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Review Paper On Wireless Sensor Networks

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***Abstract*—Advances in sensor technology and computer networks have enabled distributed sensor networks (DSNs) to evolve from small clusters of large sensors to large swarms of micro sensors, from fixed sensor nodes to mobile nodes, from wired communications to wireless communications, from static network topology to dynamically changing topology. To design these networks, the factors needed to be considered are the coverage area, mobility, power consumption, communication capabilities etc. In this paper a survey is given regarding the analysis of AC structure and DHC structure, flat tree and DG Network, sensor architecture design, Ad-hoc sensor networks, sensor applications and also an overview on the client/server model and Mobile-Agent Based network.**

Keywords— Sensor network structure, Sensor architecture design, Ad hoc wireless sensor networks, and Data processing paradigm.

I. Introduction

A sensor network is defined as a composition of a large number of low cost, low power multi-functional sensor nodes which are highly distributed either inside the system or very close to it. Nodes which are very small in size consist of sensing, data processing and communicating components. The position of these tiny nodes need not be absolute; this not only gives random placement but also means that protocols of sensor networks and its algorithms must possess self-organizing abilities in inaccessible areas. Distributed or dispersed sensor networks (DSNs) have recently emerged as an important research area. This development has been spurred by advances in sensor technology and computer networking. It is economically feasible to implement DSNs, but there are several technical challenges that must be overcome before DSNs can be used for today's increasingly complex information gathering tasks.

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These tasks, across a wide spectrum of both civilian and military applications, include environment monitoring, scene reconstruction, motion tracking, motion detection, battlefield surveillance, remote sensing, global awareness, etc. They are usually time-critical, cover a large geographical area, and require reliable delivery of accurate information for their completion.

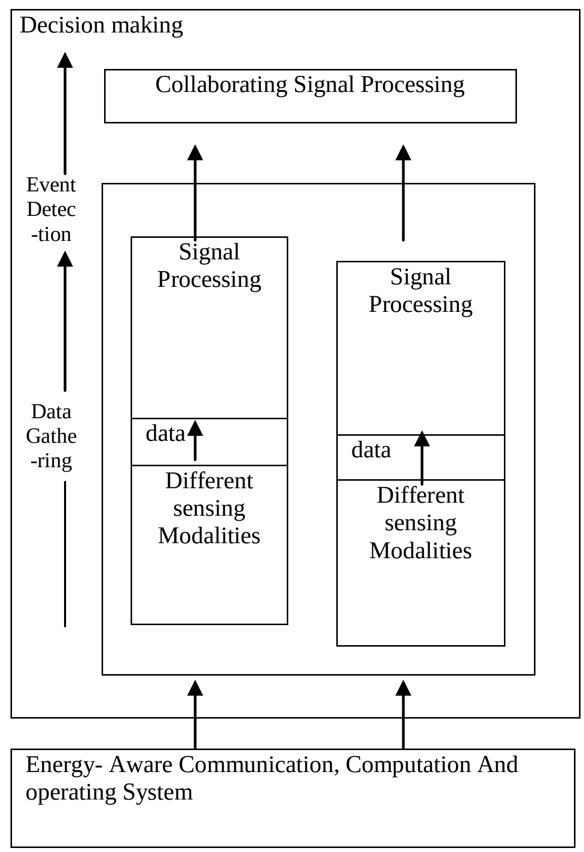

Figure 1. Block diagram of DSN from functionality point of view.

Figure1. is a block diagram, illustrating different components in a DSN from functionality point of view.

