROUP;
usdl:hasInteractionProtocol :ip_1;
```

Fig.3.RDF format using different owl vocabulary

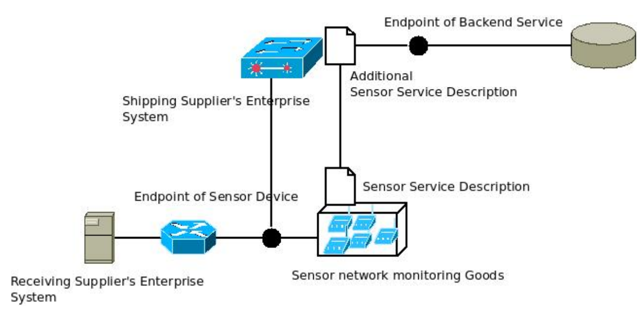

Fig.4.Sample of Sensor network Enterprise Communication

II. RELATED WORK

A. Past Methodologies for Integration of Service Oriented WSN & Enterprise IT with IoT

The problem of integration of sensor networks and enterprise IT are well research topics in the current era. CoBIs [14] middleware is a business application works as a medium of service request between the application layer and device layer. Gomez et. al. [15] proposed an additional layer called Enterprise Integration Component (EIC), which is a generic mediation layer between enterprise systems and the WSN middleware. They combine the top-down approach and bottom-up approach of context-aware and WSN middle ware respectively based on SOA architecture. Our approach also allows the usage of a middleware like the EIC, but it additionally enables the usage of SOA principles on the side of the sensor network itself. In this paper, they have empirically considered the business application like remote health care monitoring, where a patient can be remotely monitored at the home after surgery operation. His pulse, ambient temperature, body temperature and his activities is monitored per day using a WSN.

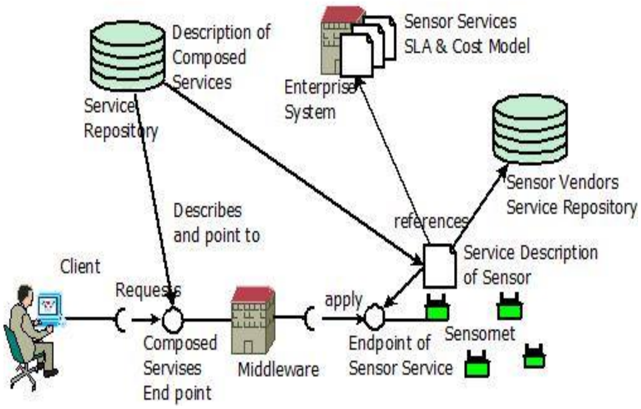

Fig.5.Genaral Architecture of Integration of Service Oriented WSN and Enterprise IT with IoT

Typical server-side WSN middleware schemes, in which the middleware is installed on servers, are Cougar [16] developed at Cornell University, SINA [17] developed at the University of Delaware, and MiLAN [18] developed at the University of Rochester. CoBIs [14] middleware is a business application works as a medium of service request between the application layer and the device layer. It access the functionality performed by the sensors via web services. The MiLAN (Middleware Linking Application and Networks) [18] middleware concentrate on sensor network management to facilitate hands-on WSN application, which hold up QoS requirement and energy constraints. A component-based middleware used by the RUNES project (Reconfigurable, Ubiquitous, Networked Embedded Systems) [17]. The RUNES carries plug-in interaction paradigms (PIPs). These PIPs are illustrated as a general APIs and can be put into practice in accordance with application requirements. WSN middleware is a software layer that exists physically between hardware and application, hardware are like sensor nodes. A number of context-aware middleware have been developed to shows the importance of context-aware techniques. The main drawback of these middleware's is interoperability. Earlier in WSN environment, heterogeneity of data captured by sensors was not taking in consideration. MiLAN middleware start the notion of general connectors, which allows collecting sensor data from any type of sensors. Nevertheless, they do not consider the standardization of sensor data in a single format.
Moreover, these middle wares do not proposed any pre-processing of sensor data such apart from aggregation of sensor data. Fusion or reasoning about information is not addressed in these middleware. The main drawback of these middleware's is interoperability. Earlier in WSN environment, heterogeneity of data captured by sensors was not taking in consideration.

B. General Architecture of Integration

Semantic Web or IoT and also popularly known terminology Linked Data principles for business process integration are known for providing specification of service description in the Enterprise IT model. Now days, the SOP is predominant in an enterprise context. In Fig 5. Service description and its component have been shown with the endpoints where all the services are composed into single point. Client can request any time to the Middleware which follow SOA phenomena and service repository select requested service and data is gathered from the endpoint of the sensor service that composite all the sensors data sense individually. All information of sensor properties and its operational time, location and cost can be collected from the Sensor Vendor's service Repository. It also stores so called SLAs (Service Level Agreements). This whole model follows SOA principles, and endpoints here show service composition and execution. RDF format are used to describe the services in standard format as explained.

