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# Review paper on Topology Issues in wireless Sensor Network

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## Abstract

***Topology issues have received more and more attentions in Wireless Sensor Networks (WSN). While WSN applications are normally optimized by the given underlying network topology, another trend is to optimize WSN by means of topology control. Lifetime extension is one of the most critical research issues in the area of wireless sensor networks due to the severe resource limitations of the sensor nodes (e.g., small battery, limited computation capabilities, inexpensive transceiver etc.). One of the key approaches for prolonging the sensor network operable lifetime is to deploy an effective topology control protocol. In this survey paper, we provide a full view of the studies in this area. By summarizing previous achievements and analyzing existed problems, we also point out possible research directions for future work.***

## I. INTRODUCTION

Wireless sensor network (WSN) are increasingly considered by the scientific community as the future of environmental monitoring. The idea of automating the collection of physical data in order to monitor environment is not new. But WSN allow for real time data processing at a minimal cost. Their capacity to organize spontaneously in a network makes them easy to deploy, expand and maintain. Comparison of communication technologies are given in the table.
Sensors have been used in precision agriculture for years. They are used in convergence with other technologies like global positioning system (GPS), Geographic information system (GIS), miniaturized computer components and automatic control and remote sensing. WSN consist of large number of small sensing nodes that communicate with each other in a wireless fashion.
Due to advancement in technologies and reduction in cost of technologies and reduction in
size, sensors are becoming involved in almost every field of life. Agriculture is one of such domain where sensors and their networks are successfully used to get numerous benefits. Agriculture has played a key role in the development of human civilization. Due to the increased demand of food, people are trying to put extra efforts and special techniques to multiply the food production. Use of different technologies towards agriculture is one of such efforts. Information technology is now being heavily used in this area.
Use of Wireless sensor networks is supporting agriculture practices in very positive directions. For sensor based agriculture varieties of terminologies are now in use like precision agriculture (PA), Smart Agriculture, Variable rate technology (VRT), Precision farming, Global positioning system (GPS) Agriculture.
In precision agriculture, WSNs have been deployed as a cost effective communication technology that allows the acquisition and transmission of different data from the crop to final users. Sensors usually measures parameters such as soil moisture, temperature, salinity or pH, etc. Once the information arrives at their operators, it is further processed and studied in order to make an appropriate decision.

Most available wireless sensor devices are very constrained in terms of computational power, memory and communication Capabilities. Wireless sensor networks present a series of serious issues that still need research effort. Challenges faced by WSNs are: Network lifetime, Scalability, Interconnectivity, Reliability, Heterogeneity, Privacy and Security.
Sensors are used for collecting information about physical and environmental attributes whereas actuators are employed to react on the feedback to have control over the situations. The sensors'
Accumulated information that characterizes the object or environment and used to identify people, location, objects and their states is Known as context . The context acquisition provides a valuable contribution in modeling situations of domains that have variety of time variant attributes. Agriculture is one such domain. Agriculture domain poses several requirements that are following:
- Collection of weather, crop and soil information
- Monitoring of distributed land.
- Multiple crops on single piece of land
- Different fertilizer and water requirement to different pieces of uneven land
- Diverse requirements of crops for different weather and soil conditions
- Proactive solutions rather than reactive solutions.

Above requirements entail parallel and distributed application and processing. In addition, wireless sensors and actuators are required to collect the requisite information and to react on different situations. Decision support imposes the requirement to have processed Information rather than raw sensor data.

### Topology Control:

Topology Control (TC) is one of the most important techniques used in wireless sensor networks to reduce energy consumption and radio interference. The term topology control has been used in two contexts i.e. to refer to the problem of adjusting the power of the sensor nodes and network connectivity, other one is to describe the process of turning nodes radio on and off to control the network topology. Fig 1 shows classes of topology control algorithm.

