Named Data Networking: A Promising Architecture for the Internet of Things (IoT)

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ABSTRACT

This article describes how the named data networking (NDN) has recently received a lot of attention as a potential information-centric networking (ICN) architecture for the future Internet. The NDN paradigm has a great potential to efficiently address and solve the current seminal IP-based IoT architecture issues and requirements. NDN can be used with different sets of caching algorithms and caching replacement policies. The authors investigate the most suitable combination of these two features to be implemented in an IoT environment. For this purpose, the authors first reviewed the current research and development progress in ICN, then they conduct a qualitative comparative study of the relevant ICN proposals and discuss the suitability of the NDN as a promising architecture for IoT. Finally, they evaluate the performance of NDN in an IoT environment with different caching algorithms and replacement policies. The obtained results show that the consumer-cache caching algorithm used with the Random Replacement (RR) policy significantly improve NDN content validity in an IoT environment.

KEYWORDS
Cache Replacement Policy, Caching Algorithms, Information Centric Networking, Internet of Things, Named Data Networking

1. INTRODUCTION

The Internet of things (IoT) is devised to interconnect an astronomic number of ordinary and everyday objects to the Internet and consequently extends the Internet to our physical world. These devices are usually resource constrained equipment: they have low computational and storage capabilities and are battery powered (Bormann et al., 2014). The number of IoT devices is expected to reach several order of magnitude the number of regular Internet devices. The IoT will therefore interconnect billions and even trillions of heterogeneous, constrained devices (Al-Fuqaha et al., 2015).

Embedding a regular TCP/IP protocol stack on IoT devices is quite problematic and raises several issues. The IP protocol has been the universal glue which interconnects various equipment to the Internet. It was designed in the mid 70’s for nodes having a well-defined, fixed location in the network. This design constant has served as the main communication pillar of the Internet. By knowing the

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exact locations of corresponding peers, nodes can retrieve any information stored within these peers. As such, current node location is a priori knowledge for information retrieval. Furthermore, an IP address has a dual semantic: it is used as a node locator as well as a node identifier. As several use cases require persistent and location-independent identifiers, a second level of indirection has been proposed to handle such identifiers. These identifiers are subsequently mapped to their correspondent IP addresses at rendez-vous proxies/nodes (Home Agents or DNS for example) disseminated throughout the network. Although this host-centric design has survived so far for more than four decades, it has been strongly stated that it cannot meet the requirements of the envisioned IoT (Msadaa and Dhraief, 2016, Al-Fuqaha et al., 2015).

The Internet is experiencing a major shift in its architecture from its classical host-centric model to a novel information-centric paradigm. Internet traffic consists in its majority in content dissemination and retrieval. However, according to the TCP/IP model, the same exact content stored in two different servers is viewed by end-users as two different elements as they are pointed out by two different naming structures (different URIs). This has led Van Jacobson to propose a new vision of the Internet centered on the information/content called Information Centric Networking (ICN) (Jacobson et al., 2009).

In ICN, contents have unique and persistent names. The used namespace (either flat or hierarchical) is completely decoupled from nodes’ topological addresses. In this way, consumers ask for information by its name rather than its address. This paradigm natively includes location-independent naming, in-network caching, name-based routing, multicast, anycast, mobility and self-secured contents.

IoT applications are inherently information-centric as they target sensed data regardless of its source. Furthermore, ICN names can directly deal with the problem of heterogeneous IoT contents and services. For instance, a given room temperature can be acquired from a wide set of devices present in this room (smartphones, cooling system, home monitoring system, etc.). Furthermore, ICN persistent and unique naming structure can be used as a framework to represent the heterogeneous IoT contents and services.

Although ICN attracts manifold researches, it is still in its early stage. Several ICN approaches have been proposed, such as DONA, NDN, NetInf, COMET, CONVERGENCE, Mobility First and PRISP. We refer the reader to (Ahlgren et al., 2012) and (Xylomenos et al., 2014) for comprehensive surveys on ICNs.

Several studies have already pointed out that the ICN approach called Named Data Networking (NDN) has the potential to become a key technology for data dissemination in IoT (Baccelli et al., 2014), (Amadeo, Campolo, Iera & Molinaro, 2014), (Hail, Amadeo, Molinaro & Fischer, 2015), (Amadeo, Campolo, Iera & Molinaro, 2015), (Amadeo, Briante, Campolo, Molinaro & Ruggeri, 2016), (Amadeo, Campolo, Molinaro & Ruggeri, 2014), (Francois, Choléz & Engel, 2013) and (Meddeb et al., 2015). It defines a receiver-driven, pull-based, robust connection-less communication model. These features are beneficial for the IoT systems in terms of easy and scalable data access, energy efficiency, security and mobility support (Amadeo, Campolo & Molinaro, 2014). Besides, NDN being inherently based on named data would be an adequate conveyor to the convergence of Semantic Web and the Internet of Things (Scioscia et al., 2014; Li et al., 2014) towards the so called Semantic Web of Things.

NDN can be used with different caching strategies. A caching strategy is considered as the cornerstone of any ICN architecture, it is composed of a caching algorithm and a cache replacement policy. The caching algorithm decides where data chunk should be saved while the cache replacement policy decides which data chunk should be evicted. This raises the natural question: which is the most appropriate caching strategy to be used with NDN in an IoT environment?

In this paper, we firstly investigate the suitability of adopting the ICN paradigm in an IoT ecosystem. Afterward, we qualitatively compare the most recent ICN approaches and investigate which solution can fully satisfy the IoT requirements. Finally, we evaluate and analyze the performance of several caching algorithms and caching replacement policies used by NDN in an IoT environment.
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