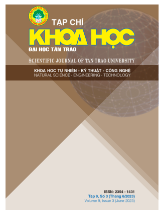
TẠP CHÍ KHOA HỌC ĐẠI HỌC TÂN TRÀO

ISSN: 2354 - 1431

http://tckh.daihoctantrao.edu.vn/



SOME INFRASTRUCTURE PROCESSES IN THE INTERNET OF THINGS

Do Thi Loan

TNU – University of Information and Communication Technology

Email address: dtloan@ictu.edu.vn

DOI: 10.51453/2354-1431/2023/961

Article info

Received:22/12/2022

Revised: 15/03/2023

Accepted: 16/5/2023

Keywords:

Internet of Things, Infrastructure Protocol, RPL, 6LowPAN, IEEE 802.15.4, BLE, EPCglobal, LTE-A, Z-Wave, Thread.

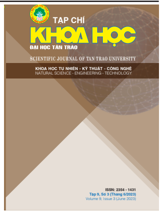
Abstract:

Internet of Things or IoT refers to billions of physical devices worldwide that are now connected to the internet, collecting and sharing data. Everything becomes more proactive and intelligent thanks to the internal processor and the wireless network. To be able to switch, route, handle multi-services, collect thousands of feature data, and so on, a protocol, language, and pathway are needed to create interconnected networks. This article will introduce some popular infrastructure protocols used in IoT networks standardized by international organizations: World Wide Web Consortium (W3C), Internet Engineering Task Force (IETF), EPCglobal, Institute of Electrical and Electronics Engineers (IEEE) and European Telecommunications Standards Institute (ETSI).

TẠP CHÍ KHOA HỌC ĐẠI HỌC TÂN TRÀO

ISSN: 2354 - 1431

http://tckh.daihoctantrao.edu.vn/



MỘT SỐ GIAO THỨC HẠ TẦNG TRONG INTERNET VẠN VẬT

Đỗ Thị Loan

Trường Đại học Công nghệ Thông tin và Truyền thông, Đại học Thái Nguyên

Địa chỉ email: dtloan@ictu.edu.vn

DOI: 10.51453/2354-1431/2023/961

Thông tin bài viết

Ngày nhận bài: 22/12/2022

Ngày sửa bài:15/03/2023

Ngày duyệt đăng: 16/5/2023

Từ khóa:

Internet of Things, Giao thức hạ tầng, RPL, 6LowPAN, IEEE 802.15.4, BLE, EPCglobal, LTE-A, Z-Wave, Thread.

Tóm tắt

Internet of Things (IoT) đề cập đến hàng tỷ thiết bị vật lý trên khắp thế giới hiện được kết nối với internet, thu thập và chia sẻ dữ liệu. Nhờ bộ xử lý bên trong cùng mạng không dây, mọi thứ trở nên chủ động và thông minh hơn. Để có thể chuyển mạch, định tuyến, xử lý đa dịch vụ, và thu thập hàng ngàn dữ liệu đặc trưng, v.v, cần có một giao thức, ngôn ngữ, con đường để tạo nên các hệ thống mạng kết nối với nhau. Bài viết này sẽ giới thiệu về một số giao thức hạ tầng phổ biến sử dụng trong mạng lưới kết nối vạn vật IoT được chuẩn hóa bởi các tổ chức quốc tế: World Wide Web Consortium (W3C), Internet Engineering Task Force (IETF), EPCglobal, Institute of Electrical and Electronics Engineers (IEEE) và European Telecommunications Standards Institute (ETSI).

1. Introduction

When talking about the Internet of Things, the essential characteristic that makes it up is communication and interaction among sensors, devices, gateways, servers, and user applications. However, what allows all these intelligent things to communicate is IoT protocols, which can be seen as the language that IoT devices use to communicate.

Infrastructure protocols in IoT will provide continuous data exchange in networks. They will choose the best path for packages, provide processes to share routing information, and allow communication with other routing (the route from this network to another network) to update and maintain the routing table. To provide an overview, the article will survey some popular protocols that have been standardized by international organizations: the World Wide Web Consortium (W3C), the Internet Engineering Task Force (IETF), EPCglobal, the Institute of Electrical and Electronics Engineers (IEEE), and the European Telecommunications Standards Institute (ETSI).

