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Battery less Surveillance Technology for Army Using Wireless Sensor Network based on Smart Dust Technology

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INTRODUCTION

Decreasing size of computing devices, ubiquity, and enhanced interaction with the physical world have recently led to increase in popularity of small computing devices, such as hand held computers and cell phones. Exponential growth of internet and the diminishing size and cost of sensors, have accelerated these trends. The emergence of small computing elements, with sporadic connectivity and increased interaction with the environment, provides enriched opportunities to reshape interactions between people and computer which can transform the world as we know it.

WIRELESS SENSOR NETWORK

WSN can be defined as a network of devices, denoted as nodes, which can sense the environment and communicate the information gathered from the monitored field (e.g., an area or volume) through wireless links. The data is forwarded, possibly via multiple hops, to a sink (sometimes denoted as controller or monitor) that can use it locally or is connected to other networks (e.g., the Internet) through a gateway. The nodes can be stationary or moving. They may or may not be aware of their location. They may or may not be homogeneous.

Traditionally WSN architecture has a single-sink but it suffers from the lack of scalability; by increasing the number of nodes, the amount of data gathered by the sink increases and once its capacity is reached; the network size cannot be augmented. A more general scenario includes multiple sinks in the network (Fig 1).

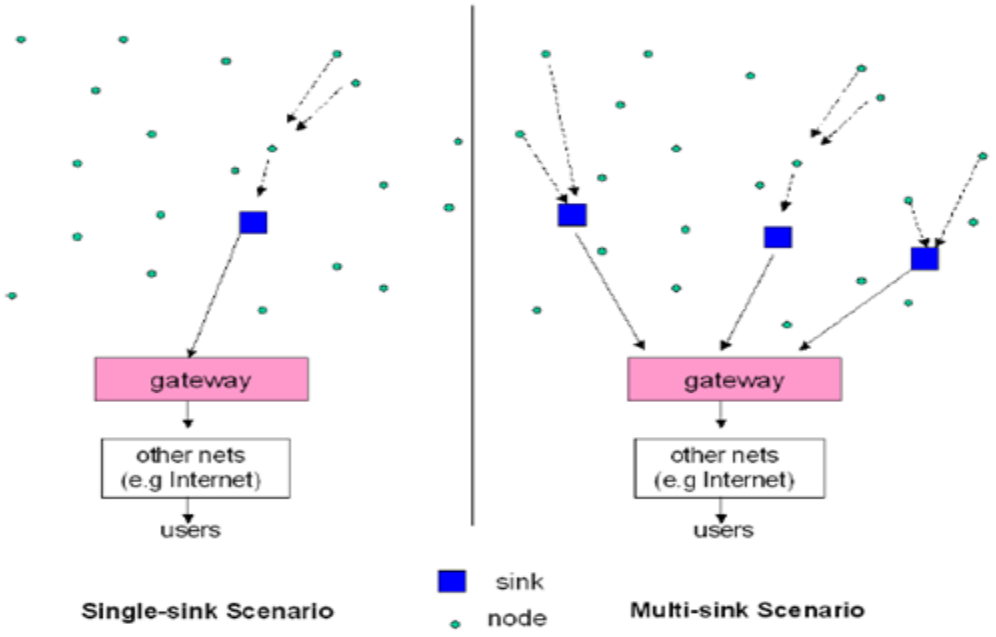

Fig 1: WSN Architecture

Required architecture can be selected based on a suitable criterion that could be, for example, minimum delay, maximum throughput, minimum number of hops, etc. Therefore, the presence of multiple sinks ensures better network performance with respect to the single-sink case (assuming the same number of nodes is deployed over the same area), but the communication protocols must be more complex and should be designed according to suitable criteria.

Progressive research in WSNs is exploring various new applications enabled by larger scale networks of sensor nodes capable of sensing information from the environment, process the sensed data and transmit it to the remote location. WSNs are mostly used in, low bandwidth and delay tolerant, applications ranging from civil and military to environmental and healthcare monitoring.

