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A Review on Software-Defined Wireless Sensor Networks (SDWSN) and its Challenges.

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Abstract: - **Software Defined Networking brings about innovation, configuration in network computing and simplicity in network management. SDN technology is an enormous approach to cloud computing which facilitates network management and enables efficient network configuration programmatically that improves network performance and monitoring. WSN consist of nodes that interact with the environment to achieve the sensing task thereby sensing the physical parameters such as temperature, pressure, volume etc and also help control them. These nodes can perform computation, sensing, actuation and wireless communication functions, particularly with the advent of Internet of Things (IoT)that is essential for monitoring several objects in applications such as smart cities, smart water networks, smart health care, smart power grids, smart farming and intelligent transport systems etc WSNs are continuously becoming important .Traditional networks often lack flexibility that brings into effect instant changes because of the rigidity of the network. It also depicts over dependency on proprietary services. SDN separates the control plane and the data plane, therefore moving the control logic to a central controller from the node. WSN is a very good platform for Low-Rate Wireless Personal Area Networks (LR-WPAN) with minimum resources and short communication ranges. Although the scale of WSN expands it faces many challenges, namely heterogeneous-node networks and network management. The approach of SDN seeks to alleviate most of the challenges and hence foster sustainability and efficiency in WSNs. The combination of SDN and WSN gives rise to a new prototype named as Software Defined Wireless Sensor Networks (SDWSN). The SDWSN model is therefore envisioned to play a vital role in the IoT paradigm. This paper presents a review of the SDWSN literature. Also it takes care of the challenges facing this paradigm.**

Index Terms— **Wireless sensor networks, Software defined networking, Software defined wireless sensor networks.**

I. INTRODUCTION

WSN consist of micro-sensors capable of monitoring physical and environmental factors such as temperature, humidity, seismic events, vibrations, motions, etc. A sensor node typically consists of a power unit, sensing unit, radio and a processing unit. WSN consists of sensor nodes deployed in a structured or unstructured manner over a chosen area of interest. The sensor nodes are small, inexpensive, and intelligent. WSN's are usually not tethered to a power source as they require a minimum amount of energy which is usually supplied by integrated batteries. WSNs are very flexible in their applications but also put up a challenge due to their resource constrain and application specific architecture. The main defect of WSN is related to the resource limitations of the sensor hardware namely processing, memory, energy and communication capabilities, although they are widely used due to the increased number of embedded devices available making deployment easier. However, other issues associated with large-scale WSNs arise with the increased node deployment such as meeting the necessary QoS for satisfactory operation as node scale up to very large numbers. This is a very essential factor to consider especially in medical and industrial applications where quality and reliability are very crucial. Due to the rigidity of the network and the over dependency on proprietary services, traditional networks often lack the flexibility to bring into effect instant changes. A Wireless Sensor Network (WSN) is a great platform for Low-Rate Wireless Personal Area Networks (LR-WPAN) with little resources and short communication ranges. However, as the scale of WSN expands it faces several issues, such as network management and heterogeneous-node networks. In addition, these nodes will not only need to process data but also need to be flexible on variations. Therefore, the nodes must be reprogrammable during operations when other tasks need highest priority. The current vendor specific sensor nodes being used in WSNs are difficult to re-task when a new parameter is required to be sensed and reprogramming would require each sensor to be taken out and the embedded software reprogrammed in the sensor hardware. For large-scale WSNs this method would not be realistic. Vendors have come with the idea of Over The Air Programming (OTAP) techniques; however, the data sensing and packet forwarding protocols are still specific to the vendor. The SDN approach to WSNs seeks to alleviate most of the challenges and ultimately foster efficiency

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and sustainability in WSNs.