The ultimate goal of DSNs is to make decisions or gain knowledge based on the information fused from distributed sensor inputs. At the lowest level, individual sensor node collects data from different sensing modalitieson-board. An initial data processing can be carried out at the local node to generate local event detection result. These intermediate results will then be integrated/fused at an upper processing center to derive knowledge and help making decisions. Research issues associated with this diagram can be summarized into three questions: where to fuse? What to fuse? And how to fuse? With the size of sensors getting smaller and the price getting cheaper, more sensors can be developed to achieve quality through quantity. On the other hand, sensors typically communicate through wireless networks where the network bandwidth is much lower than for wired communication. These issues bring new challenges to the design of DSNs: First, data volumes being integrated are much larger; second, the communication bandwidth for wireless network is much lower; third, the power resource on eachsensor is quite limited; fourth, the environment is more unreliable, causing unreliable network connection and increasing the likelihood of input data to be infaulty.

In order to overcome the drawbacks in both AC and DHC, a hybrid structure which is called flat tree network was proposed in [2, 4]. The nodes in this network are organized as many complete binary trees, and the roots of which are completely connected, as illustrated in Figure 3. Even though flat tree structure improves DSN from both hierarchical and robustness aspects, integration errors of the lower nodes will be accumulated as the information goes up the hierarchy. One way to overcome this problem is to interconnect nodes in the lower levels of this network. Iyengar et al. [1] proposed to use deBruijn graph (DG) [6] to connect nodes at each level as shown in Figure 3. DG provides several advantages over AC, DHC, and flat tree structures, such as simple routing schemes, better fault tolerant capabilities, better extensibility (the diameter of the network grows only logarithmically with the number of nodes).

II. Sensor Network Structure

DSN research in this aspect started in the early 80s. DSN may consist of many different types of sensors such as seismic, low sampling rate magnetic, visual, thermal, infra-red, acoustic and radar, which are able to monitor a wide variety of ambient conditions. Sensor nodes can be used for continuous sensing, event detection, event ID, and local control of actuators. Wesson et al. [5] were among the first to propose network structures that can be used to design a DSN.Two structures were studied in the initial work of Wesson et al. [5]: the anarchic committee (AC) structure and the dynamic hierarchical cone (DHC) structure as illustrated in Figure 2. AC can be viewed as a fully interconnected network without hierarchy, where each node can communicate with any other node, thus coordination between nodes is straightforward. Although easy for communication, AC structure is expensive to implement and also hard to extend. On the other hand, DHC provides a hierarchical structure, also called a tree structure. It only allows communications between nodes in adjacent layers, but not within the same layer.

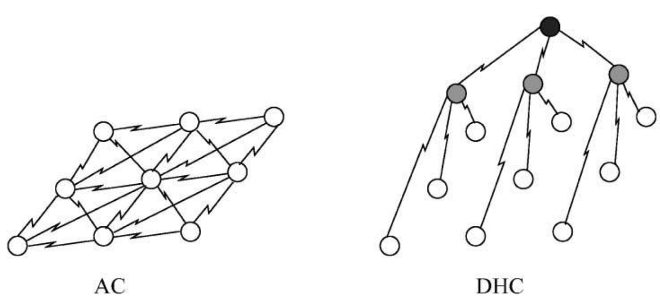

Figure 2 . AC and DHC structures from Wesson et al.[5]

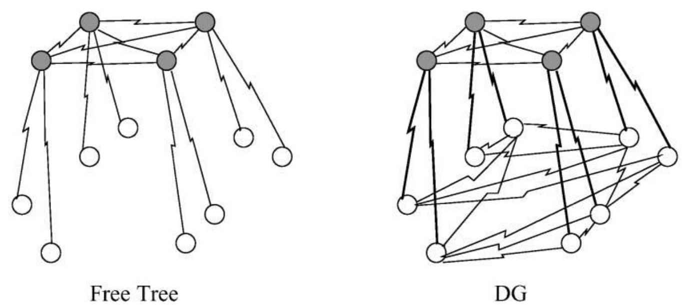

Figure 3. Flat tree and DG network.

