Flexible Service Oriented Network Architecture for Wireless Sensor Networks

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Abstract: Wireless Sensor Network (WSN) is a combination of homogeneous and heterogeneous sensor nodes which are physically deployed at different places. Heterogeneous WSM can be characterized with different parameters such as hardware resources, application, services, software platform and network. WSN are powerful technology, which is used to build up many applications in the era of technological development. These developments demand homogeneous or heterogeneous services as per the user requirements at applications level. The requirement results in increasing the number of services over the network and hence the number of complexities. Complexities of wireless sensor networks are increasing due to the lack of adoption of new services, new protocols and interoperability between heterogeneous services with common communication architecture. This paper deals with these issues of wireless sensor networks, elaborating the need of generalized communication architecture for applications, developers and users, proposing generalized Flexible Service Oriented Network Architecture (FSONA) to solve above issues along with the detailed functionality of the proposed architecture.

Keywords: Wireless Sensor Networks (WSN), Flexible Service Oriented Network Architecture (FSONA). middleware architecture, interoperability, localization.

1 Introduction

In the modern epoch wireless sensor networks are increasing rapidly in current environment for different application such as health monitoring, target tracking, mobility of object, petroleum industries, pressure measurement at various levels, environmental change etc. Sensors are small devices which are used to compute the environmental changes according to application. These devices have been developed from organizations and vendors, due to this reason hardware platform, software platform and specification can be dissimilar. Heterogeneous sensor network introduces a major issue to sensor node with its various different specification, failure prone Sensors and operation in the current dynamic environment. Failure prone sensors may affect the performance of the network. Therefore Multi objective method enhances the performance of task and network life time after detecting the failure prone sensor nodes [6]. So there is requirement to identify the failure prone nodes.

To provide a common interface between the sensor node and its requirement for sensor network, middleware architecture has been evolved which is capable to tackle the heterogeneous environment without changing the specification and its platform. Sensor middleware can be defined as a standard interface which is useful for communication and requirements of sensor, users in terms of services without affecting the platform [16]. Middleware architecture is able to manage the requirements of node in the form of request, storage of data and constraints like when, how the data and service are needed for the node operation. Middleware architecture supports a range of machine which have different configuration and provides compatibility for communication among the network and client. Wireless sensor network has the various challenging issues

which can be handled with service oriented computing model [5]. Service oriented computing model is based on the approach of service oriented architecture. Service oriented computing model intends to provide better service availability, communication protocols and accessibility of services in efficient way without knowing low level detail of hardware implementation and infrastructures. Service oriented architecture has various advantages over traditional approach such as reusability, flexibility, interoperability and loose coupling which is beneficial to develop middleware architecture.

Service oriented computing method covers the functional and non functional requirements of the application in the current dynamic environment. Service oriented middleware [20] provides a connection between various components and assist for communication over a multiple channel. Middleware layer is an approach to satisfy the need of wireless sensor network at the level of design and implementation. Various approaches have been proposed as a middleware in wireless sensor network [8]. These middleware architecture deals with dissimilar applications like installation of software in efficient manner and aggregation of data. Sometimes application needs more advanced functions to reduce the complicated design and implementation with the middleware architecture. In the current dynamic scenario Service oriented architecture is an approach which may attempt these challenges. This approach provides a flexibility which is very much useful to add a component or replace the old component to fulfil the demands of application. Various services [9] can be managed at network level with wireless sensor network by way of service oriented model i.e. Flexible Service Oriented Model. Very few researchers have done the survey on the middleware architecture for wireless sensor as well as network architecture [8]. Integration of heterogeneous platforms with a single standard interface is the demand of current era to support technological development [12].

SOM is a possible way to do such kind of things because of its property. To perform the integration among various components flexibility should be there. So In this paper we have proposed a Flexible Service Oriented Network Architecture which is based on the approach of basic Service oriented architecture [19] to provide flexibility, loose coupling and reusability. Flexible Service Oriented Network Architecture consists of following components: 1. Building Blocks, 2. Building Block Repository, 3. Workflow Engine.