Software Defined Networking (SDN) brings about innovation, simplicity in network management and configuration in network computing. SDN decouples the control plane from the data plane, thus moving the control logic from the node to a central controller. The fusion of these two models gives rise to a new model: Software Defined Wireless Sensor Networks (SDWSN). The SDWSN model is vision to play a critical role in the ominous Internet of Things (IoT) paradigm. For example, in case of data congestion, the controller will make the decision to redirect the flow of traffic and order the devices to update their flow tables accordingly. This feature of traffic management is not possible with the traditional networking models as changes to the routing paths cannot be implemented directly. Some research has shown a different view of SDN that they refer to as the software driven networks. They present a middle approach whereby some parts of the network are managed by the controller, while others are still managed by the more traditional control plane. This paper presents a comprehensive review of the SDWSN literature and also delves into some of the challenges faced.

II. SDN ARCHITECTURE

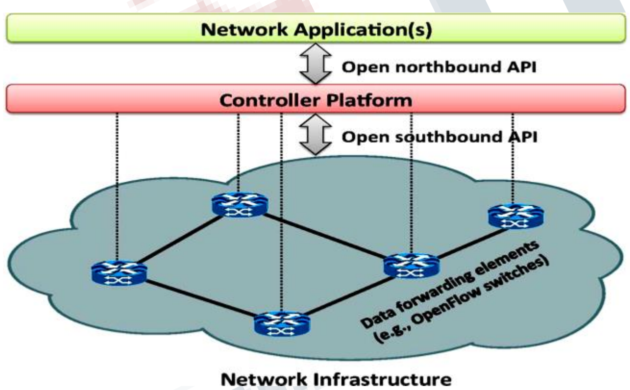

Figure1:- A Simplified view of SDN Architecture.

Software-Defined Networking (SDN) is an emerging network architecture where network control is decoupled from forwarding and is directly programmable. As per this definition, SDN is defined by two characteristics, namely decoupling of control and data planes, and programmability on the control plane. Nevertheless, neither of these two signatures of SDN is totally new in network architecture. First, several previous efforts have been made to promote network programmability SDN is a new leading architecture for networking based on the principle of dividing and separating the network into two separate planes; the control plane which determines the traffic routes and the data plane which forwards the traffic packets. SDN was initially designed for traditional wired and wireless networks therefore using it for WSNs would pose a challenge due to limited node resources and other constraints inherent in the WSN architecture. In SDN, most of the energy intensive functions are removed from the physical node to a logically centralized controller. Since functions such as routing, major processing and management are handled at the controller or application level the nodes become devices with no intelligence. Integration of SDN would enable building of a Network Management System (NMS) not different from adding another application to the control plane. As a result applications in SDN-based WSNs are being constantly developed and researched. While several management schemes for WSNs have been proposed and discussed in the past decade and for the general SDN concept in recent years, there has been little emphasis on how SDN might improve management of WSNs or on the need for integration of SDN-based management architectures in WSNs. In any network it is expected to scale up to thousands of nodes and even more for use in various applications therefore it is critical that management solutions be considered and developed. The SDN model has been applied in a variety of enterprise solutions i.e. data centers, network function virtualization (NFV) and enterprise networks. NFV is another concept closely related to SDN which virtualizes network functionalities for flexible provisioning, deployment and management. Therefore, the contribution in management of WSNs and the management techniques in which SDN has been implemented to improve the management of WSN is being reviewed here. We review SDN in general while focusing on the adoption of SDN-based management in real-world WSN applications.

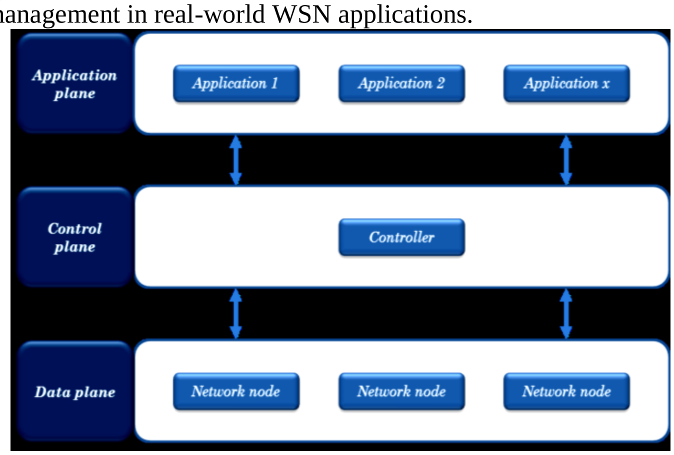

Figure2:-Basic SDN framework with 3 planes (showing central controller).

