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MINI PROJECT

Environmental Sensor Networks: A revolution in the earth system science?

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EXECUTIVE SUMMARY

Environmental sensor networks (ESNs) offer a powerful combination of distributed sensing capacity, real-time data visualization and analysis, and integration with adjacent networks and remote sensing data streams. These advances have become a reality as a combined result of the continuing miniaturization of electronics, the availability of large data storage and computational capacity, and the pervasive connectivity of the Internet. Environmental sensor networks (ESNs) have been established and large new networks are planned for monitoring multiple habitats at many different scales. Projects range in spatial scale from continental systems designed to measure global change and environmental stability to those involved with the monitoring of only a few meters of forest edge in fragmented landscapes. Temporal measurements have ranged from the evaluation of sun fleck dynamics at scales of seconds, to daily CO_2 fluxes, to decadal shifts in temperatures. Above-ground sensor systems are partnered with subsurface soil measurement networks for physical and biological activity, together with aquatic sensor networks to measure groundwater fluxes and nutrient dynamics. More recently, complex sensors, such as networked digital cameras and microphones, as well as newly emerging sensors, are being integrated into sensor networks for hierarchical methods of sensing that promise a further understanding of our ecological systems by revealing previously unobservable phenomena.

INTRODUCTION AND THEORY

Ecological research is undergoing a major technological revolution as interfaces develop between environmental science engineering and informational technology. These advances have been spurred by decreasing cost, size and weight, and improved reliability, of environmental sensing hardware and software. Coupled with the increased connectivity afforded by the Internet to transmit and share data, arrays of intelligent sensor networks are emerging as fundamental tools to address complex questions of myriad ecosystems.

- **Environmental Sensor Networks (ESN) –** An Environmental Sensor Network comprises an array of sensor nodes and a communications system which allows their data to reach a server. The sensor nodes gather data autonomously and a data network is usually used to pass data to one or more base stations, which forward it to a Sensor Network Server (SNS). Some systems send commands to the nodes in order, to fetch the data, while others allow the nodes to send data out autonomously.

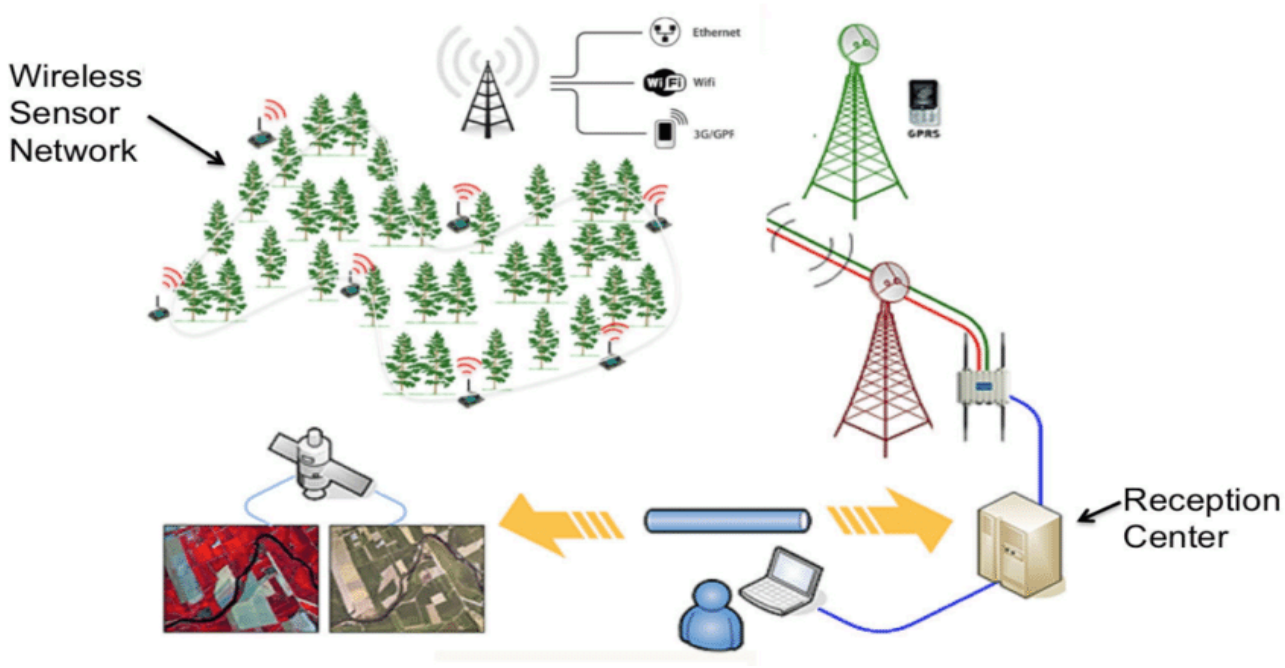


Fig .1 – Environmental Monitoring Wireless Sensor Network

- **Wireless Sensor Networks (WSN) –** WSN refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind, and so on.
- **Sensor Nodes –** Sensor network nodes typically have a set of design goals including sensor integration, data quality, size, cost, robustness and power management. Low power use is essential as well otherwise they do not run without constant battery maintenance. Low maintenance is a design goal as these systems should work independently without much intervention.
- **Heterogeneous Sensor Networks –** Heterogeneous wireless sensor network (heterogeneous WSN) consists of sensor nodes with different ability, such as different computing power and sensing range. It is based on the irregular sensor model used to approximate the behavior of sensor nodes.