The introduced Infrastructure protocols include: the Routing Protocol for Low Power and Lossy Networks RPL, IPv6 over Low power, Wireless Personal Area Networks 6LowPAN, IEEE 802.15.4, Bluetooth Low Energy (BLE), EPCglobal, Cellular Mobile Network, Z-Wave, and Thread.

2. Routing Protocol for Low Power and Lossy Networks (RPL)

RPL, proposed by the IETF, is a routing protocol for low power networks based on IPV6 for nodes with limited resources [1], [2] RPL was created to support minimal routing requirements by building a strong link structure on link losses. This routing protocol supports simple and complex traffic models such as point-to-point, point-to-multipoint, and multipoint-to-point.

RPL uses a Destination Oriented Directed Acyclic Graph (DODAG) to route. Each node in the DODAG is an awareness of the root nodes, but they have no information about the leaves. Additionally, RPL maintains at least one path for each node to the root directory and a preferred parent to follow the faster path to increase performance.

To maintain the routing link structures and keep routing information updated, RPL uses four types of control messages [3]:

The most important is the DODAG Object (DIO) information object used to maintain the node's current rank, determine each node's distance to the root directory based on specific data, and select the preferred parent node. The DIO message carries information that allows the network node to detect an RPL Instance, learn about its configuration parameters, select parent nodes, and maintain DODAG.

The Destination Advertisement Object (DAO) message is used to send destination information up along the DODAG. In storage mode, the DAO message is selected to be sent unicast from the child node to the parent node. In non-storage mode, the DAO message is sent unicast to the root node.

The DODAG Information Solicitation (DIS) message is used to request a DODAG information object. A network node can use a DIS message to probe neighboring nodes to obtain information about neighboring DODAGs. The DIS message is also used

The operation of the RPL protocol is as follows: First, one or more nodes are configured as root nodes. A mechanism for finding neighboring nodes based on ICMPv6 control messages is used to build the DAG. The DIO carries information about the DODAG, sent from the root node to the child nodes, and is used to build the DODAG. The DIS only broadcasts the presence of a node and requests other nodes to respond with DIO messages. The DAO message is sent from a child node to the parent nodes to advertise its ability to participate in the downlink routing process in the network. Once a node has joined a DODAG, it will have a path to the root node (which may be a default path) to support MP2P (Multipoint-to-Point) traffic from leaf nodes to the root node (upward direction).

3. IPv6 over Low power, Wireless Personal Area Networks (6LoWPAN)

Built by the IETF and designed to IEEE 802.15.4 standards, this technology allows data transmission through IPv6 and IPv4 protocols in low-power wireless networks with point-to-point (P2P) and mesh structures. The standard, which defines the characteristics of 6LoWPAN - RFC4944 - also allows for IoT applications [4]

The 6LoWPAN protocol provides the ability to pack and compress the header of a data packet in the 802.15.4 system. If the wireless device needs to connect to the Internet, this is a worthwhile option. 6LoWPAN was founded with three main tasks: packet splitting and merging, header compression, and link layer forwarding when using multihop.

The initial concept of 6LoWPAN originated from the idea that network protocols can and should be applied even to the smallest devices, hence the low-power devices with limited processing power can participate in IoT systems.

6LoWPAN is designed to send IPv6 packets over IEEE802.15.4 networks and IP extension standards such as TCP, UDP, HTTP, COAP, MQTT, and Websocket, which are standards that provide end-to-end node connectivity, allowing routers to connect networks to IPs.

