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POLLUTION MONITORING FOR HEALTHY ENVIRONMENT USING INTEGRATED WIRELESS SENSOR NETWORKS AND GRID COMPUTING

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Abstract— Wireless Sensor networks is an excellent technology that can sense, measure, and gather information from the real world and, based on some local decision process transmit the sensed data to the user. These networks allow the physical environment to be measured at high resolutions, and greatly increase the quality and quantity of real-world data and information for applications like pollution control. A SensorWeb Network measures data related to geospatial information and can detect the conditions of remote places as a new instrument for environmental monitoring in the physical world. On the other hand the demand for computational and storage resources led us to Grid Computing. Grid is an infrastructure that involves the integrated and collaborative use of computer, networks, databases and scientific instruments owned and managed by multiple organisations. Grid applications often involve large amounts of data and computing resources that require secure resource sharing across organisational boundaries. In this paper, pollution monitoring for a healthy environment – a system that monitors pollution levels in the environment is proposed, using integration of Wireless Sensor Networks and Grid Computing

Keywords— Wireless Sensor Networks, SensorWeb, geospatial information, environmental monitoring, Grid Computing, pollution control.

INTRODUCTION

Present advances in electronic circuit miniature and micro-electromechanical systems (MEMS) have led to the creation of small sensor nodes which integrate several sensors, a central processing unit (CPU), memory and a wireless transceiver. Sensor networks [2,5] are a collection of these sensor nodes which are easily deployable and provide a high degree of visibility into real-world physical processes as they happen, thus benefitting a variety of applications. Important applications include environmental and habitat monitoring, healthcare monitoring of patients, weather monitoring and forecasting. Military and homeland security surveillance, tracking of goods and manufacturing processes, safety monitoring of physical structures and construction sites, smart homes and offices, and many other uses that we do not yet imagine.

A parallel development in the technology landscape is Grid Computing, which is the federation of heterogeneous computational servers connected by high-speed networks connections. Middleware technologies such as Globus and Gridbus[15] enable secure and convenient sharing of resources such as CPU, memory, storage, content and databases by users and applications. Grid computing is also referred to as 'computing on tap', utility computing and IBM's mantra 'on demand' computing[1]. Applications such as bioinformatics, drug design, engineering design, business, manufacturing and logistics make use of grid computing.

The combination of sensor networks and grid computing in sensor-grid computing executing on a sensor grid architecture sensor grid in short) enables the complementary strengths and characteristics of sensor networks and grid computing to be realized on a single platform as shown in Figure 1.

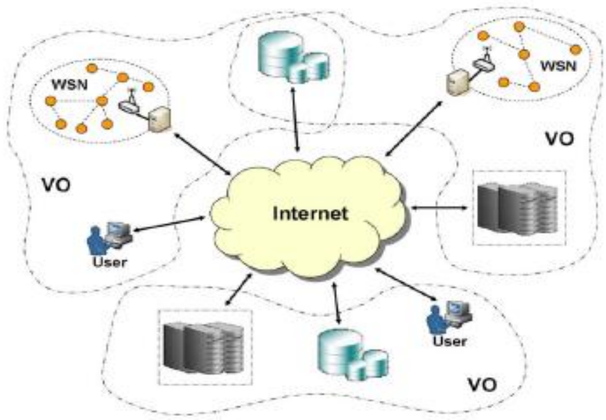

Figure 1. Sensor Grid Organisation

The resources in the sensor grid are shared by several Virtual Organisations (VOs). In fact, certain resources might belong to more than one VO. Users from various VOs may access the resources in the sensor grid, even if the resources are not owned by their VO[4].

RELATED WORK

The term Distributed Sensor Network(DNS) is defined as a collection of a large number heterogeneous collection of a large number of heterogeneous intelligent sensors that are distributed geographically over an environment and connected through a communication network[10]. A GeoSensor Network (GSN) is a network that can monitor phenomena in geographic space in which the geospatial content of the collected aggregated, analysed, and monitored [9].

A sensor network can be utilized for environmental monitoring applications. For example there is microclimate monitoring [2] application, applications that checks the climate data such as temperature, radiant light, relative humidity and barometric pressure, throughout the volume of giant trees. The Automated Local Evaluation in Real-Time (ALERT) was developed for providing important real-time rainfall and water level information to evaluate the possibility of potential flooding[12].Software tools for the management of wireless sensor networks are necessary for the efficient utilization of wireless sensor networks.