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III. SDN BENEFITS

SDN, with its inherent decoupling of control plane from data plane, offers a greater control of a network through programming. This combined feature would bring potential benefits of enhanced configuration, improved performance, and encouraged innovation in network architecture and operations. For example, the control embraced by SDN may include not only packet forwarding at a switching level but also link tuning at a data link level, breaking the barrier of layering. Moreover, with an ability to acquire instantaneous network status, SDN permits a real-time centralized control of a network based on both instantaneous network status and user defined policies. This further leads to benefits in optimizing network configurations and improving network performance. The potential benefit of SDN is further evidenced by the fact that SDN offers a convenient platform for experimentations of new techniques and encourages new network designs, attributed to its network programmability and the ability to define isolated virtual networks via the control plane.

IV. SDN CHALLENGES

An open-source Open-Flow driver is still absent for SDN controller development, a standard north-bound API or a high level programming language is still missing for SDN application development. A healthy ecosystem combining network device vendors, SDN application developers, and network device consumers, has yet to appear.SDN offers a platform for innovative networking techniques, however the shift from traditional networking to SDN can be disruptive and painful. Common concerns include SDN interoperability with legacy network devices, performance and privacy concerns of centralized control, and lack of experts for technical support. Existing deployments of SDN are often limited to small test-bed for research prototypes. Prototypes for research purpose remain premature to offer confidence for real world deployment.

One critical challenge in SDWSN is the efficient assignment of spectrum resources to the virtual network, which then contributes to the spectrum resource problem. However, dynamic programming and graph theory based spectrum sharing algorithm is proposed (5)

The major concern to discuss here is that since SDN propose to facilitate a control of the primary network from a devoted point, it is alleged that the whole network will collapse in case where the controller is disrupted or somehow fail. Also, with the current foresee about IoT through WSNs (6,7) , it must be considered as to if a applicable infrastructure can be realized on SDWSN. Successive to uncertainties that surround the standard architecture as well as the effective adoption of SDN technologies in production or application networks, some level of understanding is needed regarding its structural components and the fundamental benefits that SDN proposes to bring. Due to the distinctive architectural model of SDN, network customization (8) and resource optimization in WSNs could be achieved using this approach, thereby improving the overall network performance. SDN is also aimed at providing network stability and flexibility in WSNs, through the enhancement of some of the critical network aspects such as; process scheduling, traffic routing, resource access, network abstraction and programmability. SDWSN aims at improving resource utilization and "open" network programmability in WSNs.

V. SDWSN CHALLENGES

The challenges besetting SDWSN include some of the WSN inherent challenges not wholly addressed by SDN, such as processing clarity, memory, etc. Other challenges identified include standardization and security. Standardization is very applicable to the ideals of IoT heterogeneity, while security will also be central in IoT to ensure that future networks are secure and reliable. As discussed in this paper centralization of the controller could pose a security threat, as it could be a potential target and a reliability threat resulting in a single point of failure. There are a few papers (1),(2),(3),(4) that deal with some individual components of SDN that could be applied to SDWSN application. SDWSN challenges can be listed as below:

1) WSN Challenges: The challenges associated with WSN have not been broadly addressed yet.It is mentioned earlier the drawbacks of WSN being resource constrain and application specific architecture. The main defect of WSN is related to the resource limitations of the sensor hardware namely processing, memory, energy and communication capabilities, although they are widely used due to the increased number of embedded devices available making deployment easier. However, other issues associated with large-scale WSNs arise with the increased node deployment such as meeting the necessary QoS for satisfactory operation as node scale up to very large numbers. This is a very essential factor to consider especially in medical and industrial applications where quality and reliability are very crucial.