WSNs network configuration as shown in Fig 2 generally consist of one or more sinks (or base stations) and perhaps tens or thousands of sensor nodes scattered in a physical space. With integration of information sensing, computation, and wireless communication, the sensor nodes can sense physical information, process crude information, and report them to the sink. The sink in turn queries the sensor nodes for information. WSNs have several distinctive features like:

(a) Unique network topology.
(b) Diverse applications.
(c) Unique traffic characteristics.
(d) Severe resource constraints.

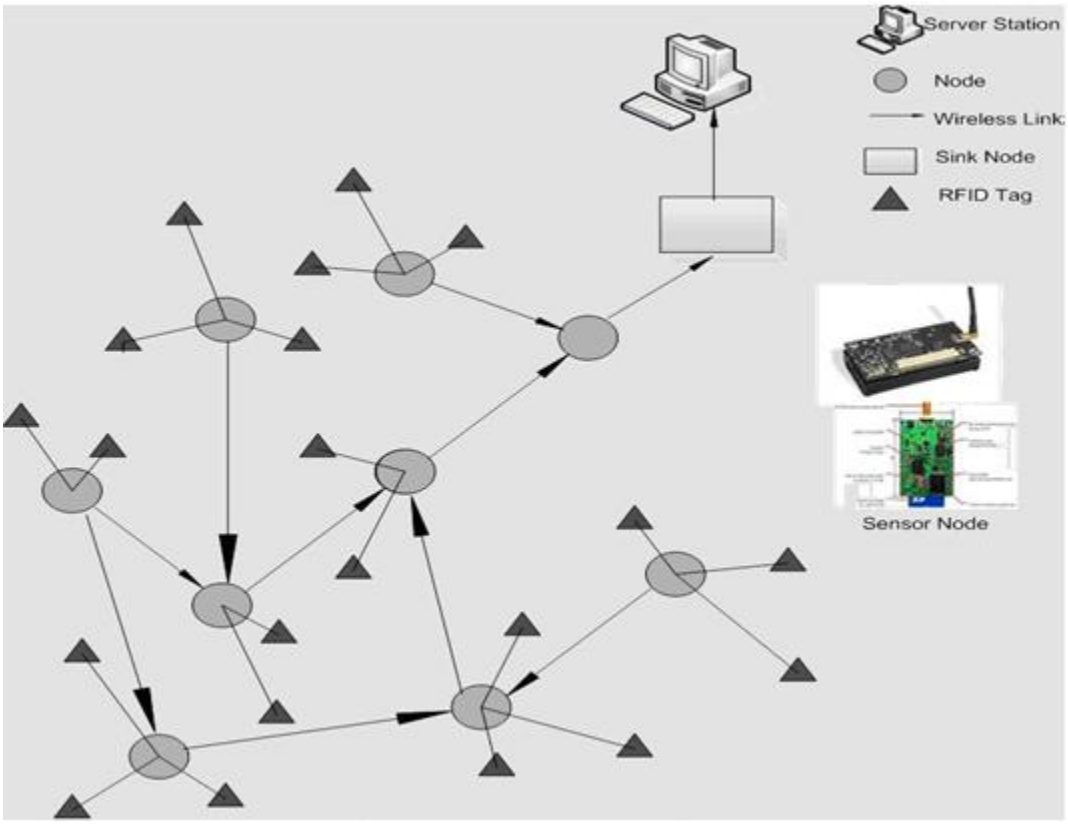

Fig 2: WSN network Configuration

SMART DUST

These are devices are small wireless micro electromechanical sensors (MEMS) that can detect everything from light to vibrations. It is a tiny dust size device with extraordinary capabilities. It encompasses nano-structured silicon sensor which can spontaneously assemble, orient sense and report on their local environment. This new technology combines sensing, computing, wireless communication capabilities and autonomous power supply within the volume of only a few millimeters. It is very hard to detect the presence of the Smart Dust and it is even harder to get rid of them once deployed. Smart Dust is useful in monitoring real world phenomenon without disturbing the original process.

Key Components of Smart Dust

(a) A semiconductor laser diode and MEMS beam steering mirror for active optical transmission.

(b) Corner Cube Retro reflector (CCR) for passive optical transmission.

(c) Photo detector and receiver.

(d) An optical receiver.

(e) A signal processing and control circuitry.

(f) A power source based on thick-film batteries and solar cells.

