

Trends, Technologies and Future Challenges in Sensor Networks

Putri Kevin

Department of Computer Science, Brahijaya University, Indonesia
Email: lettylord@yahoo.com

Dian viely

Department of Computer Science, Brahijaya University, Indonesia
Email: viely@gmail.com

ABSTRACT

Wireless micro sensor is the most significant and innovative technology in the 21st Century. The development of sensor networks is examined, and application like infrastructure security, monitoring ecosystem, and traffic management. The technical difficulties in sensor network development include routing, network exploration, signal processing, and security. This paper concludes by exploring results from different research in sensor network algorithms, localized algorithms and directed diffusion, distributed tracking in wireless ad hoc networks, and distributed classification using local agents

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I. INTRODUCTION

Cheap and smart devices with multiple onboard sensor networks through a channel and implemented on a large scale provide unrivalled opportunities for smart homes, cities, and the environment. In defense surveillance and reconnaissance, detect and track the incoming threats. Each sensor node has multiple onboard sensors with processing capabilities operating in acoustic, seismic, infrared (IR), magnetic modes, image recognition, and micro radars as shown in Table 1. Table 1: Summarizes the spectrum of potential attributes in general networks of sensors [1-3].

II. HISTORY OF RESEARCH IN WSN

For the research and development of sensor three different research technology is required. Sensing communication and computing (software and hardware) [4].

A. Early research in military

In the cold war, an acoustic sensor known as a sound surveillance system (SOSUS) under the ocean was deployed to detect and track the Soviet submarines quietly. SOSUS is now used by the NOAA (National Ocean-Atmosphere Administration), e.g., seismic and aquatic life. Airborne Warning and Control System (AWACS) planes and air defence radar systems are deployed to protect the USA and Canada. In general, these sensor networks follow a hierarchical processing system where processing occurs at consecutive stages until the information reaches the user; in most cases, humans play an important role in the system [5-7].

B. Distributed sensors program in Defense

Modern research on DNS started in 1980 by DARPA. It was assumed that local low-cost distributed networks communicate with one another but autonomously operate

with information routed to that node that best uses this information. In 1978 components for DNS were identified in distributed sensor nets [8]. It included the sensors, communication system (protocols), processing techniques, and algorithm. DARPA was sponsoring AI research for understanding signals, distributed problem-solving techniques, and assessing conditions. Few technology components were available off-shelf. The resulting DNS had to deal with distributed computing support and signal processing, tracking Distributed acoustic system was chosen for demonstration as a target problem. They innovated a communication-oriented operating system known as accents, whose first support is device configuration, rebinding, and transparent network. Accent has evolved into the Mach operating system, which has found significant market adoption. CMU activities included network protocol to support dynamic binding of active communication measures. An interface language for building distributed software, dynamic load balancing, and error reconfiguration system for DSN software [9-11].

MIT researchers focused on detecting and tracking helicopters using an acoustic microphone array by signal matching and abstraction techniques. Signal abstraction means a signal with multiple levels. Higher-level acquired by compressing information in the lower level. They offer a computational structure for thinking about signal processing processes that mimic what people use as they interactively process and view real-world signals. In addition, MIT has also created the Signal Processing Language and Interactive Computation Environment (SPLICE) for DSN data analysis and algorithm creation, and Pitch Director's Assistant for the Interactive computation of fundamental Frequency using domain Information [12-15].

In the 1980s, Advanced Decision Systems (ADS), Mountain View, CA, developed a multi-hypothesis monitoring algorithm to deal with challenging

circumstances, including high target density, missed detections, false alarms, etc. distributed implementation was decomposed. For demonstration purposes, the MIT Lincoln Laboratory built a real-time testbed for low-flight aircraft acoustic detection. The nodal machine (for target tracking) consists of three MC68000 processors with 256 kB memory, 512 kB shared memory, and a custom operating system. Ethernet and the microwave radio used for communication. This is demonstrated in figure 1 below. The DSN testbed was verified by low-flying aircraft, which were successfully tracked with acoustic sensors and TV cameras [16-19].