The proposed Flexible Service Oriented Network Architecture is able to couple or decouple the components according to the requirement of applications. In this paper we discuss the Service oriented architecture, issues of wireless sensor network with middleware architecture, Related works, Proposed Flexible Service Oriented Network Architecture for WSN as middleware, Comparison and Conclusion.

1.1   Service Oriented Model

In this model service provider play a role to develop new service module, Service broker registers the service with its description in UDDI (Universal Description Discovery and Integration), Service requester requests for service to service broker as per its need. Service oriented architecture is valuable to make a thing possible in heterogeneous environment. These advantages are: It can provide a common interface to publish or subscribe the service in the heterogeneous environment; many applications can run on different platforms and interact easily with each other, Service user can be coupled for time duration according to need of application, It can reduce the dependency among the components due to loose coupling, Service user can consume an exact service without knowing its location.

From the above features of Service oriented model we can use those models which can work as middleware architecture. This type of middleware is capable to integrate the components
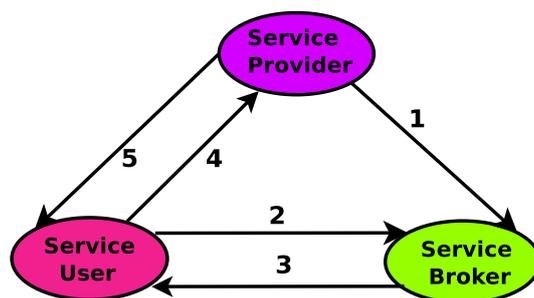
Figure 1: Service Oriented Model

and components reusability on demand in heterogeneous computing environment. It can handle the functional (service creation, communication, invocation, group management, and real-time operation) and non functional (service discovery, interoperability, reusability) requirements of application. Numerous middleware architectures have been proposed to add a new functionality like enterprise system. This approach is used to provide reusability of components like protocol, software etc. Service Oriented Model based middleware is a demand of todays environment.

2   Issues of Wireless Sensor Networks with Middleware Architecture

Middleware architecture is software infrastructure which will provide connectivity between components like hardware, operating system, communication protocol, network corresponding to application. Middleware architecture should be capable to provide runtime support, connectivity and execution of applications in dynamic environment. Middleware architecture provides isolation among various components at abstraction layer. Various challenges are present to develop service oriented model based middleware architecture for wireless sensor network. Challenges are consist of two things: one is development of middleware and another is wireless sensor network. Development of Flexible Service Oriented Network Architecture is a challenging issue which will support the applications of wireless sensor network. Some issues are discussed below.

Service Heterogeneity: Heterogeneity is a major problem in wireless sensor network at application level. This heterogeneity can be defined in terms of variation of services, platforms and networks. Services heterogeneity is increasing to fulfill the need of users requirements. Various services are present to perform the same operation in wireless sensor network at different levels of application. It is very much difficult to provide standard service in the service oriented environment to achieve the quality of service. Therefore Service oriented environment needs a common architectural platform for wireless sensor networks, which can provide a method to access the services form different platforms.

Adoption of Protocol: Requirement of users are increasing according to application, consequently number of protocols are also increasing to full fill the requirements. In current environment users or programmers are developing a protocol to support the application requirements. Number of protocol will present on the web in future but protocols may not be common to satisfy the requirements of application. Maintenance of protocol is also an issue. To address these issues, flexible middleware architecture is needed. Flexible middleware architecture should provide loose coupling. Loose coupling will provide flexibility to couple or decouple the protocols with application requirement. So flexible middleware architecture will also helpful for maintenance of protocol and users will have flexibility to choose the protocol from the web according to need.

Integration with Networks: Integration mechanism will provide interaction to share the services or information with other network according to requirements of application. So middleware architecture should have capability to integrate the WSN application with external environment. Middleware architecture can provide interface for communication.

Interoperability: In Service oriented environment service vendors, service providers and platforms are increasing to perform the task in Wireless sensor network. These services are developed on different platforms such as C, java etc. Interoperability between different platforms should be present to provide a service composition. Therefore Wireless sensor network needs interoperability mechanism to support different type of services and platforms.

