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A Review on Wireless Sensor And Networks Actor

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***Abstract**— Wireless sensor and actor networks (WSAN) are a collection of static sensors in which actors are movable unit's i.e. unmanned vehicles that examine the sensed data from their surroundings and take corrective actions. Various examples of WSAN are conducting search and rescue operation in urban areas, detecting pollution in coastal areas, detection of threats to ships and destruction of land and mines and so on. In inter-actor networks, actors need to coordinate with each other to process the sensor's data and then execute the plan. The actor's should decide the best solution among all the solutions. To perform accurate and timely actions, the collected sensors data must be valid at the time of action. This paper mainly focused on the WSAN communication architecture, design factors, layered architecture and applications of sensor networks.*

***Keywords**— Wireless sensor and actor networks, Ad-hoc networks, wireless sensor networks, coordination, transport, cross planes.*

I. INTRODUCTION

The distributed wireless sensor and actor networks (WSANs) are capable of observing the physical environment, processing the collected data, making decisions based on the observations and assumptions and taking corrective actions .The IEEE 802.15.4 standard enables many applications of wireless sensor networks (WSN). The nodes of sensor networks are capable of wireless communications, sensing, collecting data and performing computations. Thus, wireless sensor and actor network is the combination of sensor and embedded techniques, distributed information processing, and communication techniques.

A wireless sensor network (WSN) is a network that is the collection of hundreds or thousands of homogenous nodes which are deployed in a harsh environment with the capabilities of sensing, embedding, wireless communications and computation techniques.

The WSAN has several design and resource constraint such as low energy, short coverage range, low bandwidth, and limited processing and memory in each node, application dependent and based only upon the environment. The environment plays an important role in determining the network size, the deployment approach, and network topology. The network size varies with the environment such as for indoor environments there are only fewer nodes are needed to form a topology whereas in outdoor environment require more nodes to cover a larger coverage area.

An ad hoc dynamic deployment scheme is considered over pre-planned deployment of nodes when working in the harsh environment where hundreds to thousands of nodes are needed. Faults in the environment can also limit the communication between nodes, which in turn affects the network topology.

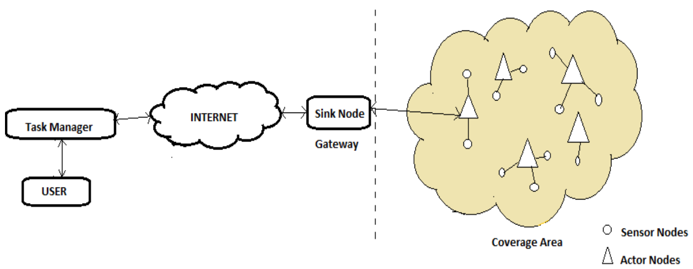

Fig 1: Architecture of Wireless Sensor and Actor Networks

In the communication architecture of WSAN, several devices are interconnected through radio waves. The coverage area or sensor/actor field covers the harsh environment, collection of sensor nodes as well as actor nodes.
All the sensor nodes are connected to their particular actor nodes. The sensors collect the data from environment (i.e. humidity, temperature etc) and then transmit their readings to the actor nodes which process all incoming data and take appropriate actions.

The collected data sends from sink node through gateway to the task manager. The user interacts to the task manager and process the sensed data.

Hence, a WSAN node should include basic capabilities such as sensing, processing and wireless communications, namely as:

- **Sensor Node:** these nodes produces sensed data by interacting with the environment and collecting a specified data such as temperature, humidity, pressure, movement etc.
- **Actor Node:** these nodes transmit data from one neighbor sensor node to another, towards the task manager, which processes and analyses the collected data.

II. COMMUNICATION ARCHITECTURE

The communication architecture of WSAN has two architectures called semi-automated and automated architecture.

A. *Semi-Automated Architecture*

In this, wherever the event occurs in the network, event information always passes through the sensor nodes in the network. Thus, these sensor nodes have excessive burden of relaying. When these nodes fail, the connectivity can be lost and the network can become useless and partitioned into several segments.

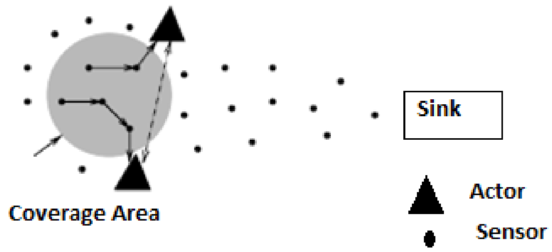

Fig 2: Semi-Automated Architecture

B. *Automated Architecture*

In this architecture, there is no central controller. The nodes within one hop from the actors may have a higher load of

relaying packets. As a result, the Automated Architecture will have longer lifetime than the Semi-Automated Architecture.