4. IEEE 802.15.4

This platform was created to define a sub-layer for two physical layers and a medium access control (MAC) layer for low-rate wireless personal area networks (LR-WPANs) [5] Due to its characteristics, such as low power consumption, low data rate, low cost, high transmission reliability, compatibility with different platforms, security, encryption, authentication, and the ability to handle a large number of nodes, it is suitable for IoT, M2M, and WSN applications. IEEE 802.15.4 supports three frequency bands and uses the Direct Sequence Spread Spectrum (DSSS) protocol. Based on the frequency channels used, the physical layer transmits and receives data at three speeds: 250 kbps at 2.4 GHz, 40 kbps at 915 MHz, and 20 kbps at 868 MHz. Higher frequency and wider bandwidth provide high throughput and low latency, while lower frequency provides good sensitivity. To minimize collisions, IEEE 802.15.4 MAC uses the CSMA/CA protocol. The standard topology for IEEE 802.15.4 networks is star, mesh, and cluster-tree. Star topologies contain at least one Full Function Device (FFD) and some Reduced Function Devices (RFDs). The FFDs work as a PAN coordinator and are placed in the center of the network structure to manage and control other nodes. Peer-to-peer topologies contain one PAN coordinator and other nodes communicate with each other within the same network or through intermediate nodes to other networks. A cluster-tree structure is a special case of a peer-to-peer topology and includes a PAN coordinator, a head cluster, and normal nodes. Zigbee Pro and Zigbee remote control (RF4CE) are designed based on the IEEE 802.15.4 protocol platform - an industrial physical communication protocol operating at 2.4 GHz, commonly used in short-range applications with low data transmission but frequent communication, evaluated to be suitable for applications in smart homes or urban/condominium areas. Zigbee/RF4CE has a significant advantage in complex systems requiring conditions such as low power consumption, high security, and the ability to expand the number of nodes.. for example, the requirements of typical M2M and IoT applications. The latest version of Zigbee is 3.0, which highlights the integration of different Zigbee standards into a single standard. For example, TI's Zigbee products and development kits are CC2538SF53RTQT Zigbee System-On-Chip T and CC2538 Zigbee Development Kit.

5. Bluetooth Low Energy (BLE)

BLE or Bluetooth Smart uses low-power radio waves to increase operating time. It has a wide coverage range (about 100m), 10 times that of older versions, while latency is reduced by 15 times [6] BLE has a transmission power ranging from 0.01 mW to 10 mW. With these features, BLE is suitable for IoT applications.

BLE standards are integrated into modern smartphones and applied in vehicle-to-vehicle communication and wireless sensor networks. BLE allows devices to operate in master or slave mode in a star topology. Unless two devices are exchanging data, they will be in sleep mode.

6. EPCglobal

Electronic Product Code (EPC) is a unique identification number stored on an RFID tag used in supply chain management. This architecture is promising for the future of IoT due to its openness, scalability, interactivity, and reliability that go beyond the support of primary IoT requirements such as object ID and discovery services. EPCs are divided into four types: 96-bit, 64-bit (I), 64-bit (II), and 64-bit (III) [7]

The RFID system can be divided into two main parts: a tag and a reader as shown in Figure 6. The tag includes one chip that stores the code and one antenna to communicate with the reader via radio waves. The reader also emits a radio wave at a suitable frequency to identify the object through the tag's reflection.

The EPCglobal network consists of four parts: EPC, Identification System, IDentification, Middleware EPC Middleware, Discovery Services, and EPC Information Services.es.

7. Mạng di động Cellular

For IoT/M2M applications that require long-distance communication or are not limited by geographical distance, choosing a data transmission route through GPRS/3G/LTE/4G/5G mobile networks is a wise choice. Of course, for solution designers, everyone understands that long-distance data transmission will correspondingly consume energy. And the power consumption factor is easy to accept in this problem. Nowadays, devices/endpoints in the industry are all supported with integrated physical communication ports such as RS232, RS485, RS422, or Ethernet. Communication media through mobile networks all support input from Serial or Ethernet ports, so integrating wireless communication solutions is no longer difficult or limited by any objective factor. LTE-A (Long Term Evolution-Advanced) consists of a set of communication protocols for mobile networks that are well suited for Machine-Type Communications (MTC) and special IoT infrastructure such as smart cities. Moreover, it is a solution for mobile systems with service cost assurance and scalability. At the physical layer, LTE-A uses Orthogonal Frequency Division Multiple Access (OFDMA) for frequency division multiple access, so the bandwidth is divided into smaller bands called Physical Resource Blocks (PRBs). LTE-A also uses Multi-Carrier Spread Spectrum (Component Carrier - CC) technology that allows up to 5 20MHz bands. The architecture of LTE-A is based on two parts: Part 1 is the Core Network (CN), which controls mobile devices and exchanges with IP packets. The remaining part is the Radio Access Network (RAN) that allows processing of wireless communication and radio access. RAN mainly includes Node Base stations (NodeBs) connected to each other via the X2 interface. RAN and CN are connected via the S1 interface. Mobile devices or MTC can directly connect to NodeBs or through the MTC Gateway (MTCG) port. They can also communicate directly with other MTC devices. However, this protocol also faces challenges such as high network congestion when the number of accessed devices is high, QoS degradation when MTC devices try to access the network through eNB or MTCG. Some studies allow for enhanced eNB selection [8] and analyze the heavy-duty effects of MTC communication with a queuing model as well as eNB selection. Based on the results, when MTC devices are inactive for a long time instead of being active, the throughput of MTC devices will be improved by reducing network contention. The architecture of the EPC consists of an identification and identification system (ID), EPC middleware software, Discovery Services, and EPC Information Services.