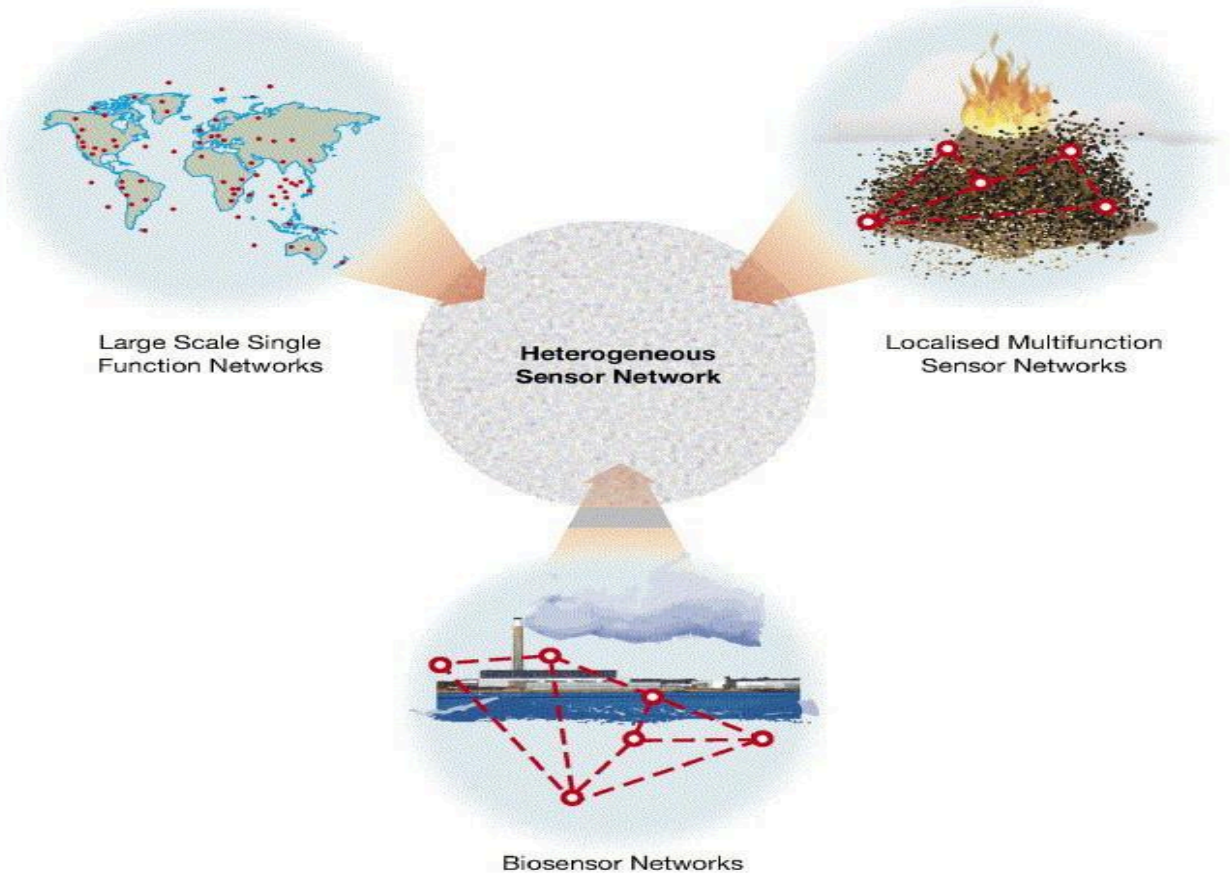


Fig .2 Environmental Sensor Networks

PROBLEMS AND THEIR IMPORTANCE

1. **Data quality —** Sensor calibration is vital for high quality data collection. In addition, defining the exact source of sensor data is important when they are analyzed. This provenance and experimental setup information will need to be preserved without placing too much burden on the users.
2. **Security —** Some ESNs require security systems in order, to prevent tampering, both at the hardware level as well as data and management levels. Although conventional network security protocols can be used these are often too “heavy” for the low-power devices used.
3. **Data mining and harvesting —** Continued efforts on standardization and semantic markup will eventually lead to a data availability unseen before, which will require concerted efforts to make data mining simple for users as well as software agents.
4. **Management and usability —** Most systems today have been produced as research platforms and required considerable technical expertise to de- ploy and

manage. There are ongoing efforts in user-driven deployments to evolve the systems towards the usability usually found in commodity items such as data loggers.

5. **Power management —** In order for an ESN to work unattended, without continuous battery changes the systems have to use sophisticated power management techniques which are coupled to their communications design as that is usually the dominant factor in power use.

