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Wireless sensor networks for smart cities in India

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ABSTRACT

Wireless Sensor Networks (WSNs) have been established as the backbone of the technological developments that have been made in recent years, allowing companies to employ them in a variety of applications through the industries. These networks are composed of a large number of the tiny, self-contained sensor nodes endowed with wireless communication, which are possibly the most appropriate to handle the collection, the processing, the storage and the transmission of information from physical world in real time. Wireless Sensor Networks (WSNs) are extensively used in applications including environment monitoring, healthcare, industrial automation, intelligent infrastructure, and military applications. By delivering quantifiable and reliable information timely for stakeholders they enhance knowledge-based decision making, resource utilization, and quality of life. The key features of WSNs such as flexibility, scalability, low cost, and ease of deployment are also very appropriate for large scale localized applications. This paper summarizes the basic elements of WSNs, sensor nodes, communication protocols, data processing methods, etc. The paper also discusses the fundamental issues involved in designing and implementing WSNs, including energy management, security, and data fusion. Particular attention is given to the role of energy efficient protocols and security in addressing the weaknesses of wireless transmission. The abstract finishes by discussing research and development (R&D) work currently under development to boost WSNs performance, reliability and security to keep pace with the increasing needs of current and future technology infrastructures.

Keywords : *WSN, smart city, advanced construction technology.*

1 INTRODUCTION

Urban Environment Monitoring (UEM) is one of the critical prerequisites for smart city projects [1] [2] [3] such as different control mechanism applications. All of these applications

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need a 4S (Smart Sensor Surveillance System). There are several technologies for the surveillance system to capture the (data) importance. The analyzisy of these data are consistent with the environmental variations [4]. These technologies are including surveillance camera systems, ambient divine monitoring technologies, etc., which have the limitation about the scalability, reliability and spatial- temporal information correlation efficiency among them [5]. “4S for UEM”, “Smart Sensor Surveillance System for UEM” where WSN is used is an application of such system, which tries to fill these gaps or limitations. Thus, this study proposes to design a standard WSN architecture which offers a generic architecture to meet the “4S for UEM” requirements. The motivation to obtain a classical WSN for different 4S-UEM applications is to tackle the bottleneck on the restrictions of selecting a single application specific architecture for another. The data collection and analysis that covers various environmental parameters such as, temperature, humidity, road traffic density, vibration to the public infrastructure, water pH values, and other parameters can be achieved as to develop smart control system of smart home, transportation, safety of building & bridges, water quality management, etc. as real application needed for the smart city project, etc. Fig. 1 is a 'snap'-view of ``4S-UEM" applications and the inherent need. As seen in Fig. 1, the intelligent system using the architecture of 4S-UEM, should have four characteristics in accordance with the satisfactory design of the 4S-UEM, the following, LS-UEM characterization could be:{Lifetime, Accuracy, Coverage, Reliability}. Another constraint other than these four are the secure communication so that 4S- UEM applications can be realized in real-time scenario. A new analytical model is presented herein for the design of the secure transmission via 4SUEM in order to provide authentic, secure and reliable communication along optimal coverage.

Related Work This section discusses the related work of designing and deploying WSN based applications of methodological briefs of urban environment monitoring system (UEMS). The topic is restricted to some resource optimization scheme which are best possible scheme for resource management. That is because when the resource management ability is improved, the security scheme will eventually be facilitated by this action. The omnipresent problem in UEMS is the efficient deployment of the sensor nodes for achieving the maximum coverage and it is also the secure communication. For relay in the communication architecture, a network of wireless sensor nodes which are in hierarchy including hop as well as local and global sink (the higher interface) and is the part of WSN as static or dynamic WSN [6] depending upon the mobility of nodes and application needs. When planning the network deployment strategy in terms of both coverage and connectivity, one should also take it into account a better network performance [7]. The optimal coverage problem is formulated as a greedy algorithm [8] or an integer optimization problem [9] that is similar to the localization or placement problem of facilities [10]. The optimal numbers of the sensor nodes are calculated by several approaches such as disk model, sector model and geometry pattern model [11]. If the localization however known, then the issue of optimal deployment in the urban area meandering and deployment of WSN would prefer an integerprogramming where popular approachlike i) divide-andconquer, ii) simulated annealing, and iii) Genetic Algorithm, where these give extra time complexity overhead [12]. Regardless of these approaches, there are some particular issues for practical WSN deployment in UEMS. Another important observation to note is that in most of the deployment, the position of the base station remains static and this does not optime the network performance [13]. No doubt, with an evolution of various methodologies and techniques there exist large number of research work being performed toward the secure routing in WSNs. The current systems provide a very high degree of issue specific addressing scheme, but neglect various challenges associated with the addressed issues. Secure scheme is not only solved by encryption, but a resource management is also required. We find little evidence from prior research with work targeting such an integrated issue. Therefore, a significant research gap which has been addressed is, researches are very less that associate hands-on energy retention with cost effective secure data aggregation in WSN while confronting difficult of distributed and large scale area.