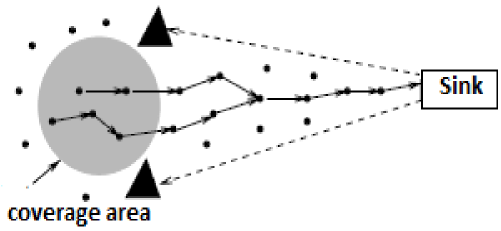

Fig 3-Automated Architecture

The paper is structured as follows: the design factors and requirements of wireless sensor networks are discussed in section 3. In section 4, the layered architecture of wireless sensor networks is introduced. section 5, presents a brief review of the applications that based on wireless sensor and actor networks.

III. DESIGN FACTORS AND REQUIREMENTS OF WIRELESS SENSOR AND ACTOR NETWORKS

This section intend to describe the design factors of overall wireless sensor and actor networks architecture as well as the design approaches of protocols and algorithms for wireless sensor and actor networks (WSANs). Many design factors have been introduced by many researchers in this field. These design factors serve as guidelines to design a protocol or algorithm for wireless sensor and actor networks.

A. *Reliability or Fault Tolerance*:

It is the ability to maintain the network functionalities without any interruption due to the node failure [1, 3]. Sensor and actor node may fail due to lack of energy, physical damage, communications problem and partition the network into different segments. Reliability is modeled as [2],

$$R_k(t) = e^{-\lambda}k^t,$$

Where, k= failure rate of sensor node, t= time period.

B. *Scalability:*

The scalability can range from a fewer sensor nodes to a hundred of nodes in an area that can be less than 10m in diameter. The density *is* calculated as [12]:

$$\mu(R) = (N\pi R^2)/A,$$

Where, *N* = sensor nodes, A=*Area*, *R*=*R*adio transmission range.

C. *Network Topology:*

The topology of a network disturbs many of its characteristics such as latency, capacity, and robustness. There are three phases related to topology maintenance are as [3]: *Pre deployment phase, Post deployment phase, and Redeployment phase.*

D. *Power consumption:*

The main component of sensor node is the power source which is limited enough. Hence; the life time of a sensor node depends strongly on the battery, especially where no power source is available.

E. *Hardware Components:*

The sensor node consists of four main major components: a sensing units, processing unit, transmission unit, and power unit. They may also have application-dependent components such as location finding systems, power generator, and mobilizer. Sensing units are also composed of two sub units: Sensors and Analog to Digital Converter.

F. *Data Aggregation:*

It is the task of reducing size of data by summarizing the data into a set of meaningful information while data are propagating through the wireless sensor and actor networks. As sensor networks made up of large number of sensor nodes; this can be easily congested the network with traffic and flooding it [4]. A solution to congestion in sensor networks is to use computation technique to aggregate the data within WSAN, then transmit only the aggregated or meaningful data to the controller of network.

G. *Transmission Media:*

In a sensor network, a wireless medium is used to provide communication between nodes. This communication links can be formed by radio, Infrared which is license free and robust.

H. *Self-Configuration:*

it is important for wireless sensor network to be self-organize; since the densely deployed sensor nodes in a coverage area may fail due to many reasons which may partition the network into several segments and new nodes may join the network.

I. *Quality of Service:*

The data delivery within a bounded latency is important; otherwise, the sensed data that delivered after certain delay will be useless. In other applications, the conservation of energy is more important than the quality of the sent data. There is a tradeoff between the quality of service and the energy conservations [5,7].

J. *Connectivity*:

A connection between any two individual sensor nodes in a sensor network defines the network connectivity. The connectivity influences communications protocols' design and data dissemination techniques. The connectivity of sensor network may not prevent the network topology from being variable and the network size from reduction as the failure of some sensor nodes.

IV. LAYERED ARCHITECTURE

The layered architecture of WSAN follows OSI model and is made up of physical layer, data link layer, network layer, transport layer, application layer, and with three management planes such as power management plane, mobility management plane, and task management plane.

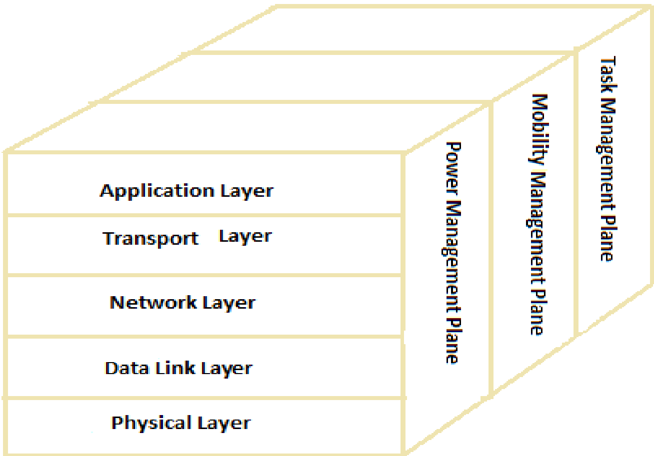

Fig 4: Layered Architecture of WSAN

A. *Physical Layer:*

The physical layer supports the needs of modulation, transmission and receiving techniques. It can provide an interface to transmit a stream of bits over physical medium. This layer is responsible for frequency selection, signal detection, Modulation and data encryption. The IEEE 802.15.4 proposed as a standard for low data rate personal area and Wireless sensor network. It provides low cost, less complexity, power consumption, range of communication to maximize battery life [8].

