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Flexible Software Defined Networking for Wireless Sensor Network: Survey and Discussion

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ABSTRACT

Wireless sensor networks (WSNs) consist of small, low-powered sensor nodes that measure specific parameters of the environment (e.g. temperature, pressure, motion, etc.) and convert the measurement results in electrical signals. Depending on applications, WSNs may include up to hundreds of sensor nodes, which communicate with the external gateway either directly, or by multi-hop data transmission. Energy efficiency is one of the key requirements in Wireless Sensor Networks (WSNs). In order to optimize energy usage at sensor nodes, IN this paper we study the various challenges regarding quality of services in the wireless sensor network and discuss about the problem in the current scenario.

Keywords: Software Defined Networking, Wireless Sensor Networks, Cognitive Network, Quality of Services, Sound Surveillance System.

INTRODUCTION

Software defined networking (SDN) is a new approach to designing networks, where network control functions are decoupled from elements like routers and switches to make them simple packet forwarder. The SDN architecture comprises management, control, and data planes. The management plane defines the network policies, which are translated into configuration rules to be installed in the data plane elements by the control plane (controller). The management and control layers communicate through a Northbound API; whereas, Southbound (SB) API is used for the control and data plane communication [1].

One of the main WSN performance parameters is reliability, which is hard to achieve due to limited resources and communication abilities of sensor nodes. In today's WSNs, sensor nodes usually forward data to the closest neighbour. This entails that the largest amount of traffic is routed over nodes near the gateway. Since batteries of these nodes rapidly drain, the risk of network collapse increases. Various distributed routing algorithms have been proposed in literature to address this problem, However, most of the solutions are too complex and optimized in a way that practical implementation is not sustainable. In general, many inherent problems of WSNs are deeply rooted in the network architecture, because each node is implemented as autonomous system equipped with all functionalities from physical up to application layer. Thus, besides traffic forwarding, the nodes perform many control tasks, including routing. Functionalities implemented on the nodes are adjusted to the needs of sensing application. This imposes negative impact on network utilization, because multiple networks are often deployed in the same or overlapping areas for the purpose of different applications, while the same goals could be reached with one programmable network [10].

The protocol stack of SDSense consists of interference management, reliable topology control, routing, and congestion management. We reduce contention but preserve reliability by deriving a new reliable routing topology that provides alternative paths to deliver event information when a primary route fails. To effectively use the bandwidth, we complement the topology with the derivation of a Time Division Multiple Access (TDMA) transmission schedules that separate interfering transmissions in time. Both of these components of the design are slowly changing and managed by the logically centralized controller with a global network view. The congestion can arise due to the unpredictable nature of event data, which is a fast-changing phenomenon. Thus, SDSense explores distributed congestion management approaches implemented directly by the sensors and using locally observed congestion to select forwarding direction [1].

Most research has been focusing on reducing energy usage on the sensor nodes so to prolong the lifespan of the nodes. The SDN model could significantly reduce energy usage on the node. Most of the energy intensive functions such as routing, processing and management are removed from the physical node to a central controller or to the application plane. The sensor nodes become sheer devices that are controlled from the central controller. The SDN model is envisaged to bring flexible configuration, easier implementation of new policies, better performance, innovation, automation, vendor independence, security, ad hoc management, seamless protocol upgrades and evolution [2].

By employing SDN, the nodes will behave as data plane devices forwarding and processing data without interfering network control tasks such as topology management and routing strategies, simplifying their architecture and enhancing their energy efficiency. Moreover, armed with network-wide view, the controller introduces comprehensive efficient management, duty-cycling, routing and coverage & connectivity strategies [3].

SDWSN is a network computing paradigm for applying software defined networking (SDN) strategies to WSNs with the purpose to improve their technological applications. This networking paradigm, promises to evolve how WSN systems operate for diverse application through the concept of programming. The SDWSN concept is aimed at, dedicating the controlling functionality of a WSN system to a global controller for compute intensive tasks and therefore maintain the underlying sensor nodes to only perform data forwarding. The controller manages numerous network devices, services, topology, traffic paths, and packet handling (QoS) policies [6]. Hence, SDWSN is envisioned to; reduce network complexity, simplify device configuration and improve network management by introducing adaptive computing evolution and simplicity to the network. This paper is the first work to review work already done in Software Defined Wireless Sensor Networks (SDWSNs) with a specific focus on QoS provisioning. Moreover, it proposes strategies for ensuring continuous and reliable QoS provision in SDWSNs.

