A review on Sensor Grid frameworks and an approach to the large-scale sensor grid based on knowledge grid

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Abstract: Integration and combination of grid computing and sensor networks together under the name of sensor grid is just like adding ear and eye to grid computing so that adding sensor network to grid increases communication network's ability and efficiency. Combination of these two technologies leads to collecting needed data in command and control critical conditions in order to make immediate decisions and making more accurate and thorough computing. Recent advancements in navigation protocols, optimizing energy consumption algorithms, data fusion and WSN networks security, have made this network able to answer various applications. As the future generation of network infrastructures, Grid computing is the most important technology to connect networks together using standard methods. Grid computing has been addressed as an approach based on standards to a coordinate sharing of various and distributed resources in order to solve large-scale problems, in virtual dynamic organizations. In this paper, the explanation of presented frameworks which are applied for integration of sensor networks and grid computing is studied and also necessity of utilizing knowledge grid in presenting large-scale sensor grid framework will be noticed.

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Key words: WSN, Sensor Grid, Grid Computing, Knowledge Grid.

1- Introduction

Sensor grid is a new research area considered for combination of WSN and grid computing in order to achieve new and powerful applications out of that. Because of the breadth of computing, storage and communication power of grid, data achieved from WSN can be shared by several users and get efficiently processed. The combination of these two technologies faces many challenging problems such as limitation of battery life in WSN, low bandwidth connection and data rate, and also non-standard communication protocols.

Combination of WSN and grid computing is indeed achieving data in real world using high power of grid computing. With this combination, power and other features of sensor networks and grid computing can be met in a single integrated platform.

Increasing development of distributed data, information and knowledge resources in geographical spaces lead the need of implementing distributed and decentralized systems. In decentralized environments, design and implementation of such programs needs several mechanisms and services to perform different operations on information and computing resources. Organizations have been come out of traditional forms and converted to open enterprises systems [24].

WSN upgrades both quantity and quality of data processed by grid computing. Grid computing also can immediately store, process and model data using extensive calculations for decision making.

WSN and grid computing are different technologies. WSN is generally based on local design and structure. For example, private communication protocol has been used in WSN and also there are limitation specifications in terms of computing, storage, transmission power, and battery life. But grid is a standard technology based on TCP/IP standard protocol and it is to provide all kinds of resources for users by means of a standard method [12,13].

Different frameworks have been presented for sensor grid, each of them designed to fill the gap between physical and digital world and also facilitating in information analysis and decision making in order to integrate sensor networks and grid systems so that both can be used in an efficient way. Integrated services coming out of sensor networks and grid computing have been introduced in these frameworks using layer models.

Then the paper continues this way: part 2 and 3 is specialized to introducing grid, main challenges in WSN and grid combination, and relevant issues. Different Conceptual architectures are presented in part 4 besides addressing sensor grid and after all, part 5 includes conclusions and suggestions.

2- Grid

'The Grid' term emerged in the middle of 1990 to address proposed distributed computing infrastructures in science and engineering and as long as such infrastructure has come up, it has been considerably progressed. However, at least in the public perspective, the term 'Grid' has been used to encompass everything from advanced networks to artificial intelligence [8].

Not all the protocols, services, APIs, and SDKs are checked out one by one in architecture explanation but only one public class of them is to be considered. The result will be an open and scalable architecture able to provide some solutions for VO demands.

In a layer form, Grid architecture and its elements have been illustrated in figure 1. Each layer's elements share public characteristics and also can develop its capabilities and lower layer behaviors [9].

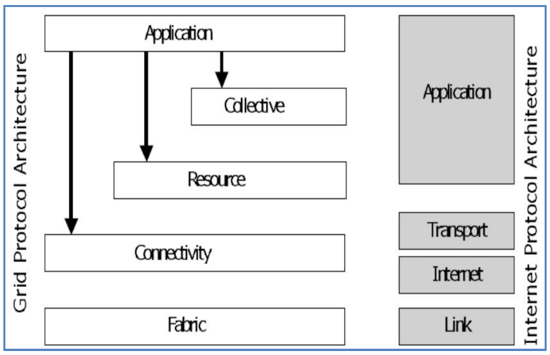

Figure 1. The layered Grid architecture and its relationship to the Internet protocol architecture [9].

The actual and specified form in grid theory is 'Coordinate sharing of resources and problem solving in multi association dynamic virtual organizations'. It has not the meaning of file transmission at all but this sharing is to be controlled by resources producers and users in an accurate and cautious way. Some of these controls are: what has been shared, who have allowed this sharing, and also what are the conditions under which sharing occurs.