Adoption of New Service: Innovation of new technique and improvement of previous technology provides new services for various application domains such as Wireless sensor networks, Adhoc networks, Cloud computing etc. These developments are the result of requirements and feedback of users after using the applications. All platforms may not be support the newly developed services. Therefore Adoption of new service is one of the crucial issues in Wireless sensor network.

Security: Sensor network is use to capture the data or information from the environment. Information or data can be sensitive according to application like military services, health services etc. This type of application requires security modules to secure the data from attacker. So security is also an issue to provide secure communication and data between WSN and system. Service oriented model can provide security modules as a service as per requirement. Very few works have been done on the security with service oriented model [2]. Therefore Flexible Service Oriented Network Architecture will suit to resolve the security issue.

3   Related Works

Various methods have been proposed to address the issues of wireless sensor network. This section provides overview of various solutions in the context of wireless sensor network issues and its solutions. These solutions are serving the way to tackle the problems. Wireless sensor network are suffering from the problem of data aggregation, resource management, energy efficiency, heterogeneity, hardware, routing etc. To solve these issues authors have been proposed various approach in terms of middleware technology. Middleware approach provides abstraction at various levels such as interoperability, language, hardware, complexity etc. We are discussing the some work in comprehensive mode.

COMiS: This is component based middleware architecture [10] which is used to satisfy the constraints like power and memory. Components of this middle- ware can be varying as per the behaviour of sensor nodes and loaded memory based application. Components of this middleware are Listener, Register, Discovery, Send and update. Each component is responsible to perform its task according to functionality. It provides a various additional functionality such as discovery of k components according to distance, component management, and registration and component updation. It is more suitable for collaborative applications.

SOMA: An SOMA [1] tries to fulfill the gap of interoperability among homogeneous platform. This middleware (Service Oriented Middleware Architecture) approach provides a communication model for wireless sensor network. To reduce the power consumption this solution is feasible at high traffic. Standards of middleware components are inspired with the web services, which will helpful to accommodate the component interoperability and reusability. This solution provides a way to manage the homogeneous platform with interoperable manner. It has some advantages like complexity reduction, service specific interface etc. In this approach major drawback is gateway dependency because failure of single point will affect the performance of whole network.

MiSense: It is Component based middleware layer [13] which is use to support distributed sensor application. MiSense reduces the complexity of system by imposing structure on top of component model. This middleware provides a resource management, network abstraction and communication without knowing the detail of low level complexities. It is a feasible to handle the issues like data aggregation, topology management and event detection.

SOM: Service oriented model [3] is much efficient than traditional middleware. Service oriented computing environment provides better availability, easy accessibility with some standard models and protocols. This approach provides a facility of interoperability and loose coupling between services in distributed scenario. SOM is capable to handle the communication, service discovery and publication among various services.

OASiS: OASiS is a programming framework [14] which provides abstraction layer to hide the complexity at low level. This is planned for resource constraint application devices. OASiS framework is combination of various service modules such as Composer, Node manager, Object manager, Service discovery protocol. These modules are responsible to perform the specific task. Node manager is responsible for routing, service discovery is responsible for search the service domain, Object manger is use identify the object and Composer is responsible for initiating a service graph, parsing of graph and binding of service. This framework is feasible to support the single object at particular instance but it can be improve.

SMC: This framework is based on service oriented architecture [4]. In this middleware various components are defined as a service. These components are use full to support various application domains. Service based midtier component (SMC) is capable to deal with different functions. This model consists of layers and each layer is responsible to perform particular task. Layers are independent to each other. Service bus layer provides a facility to establish communication between protocols. Binding is responsible to bind the service according to application. Interface repository service layer is used for repository and classification of domain. Data exchange service provides facility to exchange the data among similar nodes. Encryption is used for security of data. Synthesizer service layer is use to facilitate the processing of data and its composition. Routing layer is responsible to handle various queries at same time.

USEME: USEME is programming framework [7] which is based on service oriented approach. This framework provides facility to developer to deploy the service on sensor node and actuator. These services are developed to satisfy the real time constraint and specification. It is platform independent. This framework support to wireless sensor network as a middleware. Useme framework is combination of various components. Constraint management is use full to fulfill the demand of real time environment, Configuration management is responsible to maintain the frequency of service discovery, Invocation and communication is used to deliver the packet among various nodes, Publication and service discovery is used to store the record of service and group management is responsible to form a group to achieve the efficiency and scalability.