Sensor data quality plays a vital role in (IoT) applications as they are rendered useless if the data quality is bad. Sensor nodes are most worried about two major security issues, which are privacy preserving and node authentication. Privacy means the data confidentiality is achieved under security mechanism, and hence it allows network communications between sensor nodes and the manager station to proceed securely. Unauthorized access or alteration of cyber-systems could result in compromised strategic, proprietary, or personal information, exploitation of cyber-systems for nefarious purposes, or temporary loss of, or damage to, critical systems. In WSN energy is dissipated during the transmission of packets which make the system unreliable. Communication is the main energy guzzler and nodes dissipate more energy. In WSN rechargeable batteries not used and non-rechargeable batteries are very costly so we employ energy saving techniques.

OBJECTIVE AND SCOPE

Environmental Sensor Networks (ESNs) facilitate the study of fundamental processes and the development of hazard response systems. Environmental Sensor Networks will become a standard research tool for future Earth System and Environmental Science.

RESULTS

Environmental Sensor Networks (ESNs) facilitate the study of fundamental processes. They have evolved from passive logging systems that require manual

downloading, into 'intelligent' sensor networks that comprise a network of automatic sensor nodes and communications systems which actively communicate their data to a Sensor Network Server (SNS) where these data can be integrated with other environmental datasets. At present ESN's can be classified into three types: Large Scale Single Function Networks (which use large single purpose nodes to cover a wide geographical area), Localized Multifunction Sensor Networks (typically monitor a small area in more detail, often with wireless ad-hoc systems), and Biosensor Networks (which use emerging biotechnologies to monitor environmental processes as well as developing proxies for immediate use). In the future, sensor networks will integrate these three elements (Heterogeneous Sensor Networks). We describe the development of a glacial ESN to monitor subglacial processes in order, to understand glacier response to climate change. We discuss the advantages of the new system, and research highlights, as well as the problems of real-world ESNs. We argue that Environmental Sensor Networks will become a standard research tool for future Earth System and Environmental Science. Not only do they provide a 'virtual' connection with the environment they allow new field and conceptual approaches to the study of environmental processes to be developed. We suggest that although technological advances have facilitated these changes, it is vital that Earth Systems and Environmental Scientists utilize them.

METHODS

- While traditional sampling methods demand increased labor input for larger amounts of samples (e.g., sampling at several locations in the same area), an ideal Wireless Sensor Networks (WSNs) observes the environment at multiple locations and automatically transmits the data to a gathering point via the networked infrastructure.
- Communications are an essential part of an ESN. Most systems relay their data via radio links or wired- networks. They use radio systems, satellite phones, mobile phones or short text messaging. There may be difficulties with transmitting through the environment being sensed, e.g. through ice, water or forests; and it is often impractical to use higher power levels.

- Cyberinfrastructure the evolution from logging to ESN brought improvements in data access and management, the current activity in high-level data integration will bring about another major change. Environmental Sensor Networks produce data on a scale that has rarely been generated before in some parts of the geosciences, and this requires its own data handling, storing and visualization.

ASSUMPTIONS AND THEIR ROLE IN REULTS

Sensor Network typically consists of thousands of small sensor nodes thrown arbitrarily (e.g., from the air) onto a large target area, such as a battlefield or the scene of a natural disaster. Individual nodes have resource limitations associated with small physical size including low-power batteries, relatively slow processors, and limited memories, yes, they all are realistic. They are capable of wireless communication and once deployed form a large-scale ad hoc network. A key assumption is that the formed sensor network has no pre-existent infrastructure or centralized services. It is precisely the difficulty of creating such an infrastructure in harsh or inaccessible environments that motivates the sensor network approach. nodes in a sensor network are assumed to establish their location and remain motionless except due to environmental factors such as wind and water. In an

important departure from the typical mobile ad hoc wireless network model, nodes in sensor network literature do not have IP-address, and do not run the TCP/IP protocol suite. Instead of possessing unique ID's, sensor network nodes are usually referenced by attributes such as location. Both localization services that establish sensor network coordinate frameworks, and location-based routing services that route messages geographically have been discussed at length. Wireless sensor networks may comprise numerous different types of sensors like low sampling rate, seismic, magnetic, thermal, visual, infrared, radar, and acoustic, which are clever to monitor a wide range of ambient situations. Sensor nodes are used for constant sensing, event ID, event detection & local control of actuators. The applications of wireless sensor networks mainly include health, military, environmental, home, & other commercial areas.

CONCLUSION

In this report, we have shown a real application of a WSN. Many contributions are presented about the use of a custom platform, such as the adaptation to a heterogeneous network the study of an interesting industrial field which is applicable worldwide in many installations, the integration of management and control tools with WSNs, and so forth. The main conclusion is that WSNs provide an excellent information infrastructure for the remote monitoring, tracking and control of indoor and outdoor environments, industrial plants, and other applications. The energy consumption of the system has been addressed and methods to reduce the energy consumption have been identified. This includes the consumption of resources provided, as well as the energy efficient usage of these resources. Limitations of batteries as traditional power sources have been disclosed and alternative battery-less energy supply architectures have been presented.

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