The set of people and associations defined by such sharing rules are called Virtual Organizations (VO).

Grid architecture defines basic elements of the system, determines the goal, and also shows how these basic elements interact with each other. Defining grid architecture needs special consideration to what VO demands which is 'creating sharing communications between every potential associate'. Mid operation capability is an important issue. In a network environment, this capability means 'the existence of common protocols'. The first and the best architecture for protocols in grid architecture is using protocols defining basic mechanisms and by means of this architecture, users and VO resources can make, manage and, utilize sharing communications.

An open architecture based on standards provides scalability, mid operation capability, Portability and code sharing. Standard protocols facilitate the definition of standard services and also provide controlling capabilities. Moreover, application programming interfaces (API) and software development kits (SDK) can be made this way.

On the other hand, grid is a technology without many limitations especially in the area of grid resources. In fact, the breadth of grid (computational, data, communicational) is very considerable and also its communication rate is so high regarding to this matter that the most powerful servers and super-servers are connected together in this technology. In the early decade of the 90th, Grid computing was addressed in supercomputing society and its goal was considered as applying accessible computing resources in an easy way to make geographically distributed sites able to do complicated calculations. The main idea of grid is that resources or participant machines, through a layer of software can be used transparently and securely. This software layer has to perform duties such as resources virtualization, searching and finding resources, and management of running programs. Grid computing is simply distributed computing which has achieved a higher level of evolution. The goal is to achieve an imagination from a simple virtual computer and at the same time large and powerful which has the power to manage itself out of an extent complex of computers. This complex is consisted of a series of heterogeneous systems connected together sharing different combinations of resources. This technology looks at computing, storage, and scattered communicational resources as a large system or in a better word, a hyper system. It also generates special ability to provide resources. Here regarding to the limits of computing resources, sensor networks are to be very considerable. Grid does not use specific protocols and is fundamentally based on internet protocol and algorithms and other common protocols [9].

3- The combination of WSN and grid computing

Sensor networks have good ability to understand the environment and receive data [10]. The combination of these two technologies helps solving larger and more complicated problems, reducing computational resource needs and computing time for services in need of many resources [1].

In sensor networks, knowledge comes out of the combination of homogeneous and heterogeneous nodes data, but sharing and storing knowledge is to be difficult considering limitations and losses. But if up to date and accurate information are not available, then updating knowledge will become difficult in grid and of course keeping knowledge will be simpler in case of having more facilities [28].

Looking at sensor grid from another point of view, different users in different networks can have integrated access to other network resources. Thus any user can access anything and anywhere in any period of time. This was not possible in sensor networks that each user has been defined only in district of application and the network access resources in any time while having high flexibility, sensor grid supports the idea of '**any time- any place- anything**'. So generally this can be said that sensor grid reduces the distance between physical environment and digital world creating analysis facilities, storage, and information process. As a result it makes decision making more accurate and efficient.

3-1- Sensor grid services

Sensor grid generates an electronic skin on the earth which makes process of sensing and supervising full dimensional, full-scale, and full-phase in global, regional, and local levels. Services set to discover and publish sensor resources can be classified like this [7]:

1- Sensor observation service for data access.

2- Program and design service to apply sensor, requests acquisition, record notices and conscious warnings.

3- Warning and notification service in special circumstances.

4- Web notification service as an assignor of transmitted protocol.

5- Observing and measurement, Sensor Model Language to code and model sensor data.

3-2- Definitions relevant to sensor grid

Different definitions have been given under various titles according to explanation sensor grid such as sensor web or pervasive network [27], and etc which somehow they all have the same goals of sensor grid. In fact in some different researches, this technology has been addressed under the subject of sensor web, or pervasive networks but still it seems to be no considerable difference between sensor grid definition, sensor web, pervasive network, and other names it has been called.

A definition for sensor web was presented by web plan and research group of NASA in 2000: a sensor web is a system consisting of distributed sensor elements developed in high geographical extent to monitor, search, and new environmental researches [16]. Moreover, NASA research group has suggested another definition as followed: the concept of sensor web to link and relate between ground atmosphere-based instruments to autonomously provide a collection of collaborative observations. These observations are obtained through various resources and this can be possible by means of an integrated set of software and communicational interactions between sensors. Geography scientists believe that sensor web creates an extensive system to observe and sense. These observations are accurate, comprehensive, continuous, and multi-dimensional. They define sensor web as a web-based open information system which provides extent observation on time-location of our surrounding environment coordinately and among several kinds of intelligent sensor networks connected together [17].