C. Military sensor network in 80s

Sensor network becomes a key component of centric warfare. Sensors are mounted on weapons that are controlled by a separate platform. They collaborate over a communication network, and information is sent to the shooter and tracking performance through multiple observations, response time, extended range, and geometric and environmental diversity. US navy developed the Cooperative Engagement Capability (CEC) system with multiple radars to collect air targets data. Since all the nodes have access to the same information, a "common operating picture" is necessary for consistent military operations. Some military sensor networks include acoustic sensor arrays Anti-submarine warfare such as FDS (Fixed Distributed System), ADS (Advance Deployable System), Unattended Land Sensors (UGS), Remote Battlefield Sensor System (REMBASS), and the Tactical Remote Sensor System (TRSS) [20-23].

D. Sensor era in 21st century

Cheap and small sensors based on MEMS technology, wireless network, and low power processor allow ad-hoc wireless networks with numerous applications. DARPA started developing a new network and implementation of sensor nodes in the ad hoc network pattern. Today's networking strategies, built for voice and data, and relying on a fixed infrastructure, would not be enough for battlefield use. The second research was network information processing, which means extract useful and timely data from sensors [24-27].

SenIT developed a network with the new specification. The network is interactive and programable. Software and overall device design help low latency, energy-efficient operation, built-in autonomy and longevity, and low possibility of detecting operation. A network of SensIT nodes can enable the detection, recognition, and tracking of the target, both within the network and outside the network, such as an overhead asset.

III. TECHNOLOGY TRENDS

Local companies like an ember, crossbow, and sensorial developing sensors node. Personal digital assistants (PDAs) using Palm or Pocket PC operating systems provide considerable processing and computational power in a small kit.

Wireless networks based on IEEE 802.11 standard have bandwidth nearly equal to a wired network. IEEE 802.15

standard for PAN with a radius of 5-10m. short-range sensor network encourages to implement in PAN fashion. Further-Increased chip performance and processor production capacities have lowered the energy per bit demand for both computation and communication. Sensing communication and processing can be done on a single-chip now a day. The University of California Berkeley in 1990 developed a MEMS sensor that was small enough to best fit into a cubic millimeter. Smart Dust sensors can be deployed using a 3x10 mm "wavelet" shaped like a maple tree seed and lowered to the ground Table 2.

IV. TRACKING AND LOCALIZATION

MEMS IC technology is drastically progressing now a day along with wireless communication. Connecting multiples sensors to a network from WSN[1]. The sensor reads the physical characteristic like temperature, pressure, and distance, etc [28]. WSN helps in health monitoring of patient health, military targets with location recognition. In localization, collected data from the sensor node is useless if the location is not precise. To fix this localization problem, equip each sensor node with GPS, which is practically impossible because of cost and power consumption increase. GPS glitch in dense forest, underground and indoor. Self-localization method sensor node used localization protocol to estimate position. Beacon nodes are used to estimate location in this protocol. Blind nodes provide information about the position of non-beacon nodes, known as a blind node. Blind nodes use information messages of beacon to locate his position [29].

All localization schemes consist of two phases: 1) distance/angle approximation; 2) position computation. The most distance/angle approximation techniques used to approximate distance or angle between two sensor nodes are Time Difference of Arrival (TDOA), Time Of Arrival (TOA), Received Signal Strength Indicator (RSSI), Angle Of Arrival (AOA), and Hop-count. In position computation, the unknown node's position is estimated based on the available information of distance or angle and references nodes' positions [30]. The commonly used techniques include lateration, triangulation, bounding box, probabilistic approach, and fingerprinting.

A. Localized algorithms and distributed diffusion

In a localized (or distributed) algorithm, sensor nodes communicate with the adjacent sensor. Localized algorithms

are robust to node failure and network changes. Communication costs also go along with rising network size. However, localized algorithms are challenging to design because of the complex relationship between local behaviour and global behaviour. The local algorithm may not perform better than the international [31].

Direct diffusion is belonging to the localized algorithm. Diffusion is a type of broadcast routing that does not prescribe the address of the destination node. Packets are forwarded to adjacent nodes, and a direction or gradient is

overlaid to control the transfer or forwarding of the packet, which arrived at the destination. The gradient may depend on geographic information, power, congestion, and other resources of a network node. Intermediate nodes can transfer data locally to improve performance, robustness, and scalability.

