Turkish Journal of Computer and Mathematics Education
DOI: https://doi.org/10.17762/turcomat.v9i3.13902 *Vol.09 No.03 (2018), 1123-1129*

Research Article

Energy-Aware, Self-Contained Nodes for Distributed, Interoperable, and Cross-Domain Internet of Things

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Abstract: Numerous vertical platforms are emerging as the backbone of the Internet of Things; these platforms are tailored to a particular use case and typically adopt their own communications, device, and resource management protocols. A unified and secure sharing and access to sensing/actuating resources is made possible via interoperability across IoT platforms, which is becoming more important as the need for cross-domain IoT applications and services grows. This position paper discusses where the Internet of Things (IoT) is at the moment, what potential exist for its sustainable expansion, and what obstacles must be overcome. The goals and vision of the H2020 symbIoTe project are outlined in this context; symbIoTe seeks to facilitate interoperability between IoT platforms by providing a malleable interoperability framework that permits i) cooperation between vertical IoT platforms, ii) the formation of IoT-platform federations for resource sharing, and iii) the development of innovative cross-domain applications by independent developers.

Keywords: IoT; interoperability; federation; business models; resource virtualization; middleware

Introduction

Wireless communication networks and systems will likely always rely on IEEE.802.15.4-based protocols owing to their superior endurance in both the present and the future. Nodes in a Wireless Sensor Network (WSN) with transceiver capabilities (like ZigBee) are cheap, compact, and well-suited for short-range communication. There have been reports of successful implementations of WSNs with terminal nodes setup for wireless communication with a coordinator (often in the form of a mesh topology). All data from the nodes is sent via the IoT gateway, making them well suited for use in the developing Internet of Things. The use of transceiver networks is predicted to increase the breadth of many monitoring applications, including those in healthcare and the environment. Wi-Fi networks enable easy connection to the internet, allowing for the remote monitoring and management of IoT devices in the home. The Internet of Things is able to coexist with current technologies because to its use of a variety of internet-based tools, including sensor networks, the cloud, data modelling, communication, etc. IoT is the next step in the Internet-related environment, and its implementation may be tailored to meet the needs of the sector without disrupting the computer industry. As more and more things become capable of being linked intelligently and economically with little human involvement and also functioning as a group, IoT has gained traction in both the academic and industrial worlds. Collecting and handling massive amounts of data from a rapidly expanding network of devices and sensors is at the heart of the Internet of Things. Under normal circumstances, nodes in the Internet of Things may exchange data with one another through a centralised gateway. Everything in the real world is also digital, with its own unique identity, capabilities to perceive its surroundings, and the ability to exchange data with other like objects. However, new vulnerabilities and dangers continue to grow in IoT, making security and privacy protection crucial problems for consumers when embracing this form of network.

Communication among nodes

In this study, separate nodes perform environmental sensing and relay the data to a central processing unit through wired or wireless connections. A driver circuit, which in turn receives instructions from the CPU, controls the device in question. As shown in Figure 1, all of the devices in an IoT setup are wirelessly linked to one another and exchange data using Internet Protocol version 4 (or 6) (IPv4 or IPv6).

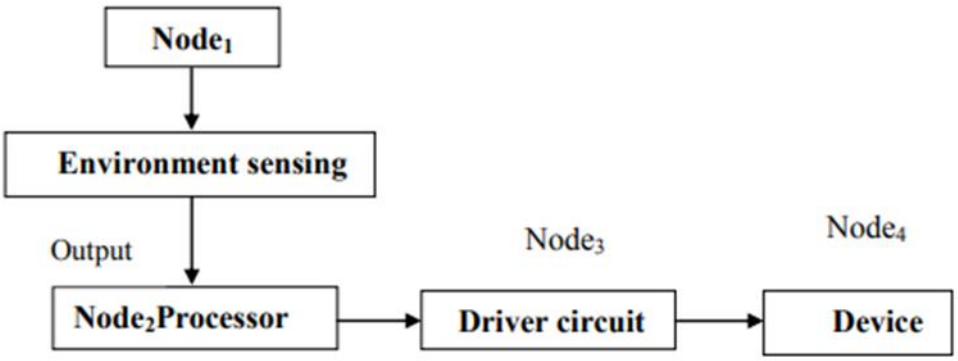

Figure 1. Block diagram of communication between two nodes

Wi-Fi, the most popular kind of wireless technology, is increasingly available in public places including cafes, bookstores, hospitals, and shopping centres. It offers low-cost or no-cost internet access to anyone using Wi-Fi-enabled gadgets like laptops and mobile phones. Figure 2 depicts Hotspot-based network connectivity between nodes. Wi-Fi-based hotspots allow for an arbitrary number of wireless nodes to participate in the Internet of Things.