8. Z-Wave

Z-Wave is a low-power wireless communication protocol for Home Automation Networks (HAN) [9] The Z-Wave connectivity standard has the advantages of low power consumption, high openness, and each device is a receiver and transmitter, creating a mesh network link that is extremely stable. The transmission capacity is about 260kbs, which is more than enough for communicating with smart home devices and BMS. The Zwave and Zigbee connectivity standards use the same frequency as WiFi (2.4GHz), but are designed to consume less power, so they can operate with mobile batteries. Sensors using Zigbee technology can be completely wireless with built-in batteries.

Z-Wave operates at a lower frequency than WiFi and Zigbee. The Z-Wave frequency ranges from 900Mhz, depending on regulations in each region. The range of each receiving and transmitting device is up to 50 meters (outdoors), making it easy and stable to connect all devices in the house. The Z-wave MAC layer has collision avoidance mechanisms and reliable transmission through optional ACK messages.

9. Thread

Thread is a new IP-based protocol, based on the IPv6 network platform, designed specifically for automation in buildings and homes. It is not a popular protocol for IoT applications like Zigbee or Bluetooth [10]

Theard Group, the Thread protocol is based on various standards, including IEEE802.15.4, IPv6 and 6LoWPAN, and provides an IP-based solution for IoT applications. Designed to work with Freescale and Silicon Labs chip products (which support the IEÊ802.15.4 standard), especially with high authentication and encryption capabilities for up to 250 nodes. With a simple software upgrade, users can run Theard on existing IEEE802.15.4-supported devices.

10. Kết luận, đánh giá và so sánh các giao thức hạ tầng trong IoT

Trong bài báo cung cấp các giao thức cơ sở hạ tầng nổi bật, cần thiết cho các thiết lập truyền thông cơ bản, cần thiết cho các ứng dụng IoT. Ở đây xem xét một số khóa cạnh hiệu quả và hiệu suất của các tiêu chuẩn này.

Trong nghiên cứu [3] trình bày đánh giá của RPL cho mạng tổn hao công suất thấp bao gồm các nội dung: đặc điểm kỹ thuật, không tương thích với chế độ lưu trữ và không lưu trữ. Một phân tích hiệu suất của RPL được báo cáo trong [11] xác định nhanh chóng thiết lập mạng và giao tiếp sự chậm trễ cũng như hiệu quả của nó trong khi chi phí cao là nhược điểm lớn. Vì vậy kể từ khi định tuyến là yếu tố quan trọng trong cơ sở hạ tầng của IoT và nhiều thông số khác của hệ thống IoT như độ tin cậy, khả năng mở rộng và hiệu suất mạnh mẽ phụ thuộc và công nghệ này, cần có thêm nhiều nghiên cứu nhằm cải thiện và tối ưu hóa các giao thức định tuyến nhằm đáp ứng các nhu cầu của IoT.

Phân tích hiệu năng của 6LoWPAN trong mạng cảm biến không dây [12] sử dụng truyền thông P2P thấy được sự độ trễ trọn vọng sẽ tăng lên khi kích thước ICMP tăng. Một số vấn đề khác cho gatway 6LoWPAN như tỷ lệ mất gói cao, và dễ can thiệp được nghiên cứu trong [13]

Ngoài việc tiêu thị điện năng thấp hơn mà BLE so với IEEE 802.15.4 [14], các nghiên cứu điều tra hiệu suất của của IEEE 802.15.4 so với IEEE 802.11ah (một tiêu chuẩn tiềm năng cho IoT và M2M hiện đang trong giai đoạn phát triển) về băng thông và năng lượng tiêu thụ, kết quả cho thấy IEEE 802.11ah đạt thông lượng tốt hơn IEEE 802.15.4 trong cả 2 trường hợp kênh truyền nhàn rỗi hoặc bận. Mặt khác, IEEE 802.15.4 tiêu thụ năng lượng nhiều hơn IEEE 802.11ah. So với ZigBee, BLE là hiệu quả hơn về tiêu thụ năng lượng và tỷ lệ truyền năng lượng cho mỗi bit truyền

