Journal of Engineering and Applied Sciences 13 (Special Issue 8): 6390-6394, 2018
ISSN: 1816-949X

Web Services Based on Software-Defined Sensor Network

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Abstract: This research proposes a generic architecture for a software-defined network for environment Sensor Network (SN) to coordinate the data collection, processing and transmission using Software-Defined Networks (SDN) techniques. These networks enabling of serving huge number of clients using less number of hardware sensing equipment to reduce the cost of services. In the current research the data is collected from different data sensors using microcontroller (Arduino cards) acts as a base station. A number of subroutines are written to control the data collected using embedded AD cards to control the sampling rate, accuracy and achieving the data. The architecture used to control and serve the data of multiple networks of services based on splitting of data and control planes. This process reduces drastically the cost of services, so, it is expected to increase the number of services customers.

Key words: Architecture, coordinate, equipment, Arduino cards, sampling rate, data

INTRODUCTION

In the last few years there is a new trends towards sensor networks and SDN due to the great evolution of the sensors and the spread of computer usage in different life activities. Sensor networks comprised of small sensors fit for checking physical and natural factors, for example, dampness, seismic, movements, vibrations, temperature and so, on. The sensor devices are intelligent, cheap and small due to the extraordinary change and improvement in Micro Electrical Mechanical Systems (MEMS).

A vast number of sensor nodes are composing sensor networks. A SN cannot just collect data from the environment but can provide reactions for the environment to do some complex applications and thus, the SN is possibly important for applications in many different domains, including therapeutic care, industry, protect the environment, military and transportation (Zhou *et al*., 2016).

The limitations of sensor resources like capability of communication, memory, processing and energy are the primary weakness of sensor networks. The smart software management of sensor resources may overcome that weakness (De-Gante *et al*., 2014).

The development of SDN is a great invention that empowers the network data-path by replacing hardware components by software control. The simple deployment of new programs, visualization of network, management and protocols is allowed by separation the control plane from the data plane hardware (Nunes *et al*., 2014). SDN allows network administrators to manage network services through the abstraction of lower level functionality. This is done by decoupling the control plane from data plane by letting the controller of the interconnection devices make forwarding decisions. In SNs, the main provided functions can be done using more cooperation between the base station and other nodes in the SDN can achieve a higher potential (Feng *et al*., 2016).

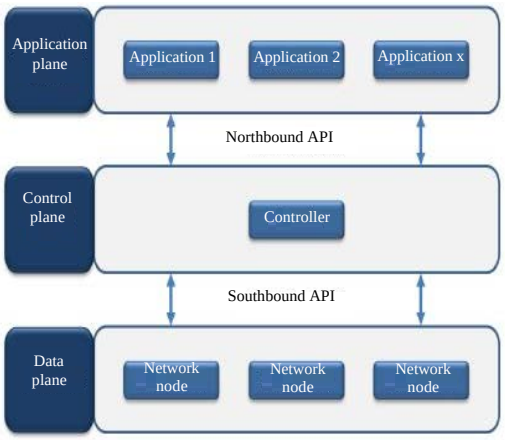

Fig. 1: The three planes and a central controller of the basic SDN framework

The framework parts of the SDN are comprised mainly of three layers as shown in Fig. 1. Different applications are connected to the SDN using the northbound layers. The application plane is the first part.

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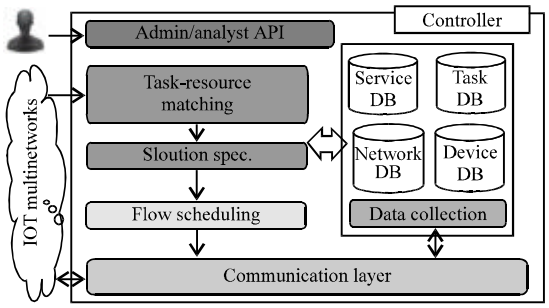

Fig. 2: IoT controller architecture

It contains different network applications. The control plane is the second part that comprises mainly the software of the control plane.

The data plane is the third part that houses the devices of the network. The northbound interface is the API that is used to do the control plane communications with the application plane while the communication between the control and the data plane is defined by the southbound API (Kobo *et al*., 2017).

Litereture review: The integration of NS and SDN is very attractive field of research because it is a new trend in IOT and there is not wide available in the literatures. Here we will address some of them:

Qin *et al*. (2014) implemented a software defined approach in the environment of Internet of Things (IoT). This approach was meant to provide preset service grades for different IoT tasks in a heterogeneous environment. Further, the SDN controller as shown in Fig. 2 was built based on a reactive middleware, i.e., the Multi network Information Architecture (MINA) that realized a close loop of "observation, analysis and adaptation". The SDN controller can schedule different flows based on different task grades and heterogeneous Ad hoc paths and improve the utilization of the service resources in IoT based on a modified intelligent algorithm. The relevant prototype system had been applied in automatic driving, smart grids and electronic tolls.