Also in another approach, sensor web is interpreted as an extent computing resource. This was addressed in an article in weekly 'Businessweek' that in the next century, planet earth will don an electronic skin which will absorb people acting in field of high efficiency computing to itself. They believe that the next generation will make sensor network very powerful out of sensor web and then this can be called under the name of Sensor Grid. Although this has not yet reached maturity and sophistication but it seems to attract a lot of attentions in near future [7].

Though there are various definitions and views of the Sensor Web and sensor grid, but all are united on one issue which that one open infrastructure is needed permitting final users to access information automatically and also extract their requests via the web or between different sensor sources better to be said Grid. This open resource infrastructure will also encounter many challenges. A more comprehensive definition than noticed definitions would be that the sensor web has been including a group of distributed homogeneous and heterogeneous sensors connected together through a communicational framework and other data and computing resources. Also the information is to be shared by means of various interfaces. Sensor web can be realized as a web-based information system to collect, model, storage, retrieval, sharing, manipulating, analysis, and even imagining sensor observations [15].

The first stimuli and concentration on sensor web occurred in order to monitor and manage sensor nodes and reaching sensors long distance information through web. From this viewpoint sensor web can be interpreted as a program provider and an interface between users and sensor nodes. Since wireless sensor networks are quite different from web, access to sensor network through web or other networks makes designing a transmission layer more accurately and completely considered to be necessary. Transmission layer protocol can partially manage and solve problems like data-centric routing, scalability, energy consumption between sensor nodes and sink nodes [10].

This might be mentioned that there is no difference between sensor web and sensor grid since they both try to widely share resources and communications. But actually what distinguishes them is the issue of management which is to be passive in sensor web while active and dynamic in sensor grid.

Moreover, resource management should be distributed and also strong to not let the stability of the sensor grid impaired.

3-3- Research projects relevant to sensor grid

Various projects in this field have been done in institutions and universities around the world such as ArchRoch by Berkeley University [18], GeoWIFT project in York University [19], Hourglass project in Harvard [20], Webpresence in HP lab [3], Sensor Grid projects in universities of India [21]. The goals of these projects can be generally classified into five categories [7]:

1- A web-based approach to manage sensor networks

2- A comprehensive standard for cooperation and collaboration between sensors

3- A middleware between web and sensor networks

4- An approach to a web-based imagination of physical world

5- As a strong infrastructure for sensor networks

The ArchRock project organized by Berkeley University is a set of sensor management products. In its industrial draft, nodes softwares are appropriate tools to quick configuration and setup of communication and management between wireless sensor networks. Each node can be separately achieved and managed by means of IP-based management tools.

ArchRoch products are designed based on industrial standards and are also completely based on interfaces and software of open resources. In this project, the gateway servers and sensor nodes software generate flexible interfaces to develop computing systems based on service oriented web interfaces such as SOAP and REST interfaces. This project was more considered as a management tool to develop the operation of control networks and wireless sensitivity.

In NASA EO-1 project [22], the goal was to create an integrated set of software and communicational interactions to hybrid ground and atmosphere tools with each other so that the results would be provided autonomously and automatically among various resources and as a consequent, data acquisition would be in a high speed.

Another representative of research projects on sensor web is OGC from York University which uses OWS demo. In this project, demo plays the role of an environmental monitoring tool to collect information from different networks including camera information of a chemical factory, cameras and airborne sensing UAV in the air, and thermometers scattered on the earth and etc [7].

To discover, access, and functionalize achieved data from different networks such as climatic monitoring, water or gas pressure sensing networks, long-distance sensor networks sensing heat, pressure, and etc, a standard interface is necessary to be according to generate needed coordination. In OGC, there is a set of features and services under the name of sensor web enablement (SWE) defined to reach this goal. SWE tries to response two challenges: first to determine services to discover sensor resources and second, facilitating coding and modeling sensor data for combining data.

