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A Survey: Managing Resource Constrained Devices in IoT

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ABSTRACT: WSN comprise of large number of sensor devices which are resource limited. The WSN could integrate with IoT for developing real world smart applications in the future. Managing such a large scale sensor device network is challenging, it is not possible to configure and deploy sensor devices manually. Maintaining massive amount of devices in real time is again challenging, specially the sensor devices. The sensor devices are resource constrained and need special device management entities to monitor and control device functionality remotely. Different web service architecture can be helpful in such scenarios. Choosing one of them depend on the application to be developed. This paper focuses on the different approaches to manage the constrained IoT devices. It mainly aimed at studying solutions involving open source technologies.

KEYWORDS: RESTful web service; WSN; IoT; CoAP; resource constrained devices

I. Introduction

Internet of Things (IoT) became a popular term in recent years. The concept of IoT [1] varies from application to applications. In general IoT consists of the uniquely identifiable physical devices, which are connected via intenet. The devices in IoT can either communicate with each other or can send data to the remote server[2]. A traditional WSN is a wireless sensor network of the sensor devices that can collect sensor data from the environment and send it to the base station for further processing over the data.

WSN is now seen as a key component of the IoT environment yielding a distributed network of intelligent sensor devices. Recent WSN application include sensor nodes deployed in environments near to humans and focused on facilitating applications such as building automation, industrial automation etc. These sensor devices are resource limited in many aspects such as with limited storage and processing capabilities, limited energy in the form of battery which is energy prone, and are connected through low power lossy links, vulnerable radio conditions, no direct human interaction [3].

The future IoT applications would be IP based. Whereas IP is not suitable for the constrained devices [4][5]. However, IP offers interoperability, scalability, ease of programming, has ready to use hardware, eliminates the need of complex gateways and IPv6-based solution is a promising to manage the constrained devices in WSN. With these advantages, IPv6 over low-powered Personal Area Network (6LoWPAN) is standardized [6]. The 6LoWPAN technology comes in picture to support the integration of IoT infrastructure with sensor networks [7]. There are recent works focusing on the use of 6LoWPAN technology for building the IoT applications. By ensuring the interoperability for both WSN and IoT, 6LoWPAN facilitate to use IP and manage the resource-constrained sensor devices efficiently.

The emerging device management standards such as TR-069 [8], ISO/IEC 14543-3 [9] cannot be used directly for constrained IoT devices.

Many device management solutions use specially designed IETF standard constrained application protocol (CoAP) [10]. Device management in IoT, in order to manage the large scale WSNs, should be able to provide a reliable and efficient way to monitor and control sensor devices remotely and it should not consume the significant resources.

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II. Related work

Recent trend in web services (WS) technologies are classified into Big WS and RESTful WS [11]. The Big WS and RESTful WS are similar in principal level but differ in technological level. Thus in general the approaches for managing the constrained devices can be categorized into three parts: Big WS approach, RESTful approach and on top of CoAP approach.

A. *BIG WS APPROACH:*

The Big-WS architectural design style consists of the big Web services technology stack, which may include technologies like SOAP, WSDL, WS-Addressing, WS-Reliable Messaging, WS Security [11] etc. Big WS, also referred as WS-*, provides interoperability features for both the Remote Procedure Call (RPC) and messaging integration styles.

As WSN comprise of huge amount of sensor nodes, it is not feasible to configure and deploy each and every sensor node manually. Use of SOA interface at such nodes increases the capability to provide various services. In [12] authors have used SOAP based WS. Authors have deployed it directly on the nodes instead of using gateways. This approach provides easy integration of sensor nodes with IT system. It supports heterogeneous devices. However, this solution only suitable for applications where the sensor data can be heavily aggregated and transmitted over relatively long periods, for example energy management domain.

In industrial automation introduction of new technologies such as embedded system, Ethernet, zigbee, WIFI, SOAs raises many problems like real time support and QoS requested by the client. In [13] authors described the enhanced service oriented architecture, which is capable of solving both above issues. Authors have used SOAs to solve the problem related to identification, discovery and communication between networked elements and extend the WS-agreement protocol for supporting real-time & QoS aspects for managing the resources in industrial automation domain.

However, both above literatures prefer the WS-* architecture, which may bring extensive overheads for resource-constrained devices.

In [14] authors compared Big WS and RESTful WS architectures based on architectural principals and decisions. With the help of these two competing methods authors argued that RESTful WS can be used for simple and ad-hoc integration scenario over web. And it is advisable to use WS-* WS architecture for professional enterprise application development which requires longer device lifespan and advanced QoS.

