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An Alternative IPv6 Addressing Scheme for Internet of Things

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Abstract- In this paper, an alternative IPv6 addressing scheme is proposed for Internet of Things(IoT). For diverse IoT devices, both domain type and device type are defined and combined with 16-bit hexadecimal number, which is called the IoT type identifier. Then, this IoT type identifier is reflected in generating EUI-64 for each IoT device. An IoT-specific IPv6 address is developed using the stateless address autoconfiguration with the network prefix and the modified EUI-64. A couple of applications of the proposed addressing scheme are given for existing IP mobility protocols.

Keywords: Internet-of-Things(IoT), Naming, Addressing, IPv6.

Introduction

The Internet of Things(IoT) is a promising and rapidly developing technology area. The objective of the IoT is the integration and unification of all communications systems that surround us. IoT has become a powerful force affecting the wide variety of industries, and has been applied in smart home, manufacturing, healthcare, and transportation[1]-[5].

The naming and addressing scheme is an important component of any kind of Internet architecture. With the arriving of IoT, naming and addressing schemes became parts of the solutions to the new challenges that lie ahead[6][7]. Among them, the IPv6(IP Protocol Version 6) is considered as the most suitable addressing scheme for the IoT, since it offers scalability, flexibility, tested, extended, ubiquitous, open, and end-to-end connectivity. The IPv6 spreads the addressing space in order to support all the emerging Internet-enabled devices. Many new technologies are driving the need for IPv6 deployment, and the IoT may be the biggest driver[8]-[13].

This paper proposes an alternative IPv6 addressing scheme for IoT. Both domain type and device type are defined for diverse IoT devices, and then combined with 16-bit hexadecimal number, which is called the IoT type identifier. This IoT type identifier is reflected in generating EUI-64 for each IoT device. Then, the stateless address autoconfiguration with the network prefix and the modified EUI-64 yields an IoT-specific IPv6 address. A couple of applications of the proposed addressing scheme are given for existing IP mobility protocols, Mobile IPv6 and Proxy Mobile IPv6.

The paper is organized as follows. In Section 2, the existing IPv6 address scheme is briefly introduced. In Section 3, an IoT-specific IPv6 addressing scheme is proposed. In Section 4, a couple of applications of the proposed addressing scheme is given. Finally, conclusions are made in Section 5.

Existing IPv6 addressing scheme using EUI-64

Stateless address autoconfiguration is a key feature of IPv6[13]-[15]. It enables serverless basic autoconfiguration of the IPv6 nodes and easy renumbering. IPv6 stateless address autoconfiguration uses the information in the router advertisement messages to configure the node. The prefix included in the router advertisement is used as the network prefix for the node address. An IPv6 node can autoconfigure itself with a globally unique IPv6 address by appending its link-layer address (EUI-64 format) to the local link prefix (64 bits).

A Media Access Control(MAC) address, is a unique identifier assigned to network interfaces for communications, such as a network card, on the physical network segment. Logically, MAC addresses are used in the MAC protocol sub-layer of the Open Systems Interconnection(OSI) reference model. Currently there exist three address spaces for MAC addresses, namely, MAC-48, Extended Unique Identifier(EUI-48 and EUI-64). As shown in Fig. 1, the MAC-48 address consists of two partitions, the 24-bit Organizationally Unique Identifier(OUI) and a 24-bit Network Interface Controller(NIC). MAC-48 addresses are used by Ethernet, 802.11 wireless networks, Bluetooth, IEEE 802.5 token ring (and most other 802 networks), FDDI and ATM.

Left-most 24 bits	Right-most 24 bits
OUI	NIC

Fig.1. MAC-48 Address Format

As shown in [13]-[15], the EUI-64 allows a host to assign itself a unique 64-Bit IPv6 interface identifier. This feature is a key benefit over IPv4 as it eliminates the need of manual autoconfiguration or DHCP as in the world of IPv4. The IPv6 address with the EUI-64 is obtained through the MAC-48 address. As shown in Fig. 2, the 16-bit hexadecimal number 0xFFFE is then inserted in the middle of the MAC-48 address to generate the EUI-64 address. IEEE has chosen 0xFFFE as a reserved value which can only appear in EUI-64 generated from the MAC-48 address. Next, the seventh bit from the left, or the universal/local (U/L) bit, needs to be inverted. This bit identifies whether this interface identifier is universally or locally administered. If 0, the address is locally administered and if 1, the address is globally unique. It is worth noticing that in the OUI portion, the globally unique address assigned by the IEEE has always been set to 0 whereas the locally created address has 1 configured.