Some of the other researches and projects deal with the problem of creating a bridge between sensor networks and web-based application programs. There is a common idea in all these projects which is the need for a middleware to connect sensor networks with application programs and resources and it would not possible just through protocols between sensor networks and web-based programs. For instance, Hourglass project organized by Harvard is a representative of such efforts. In this project, a robust framework is tried to be made based on internet and to link an extent range of sensors, services, and application programs. To reach this goal, a circuit has been introducing that hybrids its data with the achieved data from one or more sensor networks. General architecture includes a network cover with determined connections from machines which generates record, discover, and rout services of data strings from sensors to users' application programs.

SWAP [23] is another project trying to use two distributed technologies of multi-agent systems and service oriented systems in combination. In this interface, sensors or better to say sensor networks are voluntarily getting connected together in loosely coupled form. Also ontology and a series of abstracts from integration and data combination have been suggested in SWAP.

Another sensor grid project more concentrated on heightening the efficiency of computing networks, are two projects with the same name of Sensor Grid in universities of India and Singapore. Sensor grid project of international university of Singapore is trying to use computing power, storage, and bandwidth to support the grid connection of sensors with limited resources. They are after immediate data mining and decision making. In India this project operates according to adding web service technology to service oriented architecture (SOA) and a middleware based on brokers [3].

3-4- Key problems of WSN and grid computing combination

Key problems in combination of these two technologies are:

- Communicational protocol, connection, and network interface
- Scalability
- Security

Grid has been created based on internet and standard network protocol TCP/IP, thus its connections are sufficiently fast and responsive. Independent web service is the base of grid. This service SOA (service objected architecture) can make several users able to find, access, and share services, data, computing, and communicational resources provided by grid. WSN acts through wireless method with limited bandwidth. Sensor nodes have been built densely and data redundancy in WSN is so high. Due to interruptions caused by noise or environment, transmission errors can easily occur. Also because of energy storage, WSN provides private routing protocol in the whole network and allows multiple users and applications to share data provided by it. Therefore, redundant sensor nodes in an environment are not needed because sensor nodes communicate through shared wireless resource. Equipping every sensor node with a grid interface is impractical, so an efficient method is highly necessary to provide a interface between WSN and grid. The best way is commissioning a standard API grid. OGSA (open grid system architecture) is based on web service and it is the most common used. If a data achieved by WSN could change under web service it can be transmitted to and interact with OGSA. This should be concerned that transformed data into web service needs to be coded in XML format, packed by SOAP, and transmitted to standard internet protocol. This method is very appropriate because of CPU speed and energy consumption. Security mechanism can act in two aspects mentioned bellow: On one hand, the data come from different WSN, is to be concentrated in one place and processed and on the other hand the results will be sent securely to the user. In the area of providing security for sensor grid, the security mechanism should integrate WSN and grid so that no security gap could be found.

4- Sensor grid frameworks

4-1- SPRING framework

SPRING is a flexible structure based on proxy and no particular requirements and functional specifications have been determined for it. This framework has been indicated in figure 2.

In SPRING framework, proxy acts as an interface between wireless sensor network and grid. In addition, it serves some important functions [2]:

1- Proxy discovers sensor resources as grid services and makes them available. It also translates sensor data from its essential format to an OGSA format suitable with grid such as XML.

2- Proxy coordinates needed connections between wireless sensor network and grid network. Moreover it creates an interface between sensor grid protocols and internet and web protocols. Proxy can reduce the impacts of unexpected disconnections of sensor network or long-term disconnections using techniques like buffering and link management.

3- Sensor grid scalability has been increased using WSN proxy. Wireless sensor networks can integrate with an existing sensor grid by means of adding proxy systems. From grid point of view, proxy exposes sensor resources accessible in a similar method as data resource or other computing. Ultimately different proxy creates services such as energy management, scheduling, security, accessibility, and QOS for wireless sensor networks.

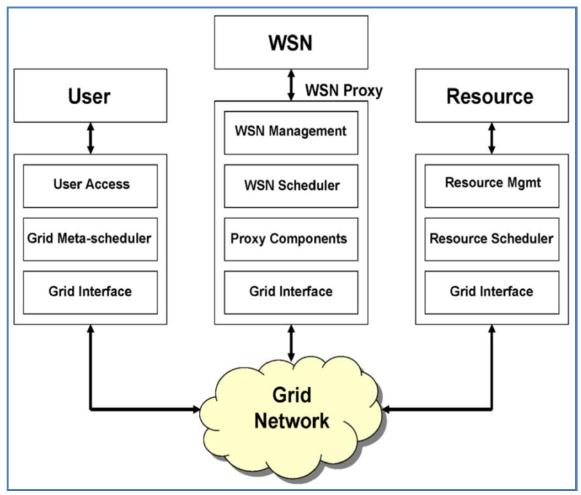

Figure 2. The SPRING framework [2].