B. *RESTFUL WS APPROACH:*

It is important to use the web services in IoT communication for network application in order to grow the industrial applications. Alternative to Big WS solution, RESTful WS architectural design style has been brought forward for developing remote procedure calls over the Web.

REpresentational State Transfer (REST) is architectural design style used to build the large-scale distributed hypermedia applications. Rather it is an abstract form which indicates the scalability feature of HTTP 1.0 [15]. The term REST often used in conjunction with HTTP. The constrained RESTful WS approach provides a simple yet flexible communication stack with some features used to deploy it on the constrained devices. In addition to this using RESTful architecture on devices could not require any special application programming interface thus provides the easy data access of the wireless sensor devices from the server. As it provides the facility to abstract all devices as the resources it is possible to access those resources over the internet with the help of some standard lightweight protocol.

In [16] authors presented a RESTful web service architecture in support to the energy constrained WSNs, which enable the collection of sensor data from sensor devices remotely. For this authors have implemented 6LoWPAN/IPv6/RPL/UDP/CoAP protocol stack over IEEE802.15.4 radio platform. Authors argued that IP-based solution is promising one to IoT development. Authors also suggested that device management and sensor device controlling can be possible using RESTful methods.

In [17] authors have described two ways to integrate the devices to the web using RESTful approach. One of the way proposes direct integration based on technological advancement in embedded devices. Whereas second way isto use a smart gateway for resource limited devices. It is found that RESTful approach facilitate the creation of new prototypes and cyber physical mashups.

However, the embedded devices used in [17] [18] are not IP based which requires a multi-protocol gateway, and protocol translation may increase the overhead on constrained devices including the conversion of different routing logics and mechanisms, offering QoS and the security provided.

Different from above two RESTful approaches, in [19] authors have developed an efficient and lightweight device management framework by extending the CoAP protocol for WSN [20], that does not consume extra resources. Authors have proposed five major device management functions: 1) Registration, 2) Provisioning, 3) Management service, 4) Observing and 5) Application data transmission applicable for WSN [1]. All functions share common resources on one sensor device. These resources are then abstracted as parameters, status and data. The devices can interact with the IoT client by triggering these resources via GET, PUT, POST and DELETE methods [21] of the CoAP protocol. The solution is simple, efficient and promising to drive the IoT development.

The evaluation of CoAP protocol with respect ot RPL [22] and LPL is given in [23], and it is found that RPL gives better performance compared to LPL. In [24] authors implemented the CoAP protocol on contiki operating system to evaluate the duty cycle mechanism to reduce the energy consumption. Contiki is an open source operating system, it is highly portable, designed for embedded devices [25]. Contiki provides many hardware drivers for each supported device thus reduces the development time and provides code portability.

C. *ON TOP OF COAP*

Many other papers have focused on developing the new technology or protocol over the CoAP protocol in order to provide a multi-protocol gateway that in-turn provides the interface for all technologies.

In [26] authors have presented an integration approach of building automation system in the IoT. Authors used an IPv6 enabled service-oriented architecture that allows integration of heterogeneous technologies into a large scaled distributed control system and discussed the IPv6 multi protocol gateway concept. Finally authors have proposed the dedicated application protocol, oBIX, on top of CoAP for mapping the application functions, since CoAP is not capable of providing the flexibility for mapping the application functionality.

In [27] authors have utilized synchronization markup language over CoAP and experiment with different message formats such as Core link format, EXI and protocol buffer, and argued that EXI is easy to implement. In prior work authors have used synchronization markup language and Hypertext Transfer Protocol in OMA-DM. Wheras in [27] authors have used two approaches: one is use of OMA-DM from prior work for device management and use of CoAP protocol efficiently with different message formats. OMA-DM is the open mobile alliance device management protocol which is developed to manage scalability of the large set of mobile devices.

In [28] author have described network management interface for constrained devices by adapting COMI from RESTCONF protocol. This is the working draft of IETF. The Constrained Application Protocol (CoAP) is used for accessing data from the management resources. CoMI use the YANG to CBOR mapping and encodes YANG names to reduce payload size.

All these approaches either build management functionalities on top of CoAP or need to support multiple protocols simultaneously, which may bring extra overhead for resource constrained devices.