MoteLab[3] is a web based sensor network testbed developed at Harvard University. MoteLab provides a web based interface that makes it easier for users to program the motes, create sensor jobs, reserve time slots to run sensor jobs on the motes, collect the sensor data, and perform simple administrative functions. Sensors Anywhere[SANY] Project[13] deals with sensor networks research for environmental applications, and tries to improve the interoperability of sensors and sensor networks. Other network management system software include Emstar [6] and Kansei [11]. However, such systems can only manage a standalone wireless sensor network testbed, and they are not integrated with the grid fabric.

Recently, research efforts are beginning to study the integration of wireless sensor networks and grid computing. The Discovery Net project (http://www.discovery-on-the-net) is a grid-based framework for developing and deploying knowledge discovery services to analyse data collected from distributed high throughput sensors. The applications include life sciences, environmental monitoring, and geo-hazard modelling. Although these architectures are efficient and can deliver good performance for the targeted applications, they are not flexible and scalable.

The Common Instrument Middleware Architecture [CIMA] project [8] aims to “grid enable” instruments and sensors as real-time data sources to facilitate their integration with the grid. The Scalable Proxy-based aRchitecture for seNsor Grid (SPRING) framework [4] integrates wireless sensor networks with the grid. SPRING architecture is scalable, and it can integrate multiple heterogeneous wireless sensor networks with the grid but it does not include wireless programing .

In our architecture, we propose a new approach in order to integrate wireless sensor networks with the grid infrastructure, developing a fully interconnected Sensor Grid System which successfully involves many different applications of these technologies. The usage of this Sensor Grid aims to achieve better performance than the other networks monitoring environmental changes and it will support users to have more accurate results about environment in real-time using the grid to process the sensor data.

Sensorgrids enable the construction of real-time models and databases about the environment with vast computational resources. This enables the construction of real-time models and databases of the environment and can used for effective early warning of natural disasters such as tornados and tsunamis.

In this paper, we demonstrate a novel architecture that is flexible and scalable because it can integrate heterogeneous wireless networks such as Sensor networks and the existing Grid infrastructure. The main goal of this paper is ensure uninterrupted processing, monitoring and storing of the results in the Sensorgrid which helps measure pollution in real-time and report status of highly polluted areas . This network is very user friendly and accessible to any user irrespective of his geographical location.

The rest of this paper is organised as follows. Section II presents the related work on the area of Sensor Networks, Grid Computing and Sensorgrids .Section III analyses the technical requirements of integrating a Wireless Sensor Network and Grid Computing.. In Section IV, a framework that provides resource coordination of the proposed system is developed. Section V demonstrates the working of the simulation model, proposed implementation and methodologies developing the integrated system.

REQUIREMENTS OF SENSORGRID SYSTEM

Environmentalists, researchers and users are interested in real-time information from the world, and they span institutions, countries and continents. They will have a better outcome if they link data, computers, sensors and other resources into one virtual environment.

Sensor web:

A Sensor Web [7] refers to web accessible sensor networks and archived data that can be discovered and accessed using standard protocols and Application Program Interfaces (API).

In an Open Geospatial Consortium,[14] Inc. (OGC) initiative called Sensor Web Enablement (SWE), members of the OGC are building a unique and revolutionary framework of open standards for exploiting Web-connected sensors and sensor systems of all types: flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, Webcams, airborne and satellite-borne earth imaging devices and countless other sensors and sensor systems.

SWE presents many opportunities for adding a real-time sensor dimension to the Internet and the Web. This has extraordinary significance for disaster management, environmental monitoring, transportation management, public safety, facility security, utilities' Supervisory Control and Data Acquisition (SCADA) operations, industrial controls, science, facilities management and many other domains of activity.

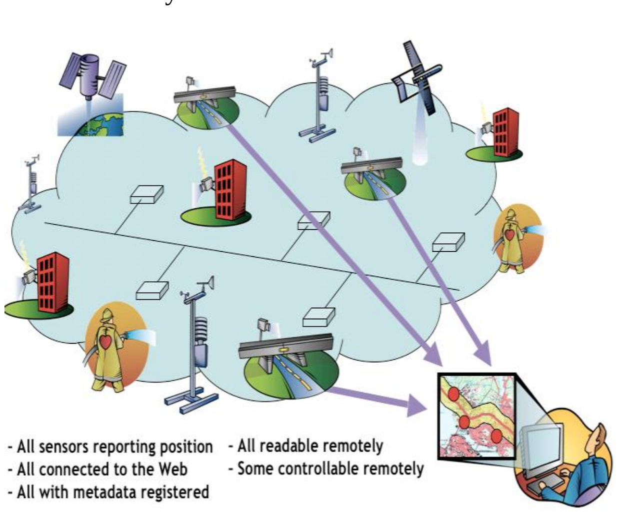

Figure 2. SensorWeb

The OGC voluntary consensus standards setting process coupled with strong international industry and government support in domains that depend on sensors have produced SWE standards that are becoming established in all application areas where such standards are of use.