SPRING is based on a layer structure. Each layer makes services needed for function or other layers by means of APIs interface.

Grid interface layer supports a standard network middleware such as Globus which enables different kind of resources to communicate all over grid network. Looking from user's view, its access layer is an interface like a network portal or workflow management tool which addresses functions to run on sensor networks. Function may include sensor operation to be enabled on wireless sensor network such as computing for sensor data processing.

A grid meta-scheduler is to be used for scheduling and routing tasks according to their needed resources. In wireless sensor network, WSN management layer generates an abstract of specific APIs and protocols to accessibility and management of heterogeneous sensor resources. Configuration manages sensor nodes and creates information of their situation. It also accepts sensor's task requirements from network and call for special commands to run that tasks on sensor nodes.

WSN scheduling, implements local resource schedule and low level schedule algorithms for sensor energy and resource management. In another word, it controls task requirements of sensor from different users. Sensor task parameters contain the amount of required sensors resources, optimal start time, duration, priority, and etc. Scheduler handles these parameters and checks if sensor resources are accessible and if needed, it will reserve resources for mentioned task. In addition, it acts better in generation of services for accessibility and QOS.

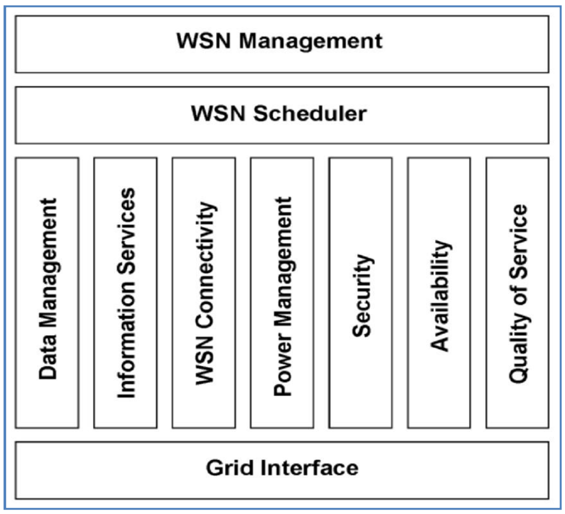

Figure 3. proxy software architecture [2].

Figure 3 shows software architecture of proxy. Resource management layer creates necessary APIs to access and manage data and computing storage resources for network's job execution. The components of data management transform sensor data from its essential format to the user's desired format. They also integrate data, do other optimizations to improve quality of collected data out of multiple sensors, and support data transmission to user.

The component of information services manages sensor resource discovering and observation. Moreover, it advertizes existing sensor resources as network services through mechanisms such as OGSA so that users can get reports of existence and status of sensor resources through mechanisms provided by OGSA. Static and dynamic information on sensor resources are directly relevant to WSN scheduler. WSN connectivity components generate services to connect sensor network protocols with grid protocols, receive their routing information from sensor nodes, and manage sensor network links.

Power management component is to control energy consumption in sensor nodes. Moreover with WSN scheduler, this component does the required operation to save sensor nodes' energy.

The component of security implements OGSA network security technologies. For instance, it can use technologies like running verification between proxy and sensor nodes.

Availability component provides services to improve the situation of wireless sensor network and checks whether sensor nodes have hardware failures or weak power levels and if so, transmits jobs from such nodes to reliable ones. This component is also able to show features of failure tolerance such as responsive services and recovery of discontinued jobs. Ultimately the quality of service component does sensor resource reservation and assignment regarding to service requirements.

4-2- A Sensor Grid Infrastructure for Large-Scale Ambient Intelligence

Service oriented sensor grid infrastructures catch the most concentrations in presenting sensor grid architectures. The objective of such infrastructure makes user free to control the environment and utilize experiences and consequences and also helps to create a real sense of environment.

The architecture of this framework has been considered with more details and not addressed in general but each layer's needed service has been concentrated. Yet it acts based on proxy like SPRING framework. As mentioned above, because of multiple data formats, a considerable amount of transmissions is to be needed due to peer to peer connectivity. It is probable that processing and computing operations have to be done on a station or a processor sufficiently strong. Services are made in this framework above WSRF which uses SOAP web service standard protocols.