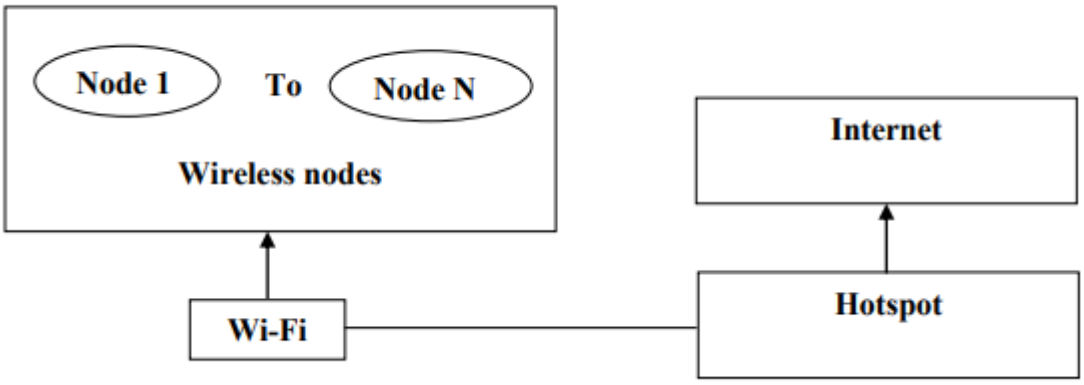

Figure 2 Hotspot based Communication between nodes

Indoor environments for ZigBee nodes may be challenging for a number of reasons, including physical blockage (such as walls or windows), changing building designs, inadequate shielding from signal interferences, and incompatibilities with other communication technologies. This issue may be remedied by establishing bidirectional acknowledgment between ZigBee nodes inside a confined indoor environment during the transmission of a message signal.

Finding a reliable method for data to be sent between Wi-Fi-enabled IoT nodes is difficult. Using the proprietary Network Simulator Netwinz Tool and the third-party vendor tool OPNET, we evaluate a wide range of Wireless LAN performance measures. The OPNET simulator is used to examine how Wi-Fi implementations of wireless nodes add to the notion of a self-powered, energy-aware Internet of Things and enable self-communication via a mailbox/message concept not dissimilar from intertask communication. In this study, many real-time applications, including smart irrigation, air pollution monitoring, personal parking slot management, and weather information reporting, are implemented. Each of these programmes relies on cloud storage and the

Internet of Things. Automatically detecting empty parking spots is made possible with the use of a personal parking management tool.

In this setup, sensors in each parking space can tell you whether or not it is currently occupied. A local microcontroller collects all of this data and sends it to a server through the internet. There are ultrasonic sensors installed in each parking space that can identify the presence of a car. At regular intervals, the sensors are scanned and the database is updated with the current status of each parking spot. The parking spot's physical entity and its virtual counterpart are both updated in the domain model. In this case, a Raspberry-pi embedded system is used, and it is equipped with ultrasonic sensors and weather monitoring equipment. The online services and open-source applications necessary for data transfer are included in the domain model. The primary goal of the weather reporting system is to gather data on local environmental factors including temperature, pressure, light, and humidity from a wide variety of end nodes. Twitter posts update followers on the local weather as it happens.

Each terminal unit incorporates a Raspberry Pi minicomputer and sensors for temperature, pressure, light, and humidity. The system is made up of several nodes spread out throughout a region for comprehensive climate analysis. Sensors (for things like temperature, pressure, light, and humidity) are built into the terminal nodes. Data collected by the end nodes is uploaded to a cloud-based database. By monitoring soil moisture levels using IoT devices, smart irrigation systems only allow water to flow through irrigation pipes when the soil has reached a certain level of wetness. The cloud also collects data on moisture levels, which is then analysed to determine when watering should occur. Soil moisture in a field may be tracked thanks to the system's various nodes, each of which is strategically positioned throughout the plot. Data is sent from the end nodes to a cloud database for storage. Gaseous sensors in an Internet of Things (IoT) based air pollution monitoring system can track the release of dangerous gases from industrial facilities and vehicles. Multiple nodes in various places form a network that can detect and report on changes in air quality. CO Sensors are installed at the terminal nodes. Data is sent from the end nodes to a cloud database for storage. The data is seen through a web-based service.