III. MATHMATICAL FORMULATION OF THE PROBLEM

For Enterprise IT, it is essential for the transported good quality of things. It would be beneficial, if the truck that carried the commodities is smart enough to tell the delivery man as well as receiver about the quality of the commodities. Here, we have taken an example related to that:
An item is always liable to rotten with the passage of time and this rate of rottenness is always exponential in nature. Hence mathematically, we can represent change in quantity 'M' with the passage of time as:

$$\frac{dM}{dt} = -\alpha M \qquad (1)$$

Where α is rotten constant measured in s^{-1}.
Integrating Eq. (1) i.e

$$\int \frac{dM}{M} = \int -\alpha \, dT \qquad (2)$$

$$In\, M = -\alpha t + d \qquad (3)$$

$$M(t) = e^{d} e^{-\alpha t} = e^{-\alpha t} M_0 \qquad (4)$$

$$M(t) = M_0 e^{-\alpha t} \qquad (5)$$

Here M(t) at time t is the quantity at that span of time and M_0 is the initial quantity at t=0. At t=0 in Eq.(4) we get $M_0 = e^{d}$.
An item may rotten via various other processes or conditions such as temperature, humidity, moisture. These conditions have different probabilities of occurrence and at different rates. Thus total rottenness of an item M depends on sum of conditions that cause the item to rotten i.e.

$$-\frac{dM(t)}{dt} = M\alpha_1 + M\alpha_2 + M\alpha_3$$

$$= (\alpha_1 + \alpha_2 + \alpha_3) M \qquad (6)$$

Where, $\pm_1$, $\pm_2$ and $\pm_3$ are the constant for humidity, moisture and temperature respectively. Putting, $\pm_1 + \pm_2 + \pm_3 = \pm_c$ as a constant value in eq. (6) and integrating it, we get eq. (7):

$$M(t) = M_0 e^{-(\alpha_c)t} \tag{7}$$

The value of M(t) differs for different items and so calculate the number of days that item will last. Thus based on values of sensors, we can predict the probability of an item getting rotten . Thus the items whose rottenness value is more that considers as a high priority item to be sold as they don't last for longer period of time. We can even differentiate the price of items i.e. the item whose rottenness value is less are sold with better prices as compared to items having higher rottenness value.

IV. ASSOCIATED CHALLENGES AND ISSUES TO DEAL

As the function of IoT is growing, the challenges in the IoT field are also growing. Various standards of WSN empower the IoT technologies for rapid development but these developments also present some major challenges of security, performance and scalability [20]. An interesting issue in the integration of WSN with RDF entities are to find sensor based on metadata such as location and type. In general, the main challenges of IoT are related to formalization and standardization of data. That means, data should be complete and reliable. Large scale heterogeneous network integration and management is also a major challenge for IoT. It can be tackled by building automatic or intelligent network management system. There is wider range of issues here concerned with handling various co-existing WSN application [21] [22]. The current challenges faced by it can be summarized as follows-

- Interoperability and development of technologies for authentication at global level to provide more security.
- For heterogeneous system and distributed resources interoperability there is a requirement of standard architectures.
- Efficient selection of cluster head for the sensor network to improve the overall performance of the sensor network. Also, efficient mechanism to take care of the sensor head from getting destroyed.
- Efficient WSN topology for the nodes so that there will be no interference among themselves.
- The data traffic that is generated will have significant sensor node since multiple sensor may generate exactly same data within the vicinity of phenomenon. The efficient routing protocol should be able to such redundancy to improve energy and bandwidth utilization. This should be taken care at the time of data gathering from multiple sensors in the environment of WSN.
- Path repair is desired when the path break is detected. To solve that a routing protocol should be able to find a new path at the Network layer even if some nodes fail or blocked due to environmental interference.
- Suitable hardware selection and parallel processing in ultra-low power multi-processor system.

Beside these issues, there are some domain oriented issues that arises after the integration of Service Oriented WSN with Enterprise IT. For ex. Calculating the number of the days that product will last and sell them before. Wireless sensor networks (WSN) generate huge volume of the heterogeneous data that can be made open source and linked for prediction or Data Mining applications. The data generated from sensor can also be used for Enterprise IT in different applications. In order to use the services and data of the sensors, it should be in the standardized format. This homogeneity of defining the data in the services is provided by the new emerging technology known as IoT. It has power of Resource Description Framework, which links URIs and thus provides easy access from different sources as well as users through Internet Cloud. The previously known data can be stored on the web for mining purpose.

V. CONCLUSION

As an emerging technology it faces many problems during development stages, so does this integration have many challenges related to standardization, architecture and interconnection with other networks. A new architecture with a appropriate application approach is needed to make utilization of the current techniques. We have found drawbacks in the current architecture as well as the applications and propose a mathematical formulation for the WSN oriented difficulties that originated while transporting goods. Enterprise IT system should be capable to maintain sustainable and smart environment between customer and seller. In future we will also try to detect path fault between sensor nodes, so that congestion can be removed and throughput can be increased.

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