B. *Data Link Layer:*
This layer is responsible for multiplexing streams, error detection, MAC (Medium Access Protocol), and error control, and also ensure reliability of point to point or point to multipoint connections. Errors or unreliability comes from [10, 9] the following problems:
   a) *Co- channel interference*- when two devices use the same frequency channel, then co-channel interference occurs at the MAC layer and this problem can be resolved by MAC protocols.
   b) *Multipath fading and shadowing*- this problem occurs at the physical layer and can be resolved by forward error correction (FEC) and automatic repeat request (ARQ).

C. *Network layer:*
This layer is responsible for routing. it has lots of challenges such as power saving, limited memory and limited buffers. The sensor does not have a global ID (identification) and have to be self organized in case of failures. This is unlike computer networks with IP (internet protocol) address and central device for controlling them [10].The basic scheme of routing protocol is to define a reliable path according to a certain metric, which varies from protocol to protocol. This layer supports many routing protocols, such as flat routing protocol i.e. direct diffusion and hierarchal routing protocol i.e. LEACH or can be further divided into time driven protocol, query driven protocol and event driven protocol.

D. *Transport layer:*
This layer is responsible to provide reliability and congestion avoidance schemes with protocols to provide upstream scheme such as user node to sink node, i.e. ESRT, STCP and DSTN, and downstream scheme such as sink node to user node, i.e. PSFQ and GARUDA. These protocols use different approaches for loss detection such as ACK, NACK, and Sequence number and loss recovery such as End to End delivery [8]. The link from sink node to user node is considered as downstream link for multicast transmission and UDP traffic because of the limited memory and message overhead avoiding. On the other hand from User node to sink node is considered as upstream link for uni cast transmission. [10].
In general, Transport protocols can be divided into two flavors':
   a) *Packet driven:* 'all packets sent by source node must reach at destination node' [8].
   b) *Event driven:* 'the events must be detected, and one notification message reaches the sink' [8].

E. *Application layer:*
This layer is responsible for traffic management and provides software for different applications that translate the data into an understandable form. Sensor networks are deployed in various fields, for example; military, medical, environment, agriculture fields etc[11].

The three cross planes of WSAN are as follows; power management plane, mobility management plane and task management plane.

A. *Power management plane:*
it manages how a sensor node uses its power to operate and manages its power consumption among the three main operations such as sensing, computation, and wireless communications. In case of duplicity, by getting duplicated messages, a sensor node may turn off its receiver after receiving a message from one of its neighbors. The remaining power is reserved for further sensing and detecting tasks.

B. *Mobility management plane:*
This plane detects and registers the mobility of sensor nodes as a network control primitive. The sensor nodes can keep track of their neighbors. Therefore, the nodes can balance their power and task usage by knowing the situation of network.

C. *Task management plane:*
This plane balances and schedules the events such as sensing and detecting tasks from a specific coverage area. Depending on the power level, some nodes perform the sensing task more than others and other performs the detecting tasks.

V. APPLICATION AREAS OF WIRELESS SENSOR AND ACTOR NETWORKS

Sensor and actor networks are applied in a wide range of areas, such as military applications, public safety, medical, surveillances, environmental monitoring, commercial applications, habitat tracking etc[9,13,6].
The idea behind these applications is that the sensor nodes are deployed in the physical environment with capabilities of sensing, wireless communications, and computation. There are some other applications for wireless sensor and actor networks that can be seen in environmental monitoring and control field such as robot control, high-security homes, tracking.

A. *Military applications:*
It includes events such as environment monitoring, tracking and surveillance applications. Sensor nodes that from sensor network are dropped to the field and surveillance applications. Sensor nodes and actor nodes are dropped to the sensor field of interest and remotely controlled by the user. User may assign new tasks to be performed by these sensor nodes.

B. *Environmental monitoring:*

It includes the events such as animals tracking, forest detection, fire detection, flood detection, and weather prediction and forecasting.

C. *Industrial Process Control:*

In industry, WSANs can be used to monitor the manufacturing process or the condition of manufacturing equipment. For example, chemical plants can use sensors to monitor the condition of their miles of pipelines. These sensors are used to alert in case of any failures occurred in the field.

D. *Health applications:*

It includes the events, such as tracking and monitoring of doctors and patients in or out the hospitals by providing them with sensors.

E. *Mining:*

When underground mine accidents occurs, availability of sensing information could enhance mine safety by including gas sensors, humidity sensors, ultrasound depth measurement devices, SOS gadgets.

CONCLUSION

In this paper, I present the state of the art of wireless sensor and actor networks along with their architecture, design factors and requirements of WSANs, their applications. Also, in this paper, the layered architecture for WSAN is introduced that follows the OSI Model. The realization of wireless sensor and actor networks (WSANs) needs to satisfy the requirements introduced by the coexistence of sensors and actors. However, WSAN networks become integral part to many applications like forest resource management, mining, military, health and soon.

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