Literature Review

Soyoung Hwang and Donghui Yu (2012) developed a ZigBee-based remote monitoring and control system, and put it into action. The system was created with a private network in mind. Web services and a smartphone are utilised to keep an eye on and manage the house. They've used JMF, a Java API extension, to provide remote monitoring in real time. Control is sent wirelessly through ZigBee networks. The client software seen in modern smartphones is likewise built using android. That way, customers can keep tabs on their home and send lighting orders straight from their computer or smartphone.

Yepeng Ni et al. (2013) Describes how the gateway's hardware and software were developed and deployed. The issue produced by the disparity in transmission speeds between the ZigBee protocol and the Wi-Fi protocol is addressed and resolved by the introduction of a technique for converting between the two protocols' data formats. The gateway's functionality is then evaluated, and tests reveal that the WiFi-ZigBee gateway meets all requirements for a smart home.

Sathya Narayanan and Gayathri (2013) proposes a smart home automation system (IHAM), built on a PIC microcontroller, ZigBee technology, a cellular data network, and voice recognition software for simple appliance management. This technique employs low-power RF ZigBee wireless modules for voice-controlled automation. The HM2007 microprocessor allows for complete voice control of the lighting and electronics in a building.

Mrunalini P Moon (2014)suggests forward node selection algorithms and self-pruning algorithms for ZigBee networks, which use a hierarchical addressing scheme. It requires knowledge of neighbours just one hop away, and some knowledge about neighbours two hops away is deduced without any data being sent between

neighbours. ZigBee's node selection algorithm selects the smallest possible set of rebroadcast nodes and transmits them.

Thomas Zachariah (2015) have suggested a software programme that runs on smartphones to act as an IoT gateway for all IoT devices that use Bluetooth Low Energy (BLE) to communicate with the Internet. This method is utilised as an alternative to the limited, use-case wireless gateway that is slowing down the expansion of IoT networks. The smart phone is used as a BLE proxy to transport profile data from the IoT device to the cloud and as an IPv6 router for less resource-constrained endpoints so that the IoT devices may act as IP-connected hosts. Because gateways often perform all three functions—in-network processing, network connection, and user interface—they contribute to the IoT gateway challenge. They believe that if these roles were separated, IoT device connection would increase. They have developed a design for IoT connectivity that takes use of the widespread availability of Bluetooth Low Energy radios. A global rollout of IoT gateways has the potential to similarly transform particular application-agnostic connection, much as Wi-Fi access points did for laptop convenience.

Integrating IoT and Cloud Services – Real Time Applications

ZigBee modules are in-built answers that link devices wirelessly at their endpoints. These modules rely on the speedy point-to-multipoint or peer-to-peer networking provided by the IEEE 802.15.4 protocol. A logic-level asynchronous serial port is used as the connection between a host device and the ZigBee/ZigBee-PRO OEM RF Modules. The module's serial port is compatible with Max-Stream's RS-232 and USB interface boards as well as any other logic and voltage compatible UART or level converter. As can be seen in Figure 3, the RF module's pins may be connected directly to devices with a UART interface.