De-Gante *et al*. (2014) designed a general framework of the Software Defined Wireless Sensor Networks (SDWSN) for intelligent system management in WSN in this work, the SDN controller was implemented in the base station. Further, De-Gante *et al*. (2014) discussed some important issues to be handled in the future including the synchronization of the network states, the necessity of the distributed controller, the security of the central controller and the applicability of open flow.

A TinyOS-based SDN framework that enabled multiple controllers for WSN, i.e., TinySDN was presented in this research to synchronize the network events. The framework was composed of two main components: the SDN controller node and where the control plane was programmed and the SDN-enabled sensor node and which included an SDN switch and an SDN end device. The TinySDN was developed and implemented to be hardware independent. Simulation experiments were conducted on the COOJA simulator and the results concerning the memory footprint and delay were given (Zhou *et al*., 2016).

MATERIALS AND METHODS

The proposed system architecture: Sensor network environment consist of an array of sensor nodes and a communications system which allows their data to reach a server as shown in Fig. 3. The sensor nodes gather data autonomously and a data network is usually used to pass data to base stations which save it to a central database designed, especially for this purpose. Some systems send commands to the nodes in order to fetch the data while others allow the nodes to send data out autonomously.

The southbound API represents the microcontroller that sensors can be connected to it. The microcontroller programmed by API interface called IDE (Integrated Development Environment) to fetch data from sensors according to specific commands sent to it by the administrator.

The preprocessing represents the application that performs some processing and controlling of data coming from the microcontroller, like data filters and handling the outliers data and saving the correct data to the central database. This module is also controlling the sensor node on/off mode, set the delay time to pull data from the nodes and setting the accuracy threshold.

The control plane is the web service application module which resides on server that prepares the data to the clients and it has two sub modules. The first and sub module is used for processing data sections of both client's data and system data that saved in the database. Based on the client's information registered in the system, the relevant data is retrieved from the database and prepares it to be sent to the desired client by the second phase (services).

The second and sub module is the web services that serve multiple web sites or web applications from different platforms. At this level the data can be visualized, analyzed and published via the web (internet or intranet) to give users seamless access to information. This generate uniform file that be read by most of platforms it represents a list array that carry the final data to its final destination.

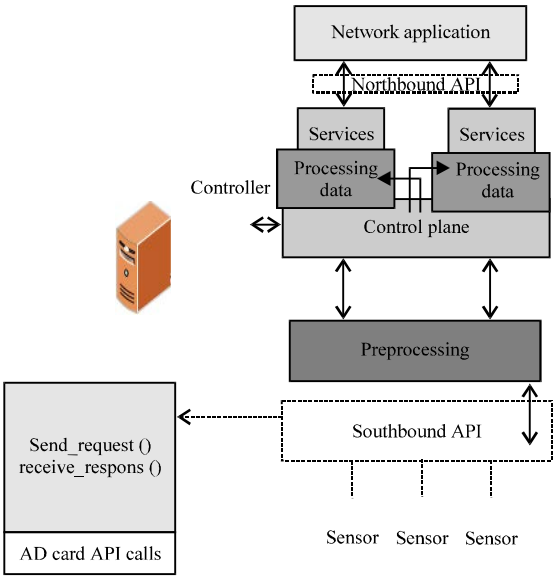

Fig. 3: Proposed architecture

The other function of this part is to manage the registration process, login and information editing of the clients that generate the user profile and some of roles to configure sensor nodes to respond to the client needs.

In the top of hierarchy is the network application. It is websites, applications or mobile applications that contain functions to fetch the collected and stored sensing data from the web services via. Northbound APIs. The function carries the clients emails and passwords that registered in the system to make login and check the configuration file of that client to see what information needed. Then gives back the clients the data to preview using his specific system or application. Moving up the hierarchy from sensor nodes through the controller the systems generally increase in computational power, data storage and power availability.

Main functions of the system: Sensor nodes are configured and managed by the application that stored in the base station that sends parameters to the microcontroller like turn on or off the sensor, baud rate, delay time to rereading data by nodes and even the address of the microcontroller that manage the data accusation process. Figure 4 shows the main idea.