Therefore, when the bit is inverted, it maintains its original scope (global unique address is still global unique and vice versa).

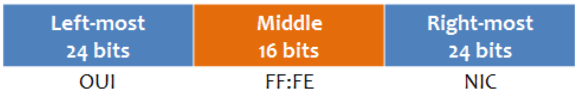

Fig.2. EUI-64 Address Format

For example, there is an internet device with MAC address of 00-1C-C4-CF-4E-D0. The transforming MAC address 00-1C-C4-CF-4E-D0 using the EUI-64 standards leads to 02-1C-C4-FF-FE-CF-4E-D0 Using IPv6 notation, 020C:29FF:FEC2:52FF can be obtained. Thus, if an IPv6 network prefix is 2001:1234:AD:5555 that usually is received with router advertisement(RA) in neighbor discovery protocol(NDP) protocol, the resulting IPv6 address with EUI-64 is shown in Fig. 3.

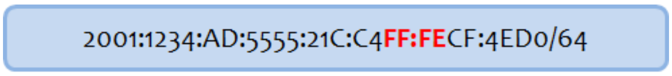

Fig.3. EUI-64 Address Format

IoT-Specific IPv6 Addressing Scheme using Modified EUI-64

An IoT-specific IPv6 stateless address autoconfiguration is proposed for diverse types of IoT devices. Many are the domains and the environments in which IoT applications would likely improve the quality of our lives: at home, while travelling, when sick, at work, when jogging and at the gym, just to cite a few. These domains and environments are now equipped with things(devices) with only primitive intelligence, most of times without any communication capabilities. Giving these things(devices) the possibility to communicate with each other and to elaborate the information perceived from the surroundings imply having different environments where a very wide range of applications can be deployed. These devices can be grouped into the following types according to application domains:

□

- Personal
- Office
- Healthcare
- Home appliance
- Transportation vehicle
- Etc.

These types are called the "domain type" of IoT devices. Each domain type can include several different IoT device types that are called the "device type". Table 1 shows an example of domain type and device type of IoT devices.

As mentioned before, in order to make EUI-64 from MAC-48, the 16-bit hexadecimal number "0xFFFE" is added in the middle of the MAC-48. To create IoT specific IPv6 address, the hexadecimal number "0xFFFE" is replaced by 8-bit upper hexadecimal number for domain type and 8-bit lower hexadecimal number for device type, respectively. As shown Fig. 4, two 8-bit hexadecimal numbers are combined. This 16-bit hexadecimal number is called the "IoT type identifier". Then, the IoT type identifier is inserted in the middle of the MAC-48 to generate the EUI-64 address. This modified EUI-64 with the network prefix can yield the IoT specific IPv6 address.

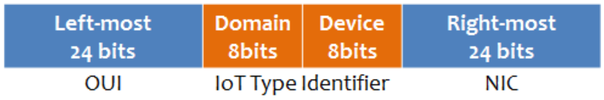

Fig.4. Modified EUI-64 Address Format

Table I shows example of IoT type identifiers for diverse types of IoT devices. For example, there is a refrigerator with MAC address of 00-1C-C4-CF-4E-D0. For the network prefix 2001:1234:AD:5555, the resulting IPv6 address with the modifed EUI-64 is shown in Fig. 5.