### Motivations for Topology Control:

**Energy Conservation-**The main motivation behind topology construction phase is to build reduced topology that will save energy. It preserves network connectivity and coverage. Energy saving can be achieved by turning off nodes not part of the active topology

Table 1 Comparison of communication technology

Comparison of communication technologies [10].

| | ZigBee | Bluetooth | Wibree | WiFi |
|---|---|---|---|---|
| Frequency band | 2.4 GHz | 2.4 GHz | 2.4 GHz | 2.4 GHz |
| Range | 30 m–1.6 km | 30–300 ft | Up to 10 ft | 100–150 ft |
| Data rate | 250 kbps | 1 Mbps | 1 Mbps | 11–54 Mbps |
| Power consumption | Low | Medium | Low | High |
| Cost | Low | Low | Low | High |
| Modulation/protocol | DSSS, CSMA/CA | FHSS | FHSS | DSSS/CCK, OFDM |
| Security | 128 bit | 64 or 128 bit | 128 bit | 128 bit |

**Collision Avoidance-**The topology construction is reducing packet collision, number of retransmission and communication cost.

**Capacity-**Topology construction can have the effect of increasing the network capacity.

**Challenges in Topology Control:**
Topology control is beneficial but it is very complex process. If it is not performed carefully may produce undesired result. Distributed Algorithm, Local information, Need of local information, Connectivity, Coverage. are important while designing topology control mechanism:

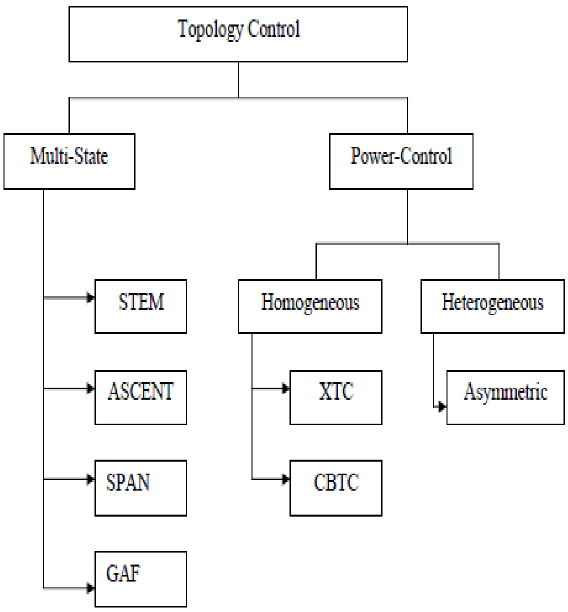


Fig .1 Classes of Topology control algorithm.

## II. MOTIVATION.

Recent emergences of affordable, portable wireless communication and computation devices and associated advances in the communication infrastructure have resulted in the rapid growth of wireless networks. *Ad hoc networks* are the ultimate frontier in wireless communication. Ad hoc networks are expected to revolutionize wireless communications in the next few years: by complementing more traditional network paradigms (Internet, cellular networks, satellite communications), they can be considered as the technological counterpart of the concept of ubiquitous computing.

*Wireless sensor networks* (WSNs) are a particular type of ad hoc network, in which the nodes are 'smart sensors'. Sensor networks are expected to bring a breakthrough in the way natural phenomena are observed: the accuracy of the observation will be considerably improved, leading to a better understanding and forecasting of such phenomena. The expected benefits to the community will be considerable. Although the technology for ad hoc and sensor networks is relatively mature, the applications are almost completely lacking. This is in part due to the fact that some of the problems related to ad hoc/sensor networking are still unsolved. In case of sensor networks also, many challenges are still to be faced before they can be deployed on a large scale. The main challenge related to WSN implementation is **topology control**.

Sensor networks are composed of nodes with sensing capabilities which perform distributed sensing task. When dealing with a large number of nodes, sensors have to be deployed randomly and their final positions cannot be engineered in advance. From the random positioning of nodes two fundamental problems arises: i) Maintaining a connected topology for communication purposes (Topology Control) ii) Identifying the geographic position of nodes for sensing purposes (localization).

Some of the issues to be considered in the design stage are Energy Conservation, Limited bandwidth, Unstructured and time varying network topology, low quality communication, data processing and scalability. With the awareness of underlying network topology most efficient routing could be achieved. Energy can be saved if network topology can be maintained in optimum manner.

## III. RELATED WORK

### *A. XTC*

XTC is a novel topology control algorithm that operates with a general notion of order over the neighbors' link qualities [Wattenhofer & Zollinger, 2004]. Surprisingly the XTC algorithm features all the relevant properties (symmetry, connectivity, sparseness, and planarity) of topology control while being faster than any previous proposals. The proposed topology control algorithm XTC works without assuming the exact node coordinates being known, and even in a mountainous and obstructed environment.