Construction of Smart Dust

As fabrication technology is ever growing enhanced features are being provided in smaller and smaller electronic devices. An example of this technology trend is electronic motes/ Smart Dust. These are so small and light in weight that they can remain suspended in the environment like an ordinary dust particle. Even the air currents can also move them in the direction of flow. The main features of motes are:

(a) Support the collection and integration of data from a variety of sensors.

(b) Analyse the sensor data as specified by system level controls. Wirelessly communicate the results of their analyses to other motes, system base stations, and the internet as specified by system automation.

(c) Mote is composed of a small, low powered and cheap computer connected to several sensors and a radio transmitter capable of forming ad hoc networks. The computer monitors the different sensors in a mote. These sensors can measure light, acceleration, position, stress, pressure, humidity, sound, and vibration. Data gathered are passed on to the radio link for transmission from mote to mote until data reaches the transmission node.

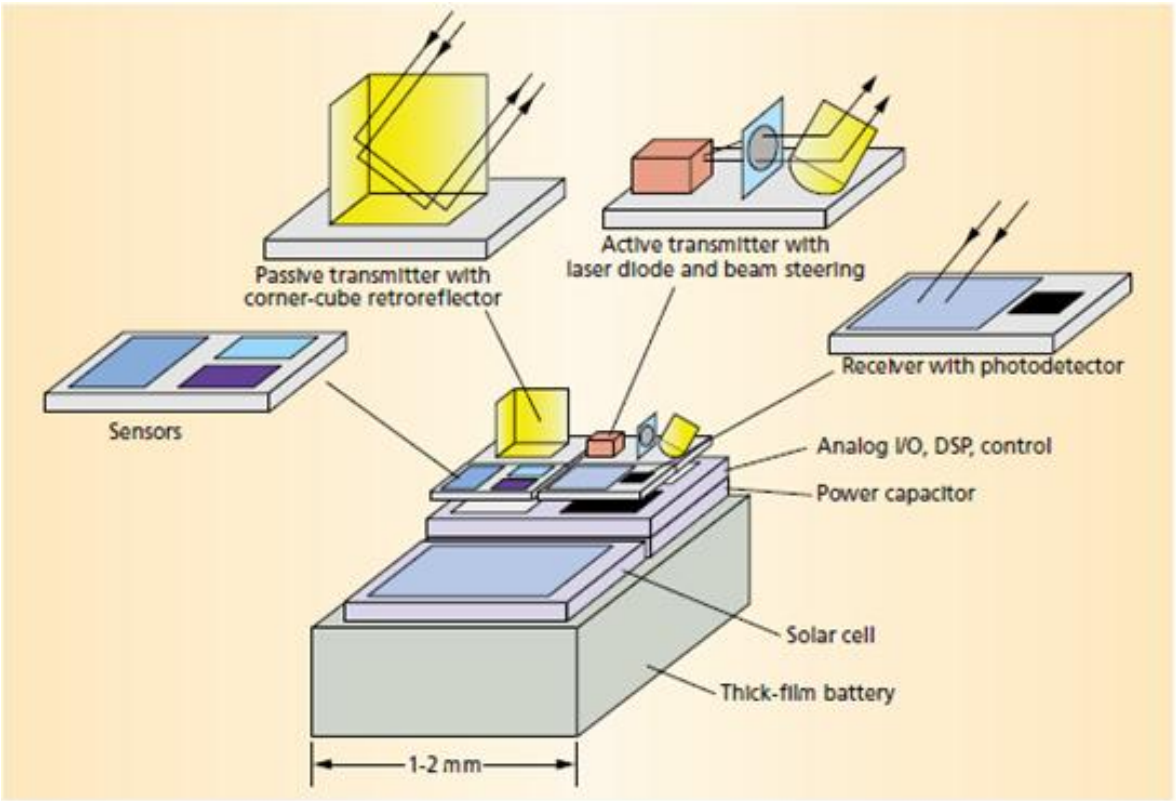

Fig 3: Mote / Smart Dust

WORKING PRINCIPLE OF SMART DUST

Smart Dust motes are run by microcontrollers. These microcontrollers consist of tiny sensors for recording various type of data. Timers are used to run these sensors. These sensors do the job of collecting the data. The data obtained are stored in its memory for further interpretations. It can also be sent to the base controlling stations. Corner cube Retro reflector (CCR), that comprises of three mutually perpendicular mirrors of gold coated polysilicon, has the property that any incident ray of light is reflected back to the source provided that is incident within a certain range of angles centered about the cubes body diagonal. The micro fabricated CCR includes an electrostatic actuator that can deflect one of the mirrors at kilohertz rate. Hence, the external light source can be transmitted back in the form of the modulated signal at kilobits per second. It can transmit to the bus only when the CCR body diagonal happens to point directly towards the bits, within a few tens of degrees.

WSN using Smart Dust for Army

WSN node is comprises of low power sensing devices, embedded processor, communication channel and power module. The embedded processor is generally used for collecting and processing the signal data taken from the sensors. Sensor element produces a measurable response to a change in the physical condition like temperature, humidity, particulate matter (e.g. CO2) etc. The wireless communication channel provides a medium to transfer the information extracted from the sensor node to the exterior world which may be a computer network and inter node communication. Although, WSN using Wireless Personal Area Network protocol (WPAN) or Bluetooth is complicated and costly. But, using RFID to implement wireless communication is relatively simple and cheap. Zigbee protocol can also be used for communication; alternatively the RS232 standard for wireless transmission of data can be adopted because the data rate of RFID and that of RS232 is same in terms of bits per second (bps).