A. *Sensor Architecture Design*

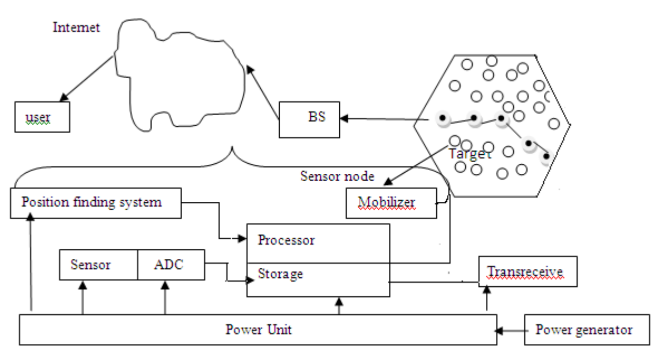

Figure 4 .Sensor nodes scattered in a sensor field and components of a sensor node

Senor nodes are usually distributed in a sensor field as shown in figure 4. Each of these distributed nodes has the capabilities to collect data and route data back to the sink and the end users. Data are routed back to the end user by a multi-hop infrastructure less architecture through the sink. The protocol stack combines power and routing awareness, integrates data with networking protocols, and communicates power efficiently through the wireless medium. The protocol stack consists of the application, transport, network, data link, physical layer, power management plane, mobility management plane and task management plane. Depending on the sensing task, different types of applications software can be built and use on the application layer. The transport layer helps to maintain the flow of data if the sensor networks application requires it. The network layer takes care of routing the data supplied by the transport layer. Since the environment is noisy and sensor nodes can be mobile, the MAC protocol must be power aware and able to minimize collision with neighbors broadcast. The physical layer addresses the needs of the simple but robust modulation, transmission and receiving techniques. In addition, the power, mobility and task management planes monitor the power, movement and task distribution among the sensor nodes. These planes help the sensor nodes coordinate the sensing task and lower the overall power consumption [7].

B. *Ad hoc wireless sensor networks*

Advances in sensor technology and wireless communication have made ad hoc wireless sensor networks (AWSNs) a reality. Unlike traditional wired networks, the connection between sensor nodes in AWSNs is dynamically changing. A short-lived network is set up only for the communication needs of the moment [8].Take the example of battlefield which provides daunting challenges to sensor fusion networks. Lightweight, inexpensive, highly specialized sensors are usuallydeployed with irregular patterns in a hostile environment. Each individual sensor node may come and go, and they may also suffer intermittent connectivity due to high error rate of wireless link, and it can be further deteriorated by environmental hazard. Therefore, an effective sensor fusion network must be able to provide robust communication infrastructure and survivability to cope with node failures, connectivity failures, and individual service failures.

C. *Differences between sensor networks and ad-hoc networks are as follows:*

1. Sensor nodes mainly use broadcast communication whereas ad-hoc network uses point to point communication.
2. The topology of a sensor network changes very frequently.
3. Sensor nodes may not have global identification because of the large amount of overhead and large number of sensors.
4. The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in ad-hoc network.

D. *Sensor Networks Applications*

We categorize the applications into military, environmental, health, home, and other commercial areas:

- **Military Applications***:* Wireless sensor networks can be an integral part of military command, control, communication, computing, intelligence, surveillance and targeting (C4ISRT) systems. The rapid deployment, fault tolerance and self-organization characteristics of sensor networks make them a very promising sensing technique for military (C4ISRT). Since sensor networks are based on dense deployment of disposable and low cost sensor nodes, destruction of some nodes by hostile actions does not affect military applications as much as the destruction of traditional sensor, which makes sensor networks concept a better approach for battlefield. Various military applications of sensor networks are monitoring friendly forces, equipments and ammunition; biological and chemical (NBC) attack detection and reconnaissance.

- **Environmental Applications***:* Some environmental applications of sensor network include tracking the movement of birds, small animals and insects; monitoring environmental conditions that affect crops and livestock ; irrigation; macro instruments for large scale earth monitoring and planetary exploration; chemical/biological detection; precision agriculture; biological, Earth and environmental monitoring in marine, soil and atmospheric contexts; forest fire detection and meteorological and geo physical research; flood detection; bio complexity mapping of the environment and pollution study.

