IETF Smart Object Workshop
Position Paper

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February 11, 2011

Routing Challenges and Directions for Smart Objects in Future Internet of Things

Abstract

The Future Internet of things will consist of smart objects that will form distributed and autonomous peripheral wireless networks near the user end. The distributed nature of smart object networks, also termed ad hoc networks, require novel cooperative effective and efficient protocols for dynamic environment. It is therefore very important to provide a unified flexible framework for Ad hoc smart object communication that will allow adaptive, hybrid routing in order to satisfy Ad hoc networking requirements as proposed by the Cognitive and Adaptive Module (CAM) in [15].

1. Introduction

The Future Internet of Things (IoT) is widely viewed as the interconnection of smart devices including the autonomic machine-to-machine (M2M) networks [3][4][5][6][8][9]. The emergence of smart objects for everyday civil use is already substantial e.g. smart PDAs, smart netbooks and smart sensorized environments. As indicated in [1], it is important to consider the "tussles" that are attached with such developments in order to engineer the appropriate architecture of the future internet. It is also important to consider the drivers such as novel applications and network paradigms in order to identify proper architectures for future internet[9].

Currently, applications such as email, instant messaging and social networks use the core Internet infrastructure to exchange data. However, with the proliferation of wireless communication enabled smart objects, there is an emerging trend to exchange information pervasively and in a distributed manner among users and devices [3][4][5][9]. Therefore, future Internet applications and services will entail smart objects to be able to communicate using ad hoc networks i.e. in an autonomous and distributed fashion. Such peripheral networks would then be connected to the internet core using IP gateways such as in the case of future emergency services as proposed in the European Union (EU) 7th Framework Programme (FP7) ICT PEACE project [10]. In addition, the autonomy of such wireless networks is important for automated smart machines and networks of future IoT and beyond [11]. In this context, it is essential to consider the routing of

information among such ad hoc networks of smart objects and their integration to the core internet. For instance, PEACE [10] proposes the integration of rescuer ad hoc networks of smart objects to the IP Multimedia Subsystem (IMS). Popular distributed networks include RFID, Sensor, Mesh and Mobile Ad hoc networks that are being widely researched and developed for the IoT especially in the realm of EU FP7 where proposed deployments include smart homes and cities [3][4] [9][10][12]. Within the IETF domain, several working groups (WGs) are chartered for work related to ad hoc networking including core, roll, 6lowpan, autoconf and manet Working Groups (WGs), investigating the various challenges and required protocols.

The mobile flavour of ad hoc networks termed as Mobile Ad-hoc Networks (MANETs), is a collection of smart machines that are able to communicate autonomously without any central infrastructure and should form a pivotal part of future Internet peripheries [13]. The MANET WG is working towards the standardization of appropriate routing algorithms for such networks. Nonetheless, the current proactive and reactive standardization tracks have their limitations. Since constituent mobile MANET smart devices can distinctively or simultaneously act as data source, router or destination for various data connections, the provisioning of routing quality of service (QoS) for applications is a formidable challenge. This challenge is compounded by the fact that the routing algorithm has to be both efficient and effective as described in RFC 2501 [14]. Therefore, a unique optimal routing approach is not achievable for all MANET environments. Instead, the performance of the MANET protocol is subject to the dynamic network state.

We have hence proposed a Cognitive and Adaptive Module (CAM) [15] for hybrid and adaptive routing in MANETs. The module consists of logical components that are pluggable as per the user or designer preference. These components are segmented so that they provide all the essential functionalities required for MANET routing while also allowing designers to use their choice of optimal algorithm. The CAM also has a component for monitoring and adapting to network states so that changes in routing behavior are seamless and interoperable with other MANET protocols that follows RFC 5444 [17]. Thus, the CAM will be able to take advantage of the better features of proposed proactive and reactive mechanisms by MANET WG protocols while rendering these to be adaptive according to the changing network state. Overall, CAM will provide a more flexible framework for routing in MANETs whereby the essential distributed processes, e.g. route discovery and route maintenance, can be carried out in a more dynamic fashion as required by the network set-up.

Furthermore, CAM can provide both self-configuration and user configuration functionalities in order to satisfy the various requirements of users. The components can accommodate different algorithmic for each routing function required for MANETs and thus encouraging the use of both open and proprietary protocols in such Internet peripheral networks thus alleviating

the risk of "tussles of openness" [1]. In addition, the CAM will be extended to include components with interfaces to gather and disseminate cross layer information. Finally, a generic framework for ad hoc networking should be designed as a generalization of CAM. Such a framework will ensure optimized interoperability for smart device communications in future Internet peripheral networks. This will encourage data sharing among different ad hoc networks and their interconnectivity to the core Internet. It is demonstrated in [18] that a hybrid and adaptive approach such as CAM, can improve routing scalability and power efficiency in MANETs.

2. Security Consideration

Ensuring end-to-end communication security is very important and complex in such decentralized networks. There are many situations where the information that is stored on a device should be regarded as private information. For instance, end-users would like to be unlinked form their belongings when outsiders try to establish communication links with them. In order to make the IoT a widely used source of information we need to ensure secure and privacy-aware information provision and communication. We also need techniques to implement access control on a distributed architecture, in order to ensure both: protection of data and free interconnection of objects (eg devices) and access of contents.

CAM will have a security and privacy component where primitives for security set-up will be store. There are special security considerations for MANET routing protocols as described in [2]. It is worth mentioning that smart intrusion detection and prevention mechanisms will enable CAM to recognize different types of malicious entities or actions.

3. Conclusions

The future IoT networks will consist of smart objects where autonomous networking will be essential. It is important to consider an appropriate open-end framework for such communications in order to offer optimized interoperability among ad hoc networks and secure loose or tight coupling with the core Internet. Thus, the introduction of a CAM inspired generic framework would allow adaptivity and hybridization of protocols while maintaining interoperability among different protocols and different types of Ad hoc networks. Furthermore, this will allow interconnection of such devices with the Internet core and provide a means for optimized routing with respect to required QoS guarantees and network constraints. The CAM suite will also include a module for enabling cross-layer data sharing in order to reduce overall communication system overhead in addition to a security and privacy component.

4. References

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