Để giảm các số lượng các va chạm trong giao thức EPC Gen-2 và cải thiện quy trình nhận diện mã thẻ, các nghiên cứu trong [15] đã đề xuất sử dụng kỹ thuật đa truy cập phân chia theo mã (CDMA) thay vì kỹ thuật Dynamic Framed Slotted ALOHA. Đánh giá hiệu suất của các kỹ thuật này được thực hiện trong [16], các nhà nghiên cứu đã sử dụng số truy vấn trung bình và tổng số bit truyền được để yêu cầu xác định tất cả các thẻ trong hệ thống, kết quả cho thấy số lượng dự kiến của các truy vấn để xác định thẻ sử dụng công nghệ CDMA thấp hơn so với giao thức EPC Gen2. Nguyên nhân là công nghệ CDMA làm giảm số lượng các va chạm nên làm giảm các truy vấn. Nhưng khi so sánh sô bit truyền và thời gian cần thiết để xác định tất cả các thẻ trong hệ thống, giao thức EPC Gen-2 cho hiệu năng tốt hơn công nghệ CDMA.

Z-Wave có hiệu năng tốt hơn Zigbee tuy nhiên giá thành thiết kế cao hơn, nó được hưởng lợi từ sự linh hoạt và bảo mật của Zigbee [17]

Bảng 1 cung cấp các thông tin so sánh về Tốc độ truyền thông, Băng thông, Phạm vi hoạt động, Môi trường ứng dụng và Thiết bị sử dụng, và Bảng 2 đưa ra ưu, nhược điểm của 8 giao thức hạ tầng trong mạng IoT.

Table 1. Differences between Infrastructure Protocols in IoT Networks

No.	Protocol	Data Transmission Rate	Bandwidth	Operating Range	Application Environment	Devices Used
1	RPL (Routing Protocol for Low Power and Lossy Networks)	250 Kbps - 1 Mbps	2.4 GHz	Narrow	Sensor networks, smart homes	IoT sensors, wireless sensor networks, remote control devices
2	6LowPAN (IPv6 over Low power, Wireless Personal Area Networks)	250 Kbps - 1 Mbps	2.4 GHz	Narrow	Sensor networks, smart homes	IoT sensors, wireless sensor networks, remote control devices
3	IEEE 802.15.4	250 Kbps - 2 Mbps	2.4 GHz	Narrow	Sensor networks, smart homes	IoT sensors, wireless sensor networks, remote control devices
4	Bluetooth Low Energy (BLE)	125 Kbps - 2 Mbps	2.4 GHz	Narrow	Mobile devices, IoT	Smartphones, smartwatches, wireless keyboards
5	EPCglobal	40 Kbps - 400 Kbps	860-960 MHz	Medium	Supply chain management, manufacturing	Smart cards, card readers
6	Mobile Cellular Network	50 Kbps - 100 Mbps	900/1800 MHz	Wide	Mobile phones, computers	Mobile phones, tablets, 4G modems
7	Z-Wave	9.6 Kbps - 100 Kbps	900 MHz	Medium	Smart homes, security	Smart home controllers, alarm systems
8	Thread	250 Kbps - 2 Mbps	2.4 GHz	Wide	Smart homes, security, IoT	Air conditioners, measuring devices, smart home controllers

Table 2. Comparison of the Pros and Cons of Infrastructure Protocols in IoT Networks

No.	Protocol	Advantages	Disadvantages
1	RPL (Routing Protocol for Low Power and Lossy Networks)	Energy-efficient and low network overhead	Not suitable for IoT networks with wide operating ranges
2	6LowPAN (IPv6 over Low power, Wireless Personal Area Networks)	Supports IPv6 and low power consumption	Low throughput capacity and cannot meet high data transmission requirements
3	IEEE 802.15.4	Low cost and energy-efficient	Low data transmission rate and no security features supported
4	Bluetooth Low Energy (BLE)	Energy-efficient and suitable for mobile devices	Cannot be used in IoT networks with wide operating ranges
5	EPCglobal	Effective product management and tracking	Not suitable for two-way high-speed data transmission requirements in IoT applications
6	Mobile Cellular Network	High data transmission rate and wide operating range	Costs more than other IoT protocols
7	Z-Wave	Energy-efficient and compatible with various devices	Does not support IP addresses and may be interfered by other signals
8	Thread	High flexibility and supports more complex IoT applications	Requires special hardware for implementation and may have difficulties integrating with existing systems

REFERENCES

[1] J. Vasseur et al., "RPL: The IP routing protocol designed for low power and lossy networks," *Internet Protocol for Smart Objects (IPSO) Alliance, San Jose*, CA, USA, 2011.