GEM: GEM is a generic event service middleware framework [11]. This framework is designed to support the new event based service. Gem is generic middleware, which is use to facilitate the wireless sensor application along with service package. Generic middleware architecture provides multilevel event detection, event language description and mote module to encode the code. Language of event defines the format of data and storage in mote. Information of every mote is required to identify the event at group level.

A range of solutions are existing to address above issues.These solutions are capable to resolve the above issues of wireless sensor network.Some issues of wireless sensor networks still exist such as adoption of new services, new protocols, and interoperability between heterogeneous services.Therefore we are providing a Flexible Service Oriented Network Architecture as a solution which is capable to tackle these issues.

4   Proposed Work

This is generic architecture of the system with proposed Flexible Service Oriented Network Architecture. Generic architecture consists with four layers (Figure 2). Every layer is responsible to perform specific task as per the need of application. Proposed Flexible Service Oriented Network architecture exists on top of every layer. Other layers are application software, X- operating system and system software. Application s/w is repository of softwares like web browsers, database spread sheet etc, which provides a communication between proposed architecture and X- operating system. X- Operating system is component based operating system. System s/w provides a communication between h/w and X- Operating system.

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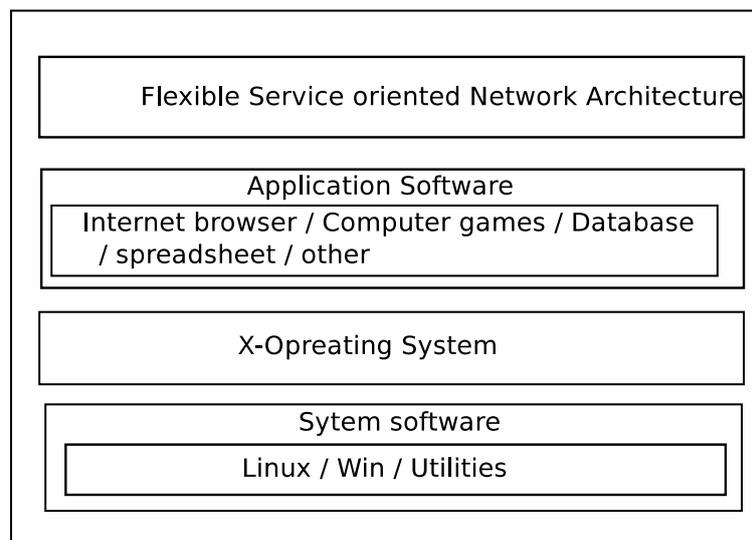
Figure 2: Generic System Architecture

In proposed Flexible Service Oriented Network Architecture, a new solution for the Wireless sensor network which is constraint based and constraint free. Constraint based and constraint free network can have various issues such as adoption of new service, adoption of new protocol, Interoperability, service selection and composition availability of service, security, heterogeneity of platforms. Detail functionality of Flexible Service Oriented Network Architecture in Figure 3.

Service user will be able to find out the service as per the requirements of application. Service user can be classified in terms of domain expert and general user with its knowledge. Users can give input to API with requirement such as application requirements, user requirement, and network requirements.

Service broker will get the request through the API. Broker will search the service in its local repository as per the requirement. If service will available then broker will return optimized service for application otherwise send the request to another broker to get best service. Service provider will provide the service to user through broker. Service provider will compose the service as per the user requirements and reply back to broker. Broker will send the service to user without knowing the low level detail of service.

Completion of above steps user will get the best service as per the requirements. Then user will be able to deploy the service for wireless application like sensor network through the API.