III. DISCUSSION

In this paper the various approaches for maintaining the constrained IoT devices based on the use of web service architectural design style are presented. The Internet of Things (IoT) is a revolutionary paradigm and IoT technologies are rapidly developing in the wireless telecommunications platform. WSN offers processing, sensing and peer-to-peer communication platform. Various applications emerge from the integration of IoT with WSN are discussed in [29].

The choice among the WS-* and RESTful approaches is depend on the type of application to be built. RESTful WS approach is simple to implement compare to the implementation of the complex WS-* protocol stack, no need to considering much more further architectural decisions in case of RESTful.

WS-* could be preferred in the scenario where the devices have long lifespan and the service need to support the client requested QoS. Basically WS-* well suited to the professional enterprise application development. The WS-* architectural design style may increase the overhead on constrained devices. So it is not good to use WS-* approach for managing the large scale resource constrained devices [30].

The lightweight RESTful approach as discussed in [19] mapped the CoAP methods to the device management functions. Authors have used the open technologies to tackle the management of resource constrained sensor devices in

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IoT. Authors also have introduced the IPv6 protocol stack using IETF's CoAP at application layer for resource constrained networks.

IV. CONCLUSION

Various solutions for managing the resource limited devices are mentioned in this paper. The solutions are classified according to the web service architectural design style used for device management solutions.

Recently the solutions are focusing on the use of RESTful WS architecture using the open technologies such as the work done to standardize the communication protocol by the Internet Engineering Task Force. The incorporation of CoAP protocol, which is specially designed for resource constrained devices, with the special device management entities on IPv6 sensor nodes facilitate to overcome this issue. The CoAP based device management is found to be a promising solution for IoT application development in future.

However, such solutions lack in the implementation of the security and privacy features as well as real time management is also a challenging issue to be considered.

