Short Paper: IoT-NDN: An IoT Architecture via Named Data Netwoking (NDN)

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***Abstract*—The Internet of Things (IoT) is gaining importance in everyday life, science, and industry. While current IoT systems can be modeled in IP, future systems with over a billion devices will face great challenges. Data aggregation, naming scalability, and the handling of resource-restrained devices are problems that need to be solved. Named Data Networking (NDN), addresses many issues by using named data. IoT based on NDN (IoT-NDN) is to solve many issues that are mentioned in this work.**

I. Introduction

This short paper is based on [1]. Currently, the Internet Protocol (IP) is used in IoT, but it lacks scalability, robustness, and efficiency. Mobility isn't supported in the location-based IP; protocols are needed for support. Named Data Network (NDN) is data and not location-focused; it allows devices to request data using unique, location-independent names. NDN offers scalability, lightweight configuration, and simplified communications, resulting in NDN being a solution for IoT systems [2].

II. Analysis of IoT and NDN

This section will discuss the limitations of IoT devices and the challenges of the current Internet architecture.

A. Challanges of the IoT

1) **The connectivity of IoT devices:** Currently, IoT devices use a server-client or host-to-host connection, neither is scalable enough for a billion devices. In the host-host architecture, every host has to communicate with every other host, resulting in exponential resource consumption.

2) **Technological Standards:** The current standards are inadequate for network protocols, communication protocols, and data aggregation. They lead to inefficient caching and aggregation. In addition, mobility protocols are needed to mitigate the effect of a connection loss.

3) **Mobility:** IoT systems that use mobile devices need to note, that devices are numerous and technologically diverse, and consumer reliance is increasing.

4) **Complexity and Integration Issues:** IoT systems comprise many unique Application Programming Interfaces (APIs), protocols, and platforms. The integration of technologies into the system is very complicated due to all the different combinations. This system should consider the resource limitation of its components.

B. NDN for the IoT

1) **NDN Packet Length:** Packages in NDN are not bound to a specific length, which allows expansion of further protocols by adding or subtracting from the overhead. IoT devices are limited in memory, resulting in small packages with a necessity of a small overhead.

2) **Caching in IoT/NDN:** IoT devices have too little memory for efficient caching, resulting in higher unnecessary package flow and a reduction in data availability. The solution is in-network caching, a feature of NDN.

3) **Data Aggregation in Wireless Networks:** If a user requests data that includes multiple packages, each package will be requested separately (excluding the others). This results in a greater overhead and more unnecessary package flow. The new system should fix the request problem.

4) **Naming Problems in Wireless Networks:** NDN supports name-centric services, which facilitates access without knowing their location. There is still a need to automate naming conventions, because of the size of the networks. These names should be kept short to minimize storage usage [5] [6].

5) **Routing Scalability in NDN:** In NDN routing is managed by names, instead of usual number based systems. The scalability of routing is important to facilitate a large network.

III. Architecture of IoT-NDN System

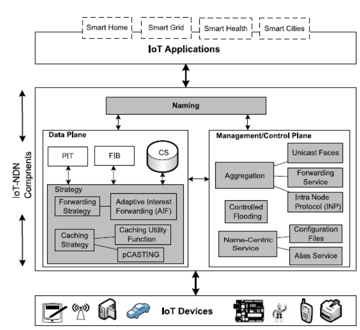

Fig. 1: IoT-NDN System architecture and its components

The IoT-NDN has three main components that are responsible for packages, caching, strategies, and others.

Devices in the IoT-NDN architecture have three tables: CS, PIT and FIB.

A. Naming

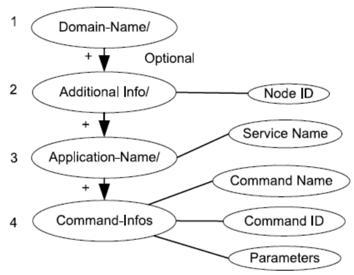

Fig. 2: Name Structure of the suggested Approach

In IoT-NDN the structure in which data is addressed is hierarchical, as shown in Fig. 2. The first component is a global domain name. The marker component is the additional fifth component of the name, specific to IoT-NDN. It contains application, service, or device resource information.