HIGH LEVEL ARCHITECTURE OF SWE

The models, encodings, and services of the SWE architecture enable implementation of interoperable and scalable service-oriented networks of heterogeneous sensor systems and client applications. In much the same way that Hyper Text Markup Language (HTML) and Hypertext Transfer Protocol (HTTP) standards enabled the exchange of any type of information on the Web, the OGC's SWE initiative is focused on developing standards to enable the discovery, exchange, and processing of sensor observations, as well as the tasking of sensor systems. The functionality that OGC has targeted within a sensor web includes:

a. Discovery of sensor systems, observations, and observation processes that meet an application's or user's immediate needs;
b. Determination of a sensor's capabilities and quality of measurements;
c. Access to sensor parameters that automatically allow software to process and geo-locate observations;
d. Retrieval of real-time or time-series observations and coverages in standard encodings
e. Tasking of sensors to acquire observations of interest;
f. Subscription to and publishing of alerts to be issued by sensors or sensor services based upon certain criteria.

B.GRID COMPUTING

The grid computing environment supports wireless sensor networks in side of processing power and vast storage capabilities. Thus, it is necessary to incorporate the grid network in a GSN because it can store the huge observational data inputs that ate produced by the sensors. Due to the environmental characteristics of our network, the monitored data consists of contents such as gas pollutants or pesticide pollutants. The grid can host a variety of engineering software for various environmental experiments, environment data analysis processing and simulations. The researcher can develop various software modules that can be plugged into this facility and make it available for other researchers to use. The submitted jobs through Web-based interfaces are in queue and automatically run on these computer nodes depending on their availability. The output files generated during the run are stored in a temporary location in the data server and will be deleted after transferring data to the users. The output is available as maps for easy identification to the users.

This global environment will be accessible by any researcher through the integrated grid infrastructure interconnecting him/her to any remote place through wireless sensor networks. Any user will be able to retrieve data related to environmental observations in real-time across any agricultural field, mountain or any geographic environment.

FRAMEWORK OF PROPOSED SYSYEM

Figure 3 illustrates a framework that deploys the integration requirements. It provides a reliable solution to environment monitoring and focuses an interface which ensures the security by preventing unauthorised users to have access to the sensor database. The system supports the utilisation of the distributed networks resources ensuring an effective collaboration between various shared computational systems and applications. It also needs effective integration design techniques between different high performance computing centers of laboratories, institutions and universities around the world.

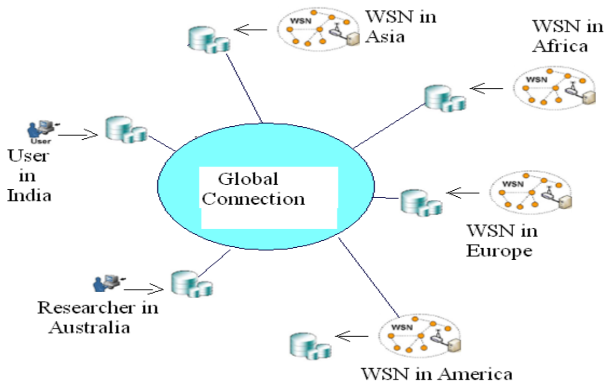

Figure 3.Frame work of .Sensorgrid system showing user in India retrieving data from Sensor network in Europe

This framework can be the basis of next-generation computer systems, if we ensure continuous flow of knowledge and information between various user and research communities Thus a user from India can log into the system in India and through this system, he is able to observe, collect, and process the sensed data from the distributed WSN of Malaysia or any other country which is connected.

Pollution Monitoring System:

A Sensorgrid system is useful in environmental protection because it continuously monitors and collects environmental measurements from the sensors. Sensor data monitoring systems receives the sensor data from the sensor networks and stores it in a database. Our system assumes that the data stored can be retrieved by any authorised user or real-time data can be sensed by the network and reported to the user.