System Requirements

The characteristic requirements of a system comprising wireless sensor nodes should be:

(a) Fault tolerant. The system should be robust against node failure (running out of energy, physical destruction, H/W, S/W issues etc). Some beep mechanism should be incorporated to indicate that the node is not functioning properly.

(b) **Scalable.** The system should support large number of sensor nodes to cater for different applications.

(c) **Long life.** The node's life-time entirely defines the network's life-time and it should be high enough. The sensor node should be power efficient against the power resource. The node's communication, computing, sensing and actuating operations should be energy efficient too.

(d) **Programmable.** The reprogramming of sensor nodes in the field might be necessary to improve flexibility.

(e) **Secure.** The node should support the following:

(i) **Access Control.** To prevent unauthorized attempts to access the node.

(ii) **Message Integrity.** Detect and prevent unauthorized changes to the message.

(f) **Confidentiality.** Assure that sensor node should encrypt messages so only those nodes would listen who have the secret key.

(g) **Replay Protection.** Assure that sensor node should provide protection against adversary reusing an authentic packet for gaining confidence/network access, man in the middle attack can be prevented by time stamped data packets.

(h) Affordable. System should use low cost devices since the network comprises of thousands of sensor nodes, tags and apparatus. Installation and maintenance of system elements should also be significantly low to make its deployment realistic.

(j) Self Powered. These systems are required to recharge themselves in order to ensure functionality for prolonged duration.

BATTERY LESS SMART DUST

Since smart dust need to function for prolonged periods in inaccessible remote, hostile territory, these need to be self-powered and recharge themselves. This can be achieved through employment of highly sensitive high capacity solar cells. Although the term "Battery less" is a misnomer but the lack of need to replace the power source once installed, more than makes up for it.

WSN can help coalesce, collection of equipment into a single war-fighting entity. The system that will complement both new-generation and older systems by sharing sensor, decision, and engagement data among combat units, yet without compromising the timeliness, volume, and accuracy of the data. The system is capable to create an identical picture at each unit of sufficient quality to be treated as local data for engagements, even though the data may have arrived from very far away. If a common, detailed database is available to provide a shared air picture as well as the ability to engage targets that may not be seen locally, a new level of capability may be attained. It will enable commanders at all levels to take informed decisions when the fog of war hits the TBA. Fig 4 depicts a concept of application of Battery less Surveillance Technology for Army Using Wireless Sensor Network based on Smart Dust Technology.