2 METHODS

A. Sensor Node Deployment and Data Analytics Framework

For the efficient surveillance of the urban environment, its proposed 4S-UEM (not short for 4-Step Urban Environmental Monitoring rather used to designate its 4D0 architechural outline) structure tracks real-time temperature, CO_2 concentration, environment by the wireless sensor networking (WSN). The model adopts a data analytics engine (DaE) to perform data processing and interpretation, so that the model is different from traditional models transmitting raw data. Sensor nodes (Sn) are randomly and uniformly distributed on a given square area (A = L × L) which is a represented by a graph G(V), where V is the set of Sn positions. Algorithm-1 guarantees the optimal coverage and connectivity-based node deployment integrating DaE and Lg as key architectural blocks. The deployment phase consists in computing for each Sn and DaE the coordi- nates distributing the position of the interested sensors over the terrain T, building a virtual gra- phical tiles structure that will be used for following clustering and routing processes 2.1.2 Optimal deployment phase The optimal deployment phase manager Objective: Given an Area of Interest (AoI) T with a set ESens of interesting sensors, the goal of the optimal deployment phase is to compute the optimal set of Tan targ of target points whose corresponding sn design to cover the area T is a known target configuration.

B. Urban Geographical Clustering and Gateway Selection

One of the main novelty of 4S-UEM is the Urban Geographical Clustering (UGC). In contrast to static zoning, we dynamically divide the urban region into clusters (uC) to minimize the communication overhead and energy consumption by UGC. The local gateway (Lg), whose role is to perform initial data aggregation and translation, is chosen probabilistically from Sn nodes in coverage by energy reserves and boundary restrictions to avoid spatial overlapping. The number of clusters nC is determined as m^2, where m is a positive integer which minimizes the gap $|nC - nLg|$. The boundary vectors $\vec{B}$ are then generated with linearly spaced intervals of L which divides the monitoring area. Each Sn is labelled with a Cluster-ID (Cid) according to its (x,y) position and appropriate boundary. A 2D reshaping of Sn IDs also clarifies the association between them in each of the clusters. lg selection is then elaborated through a model using a threshold, which takes into account the activity of a node and its prior participation.

C. Secure Routing and Lightweight Data Authentication

A two-level secure routing approach is presented in 4S-UEM. First, Sn sends data to its assigned Lg, and second, Lg forward aggregated and authenticated data to the DaE. The approach counteracts dead nodes (DSn) by isolation, allowing only active nodes (ASn) for Lg capability. The threshold probability (Th) of Lg candidacy is based on the historical node participation and energy, similar to the LEACH protocol, and contains additional security factors. Data are protected by a light weight security model using a tailor-made ECC (Elliptic Curve Cryptography). During setup, cyclic groups $\{G_1, G_2\}$ are formed by prime numbers and random seeds. Each message undergoes double hashing (fhash-1, fhash-2) and signing with node identity keys with additional group operations on cyclic groups. The signature (u_1, P_1, etc.), that contains signature value u_1 as well as u_1, P_1, (…) is verified at the Lg before forwarding the data to DaE. This ECC-based scheme loads little computation that matches with Sn's limited capability, while preserving security against data tampering and spoofing in layer-wise communications. It operates inside the sleep interval of the sensor nodes to save their energy resources and prevent data conflict.

3 PERFORMANCE EVALUATION AND RESULTS

The integrated architecture proposed in this paper is referred to as 4S-UEM, it is noted that in order to implement a smart monitoring system for urban monitoring the entire urban zone is partitioned into urban clusters and a local gateway is selected in an intelligent manner. The data are gathered by the local gateway as is then sent directly, or via inter-local gateway routing with data verification configuration. The significant outcomes of this work are i) The developed system provides approximately 47- 58%maintenance of energy over a heavy network of smart city, ii) The clustering model is compatible with the public key encryption model adopted by many existing models, iii) The result gives a non-iterative approach for the resources optimization and therefore it is very much cost efficient. This model of 4S-UEM yields consistent result for network lifetime with different node density (no. of cluster). The prospective research direction will be to develop the routing model in such a way that along with the priority based routing the additional consideration will be in the channel allocation and also the collision of the packets should be avoided by using the optimal timeslot scheduling of the radio resulting in to minimal usage of energy for the node under consideration.

4 CONCLUSION

The unified architecture proposed in this paper is named 4S-UEM, keeping in mind that to deploy a smart monitoring system for the urban environment monitoring purpose, the entire region of the urban zone is divided into the urban clusters where a local gateway is chosen smartly and intelligently. The local gateway collects the data and sends the data either directly or through inter-local gateway routing with the data verification provisioning. The important findings of this paper are i) proposed system offers approximately 47- 58%of energy conservation over a large network of smart city, ii) The clustering model suits well with the public key encryption mechanism implemented unlike any existing methods, iii) the study offers no iterative scheme towards optimizing resources and hence it is highly cost effective. The 4S-UEM model provides a consistent result in terms of the network lifetime with a varying number of node density and the cluster. This work's future direction is to evolve a routing model so that priority-based routing takes place with further energy optimization during the channel allocation and avoidance of the collision of the packets utilizing optimal timeslot scheduling of the radio.

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