The grid users can access the GSN system through the web by inquiring a gateway server which translates the standardised protocol to the proprietary protocol for both sides. Though several integration methodologies, our implementation is based on Open Sensor Web Architecture (OSWA) as in[7]. The OSWA provides complete standards complaint platform for integration of sensor networks with emerging distributed computing platforms such as grids.

In our system an authenticated user can log into the system through an application client which is based on a user's browser. After his authentication from a grid node(in our example it is the local server at India) ,he is able retrieve the data in real-time the sensed data across the network(eg. The sensor data from the Wireless Sensor Network in Europe). The grid network apart from the authentication process provides access to vast processing and storage resources.

The sensors are able to sense physical environment information, process locally the acquired data and send the outcome or aggregated features to the cluster and/or one or more collection points, named sinks or base stations. The nodes are generally powered by batteries which have limited capacity and, neither can be replaced or recharged due to environmental constraints. So the sampling interval should be carefully set so that energy is used judiciously. They sensors will be in the sleep mode until the ordered time. The timer is alive in the sensors always and when it is time for wake up, all the sensors wake up and send their measured values to the network control system.

Sensor nodes are arranged in the environment randomly and to send data to a base station, one of the nodes act as a cluster head. This ensures that data is sent after aggregation and compression to the base station for further processing. The cluster head is chosen so that the node with the highest available power is the next cluster head. This helps the network have a higher lifetime since nodes near the base station are normally tasked with communication to the base station.

COMMUNICATION BETWEEN SENSOR NODE AND CLUSTER HEAD

The cluster consists of many sensor or leaf nodes with one cluster head. The sensor or leaf nodes gather data and turn on the radio only when they want to transmit data after data compression. The timing diagram(Figure 4) given below shows how sensor nodes and cluster head communicate with one another.

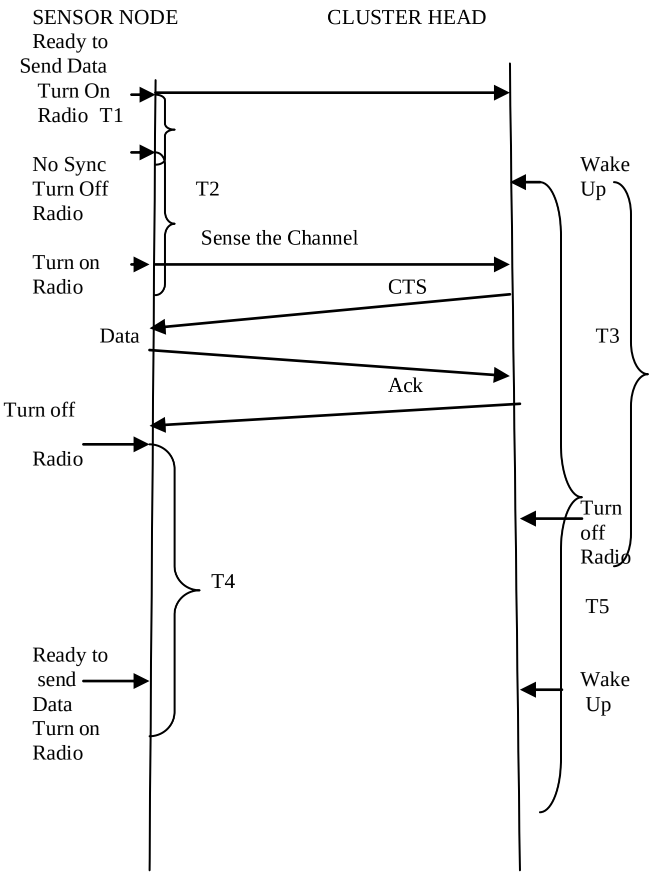

Figure 4: Timing Diagram for Sensor Node and Cluster Head

Sensor Node:

a. T1 is the time after which the sensor node radio is switched off if it does not receive any Sync from the Cluster Head.
b. T2 is the mean time after which sensor tries again and senses the channel. This could be distributed between T2(min) to T2(max).
c. T3 is the time duration when the cluster head is awake.
d. T4 is the time after which the Sensor Node awakens . This time could vary widely depending on the conditions that are being monitored because the node awakens onle when it has data to send after compression. In the simulation it could be as a random number between T4 (min) and T4(max).
e. T5 is time time after which the Cluster Head awakens periodically.