4-3- Autonomic management of hybrid Sensor Grid (ASGrid) and application programs

ASGrid is an autonomous management framework designed to fill the gap between physical and digital world also facilitating information analysis and decision making. ASGrid framework (figure 5) contains layer modules below from down to up [6]:

1- Self-configuration: is a covering network based on content-based addressable network protocol with the spatial and temporal load balancing in an intelligent and adaptive copy form.

2- Content-based routing: routing is done through meeting messaging in a relationship and collection is done based on semantic.

3- Autonomic managers: contains Master Autonomic Managers (MAM) and Tiny Auto. MAM provide various self-managing and suitable functions. Tiny Auto is a low weighted element specifically designed for sensor networks concentrate on energy efficiency and other resource limitations for.

4- Two-row schedule engine: is separation of duties, scheduling, and resource management in high level. In case of duties in low level, a scheduling strategy is embedded to sense and combine data.

5- Upper layers: contains pre-process, programming models of application interface. This way the queries and duties supported by users are initially pre-processed, and then they are separated and are scheduled for appropriate resources. Models are used in order to quick achievement to resources and information.

6- Self-protection modules: management plans of low level active key (dynamic key) can be used in both sensor networks and grid networks.

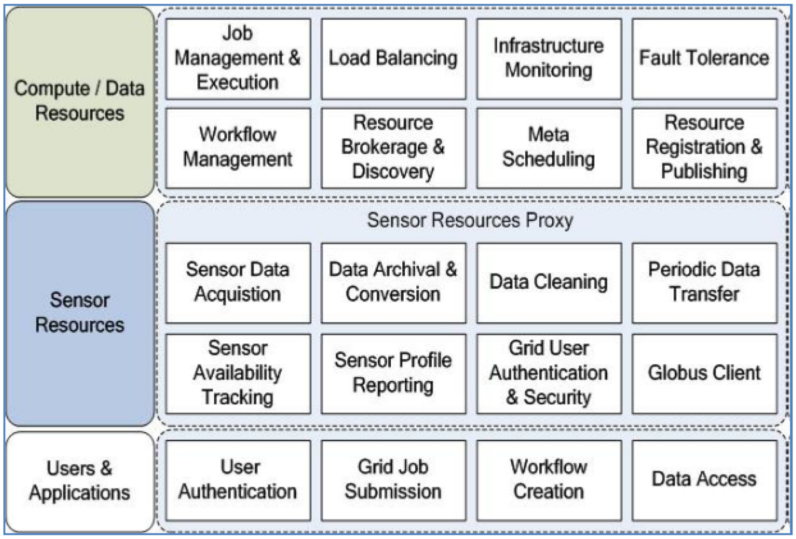

Figure 4. A Sensor Grid Infrastructure for Large-Scale Ambient Intelligence [4].

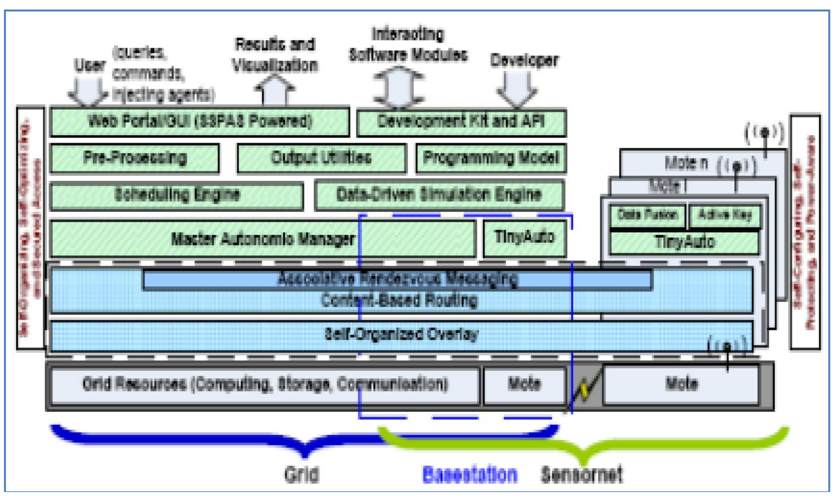

Figure 5. ASGrid framework [6].

To respond the queries, sensor networks are self-configuration in order to generate content-based collecting service just like semantic routing structure in Tiny DB (Tiny Data Base's sensor software implementation which can be executed on every node, includes a network topology manager for efficient routing which is to be based on semantic.) existing in WSN. A high level duty is to be segmented and distributed among the computational resources. Duty can be a query from past time data archive or from a proactive phenomenon [6].