Service user: In this architecture level of users are classified in two categories such as Non parametric user and parametric user based on expertise. The execution of services in flexible
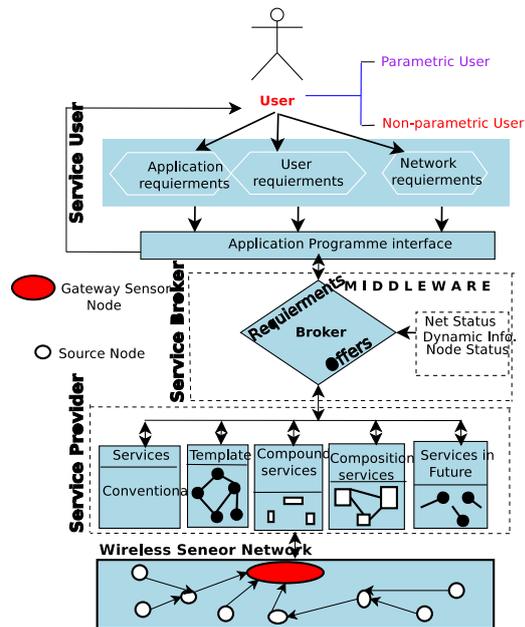
Figure 3: Flexible Service Oriented Network Architecture

service oriented network architecture begins with requirements of application as a user input.

Non Parametric User: Non parametric users are passive recipient of service without knowing the technical or low level details. The service request of Non parametric user is forwarded to broker through the application programming interface without any technical requirements; the requested services are fetched from service provider with default setting and delivered to the user through the broker. In this case non parametric user may not get filtered services due to lack of technical requirements as an input.

Parametric User: Parametric users are service users, who have detailed technical knowledge of application requirements. These requirements are application requirements, user requirements and network requirements. A parametric user sends request in the form of requirements parameters of application to the service broker. Service Broker will fetch the service from the service provider after composition as per the requirements and reply back to the Service users. Composed service will be filtered and most suitable for the application. Service users will deploy the service in application after getting the reply from broker.

Service Broker: There three types of functionalities, which are performed by a broker to complete the success full communication in flexible service oriented environment.

Protocol Graph Generator: A specific pattern of combination or sequence of building block known as protocol graph. Complex services can be made with the combination of various simple service s. A graph sketch specifies the specific pattern, which is needed for getting a service of user. Every node has capacity to generate the protocol graph. Requirements like user, application, and network are playing important role for dynamic generation of protocol graph.

Message Translator: In this module some messages are composed with the combination of more than one message, which is performed by the message list. A building block can add message, create message read message and removes the message from message list as per the compatibility. Application building block is used for message transformation. This building block also plays a role of bridge between workflow and application.

Message Transmission: This module is responsible for the transmission between application and Network building blocks. Message Formats for communication Following pattern is

used for communication in flexible service oriented network environment.

msg 1 and msg2: A XML file name in string format.

msg4 and msg5: This is msg1,built in message list format.

msg3 and msg6: Tagged message with filename and fragmented data to be transferred.

Figure 4: Communication Process between Brokers

After receiving the request from user end, Broker generates a list of unavailable building blocks (Service module) in XML format. Building blocks information sent to application building block in the form of msg1 (Figure 4) [15]. Up port of Transmission building block receives a msg2 from application building block after translation. Transmission building block forwards msg3 to the data port of Network building block. Then received msg3 sent to the other Network Building block with same msg format. At the receiver end, Network building block sends msg to the down port of transmission building block. The data pull out from Transmission building block, will be copied in XML format. Above process will be repeated for reply msg in appropriate format.

Service Providers: The service providers are entity of our proposed architecture, which provides service to user as per the requirements. These services are classified according to its nature in various categories such as Compound, composition, conventional, template and services in future. A Service provider plays a role of developer and provider for consumer. Service provider provides a many flavour of service along with same or different providers. Service providers have facility to develop a new service based on predefine, precompiled and precomposed methods as per the requirement parameters of users. These above methods are helpful at the time of service composition. The service provider can use static or dynamic methods to develop a new service. When parameters of service need not change frequently at run time then developer follows the static method otherwise dynamic method to support the frequent change at runtime.