When the user starting the system by clicking connect button to connect the application to the microcontroller to set active link between the server and the base station then the base station will be ready to send and receive data from and to the server. The start button sending the packets carrying arguments to the

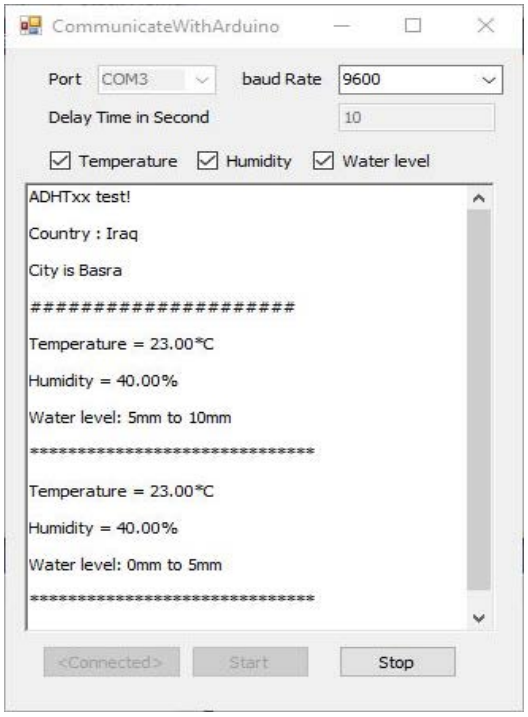

Fig. 4: The main application form

microcontroller and will be ready to receiving the sensing data. The response that received will carry the location of the sensors (country and city), temperature, humidity and the level of the water. Before viewing information in the user page the response data will be filtered and preprocessed to remove noisy data and extracting correct data and ensuring that sensing information is actual and correct to be prepared for the next step. The data is sent to the central database to be saved. Therefore, the web services can access data and present it to the desired users according to the access rights stored in the database; each client has special access rights granted at registration time.

RESULTS AND DISCUSSION

Test cases: The data captured by network sensors can be retrieved from the system database, such as sensor value, sensor type, country, city and so on. Information can be accessed through software functions implemented for this purpose (by controller and request). The information organized in database records with size of nine columns. Where the (id) column is store each row with unique identifier. And (value) column is the sensor value that fetched from an environment. The column (country and city) carry the location of the sensor. Where the (flag) refer to the sensor type such as temperature or humidity

id	value	country	city	flag	timeOfSens	dayOfSens	note
1095	23.00	Iraq	Najaf	Temperature	01:23 AM	08/07/2017	nothing
1096	17.00	Iraq	Najaf	Humidity	01:23 AM	08/07/2017	nothing
1097	5mm - 10mm	Iraq	Najaf	Water level	01:23 AM	08/07/2017	nothing
1098	23.00	Iraq	Najaf	Temperature	04:23 AM	08/07/2017	nothing
1099	17.00	Iraq	Najaf	Humidity	04:23 AM	08/07/2017	nothing
1100	5mm - 10mm	Iraq	Najaf	Water level	04:23 AM	08/07/2017	nothing
1116	21.00	Iraq	Najaf	Temperature	10:49 AM	08/07/2017	nothing
1117	20.00	Iraq	Najaf	Humidity	10:49 AM	08/07/2017	nothing
1118	10mm - 15mm	Iraq	Najaf	Water level	10:49 AM	08/07/2017	nothing
1119	21.00	Iraq	Basra	Temperature	10:51 PM	08/07/2017	nothing
1120	20.00	Iraq	Basra	Humidity	10:51 PM	08/07/2017	nothing
1121	10mm - 15mm	Iraq	Basra	Water level	10:51 PM	08/07/2017	nothing
1122	21.00	Iraq	Basra	Temperature	01:51 PM	08/07/2017	nothing
1123	20.00	Iraq	Basra	Humidity	01:51 PM	08/07/2017	nothing
1124	10mm - 15mm	Iraq	Basra	Water level	01:51 PM	08/07/2017	nothing
1125	21.00	Iraq	Basra	Temperature	04:51 PM	08/07/2017	nothing
1126	36.00	Iraq	Basra	Humidity	04:51 PM	08/07/2017	nothing
1127	10mm - 15mm	Iraq	Basra	Water level	04:51 PM	08/07/2017	nothing

Fig. 5: Sample of sensors data stored in the DB

and so on. Moreover, timeOfSens and dayOfSens is the day and time that the information was sensed and stored. Figure 5 Sample of sensors data stored in the DB. Then the retrieved information is used by the control plane of the SDN to transfer it to the clients.

System data analysis: The system data stored in the DB represents very rich storage of environment profile data for the current system agents and the other interested users like environment or climate researchers. The data is ready to be studied and analyzed in different data format like curves, bar charts and pie charts to simplify its perceive for most types of users.

CONCLUSION

The research integrates the SDN and SN to reduce the cost of services by reducing the equipment required to operate the network. The research leads to reduce the energy consumed by the equipment by running components only when needed and this procedure leads to reduce the whole system operation cost and preserve environment. The number of virtual users is expected to be increased due to the reduction of system and running cost. The accuracy of the system output has increased through the use of the computer in the process of data acquisition and analysis. Data storage is done in the central database, making it available for further analysis by the beneficiaries for research and development purposes and archived for indefinite periods.

SUGGESTIONS

For future research, we propose dealing with the huge data and the possibility of extracting information from them as well as the process of predicting the future weather of temperatures and humidity and also the possibility of rain.

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