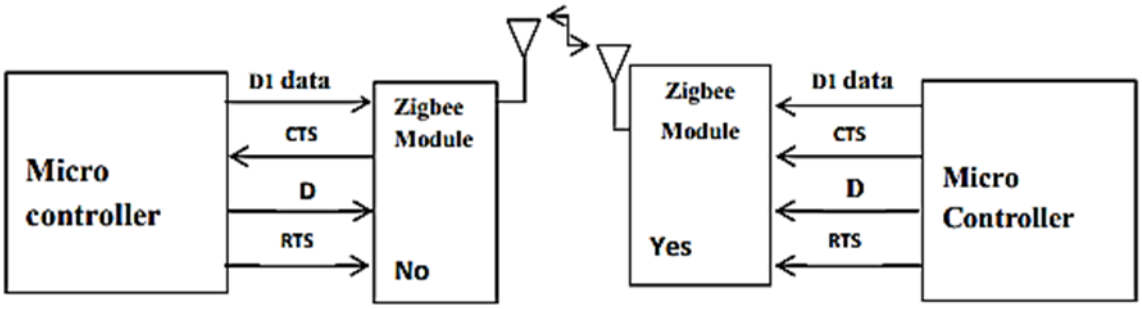

Figure.3 ZigBee communication

Cisco and other pioneers in the field came together to create the Hotspot 2.0 Task group inside the Wi-Fi Alliance. The primary purpose was to establish universal standards that would enhance the hotspot experience for subscribers and facilitate service providers' commercial goals. Improved Wi-Fi for travelling users is the current focus of the research community's efforts. Using the IEEE 802.11u protocol, a mobile device may establish a connection with a Wi-Fi AP and learn about the network's capabilities. Hotspot 2.0 is made possible by the employment of two protocols, 802.11u's GAS (generic advertising service) and ANQP (access network query protocol), which operate atop the base 802.11 protocol.When a user's HS2.0 mobile device is in range of a Hotspot 2.0 AP, it will initiate communication with the AP to discover its capabilities. The GAS service uses ANQP packets for this purpose, transporting them at layer 2.By exchanging ANQP packets, mobile devices immediately learn an access point's capabilities.

Experimental Setup

Using OPNET Modeller simulation software, this study evaluates the system performance of the proposed WLAN hotspot network architecture. Software for building a virtual network and analysing its networking parameters using the OPNETTM Riverbed Academic version. The OPNET programme simulates networks visually. Both wired and wireless communication network simulations may benefit from its utilisation. The components of the setup for this project are:Important characteristics of five mobile nodes, an HTTP server, a 100 BaseT, and an access point are reported in Table 1.

Nodes	Model	Trajectory	Address
Mobile node 0	Wlan_wkstn_adv	Trajectory_2	Client address: Auto assigned
Mobile node 1	Wlan_wkstn_adv	Trajectory_1	
Mobile node 2	Wlan_wkstn_adv	Trajectory_3	
Mobile node 3	Wlan_wkstn_adv	Trajectory_4	
Mobile node 4	Wlan_wkstn_adv	Trajectory_5	
Access point	Wlan_ethernet_slip4_adv_1_upgrade	----	Server address: Auto assigned
Http server	Ethernet_server	----	

Table 1. Wireless Lan Attributes

The infrastructure components are used in the proposed WLAN system concept, as shown in Figure 4. A Http server's job is to authenticate users and keep tabs on the network as a whole so that services may be provided effectively. Network traffic-generating apps were developed with the help of Application Definitions. Activity-specific profile settings that users consistently apply throughout the course of their sessions. A simulation was run once the model was established, and the results were visualised.

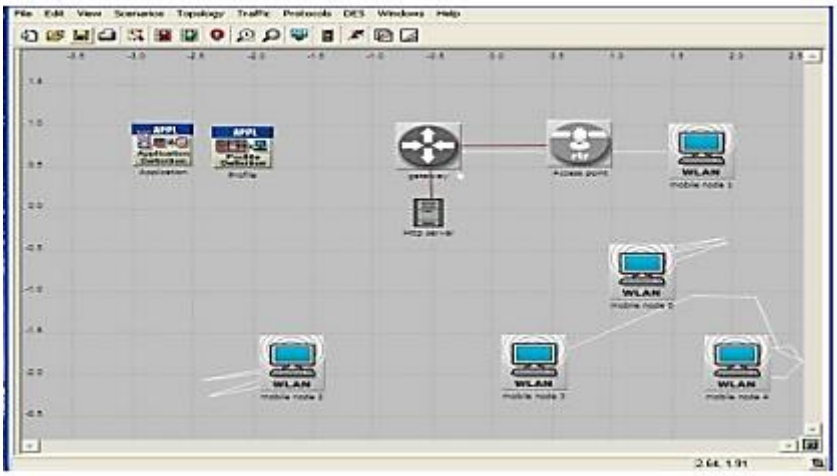

Figure 4 WLAN nodes setup with Server and Access point

Conclusion

In this study, we introduce self-powered, energy-aware nodes that are Internet of Things-based, Wi-Fi-enabled, and capable of interacting independently via a mailbox. In this paper, we explore how a network of intelligent

devices might help save energy by exchanging data with a centralised hub using Internet Protocol addresses. The Internet of Things (IoT) is made up of interconnected electronic devices that may exchange data and interact with their surroundings. IoT-enabled gadgets may manage their own functions with little or no human input, cutting down on wasted effort and time. All the nodes in this configuration talk to one another using IPv6 through wireless connections established by Wi-Fi, ZigBee, and Bluetooth. IPv6's vastly expanded address space is crucial to the expansion of the Internet of Things. Received Signal Strength Indicator (RSSI), signal strength, and Signal to Noise Ratio (SNR) are all indicators of whether or not a Wi-Fi network's coverage is sufficient.

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