REFERENCES

1. Ashton, K., "That 'Internet of Things' thing," *RFID J.*, Jul. 2009 [Online]. Available: http://www.rfidjournal.com/articles/view?4986
2. Da Xu, L., He, W. and Li, S., "Internet of things in industries: A survey," IEEE Transactions on Industrial Informatics, vol. 10, no. 4, pp. 2233-2243, 2014.
3. Gungor, V.C. and Hancke, G.P., "Industrial wireless sensor networks: Challenges, design principles, and technical approaches." *IEEE Transactions on Industrial Electronics, vol* 56, no. 10, pp. 4258-4265, 2009.
4. Heer, T., Garcia-Morchon, O., Hummen, R., Keoh, S.L., Kumar, S.S. and Wehrle, K., "Security challenges in the IP-based Internet of Things," Wireless Personal Communications, vol. 61, no. 3, pp. 527-542, 2011.
5. Hennebert, C. and Dos Santos, J., "Security protocols and privacy issues into 6LoWPAN stack: a synthesis," IEEE Internet of Things Journal, vol. 1, no. 5, pp. 384-398, 2014.
6. Hui, J., Culler, D. and Chakrabarti, S., "6LoWPAN: Incorporating IEEE 802.15. 4 into the IP architecture-Internet Protocol for Smart Objects (ipso) alliance, white paper# 3", January 2009.
7. Mulligan, G., "The 6LoWPAN architecture." *Proceedings of the 4th workshop on Embedded networked sensors*. ACM, pp. 78-82, 2007.
8. Rachidi, H. and Karmouch, A., "A framework for self-configuring devices using TR-069," in *Proc. Int. Conf. Multimedia Comput. Syst. (ICMCS)*, pp. 1–6, Apr. 2011.
9. Ruta, M., Scioscia, F., Di Sciascio, E. and Loseto, G., "Semantic-based enhancement of ISO/IEC 14543-3 EIB/KNX standard for building automation," *IEEE Trans. Ind. Informat.*, vol. 7, no. 4, pp. 731–739, Nov. 2011.
10. Shelby, Z., Hartke, K. and Bormann, C., "The constrained application protocol (CoAP)," Tech. Rep., No. RFC 7252. 2014.
11. Fielding, R.T. and Taylor, R.N., "Principled design of the modern Web architecture." ACM Transactions on Internet Technology (TOIT), vol. 2, no. 2, pp. 115-150, 2002.
12. Kyusakov, R., Eliasson, J., Delsing, J., van Deventer, J. and Gustafsson, J., "Integration of wireless sensor and actuator nodes with it infrastructure using service-oriented architecture," IEEE Transactions on industrial informatics, vol. 9, no. 1, pp. 43-51, 2013.
13. Cucinotta, T., Mancina, A., Anastasi, G.F., Lipari, G., Mangeruca, L., Checcozzo, R. and Rusinà, F., "A realtime service-oriented architecture for industrial automation," IEEE Transactions on Industrial Informatics, vol. 5, no. 3, pp. 267-277, 2009.
14. Pautasso, C., Zimmermann, O. and Leymann, F., "Restful web services vs. big'web services: making the right architectural decision." *Proceedings of the 17th international conference on World Wide Web*. ACM, pp. 805-814, 2008.
15. Fielding, R.T., "Architectural styles and the design of network-based software architectures," Doctoral dissertation, University of California, Irvine, 2000.
16. Sheng, Z., Zhu, C. and Leung, V., "Surfing the internet-of-things: lightweight access and control of wireless sensor networks using industrial low power protocols," EAI Endorsed Transactions on Industrial Networks and Intelligent Systems, vol. 14, no. 1, p. e2, 2014.
17. Guinard, D. and Trifa, V., "Towards the Web of Things: Web mashups for embedded devices," in *Proc. Int. World Wide Web Conf. (WWW)*, p. 15, Apr. 2009.
18. Guinard, D., Trifa, V. and Wilde, E., "A resource oriented architecture for the Web of Things," in *Proc. Internet of Things (IoT)*, pp. 1–8, IEEE, Dec. 2010.
19. Sheng, Z., Wang, H., Yin, C., Hu, X., Yang, S. and Leung, V.C., "Lightweight management of resource constrained sensor devices in internet of things," IEEE internet of things journal, vol. 2, no. 5, pp. 402-411, 2015.
20. Schönwälder, J., Tsou, T. and Sarikaya, B., "Protocol profiles for constrained devices," Tech. Rep., Mar. 2011 [Online]. Available: https:// www.iab.org/wp-content/IAB-uploads/2011/03/Schoenwaelder.pdf
21. Karagiannis, V., Chatzimisios, P., Vazquez-Gallego, F. and Alonso-Zarate, J., "A survey on application layer protocols for the Internet of Things," Transaction on IoT and Cloud Computing, vol. 3, no. 1, pp. 11-17, 2015.
22. J Vasseur, J., Agarwal, N., Hui, J., Shelby, Z., Bertrand, P. and Chauvenet, C., "RPL: The IP routing protocol designed for low power and lossy networks," Internet Protocol for Smart Objects (IPSO) Alliance, vol. 36, 2011.
23. Pötsch, T., Kuladinithi, K., Becker, M., Trenkamp, P. and Goerg, C., "Performance evaluation of CoAP using RPL and LPL in TinyOS," in 2012 5th International Conference on New Technologies, Mobility and Security (NTMS), pp. 1-5, IEEE, 2012.

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24. Kovatsch, M., Duquennoy, S. and Dunkels, A., "A low-power CoAP for contiki," in 2011 IEEE Eighth International Conference on Mobile Ad-Hoc and Sensor Systems, pp. 855-860, IEEE, 2011.
25. Sehgal, A., Perelman, V., Kuryla, S. and Schonwalder, J., "Management of resource constrained devices in the internet of things." IEEE Communications Magazine, vol. 50, no. 12, pp. 144-149, 2012.
26. Jung, M., Weidinger, J., Kastner, W. and Olivieri, A., "Building automation and smart cities: An integration approach based on a service-oriented architecture," *Advanced Information Networking and Applications Workshops (WAINA), 2013 27th International Conference on*. pp. 1361-1367, IEEE, 2013.
27. N Gligorić, N., Krčo, S., Drajić, D., Jokić, S. and Jakovljević, B., "M2M device management in LTE networks," in *Proc. 19th Telecommun. Forum (TELFOR)*, pp. 414–417, Nov. 2011.
28. van der Stok, P. and Greevenbosch, B., "CoAP management interfaces (draft-vanderstok-core-comi-04)," IETF [Online]. Available:https://datatracker.ietf.org/doc/draft-vanderstok-core-comi/, 2014.
29. Atzori, L., Iera, A. and Morabito, G., "The internet of things: A survey," Computer networks, vol. 54, no. 15, pp. 2787-2805, 2010. doi:10.1016/j.comnet.2010.05.010
30. Banu, R. and Taranum, A., "Surveillance and sequestration issues of internet of things (SSIoT)," World Scientific News, vol. 41, p. 185, 2016.

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