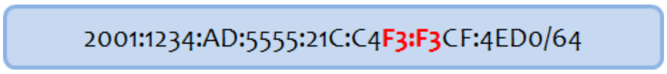

Fig.5. IoT-Specific IPv6 Address with Modified EUI-64 Address Format

TABLE.1. Example of IoT Type Identifier

Domain Type	Upper 8-bit	Device Type	Lower 8-bit	Iot Type Identifier (16-bit)
Personal	0xF0	Phone	0xF0	0xF0F0
		Tablet	0xF1	0xF0F1
		Watch	0xF2	0xF0F2
		□	□	□
Office	0xF1	Desktop	0xF0	0xF1F0
		Labtop	0xF1	0xF1F1
		Printer	0xF2	0xF1F2
		□	□	□
Healthcare	0xF2	Wearable	0xF0	0xF2F0
		Monitoring	0xF1	0xF2F1
		Talking	0xF2	0xF2F2
		□	□	□
Home Appliance	0xF3	TV	0xF0	0xF3F0
		PC	0xF1	0xF3F1
		Washing Machine	0xF2	0xF3F2
		Refrigerator	0xF3	0xF3F3
		Microwave	0xF4	0xF3F4
		□	□	□
Transportation Vehicles	0xF4	Personal Car	0xF0	0xF4F0
		Bus	0xF1	0xF4F1
		Taxi	0xF2	0xF4F2
		Airplane	0xF3	0xF4F3
		Logistics	0xF4	0xF4F4
		Ship	0xF5	0xF4F5
		□	□	□
□	□	□	□	□

Application to IP Mobility

The future Internet presents a more ubiquitous and mobile Internet. A mobility support increases the applicability of Internet to new areas. The future Internet potential is not limited to mobile platforms such as smart phones and tablets, else IoT is another emerging area of the future Internet. The mobility support in the IoT enables a global and continuous connection of all the IoT devices without requiring the disruption of the communication sessions when they move from one network to another network.

As shown in [3][9], for example, mobility management in hospitals is required since medical devices can be connected through various kinds of wireless technologies. Mobility offers highly valuable features such as higher quality of experiences for the patients, since this allows the patients to move freely, continuous monitoring through portable/wearable healthcare sensors, extend the coverage within all the hospital, and finally a higher fault tolerance since the mobility management allows the connection to adapt dynamically to different access points. Thus, medical environment is one of the main scenarios where the mobility for the IoT-based applications exploit these capabilities, in terms of fault tolerance influences directly in the life support, and continuous monitoring influences the quantity of data available which is required for real-time diagnostic. Thus, this section gives a couple of applications of the proposed addressing scheme to existing IP mobility protocols[16]-[19].

A. Mobile IPv6

Mobile IPv6 is an IETF standard that has added the roaming capabilities of mobile nodes in IPv6 network[16][18][19]. The major benefit of this standard is that the mobile nodes change their point-of-attachment to the IPv6 Internet without changing their IP address. According to the MIPv6 specification, the mobile IoT device should generate a new primary care-of address(CoA), after detecting that it has moved to a foreign link. In order to form a new CoA, the mobile IoT device can use the proposed addressing scheme. Using the proposed IoT-specific IPv6 addressing scheme, the CoA can be specified to indicate domain name and type of the mobile IoT device for handovers in wireless access networks environment. In this case, both foreign link and correspondent node can recognize domain name and type of the mobile IoT device.

B. Proxy Mobile IPv6

As an alternative of MIPv6, Proxy Mobile IPv6(PMIPv6) can be considered, which is a network-based mobility management protocol standardized by IETF[17]-[19]. PMIPv6 enables the same functionality as MIPv6, without any modifications to the mobile IoT device's TCP/IP protocol stack. When a mobile IoT device enters a PMIPv6 domain, it attaches to an access link provided by a mobility access gateway(MAG). The MAG proceeds to identify the mobile IoT device, and checks if it is authorized to use the network-based mobility management service. If it is, the MAG performs mobility signaling on behalf of the mobile IoT device. The MAG sends to the local mobility anchor(LMA) a proxy binding update(PBU) associating its own address with the identity of the mobile IoT device. Upon receiving this request, the LMA allocates a prefix the mobile IoT device. Then the LMA sends to the MAG a proxy binding acknowledgment(PBA) including the prefix allocated to the mobile IoT device. It also creates a binding cache entry and establishes a bidirectional tunnel to the MAG. The MAG sends RA messages to the mobile IoT device, including the prefix allocated to the mobile IoT device, so the mobile IoT device can configure an address using the proposed IoT-specific IPv6 addressing scheme.

Conclusion

This paper has proposed an alternative IPv6 addressing scheme for IoT. Both domain type and device type have been defined for diverse IoT devices, and then combined with 16-bit hexadecimal number, which is called the IoT type identifier. This IoT type identifier has been reflected in generating EUI-64 for each IoT device. Then, the stateless address autoconfiguration with the network prefix and the modified EUI-64 has yielded an IoT-specific IPv6 address. A couple of applications of the proposed addressing scheme have been given for existing IP mobility protocols, MIPv6 and PMIPv6.

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