### *B. CBTC: Cone-Based Topology Control Algorithm*

The Cone-Based Topology Control algorithm (CBTC) is a novel distributed cone-based topology control algorithm that increases network lifetime while maintaining global connectivity with a reasonable throughput in a multi-hop wireless ad hoc network. Network operational lifetime is increased by determining per node minimal operational power requirement that guarantee the same maximum connected set of nodes as when all nodes transmit at full power [Wattenhofer *et al.*, 2001]. In contrast to some previously proposed approaches in literature that rely on

knowing and sharing the global coordinates information of the nodes in the network, the proposed algorithm is a distributed algorithm that relies solely on local information using directional information of incoming signals from neighboring nodes..
The

Antonio-Javier Garcia-Sanchez proposed an integrated WSN based system for crop monitoring, Video surveillance and process cultivation control. This network implies an innovative redeployment of precision agriculture using IEEE 802.15.4 cost effective technology. Their approach has been developed to conduct all these functions not only in a single crop but also in deployments considering scattered crops separated several kilometers from the farmer's cooperative premises. The complete system satisfies all these requirements, providing an efficient and coordinated communication infrastructure among the different sensing node placed in crops and end user.

Damas developed and tested a remote controlled, automatic irrigation system for irrigated area in Spain. The area was divided into seven sub regions. Each sub region was monitored and contended by a control sector. The seven control sectors were connected with each other and with the central controller via Wireless LAN. Result showed significant water Conservation i.e. up to 30-60%.

Zhang et al. utilized sensor network to monitor air temperature, humidity, soil moisture and temperature that helped them in analyzing the current state of art nursery. They further suggested that such network may help in finding the plant disease.

J. He developed and integrated optimal fertilization decision support system using wireless sensor LAN using 802.11 protocol and GPS analysis server sensors were used to acquire real time data of soil moisture, conductivity, temperature, pH value, air temperature, humidity, CO2 concentration. The system was designed using Browser/Server structure mode to provide high interconnectivity.

Y.Challal, A.quadijaut,N.Lasla presented paper in "Journal of network and computer application." on reliable system in wireless sensor networks. Authors presented a new intrusion fault tolerant routing scheme offering a high level of reliability through a secure multipath routing construction. Contribution of this paper is to develop a new approach of multipath routing called SMRP (Sub branch Multipath Routing Protocol) and an efficient and lightweight security scheme SEIF(Secure and efficient Intrusion and Fault Tolerant Protocol) based on above multipath protocol. They have investigated problem of fault tolerance and intrusion tolerance. These two concepts represent important issues in WSN.

Mobility is also the key aspect in self organizing network. Nodes move independently one of each other. In the case of mobile network, this is to be the case of rescuing team in disaster environment and military unit in battlefield. They also described different methods that enable randomly deployed sensor nodes to determine their position. Locally from a number of distance estimates to know references positions can be calculated by multilateration. Local positions estimates ca Authors (37), proposed a simple distributed algorithm where each node makes local decision about its transmission power. These local decisions collectively guarantee global connectivity. There are two phases in this algorithm. In the first phase, each node broadcast neighbor discovery message with arbitrary power.. Each receiving node acknowledges this broadcast message. All acknowledgements are to be recorded for further use. They determine the direction by IEEE antennas provided by Score.

Research work carried out by (price of ignorance) examines the price of ignorance in topology control in cognitive network with power and spectral efficiency objective. They proposed distributed algorithm that, if radio posses global knowledge, minimize both the maximum transmit power and spectral footprint of the network. They showed that while local knowledge has little effect on the maximum transmission power used by the network, it has the significant effect on the spectral performance. They have presented an approach to achieving end to end objective through learning and reasoning. For dynamic networks, as radios join the network, more knowledge provides better spectral performance.