- **Health Application***:* Some of the applications are providing interfaces for the disabled; integrated patient monitoring; diagnostics; drug administration in hospital;

monitoring the movements and internal process of insects or other small animals; telemonitoring of human physiological data; and tracking and monitoring doctors and patients inside a hospital.

- **Home Applications**: Home automation; as technology advances, smart sensor nodes and actuators can be buried appliances, such as vacuum cleaners, microwave ovens, refrigerators and VCRs. These sensor nodes inside the domestic devices can interact with each other and with an external network via the internet or satellite. They allow end users to manage home devices locally and remotely more easily.

- **Other Commercial applications**: Some of the commercial applications are monitoring material fatigue; building virtual keyboards; managing inventory; monitoring product quality; constructing smart office spaces; environmental control in office buildings; robot control and guidance in automatic manufacturing environment; interactive toys; interactive museums; factory process control and automation; monitoring disaster area; smart structures with sensor nodes embedded inside; machine diagnosis; transportation; factory instrumentation; local control of actuators; detecting and monitoring car thefts; vehicle detection and tracking; and instrumentation of semiconductor processing chambers, rotating machinery, wind tunnels and anechoic chambers[9].

III. Data Processing Pradigm

The network structure may be different and the current data processing approaches may tend to use a common network computing model: the client/servermodel. Client/server model has been supporting many distributed systems, such as remote procedure calling (RPC) [10], common object request broker architecture (CORBA) [11, 12], etc. In this model, the client (individual sensor) sends data to the server (processing element) where data processing tasks are carried out. This model, however, has several drawbacks [13] like client/server model usually requires many round trips over the network in order to complete one transaction. Each trip creates network traffic and consumes bandwidth. In a system with many clients and/or many transactions, the total bandwidth requirements may exceed available bandwidth, resulting in poor performance of the system.

A. *Mobile-agent-based DSN*

Mobile agent paradigm was proposed in [14] to respond to the above challenges. The corresponding DSN is referred to as mobile-agent-based DSN (MADSN). MADSN adopts a new computation paradigm: data stay at the local site, while the integration process (code) is moved to the data sites. MADSN offers the following important benefits:

- Network bandwidth requirement is reduced. Instead of passing large amounts of raw data over the network through several round trips, only the agent with small size is sent.

- Better network scalability. The performance of the network is not affected when the number of sensor is increased.

- Extensibility. Mobile agents can be programmed to carry task-adaptive fusion processes which extend the capability of the system.

- Stability. Mobile agents can be sent when the network connection is alive andreturn results when the connection is re-established. TABLE 1.1 provides a comparison between DSN and MADSN from feature point of view.

TABLE 1
Comparison between DSN and MADSN from feature point of view

Features	DSN	MADSN
Elements moving on the network	Data	computation
Bandwidth computation?	High	Low
Scalable?	No	Yes
Extensible?	No	Yes
Affected network reliability	Yes	No
Fault-tolerable?	Yes	Yes

IV. Conclusion

In this paper, first we studied the two networks AC and DHC for the design of DSNs and we came in contact of various drawbacks of AC and DHC. To overcome the drawacks of AC and DHC we studied the Flat tree in which nodes of network are organised as many complete binary trees, and the roots of which are completely connected. In the data proceeing paradigm we compare two models client-server model and Mobile-agent based DSNs and conlude the MADNs has better network scalability, extensibility,stability than the client-server model.

V. Future Work

In the future, the wireless sensor networks will have wide range of application areas to make sensor networks an integral part of our lives. However, realization of sensor networks needs to satisfy the constraints introduced by factors such as fault tolerance, scalability, cost, hardware, topology change, environment and power consumption.

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