4-4- Context-aware sensor grid

Context-aware sensor grid framework is the combination of three well known technologies of context-aware computing, grid computing, and sensor network. Context-aware is called to a system which based on the operational state can adapt a set of components and objects together for that application and apply that in determined time. Figure 6 is context-aware sensor grid framework based on agricultural ontology. This framework has been considered in 3 layers. The layer of context-aware programs is to determine different conditions and this can be said considering different applications this layer can be changed according the ontology of those applications. Grid middleware layer is in fact to achieve the advantages of high executive computing and store a huge amount of data which determines necessity of utilizing grid. Sensor network layer is also to collect information of current situation, positions, and physical states

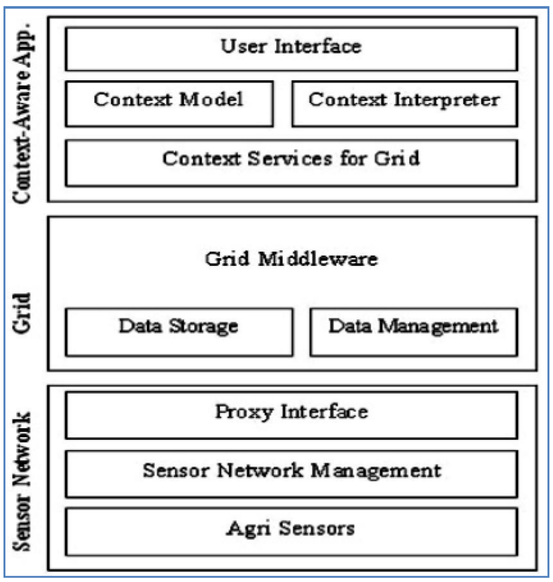

Figure 6. Context-aware sensor grid framework for agriculture [11].

Structural blocks of this framework have been considered in the following form [5]:

1- Context model: this model's block has to do content acquisition, definition and saving it.

2- Context interpreter: this block provides service generation for manager in order to interpret content values as the input.

3- Grid context services: is to generate and activate grid content services which are not found in OGSA so this block is necessary to provide such services.

4- Data storage/ management: This block has to deal with the storage and management of data services. Considering heterogeneity and quantity difference in sensors, collected data need to be classified, categorized, dense, and integrated.

5- Proxy interface: the connection of sensor network to the grid needs an interface able to convert formats to a compatible form with grid. Proxy interface block provides such facility.

6- Sensor network management: due to essential high dynamic of sensor network, management of that is to be very complicated. In this block is involved with problems dealing with sensors communication, topology, energy management, and etc.

7- Agricultural sensors: the area of agriculture needs determining different conditions for soil, water flow, harvest, and etc so that different sensors are to be needed. This block is to define the distribution of sensors relevant to agriculture and their requirements.

Just like other frameworks, there are various challenges in design interface of context-aware sensor grid. But some of them need special concentration because of being context-based. For example in context-aware model, main principals in content ontology design include simplicity, flexibility, scalability, and generality. OGSA provides several services for service-based applications but unfortunately it has not yet presented an approach for context-aware services.

Anyway this application-based framework tends to use sensor grid structure for specific applications. Although these structures can provide good efficiency for target applications, yet they are not scalable and flexible. There are also many difficulties in this area to define middleware which are to facilitate integration with grid. This framework uses CIMA (Common Instrument Middleware Architecture) middleware which is based on a format presenting standard grid tool such as OGSA.

4-5- The comparison of sensor grid presented frameworks

'SPRING' framework, 'sensor grid for large-scale ambient intelligence', and 'context-aware sensor grid' have been built upon presenting service and the main part of duties, conflict resolutions, and adaptations are to be done by proxy interfaces. But in 'ASGrid' architecture, middleware layers are considered for these duties.

On the other hand, management is distributed and multi-level in all these architectures. For instance, architecture of ASGrid uses a two-level management in interface.

Of security, the architecture of ASGrid utilizes 'active key management' approach but only the authentication block has been set in interface layers or on proxy in other architectures.

Service discovering, QOS mechanisms integration, running distributed and hierarchical algorithms, appropriate queries, self-organization, and adaptation can be mentioned as some of the other effective challenges in framework design.