2) Standardization: There is an urgent need for SDWSN standardization lacking it would result in incoherent and incompatible architectures that is against the SDN's principle of heterogeneity. While there is yet a formal standard for SDWSN to emerge, the standardization of its constituent i.e. WSN and SDN are

developing with pace as seen in IEEE 802.15.4 [12], ZigBee [11] and ONF [10], IETF [9] respectively. It is yet to be known whether these 2 standard groups would satisfy the requirements of SDWSN, or a new standard will be necessary. The standardization of the IoT framework is also imperative which likewise has seen standardisation of its constituent networks.

3) Practical Aspect: In spite of the research efforts used to tailor Open Flow for SDWSN, there is no practical application, because most results are simulated or proposed general framework. The practicality of SDWSN would be able to provide a clear indication of the progress made which would accompany in an opportunity to evaluate the most common wireless network issues namely QoS, reliability, packet loss, efficiency, scalability, bandwidth, etc.

4) Network Operation: There appears to be a discrepancy in the use of the network operating system and functional protocol. Some implementations appear to be more inclined to an OS that includes some basic functionalities of a protocol and the protocol based architectures seems to include some functionalities of an OS. This disagreement needs proper evaluation to determine if this 2 should co-exist or operate independently.

5) Security: As we are in the cyber age on very important aspect that needs to be addressed on architectural point of view is the security. As far as the security in SDWSN is concerned it is still a very open area and is yet to receive attention. Almost all of the work in SDWSN is still based on the architectural framework due to the formative years of this field.

VI. FUTURE SCOPE

Looking at the drastic improvements and changes in today's network computing as well as the achievements in this domain, it is most certain that in the future more sophisticated but easy to use and manage technologies will be obtained. Certain level of attention needs to be drawn towards the SDN/Open Flow northbound and southbound interfaces as these parts of the framework are of empirical means to the overall technological approach. This paper suggests that these interfaces still need to be further explored for efficient network understanding as well as resource optimization. In terms of future the following research opportunities can be considered:-

1) SDN controller virtualization for multi-controller sensor clusters

2) Enhanced global network experience: Improvements on northbound interface communication

3) Southbound interface optimization for efficient device access and controller communication and

4) SDN strategies for runtime and computational overhead in sensor clusters.

CONCLUSION

This paper reviewed the current state of the art application of SDN in WSNs, the SDWSN. The SDWSN falls within the broader context of the Internet of Things This exercise was also to locate the purpose and role of SDWSN within the IoT space. The IoT paradigm seeks to create a networking environment for all devices expected to partake. Most of the devices will be equipped with sensors and actuators. Data from these devices will be carried by various networks such as enterprise, mobile wireless and optical networks. Various computing platforms such as cloud, fog, mobile cloud and mobile edge computing will feature prominently for service provisions.

The SDWSN model is very challenging, as it comprises of 2 models (SDN and WSN) which are still entangled in their own complexities. The WSN networks are resource constrained, therefore restricting all research efforts to be energy conscious. In spite of several efforts, this is yet to be fully realized and reach its optimal efficacy. The introduction of SDN in WSN presents a new and progressive step in leveraging the challenges of resources in WSN. Likewise SDN model brings along its own challenges namely the trade-off between functionalities that need to be retained on the sensor device and the blow on common network factors like latency, congestion, etc. As per the study most of the architectures proposed for SDWSN are still in the development stage. The prevalence of the Open Flow protocol in SDN applications seems to have inspired the SDWSN model. Even though there are still many challenges in this model, great efforts have been made. On the other hand, the lack of standardization in SDWSN is still a concern and hence standards have to be developed to create an oversight for compatibility and sustainability.

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