Simulation and experimental findings of direct diffusion in sensor networks suggested that multicast protocols (an IP-based multicast routing technique) require less than half of the energy needed for flooding, and diffusion needs just 60% of the energy for multicasting. These savings are accomplished by removing paths expended delivering redundant data and in-network consolidation, such as intermediate nodes suppressing duplicate position estimates [32].

B. Distributed tracking in wireless Ad-hoc networks

Sensors should communicate and exchange data for exploiting the advantages of data fusion of the sensor, but this should be achieved without submitting data requests and gathering data from all sensors, thus overloading the network and consuming energy resources. The ad hoc networks with microsensors face various challenges due to communications and processing. Target tracking has been extensively studied for the sensor node wide networks, and distributed tracking algorithms are available [33].

In the distributed tracking system, the problem of the dynamic sensor network. The approach to information-

driven sensor querying (IDSQ) has been developed, allowing cooperation based on resource constraints and the cost of transmitting the information. Each sensor measures the estimated information utility of a piece of non-local sensor data and uses this measure to decide from which sensor the data is requested. The information utility functions used include entropy, Mahala Nobis distance, and the predicted post-distribution measure. A data association is required in multiple targets tracking close to each other relative to sensor measurement error. It is computationally expensive to implement on an ad hoc network.

C. Distributed classification in WSN using mobile agents

In the sensor network, data is collected by the sensor and transmitted to centre nodes for processing. Usually, the sensor's bandwidth is smaller than the wire, so the network communication requirement exceeds. Mobile agents suggested to this problem. In a mobile-based agent in DNS, data stay at the sensor while fusion code is moved to data. If the agent is smaller than the data, the bandwidth requirement may be shorter. A sensor network is scalable, and performance is not affected by the number of sensors in a network.

Sensors	Size: MEMS large (Radar, Satellite) Number: Small, Large Type: Passive (Acoustic, IR, Magnetic, Video), Active (Radar, Lidar) Spatial Coverage: Dense and Spare Deployment: Fixed and Planned, Ad-hoc Dynamics: Static and Mobile
Sensing Entities of Interest	Extent: Distributed Localized Mobility: Static and Dynamic Nature: Cooperative and non-Co-operative
Operating Environment	Benign Adverse
Communication	Networking: Wired Wireless Bandwidth: High, Low
Processing Architecture	Centralized Distributed Hybrid
Energy Availability	Constrained and non-constrained

Table I. A sensor layout and architecture

	Yesterday (1980's – 1990's)	Today (2000 – 2003)	Tomorrow (2010)
Manufacturer	Custom contractors, e.g., for TRSS	Commercial: Crossbow Technology, Inc. Sensoria Corp., Ember Corp.	Dust, Inc. and others to be formed
Size	Large shoe box and up	Pack of cards to small shoe box	Dust particle
Weight	Kilograms	Grams	Negligible
Node architecture	Separate sensing, processing and communication	Integrated sensing, processing and communication	Integrated sensing, processing and communication
Topology	Point-to-point, star	Client server, peer to peer	Peer to peer
Power supply lifetime	Large batteries; hours, days and longer	AA batteries; days to weeks	Solar; months to years
Deployment	Vehicle-placed or air-drop single sensors	Hand-emplaced	Embedded, "sprinkled" left-behind

Table II. Type Styles

IV. NEW APPLICATIONS

Research on sensor networks was initially motivated by military applications. The development of communication networks has resulted in developing many other potential applications, from infrastructure security to industrial sensing.

A. Infrastructure Security

The sensor network is used to secure and protect the critical infrastructure like govt facilitation centre; forces headquarter to protect from terrorist attacks. Video and image sensor, acoustic chemical, and biological sensors are used in network form around these facilities [34-39].

B. Environmental and Habitat Monitoring

The Center for Embedded Net-Work Sensing (CENS) focuses on environmental and ecosystem monitoring. Environmental sensors are used to research the reaction of vegetation to temperature trends and diseases. Acoustic and imaging sensors can recognize, monitor, and bird populations and other animals. For the Amazon Basin, the System for the Vigilance of the Amazon (SIVAM) provides environmental monitoring, drug trafficking monitoring, and air traffic control.