Self-organization is one of the most important factors in sensor networks thoroughly considered in ASGrid architecture while not concerned in other architectures. In the architecture of context-aware sensor grid, architecture has been considered application-based to simplify duties and accurate more the answers of the queries. But this matter cause scalability under question. Yet considering that all these architectures operated based on OGSA services and have not yet presented context-based services in OGSA, therefore it seems necessary to notice this frameworks to present a comprehensive middleware.

Table 1. The comparison of sensor grid presented frameworks.

Context-Aware Sensor Grid for Agriculture	ASGrid	Large-Scale Ambient Intelligence	SPRING	Framework / Capability
✓	✗	✓	✓	Based on proxy interface
✗	✗	✓	✓	Supporting standard middleware (Globus)
✓	✗	✓	✓	Supporting service oriented architecture
✗	✓	Management based on OGSA	Management based on OGSA	Self management
✓	✗	✗	✗	Supporting context based services
✗	✓	✗	✗	Self-organization
✗	active key management' approach	Based on security services of OGSA	Based on security services of OGSA	security
✓	✗	✗	✓	specific application based

Generally to present a comprehensive and robust framework, a combination of mentioned frameworks and utilizing their strengths result in improving the strengths of the middleware. Among all and due to its approach of presenting a more autonomic management, considering ASGrid architecture would be more effective on content-based routing and self-organization.

5- Conclusions and suggestions

The combination of two technologies of sensor networks and grid computing faces many challenges so that in this area many efforts and researches can be done relevant to middleware, protocols, and network connectivity.

Management in sensor grid should be dynamic, active, and distributed to heighten robustness and failure tolerance. In all mentioned architectures, challenges in management, security, and accessibility mechanisms have been considered through different approaches and methods.

Studying various frameworks of sensor grid, this can be concluded that these architectures have been already designed based on specific applications and not yet a general framework and architecture have been presented and this is totally different with the main goal and idea of integrating networks in sensor grid. So presenting a robust and reliable framework to form resources' sharing spine should be mentioned to be necessary. An interface facilitating secure accessibility for sensors and computing and storage resources come out of the combination of these two technologies.

In these frameworks, grid is considered as a social network which people, machines, and virtual roles are communicating in. moreover, other knowledge management systems in grid which have not been even mentioned under the name of knowledge grid are considered as a knowledge-based grid that sensor grid is in interaction with.

As an infrastructure for grid, knowledge grid can be noticed as a social network to meet trust and commitment of providing data supply and distribution. Trust is to be noteworthy in process of knowledge grid. It shows itself in form of commitment in referral agent [25]. Factually in social networks, whenever an agent asks its neighbor for something, it has trusted that neighbor and whenever the called agent refers the other agent to another one, there has been commitment in it.

As the social elements, awareness, trust, and commitment play the main role in social networks interactions. Trust and awareness lead to server recognition in knowledge grid and requesting it. Awareness and commitment also cause referral [26]. All these cognitive characteristics lie implicitly in agents cause to discover, extract, affirm, and transmit knowledge from one to another. All these factors result in autonomic management together.

Sensor grid nodes in a network based organization contain all human and software agents or generally equipped nodes with one or more sensor involving with environment. Interactions between these agents create the network. Right data download and accurate processes and interactions play the key role in command and control the situation and ultimately lead to better decisions and newfound behavior in knowledge grid. Knowledge grid is an infrastructure for sensor grid and various tasks in different applications can be implemented along with it.

The purpose of using knowledge grid is to achieve shared awareness between the nodes of the network. We are supposed to provide sharing nodes' acquired data between the other nodes (people and virtual organizations) using grid equipments and ideas so that in addition to share their own knowledge, the nodes can provide required knowledge of their fellow group members and society (network) nodes if possible and this is not possible without the use of knowledge grid power.

Regarding to the mentioned architectures for sensor grid in part 4 and also considering demands of network based organizations and studying their needed services, a combination of sensor grid architectures can be considered as a prerequisite of the noticed architecture for large-scale sensor grid and also apply some changes on them according to the necessity of utilizing knowledge grid in needed.

In addition, in the large-scale sensor grid with the purpose of global sensor grid, there is an obvious need for design a cognitive and autonomous framework with information capabilities and services. Therefore, some alterations in these architectures and adding capabilities for utilizing knowledge grid is absolutely necessary to make the infrastructure of global sensor grid or in another word 'the large-scale sensor grid'.

By the way, the more advanced technologies and services of Adhoc networks become, the more real and possible the dream of creating a pervasive network as an electronic skin all over the world comes to be.

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