B. Managment and Control Plane

1) **Aggregation:** Combining similar information into one package will reduce the memory stress and energy consumption of the Content Store (CS) [3]. Data aggregation is achieved by three components. The components are: Forwarding Service, Unicast Faces, and Intra Node Protocol (INP). They are explained in greater detail in [3].

Unicast Face needs every package (in the radio layer) to include the source and destination address. When a device receives a package, it will build a connection to the sender of the package. If a connection is lost, for this connection allocated resources will be released.

2) **Controlled Flooding:**

IoT devices aren't reliable in power or connectivity, usually resulting in the Forwarding Information Base (FIB) tables not being populated in advance by routing information. Controlled flooding is used for its robustness and by adding a timer-based package suppression, overhead can be reduced. Packages won't be sent out while the timer is running, if the same package is received it will only be sent out once.

3) **Name-Centric Services:** The use of a gateway enables IoT-Devices to be reachable from any internet device. The gateway allows wireless and wired connections, via protocol conversion. It provides all important configurations of names and IoT-NDN devices. Services on the gateway can be developed as IoT-NDN applications, enabling communication to each other threw the IoT-NDN daemon and face. In order to reduce the workload on the IoT devices the gateway will use aliases (that are shorter) to reduce the size of the packages. Names received from the internet will be mapped to names used in the Iot-NDN network.

C. Data Plane

1) **Strategy-In-Network Caching:** The CS is a caching place in IoT-NDN devices, unlike routers in the Internet Protocol it can send cached packages more than once. If a device receives a package request, it will first check the CS by checking for matching prefixes. This is done because the same data will probably be requested many times in IoT-NDN networks. The standard replacement strategy is LRU, but others can be implemented. IoT-NDN devices have a special probabilistic CAching STrategy (pCASTING), that considers data freshness and the charge and storage of devices. This strategy is used when a device receives a data package with a matching PIT.

2) **Strategy-Forwarding:** The forwarding path is selected from the FIB to forward Interest packets, by the forwarding strategy component. By remembering the number of unsatisfied interests, the forwarding strategy could be used to control the traffic. The forwarding component is the path of the interest by using data such as delay and throughput. Forwarding steps on devices are supported by IoT-NDN and the forwarding strategy allows the request of lost packages in network, by using its metrics. These metrics can be used to study the performance of every face. Finding missing packages can also be achieved with the InterestLifeTime parameter. For more information, see [4]

IV. Conclusion

First, the paper highlights the problems of IoT if implemented in IP. NDN isn't built with resource-constrained devices in mind. This paper names the problems and solutions to integrate NDN into IoT. The result Iot-NDN is a new type of network that includes communication and data access, based on names.

References

[1] M. A. Heil, "IoT-NDN: An IoT Architecture via Named Data Netwoking (NDN)" "in" Software Embedded System Department Euroimmun AG, a PerkinElmer Company

[2] Z. Sheng, S. Yang, Y. Yu, A. V. Vasilakos, J. A. Mccann, and K. K. Leung, "A survey on the ietf protocol suite for the internet of things: standards, challenges, and opportunities," IEEE Wireless Communications, vol. 20, no. 6, pp. 91–98, December 2013.

[3] T. Teubler, M. A. M. Hail, and H. Hellbr¨uck, "Efficient Data Aggregation with CCNx in Wireless Sensor Networks," in 19th EUNICE Workshop on Advances in Communication Networking (EUNICE 2013), Germany.

[4] M. A. Hail, M. Amadeo, A. Molinaro, and S. Fischer, "On the performance of caching and forwarding in information centric networking for the iot," in 13th International Conference on Wired and Wireless Internet

[5] V. Jacobson, D. K. Smetters, J. D. Thornton, M. F. Plass, N. H. Briggs, and R. L. Braynard, "Networking named content," in Proceedings of the 5th International Conference on Emerging Networking Experiments and Technologies, ser. CoNEXT '09. New York, NY, USA: ACM, 2009, pp. 1–12. [Online]. Available: http://doi.acm.org/10.1145/1658939.1658941

[6] T. Teubler, M. A. M. Hail, and H. Hellbr¨uck, "A solution for the naming problem for name-centric services," in Wired/Wireless Internet Communications, A. Mellouk, S. Fowler, S. Hoceini, and B. Daachi, Eds. Cham: Springer International Publishing, 2014, pp. 214–227.