Various military applications envisaged is as follows:

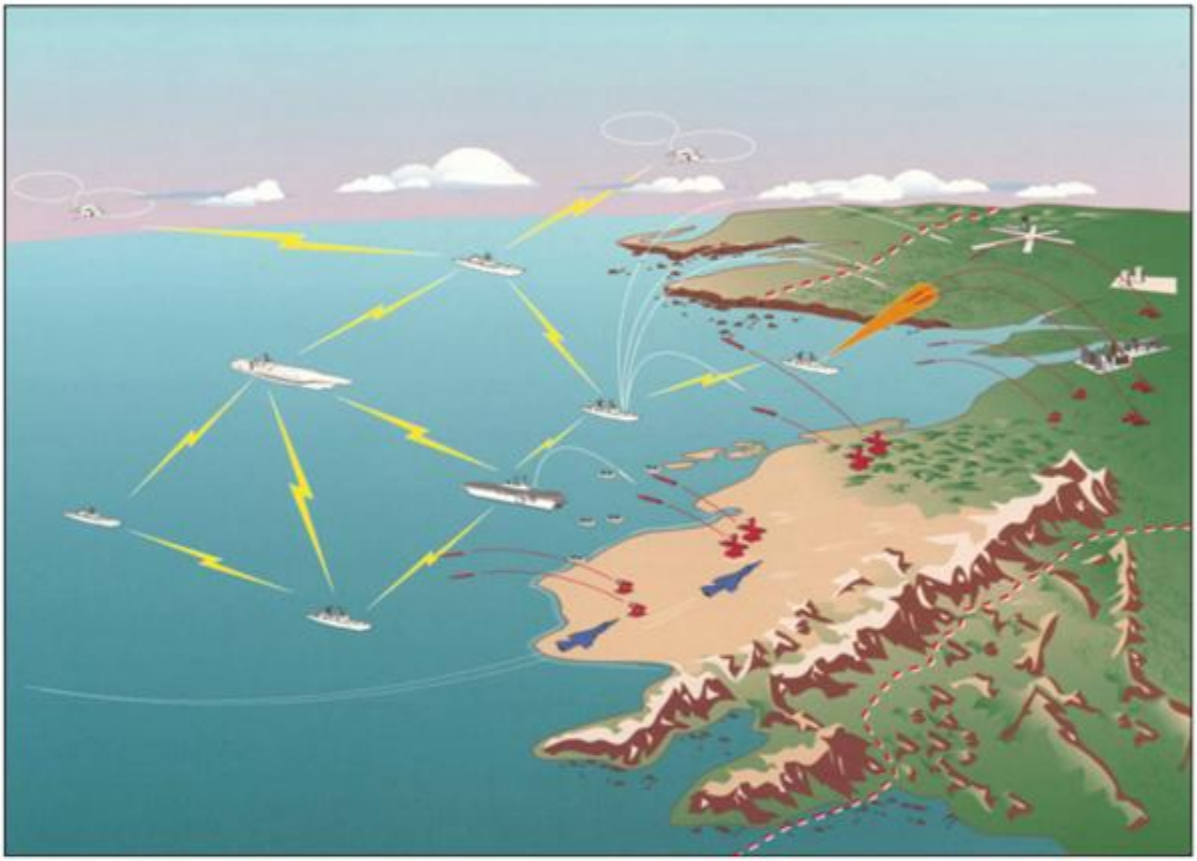

Fig 4: WSN Integrating TBA

(a) Security and Tracking using surveillance tags.

(b) Monitor activities in inaccessible areas.

(c) Accompany soldiers and alert them to any dangerous chemical, biological or radioactive substances in the air.

(d) Use a remote sensor chip to track enemy movements.

DISADVANTAGES OF SMART DUST

Major hurdles which threaten Smart dust to become a viable technology are as follows:

(a) Security. One of the major disadvantages of Smart Dust is the security for organizations using it. Detecting even the most subtle changes, Smart Dust leaves little to the imagination. Smart Dust are miniature sensors. They can record whatever you want them to record. Since this technology is in nascent stage, the fear remains that they would be spied on.

(b) Cost. Although Smart Dust is gaining popularity in many fields, it remains costly to implement such a system. The little chips themselves saw their prices go down by a lot in the recent years, however implementing all the satellites and other elements needed may cost a lot of money.

CONCLUSION

This technology has the capability of bringing a new era in war fighting in which precise knowledge is available to theatre forces, enabling highly cooperative operations against technologically advanced and diverse threats.

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