In a environment monitoring scenario, it is important to prolong the battery and hence the network lifetime because energy should be used judiciously . So instead of the Sensor sensing if the Cluster Head is awake periodically, both can follow their respective sleep – wake schedules until they coincide.

Pseudo-code that runs on the Sensor Node:

```
Event timeElapsed( )
{
Call stopSleeping( );
Call readSensor();
Call storeSensorreading( );
Call compressData( );
        If(ready-to-send-data)
        {
        Call turnRadioOn( );
        Call sendSync( );
        If (RTS is received)
                {
                Call sendData(DestNode);
                }
        Call turnRadioOff( );
        }
Call startSleeping();
}
```

Pseudo code that runs on the Cluster Head:

```
Broadcast(schedule);
Event timeElapsed( )
{
Call turnradioOn( );
While(listen_time_not_over)
{
If(SYNC_received)
        {
        Send(CTS);
        Receive(DataSent);
        Send(ACK);
        }
}
Call turnradioOff( );
}
```

The sensed data are transmitted from the sensors to data model of the pollution monitoring system. The data model receives the sensed data and uploads and stores them in the grid infrastructure. The sensed data is accessible from SQL databases.

The pollution control model works as follows:

a. The user (in India in our example – Fig 3) logs on to the local server after authentication.
b. The local server processes the request of user to get access to the destination server.
c. The destination server get access of Wireless Sensor Network (in Europe in our example) by awaking the sensors.
d. The Wireless Sensor Network sends real-time data to destination Server.
e. The sensed data is stored in local database by destination Server.
f. The Wireless Sensor nodes go to sleep mode after transmission of data.
g. The user gets information from destination Server B through several gateways and local server.
h. User can view the status of pollution through map (as shown in Fig 4) or continue steps 3 to 8 for some other place on the map.

In order to support the system operations and queries of multiple databases, we have to encode the abstracted geosensors data by adopting the Geography Markup Language (GML) specification. GML is an eXtensible Markup Lanuage (XML) grammar for expressing geographical features [18].The abstracted data allows us to perform detailed investigation of the pollution levels of the monitored area. The areas with high pollution levels are likely to cause health hazards to people and animals. So these areas can be checked regularly for environmental protection and steps taken to reduce pollution.

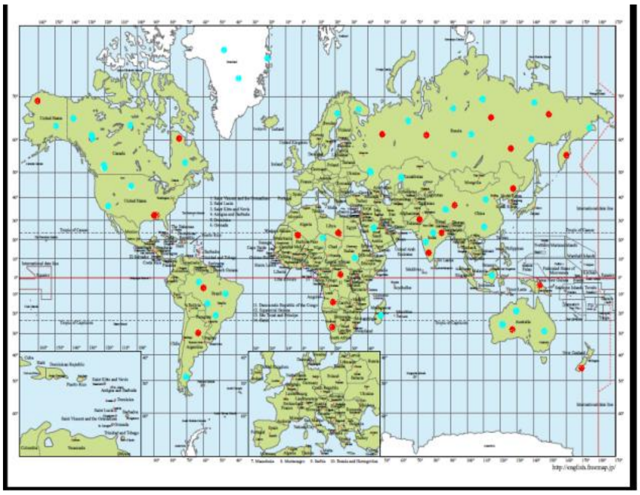

Figure 4. Map shows highly polluted areas in red and lesser polluted areas in green.

First the application checks the network availability and retrieves the data in real- time. Then the data is stored in grid database for further use. The stored data can be viewed on the map as red spots if the area is highly polluted, else as green spots(Figure 4).

The model helps in understanding real-time transfer of data from the sensor nodes and use of grid computing at the servers and other resources like databases and communication devices.

CONCLUSION

In this paper, a novel architecture which provides integration and coordination between heterogeneous networks such as sensor networks and grid infrastructure is presented demonstrated. Through the proposed framework a vision of global interconnection for pollution control for a better environment around the earth in real time is produced. Our pollution control model ensures interoperability and exchange of data across the Senserweb and the grid by integrating wireless sensor networks and the grid. Sensorgrids will greatly enhance the potential of these technologies for new and powerful applications. Our system is useful for applications including monitoring pollutants like Endosulphan used for agriculture that created permanent disabilities in animals and human in Kerala and pollution of toxins like chemical wastes found in Coimbatore that pollutes drinking water.

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