Services: Service is functional module, which is used to perform single or multiple tasks. Functional module of service may be a single or combination of other modules. These modules can be implemented by any technology on any platform with scalability, flexibility and fault tolerance. The goal of concerning things are interoperability, heterogeneous system services should be capability to connect, loose coupling, to minimize interdependencies between modules and heterogeneous data type, interaction pattern at the time of platform binding, logical deployment. These are performed with loose coupling. Our Flexible service Oriented Network architecture supports for wide range of wireless sensor network services.Conventional Service Represents those type of services which developed in previous days and we are using without any required modification. These services have some flaws like network protocol adaption, Localization algorithms and its complexity, tight coupling etc.

Template: Template is a service, which is defined as set of reusable service related data that will minimize the required time to create service. This is applied for designer, developer and user to create or use the service. The template is used by various applications in order to save time needed to develop network interface, network load balancer and one or more virtual machines. This architecture provides a facility for developer, architect to develop or design new template as a service and register it for use of public environment.

Compound Service: The Compound service is a result from combination of two or more modules, which may be different or same according to configuration. Development of compound service is not easy task because before the development of this service user should know the compatibility of application programming interface, protocol and integration requirements for application. Prior knowledge of low level detail of different services and platform is not easy. So there is need of architecture to support in the development and deployment of compound services for application. Our Architecture resolves above issues and provides support to developer and user without knowing the low level details of other services.

Service Composition: Service composition is a way to build a new service from a set of service modules at run time. Service location and selection plays an important role in the process of composition. In this architecture we are considering two types of service compositions. Static service composition all requirements are fixed at the time of service designing. The requirements cannot be changed frequently at run time because lack of flexibility, agile for run time. Therefore we are also considering dynamic service composition to accomplish the requirements of user as a service. In dynamic service composition various complications comes like operating service, service selection criteria. It is not necessary that composition process will always give correct result as per the user requirements. So through the application programming interface provides a facility to change in the requirements to get an available service. Dynamic service composition reduces the human effort in service selection. We are considering both environments for service selection in our proposed architecture. Service in future Services in future are vision to develop a new service, protocol, tools, plat- form, language etc. In the current era of development researchers and developers are providing a new solution for the specific problem as a service to fulfill the demand of users with fast speed. So services are increasing with rapid rate on the internet. Users may not know all solutions of specific problem. Therefore we are providing architecture which will give the best service which will available on internet in future.

Technical Requirements: Many solutions are available in the form of service for specific task on the web. These services are required to execute the application. User will have flexibility to give an input in terms of requirement for service selection and composition [18]. Therefore user has option to select a service with specification of requirements. Being a user, requirements can be categorized such as user requirement, application requirement and network requirement which are given in Figure 5.

User requirements can be defined as a goal of application.This requirement is useful to find out the type of service for application [17]. There are various type of applications are used in sensor network so requirements of application will also be differ as per the performance. Application requirements may be defined as accuracy, computation time, bandwidth, delay etc. network requirements is defined as, need of network related constraints. These constraints may be the selection of protocol, level of fault tolerance, transmission speed, life time of network etc. These requirements play an important role to find out the best service for the application.

Let S be the set of services which is represented as:
$$S = \sum_{i=0}^{l} U_i + \sum_{j=0}^{n} A_j + \sum_{k=0}^{m} K_m.$$
User requirement may be single or multiple, which is mandatory. A is application require-

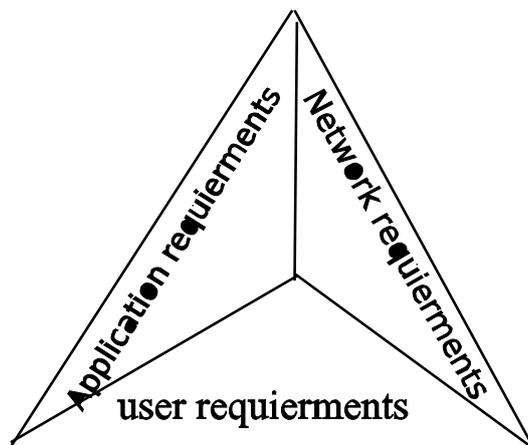Figure 5: Technical Requirements

ments, N is network requirements.These requirements are optional, which can be represented as:

$$A=\{a_1, a_2, a_3, ...a_n\}$$
$$N= \{n_1, n_2, n_3, ...n_k\}.$$

When n, k=0 then interaction pattern of application is similar to current pattern, where user will get minimal facility of service selection. When j=1...n and k= 1...m, then this condition will increase the better tune of service. The application uses different protocols for communication and also there are many applications which can work with diverse of protocols.