C. Industrial Sensing

Industries have been gripping in deploying the sensor network to enhance efficiency, machines' performance, and maintenance. They are monitoring the health of the machine by measuring vibration and lubricant levels. Technology (NIST) developed the P1451 Smart Transducer Interface Standard to allow full plug-and-play sensors and networks in industrial environments. Factories continued to automate assembly lines and implement advanced on-line quality control checks activated by the sensors. Obtrudes and pH probes for a right spectral sensor that can serve as miniature spectrometers, optical sensors can replace existing instruments and perform structural properties and composition measurements. Inputs from

sensors feed into databases to show real-time information on a large or small scale [40].

D. Traffic Control

Sensor networks have been used to track and regulate car traffic, sensors overhead, and buried to control and track traffic. When cars approach each other, they share summary information about each other. Ground sensors may create information about traffic jams and the speed and density of traffic. This helps the driver to avoid traffic jams and plan alternative routes.

V. PROBLEMS AND TECHNICAL CHALLENGES

Network sensors typically face significant technological challenges in processing data, communication, and sensor management. Due to potentially extreme, unpredictable, and dynamic environments, with energy and bandwidth limitations, ad hoc wireless networks face additional technical difficulties in network discovery, management, and control routing, shared sorting, querying, and tasking [33].

Ad-Hoc Network Discovery

For an Ad Hoc network, discovery topology must be built-in real-time and modified regularly when sensors fail, or new sensors are installed. Each sensor node interacts with the adjacent sensor. In addition, each sensor knows its location when GPS is not feasible. Relative position algorithm requires for self-location [42].

A. Network Control and Routing

The network must deal with energy, bandwidth, and processing power resources that are dynamically evolving, and the device can function independently, changing its configuration as necessary. There is no expected connectivity in ad hoc networks, and connectivity must arise from algorithms and software as required. Since communication links are unstable and shadow fading will erase linkages, the software and device design should produce the necessary reliability. This includes analysis

into topics such as the scale of the network or the number of connections and nodes required to ensure sufficient redundancy. Communication gaps and resources need to be well handled. One of the advantages of not having IP addresses at each node is that it is easy to install network devices in vast numbers. routes are built up from geoinformation on an as-needed basis and optimized for survivability and energy Diffusion routing techniques, which depend only on information in the vicinity of Nodes are a way to fix this, but such approaches do not meet a spatially dispersed wireless network's information-theoretical ability. This is a means of creating relations on demand for data-specific or application-specific purposes. Collaborative signals and information processing

In ad hoc nodes can collaborate to collect and process data to generate the information data. The most technical problem includes the degree to which information exchange data between the nodes and fusion data at nodes. More sensor process data results in better performance and requires more resources.

The sensor network is used for the detection, tracking, and classification of the target. If multiple targets are present in a small area, the data association is the primary concern. Each node must associate the measurement with a single target. Targets detected by one node must be aligned with other nodes' targets to prevent replication and allow fusion. Optimal data association is computationally costly and needs a large bandwidth of communication. Processing issue includes latency and reliability and minimizes sensor network life.

B. Tasking and Querying

A sensor area is like a database with a lot of unique features. Data is dynamically obtained from the environment as opposed to being entered by an operator. Unreliable connections connect geographically scattered nodes; the information is spread across nodes. These features make the database view more complicated for military applications given the low latency, real-time, and high reliability needs of the battlefield. One challenge is to build a querying and tasking language and database that can be quickly queried. Other challenges include discovering effective distributed query and assignment compilation and placement systems, data organization, and caching. Mobile has sensors and query devices. Inter-networking between mobile and fixed devices without any infrastructure crucial and requirement of a sensor network [43-46].

C. Security

Since the sensor network will run in a hostile environment, security should be designed. Network strategies are required to provide low-latency, secure and stable networks. The network should be protected against invasion.

VI. CONCLUSION

Early research in DNS was obstructed by the state of the art sensors, computers, and communication networks. MEMS technology, more efficient wireless connectivity,

and low-cost production have resulted in small, inexpensive, and effective sensors with embedded processing and wireless networking capabilities. The wireless sensor is used in numerous applications in the environment, industry, and military.

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