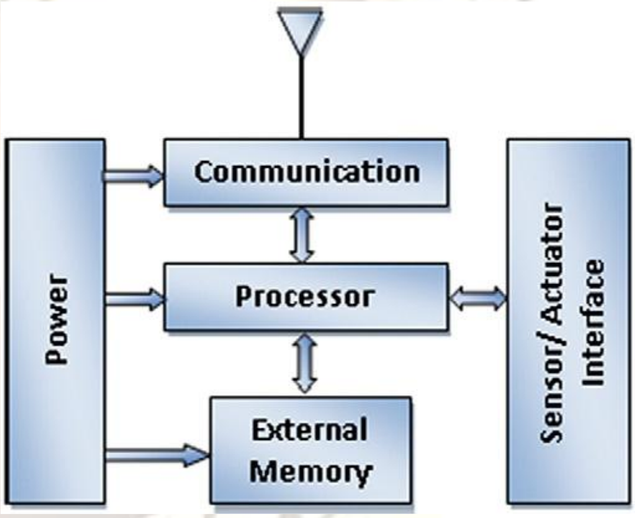


Fig. Architecture of Wireless sensor network

When radio leaves the network, some ignorance in the network results into better performance.

## IV. Topology Control Problems

### A. *Sensor Coverage Topology*

We break this family of problems into small categories: Static Network, Mobile Network and Hybrid network. For a static sensor network, proposed approaches have different coverage objectives. We introduce these approaches separately.

1) *Partial Coverage*

The Ye propose PEAS, which extends WSN system functioning time by keeping only a necessary set of sensors working in case the node deployment density is much higher than necessary. PEA's protocol consists of two algorithms: Probing Environment and Adaptive Sleeping. In PEAS protocol, the node location information is not required as a pre-knowledge. Cao et al. develop a near-optimal deterministically rotating sensory coverage for WSN surveillance system. Their scheme aims to partially cover the sensing area with each point eventually sensed within a finite delay bound. Their assumption is that the neighboring nodes have approximately synchronized clocks and know sensing ranges of each other.

*2) Single coverage*

For single coverage requirement, Zhang and Guohuan Lou have proposed the Optimal Geographical Density Control (OGDC) protocol. This protocol tries to minimize the overlap of sensing areas of all sensor nodes for cases when $Rc \geq 2Rs$ where Rc is the node communication range and Rs is the node sensing range. OGDC is a fully localized algorithm but the node location is needed as a pre-knowledge.

*3) Multiple coverage*

Wang present the Coverage Configuration Protocol (CCP) that can flexibility in configuring sensor network with different degrees of coverage. The CCP protocol needs node location information as assistance. Huang et al. propose polynomial-time algorithms to verify whether every point in the target area is covered by at least the required number of nodes. The authors suggest a central controller entity that can collect the details of sufficiently covered segments and dispatch new nodes to supplement.

### *B. Mobile Network*

Howard and Heo study the sensor network in the viewpoint of virtual forces. In , nodes only use their sensed information to make moving decisions. It is a cost effective and no communication among the nodes or localization information is needed. For the DSS (Distributed Self-Spreading) algorithm proposed in , sensors are randomly deployed initially. They start moving based on partial forces exerted by the neighbors. The forces exerted on each node by its neighbors depend on the local density of deployment and on the distance between the node and the neighbor.

### *C. Hybrid Network*

The coverage scenario with only some of the sensors are capable of moving has been under active research, especially in the field of robotics for exploration purpose. The movement capable sensors can help in deployment and network repair by moving to appropriate locations within the field to achieve desired level of coverage.
Wang et al. [39] address the single coverage problem by moving the available mobile sensors in a hybrid network to heal coverage holes. A comparison of different sensor coverage approaches are listed in Table 2. As you can see from the table, most of the proposed approaches need node location information as assistance and the unit-disk model is widely adopted as a simplification of the node transmitting model.

## V. CONCLUSION

In this survey paper, we have reviewed two major topology issues in WSNs, namely topology awareness and topology control. Topology awareness problems construct applications or upper protocols to conform the underlying topology. Typical approaches applied in this category do not actively consider improving the topology itself for the specific applications. Topology control mechanisms focus more on constructing an energy-efficient and reliable network topology and normally do not touch individual applications. So the first major question we raise is how to relate the topology control mechanism to the upper topology aware applications more tightly in WSNs. For topology control problems, sensor coverage topology and sensor connectivity topology have been separately discussed in most of the literatures. However, while the sensing coverage topology represents the network sensing ability, the connectivity topology should as well maintained as a necessity for the successful information delivery, including queries, sensing data and control messages. How to construct an optimized coverage topology while maintaining efficient and low cost connectivity is not well understood and deserves further studies.

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