The rest of this paper is organized as follows in the first section we describe an introduction of about the software defined networking and their application. In section II we discuss about the wireless sensor network, In section III we discuss about the SDSENSE architecture in detail, In section IV we discuss about the rich related work, finally in section V we conclude the about our paper.

II WIRELESS SENSOR NETWORK (WSN)

A WSN is made up of a large number of small, low-cost, low powered sensor nodes. These nodes monitor environmental conditions, such as temperature, sound, pressure, humidity, etc., and then send that information wirelessly over the network to a host system where it is processed, analyzed and presented in a readable format [5]. These networks, as illustrated in below figure, have a wide range of applications. They can be used to monitor weather conditions on farm fields or to detect enemy's movements in warzones.

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They can also be used to monitor the traffic to keep it away from jams and accidents or to predict natural disasters such as volcanoes and earthquakes.

Figure 1: WSN Environment [5].

The history of WSNs dates back to several decades. According to a report published by the Silicon Labs on the evolution of WSNs [9], the Sound Surveillance System (SOSUS) was the first wireless system that shows any resemblance to the modern day WSN. It was invented by the US military to keep track on Soviet submarines. The system consisted of a large number of submerged acoustic sensors called hydrophones that were dispersed all over the Atlantic and Pacific Ocean. This detecting technology is still being used in some areas to monitor natural disasters.

III SDSENSE ARCHITECTURE

In this section, we discuss SDSense architecture that accommodates a logically centralized controller along with a local controller associated with the software-enabled sensors. The centralized control allows intentional control of the network to place it in a state that may be difficult to achieve as emergent behavior from distributed protocols. In addition, the functionality of the network, which is encapsulated in the control plane is centralized and can be modified, providing the ability to evolve protocols easily, possibly without reprogramming the sensors [1]. Resulting reconfiguration of the sensors is then isolated to changes to the data plane configuration which is supported by the SDN operation. In SDSense, the data plane is composed of software-enabled sensors associated with a local controller. The control plane or controller manages the network functions and resides in the sink, as well as distributed control agents that operate on the sensors.

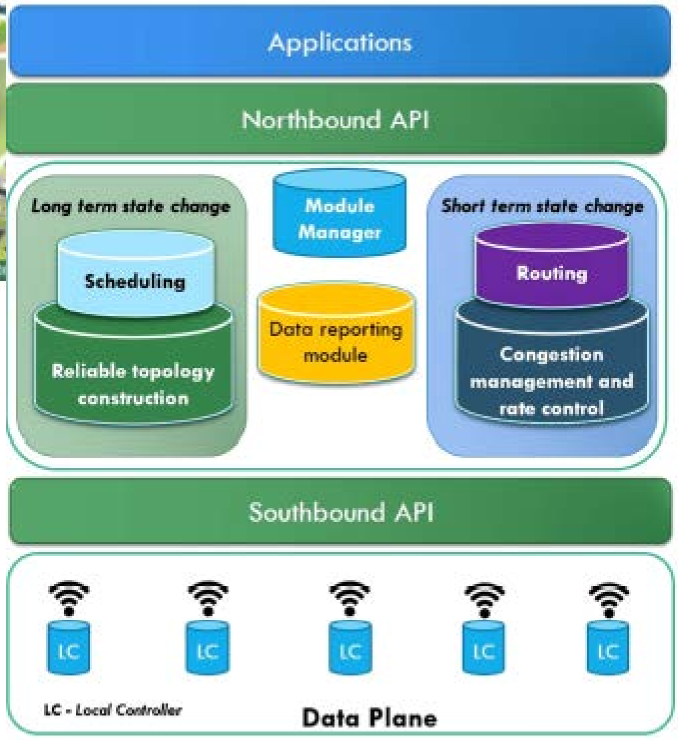

Figure 2: Architecture of SDSense.