[2] T. Winter et al., "RPL: IPv6 routing protocol for low-power and lossy networks," *Internet Eng. Task Force (IETF)*, Fremont, CA, USA, Request for Comments: 6550, 2012.

[3] T. Clausen, U. Herberg, and M. Philipp, "A critical evaluation of the IPv6 routing protocol for low power and lossy networks (RPL)," in Proc. *IEEE 7th Int. Conf*. WiMob, 2011, pp. 365–372.

[4] M. R. Palattella et al., "Standardized protocol stack for the Internet of (important) things," *IEEE Commun.* Surveys Tuts., vol. 15, no. 3, pp. 1389–1406, 3rd Quart. 2013.

[5] IEEE Standard for Local and Metropolitan Area Networks—Part 15.4: *Low-Rate Wireless Personal Area Networks (LR-WPANs)*, IEEE Std. 802. 15. 4-2011, 2011.

[6] R. Frank, W. Bronzi, G. Castignani, and T. Engel, "Bluetooth low energy: An alternative technology for VANET applications," *in Proc. 11th Annu. Conf.* WONS, 2014, pp. 104–107.

[7] E. C. Jones and C. A. Chung, RFID and Auto-ID in *Planning and Logistics: A Practical Guide for Military UID Applications*. Boca Raton, FL, USA: CRC Press, 2011.

[8] M. Hasan, E. Hossain, and D. Niyato, "*Random access for machineto-machine communication in LTE-Advanced networks: Issues and approaches*," IEEE Commun. Mag., vol. 51, no. 6, pp. 86–93,Jun. 2013.

[9] C. Gomez and J. Paradells, "*Wireless home automation networks: A survey of architectures and technologies*," IEEE Commun. Mag., vol. 48, no. 6, pp. 92–101, Jun. 2010.

[10] Wojciech Rzepecki, Łukasz Iwanecki, Piotr RybaIEEE 802.15.4, "*Thread Mesh Network – Data Transmission in Harsh Environment*", International Conference on Future Internet of Things and Cloud Workshops (FiCloudW), 6th 2018.

[11] N. Accettura, L. A. Grieco, G. Boggia, and P. Camarda, "*Performance analysis of the RPL routing protocol,*" in Proc. IEEE ICM, 2011, pp. 767–772.

[12] B. Cody-Kenny et al., "*Performance evaluation of the 6LoWPAN protocol on MICAz and TelosB motes*," in Proc. 4th ACM Workshop Perform. Monitoring Meas. Heterogeneous Wireless Wired Netw., 2009, pp. 25–30.

[13] B. Enjian and Z. Xiaokui, "*Performance evaluation of 6LoWPAN gateway used in actual network environment,*" in Proc. ICCECT, 2012, pp. 1036–1039.

[14] M. Siekkinen, M. Hiienkari, J. K. Nurminen, and J. Nieminen, "*How low energy is Bluetooth low energy? Comparative measurements with ZigBee/802.15.4*," in Proc. IEEE WCNCW, 2012, pp. 232–237.

[15] J. Y. Maina, M. H. Mickle, M. R. Lovell, and L. A. Schaefer, "*Application of CDMA for anti-collision and increased read efficiency of multiple RFID tags,*" J. Manuf. Syst., vol. 26, no. 1, pp. 37–43, Jan. 2007.

[16] E. Vahedi, R. K. Ward, and I. F. Blake, "*Performance analysis of RFID protocols: CDMA versus the standard EPC Gen-2*," IEEE Trans. Autom. Sci. Eng., vol. 11, no. 4, pp. 1250–1261, Oct. 2014.

[17] C. Withanage, R. Ashok, C. Yuen, and K. Otto, "*A comparison of the popular home automation technologies,*" in Proc. IEEE ISGT Asia, 2014, pp. 600–605.