Let P be the total number of protocols available which can be represented as:

$$P=\{p_1, p_2, p_3................p_n\} , a_f =\{p_f|p_f \subset p\}.$$

Convergence of service request interpretation:

$$E(X - S)^2 = 0$$

then X='S' with probability 1 or x converges to S with probability 1 let $\sigma^2 x$ is variability of measurement according to Chebyshev inequality:

$$p\{|X - A| \leq \epsilon\} \geq |\sigma^2 x \div \epsilon^2 x.$$

If σ_x is very much smaller than ϵ then observed variable X is between (S-ϵ) and (S+ϵ) which is almost certain and one measurement of X is sufficient. However if σ_x is not sufficiently smaller compared to ϵ, then the result will not be of sufficient accuracy.

5 Comparison of Various Service Oriented Approaches with Flexible Service Oriented Architecture

Wireless Sensor network is distributed service over the network with well-defined interface. These services are easily accessible and deployable by WSN application through service oriented model based Interfaces. Service oriented model covers functional and non functional requirements of users to fulfill the gap of applications. These applications can be use the services to get the better result as per the requirements. To achieve result communication should be perform in between two parties with indirect manner i.e. with service brokers. Services are accessible through multiple paths; best path will increase the response time of service with UDP, SOAP transport. In the comparison table 1. We have tried cover all the requirements of user and applications with Flexible Service Oriented Architecture for WSN. Few of them are covered in individual model but no one covers all the requirements and flexibility of module implementation

as per the new requirements, which may come in future. Therefore we have shown comparative analysis in Table 1.

Table 1: Comparison with main features

SI. No.	SOA based Approach	Environment	Features	Covered Requierments
1	Flexible Service Oriented Network Architecture for WSN	Wireless/Wires Sensor Networks, Supports TCP/IP based networks	Flexibility to Innovation, Loose Coupling, Automatic service discovery, Adaption of New service, Support real time constrains of users	Run time support,Service transparancy, Interoperability among service,QOS,Integration with other sytem,Service discovery, Service abstraction.
2	USEME	Wireless/Wires Sensor networks	Handles publicationand discovery,Management of real time constraint	Runtime support service discovery Service abstraction
3	OASiS	Wireless Sensor Networks	Environment based sepration Concerns,Dynamic service discovery and deployment	Runtime support system, Service discovery,Abstraction.
4	Misense	Wireless Sensor Networks	Content based on sepration of concers and subscription model, Flexible data management,Programming API	Service transparancy,Efiicient large amount of data.
5	Stream Ware	Sensor network (Wired/Wireless)	Query based access. Hetroginity Management,Scalability	Service discovery,management,Efficient handling of large amount of data.
6	(SI) 2	Smart items Network	Platform independent service, description, deployment	Run time support, service discovery and deployment. Abstraction, Integration with other system.
7	DySSco	Wireless sensor network	Dynamic self configuration service coverage	Service deployment, transparency, abstraction, Configurable service.
8	B-VIS	Distributed RFID and Sensor networks	Real time Tracking and monitoring trough sensors, Programming for real time data.	Abstraction ,Interoperability, Efficient for handling large amount of data. Integration with other system.
9	SOMDM	Wireless Sensor Network	Component architecture to reduce data processing	Service transparency, abstraction to heterogeneous nodes, interoperability between other nodes.

6   Conclusions and Future Works

Our Proposed Flexible Service Oriented Network Architecture is developed with java platform. XML format is used to provide interoperability between different services. Flexible Service Oriented Network Architecture is providing a facility to user for service selection and composition, adoption of new service, protocol. Through this architecture users can get best service from the broker as per the requirements of application.

Also, the architecture provides a facility to couple the module (service) in the real time service domain and feasible to connect the heterogeneous and homogeneous services on common

platform. This architecture can be used by novice users having no or little knowledge regarding the low level technical detail of services. In future we will convert the XML format to RDF format, rating of service on constraints.

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