IV RELATED WORK

[1] In this paper, they state that SDN-based design is beneficial in the multi-hop wireless networks like wireless sensor network (WSN) and propose an architecture called SDSense. They propose a novel principled approach of SDN-based WSN design, where they decompose network functions as slow (e.g., topology control) and fast (e.g., congestion control) changing components. Furthermore, they derive a network utility maximization framework for better resource allocation. They implement SDNSense, where

software enabled sensors are dynamically reconfigured to adapt to current network conditions and demonstrate that SDSense can significantly improve the network performance compared to its counterparts. [2] This paper evaluated the viability of a distributed control system for Software Defined Wireless Sensor Networks (SDWSN). SDWSN is a new networking paradigm that seeks to improve the efficiency of WSNs by leveraging the SDN model. Distributed control solutions have been proposed for SDN enterprise networks but few for SDWSN. The SDN model centralizes the control intelligence of the whole network; although this abstraction brings lots of positive benefits, it also introduces several challenges. The entire network could be at risk if the central controller gets compromised. Failure of the controller could also negate the availability of the network thereby rendering it unreliable. [3] Addresses the uplink and downlink routing mechanisms in software defined wireless sensor network (SDN-WSN). They proposed an integrated communication protocol, called MINI-FLOW, that surrounds three data routing mechanism, the uplink routing (from the end nodes to the controller), the downlink routing (from the controller to the end nodes) and the information reporting in the network initialization level (i.e., when the controller knows nothing about the end nodes). The routing mechanism is designed based on a heuristic function that captures three values, the number of hops to the sink, the Received Signal Strength (RSS) and the remaining energy. [4] In this paper, they have provided an overview of some grand challenges that call for further advances in computing, communication, and control technologies for tomorrow's cyber-physical systems. They have also presented a partial account of several research issues to overcome these challenges, and have surveyed recent research efforts in (i) stability, performance, and safety, (ii) sensing, computing, and networking systems, and (iii) modeling, design, and development. [5] In this paper, they have briefly introduced the background of SDN as well as its feasibility in WSNs. After carefully examining various features offered by the SDN, the SDN has been shown to not only offer a more simplified network management with more control over the network devices, but also to provide richer programmatic interfaces. The ability to shape and control data traffic ensures guaranteed content delivery which can be very useful for VoIP and multimedia transmissions. It has also been shown that the SDN and large-scale deployment of the WSNs are the future of networking. [6] Provides a review on QoS provision in WSNs particularly for mission critical applications. The review focuses on QoS metric implementation, QoS challenges and improved communication opportunities in WSNs. The paper, further proposes Software Defined Wireless Sensor Networking (SDWSN) strategies for efficient resource management and guaranteed QoS support to improve network performance. The proposed strategies are aimed at simplifying QoS provisioning for these constrained technologies using programming methods to advance WSNs applications and their implementations. [7] This paper introduces two novel topology control techniques for Software Defined WSNs that can be combined and adapted to the context environment. In this direction, they propose CORAL-SDN, an SDN framework for WSNs that enables dynamic deployment and configuration of multivariate topology control mechanisms. They evaluate such topology control strategies using our own novel SDN experimentation facility for IoT. The results demonstrate significant improvements on WSNs management, control features and performance in terms of topology construction time and reduced topology maintenance overhead. [8] This paper presents Atomic-SDN, a highly reliable and low-latency solution for SDN in low-power wireless. Atomic SDN introduces a novel Synchronous Flooding (SF) architecture capable of dynamically configuring SF protocols to satisfy complex SDN control requirements, and draws from the authors' previous experiences in the EWSN dependability competition: where SF solutions have consistently outperformed other entries. Using this approach, Atomic-SDN presents considerable performance gains over other SDN implementations for low-power IoT networks. They evaluate Atomic-SDN through simulation and experimentation, and show how utilizing SF techniques provides latency and reliability guarantees to SDN control operations as the local mesh scales. [10] In this paper they explored possibility of applying SDN concept in WSN networks. They identified major weaknesses of WSN networks in general, and presented new SDN-based WSN architecture. In particular, three possible benefits of software-defined network design have been identified: energy efficiency, mobility support and management simplicity. Through MATLAB simulations it has been shown that significant energy savings could be achieved without duty cycle and data aggregation mechanisms, just using a simple centralized routing algorithm. An important step in validating the results is to implement a prototype version of SDN architecture.

V CONCLUSION AND FUTURE SCOPE

Software-defined networking (SDN) is a cornerstone of next-generation networks and has already led to numerous advantages for data-center networks and wide-area networks, for instance in terms of reduced management complexity and more fine-grained traffic engineering. This survey gave a brief overview of WSNs and SDN and introduced the concept of software-defined WSNs (SD-WSNs) including their operations, e.g., topology discovery and routing decisions, that are different from WSNs. Coordination of distributed nodes and energy efficiency are the most important challenges in WSNs. In non-SDN based WNSs, they are mostly solved in a distributed manner. SD-WSNs favor central control.

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