A New Hybrid Method of IPv6 Addressing in the Internet of Things

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***Abstract*—Humans have always been seeking greater control over their surrounding objects. Today, with the help of Internet of Things (IoT), we can fulfill this goal. In order for objects to be connected to the internet, they should have an address, so that they can be detected and tracked. Since the number of these objects are very large and never stop growing, addressing space should be used, which can respond to this number of objects. In this regard, the best option is IPv6. Addressing has different methods, the most important of which are introduced in this paper. The method presented in this paper is a hybrid addressing method which uses EPC and ONS IP. The method proposed in this paper provides a unique and hierarchical IPv6 address for each object. This method is simple and does not require additional hardware for implantation. Further, the addressing time of this method is short while its scalability is high, and is compatible with different EPC standards.**

***Keywords*—IoT, Internet of Things, Addressing Methods, IPv6, EPC, Electronic Product Code**

I. Introduction

Although the detection technology through radio frequency is not a new subject, this technology is less than a century that has been used under the title of RFID. In 1980-1990, innovation in radio frequency-based technologies caused passive to be introduced into the market as part of this technology to achieve sufficient range across various uses [1].

As RFID grows day by day and the number of devices connected to the Internet increase worldwide. an interoperable standard was needed [2]. Therefore, Electronic Product Code (EPC) was developed to resolve the problem of object detection by MIT Auto ID Center [3]. RFID is one of the widely used technologies in Internet of Things (IoT) and it is expected that integration of this technology with EPC would cause development of IoT. Fig. 1 represents the number of devices connected to IoT in 2018 according to IHS report [4].

IoT technology plays a significant role in establishing communication between objects by connecting them through EPC by IPv6. Among the various technologies that have been used so far in this area are: RFID (Radio Frequency Identification) tags, NFC (Near Field Communication), mobile phones, Sensors, Low Power Wireless Personal Area Networks (6LoWPAN), IEEE 802.15.1 (Bluetooth), Machine to Machine (M2M), IEEE 802.15.4 (ZigBee) and etc.) [5,6,7].

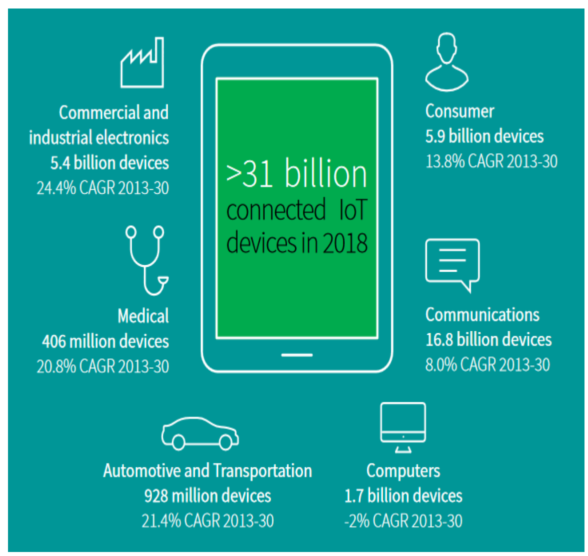

Figure. 1. The Number of Connected IoT Devices in [4]

RFID tags save an EPC code on their chip. The antenna then transfers this code to the Reader. The Reader reads the code and transfers to Object Name System (ONS), which eventually can obtain precise information about the place of objects. However, to achieve information in a real-time fashion, the connection between the object should be established through the Internet and by IPv6[8].

RFID tags cannot directly use IPv6. Thus, IPv6 is defined in different ways for the tag. Tag Reader has an ID which distinguishes the tagged object from other objects. Thus, ID can be used for creating and allocating an IPv6 address. This should be done in a simple and inexpensive way, such that it can resolve the challenge of linking tags to objects on the Internet [9]. Various methods have been presented for

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allocation of IPv6 to RFID tags, which are discussed in subsequent sections.

This paper has been organized as follows. Different EPC standards are examined in Section II. Then, Section III presents the related works. Our proposed mechanism is then explained in Section IV. Eventually, our study is concluded in Section V.

II. EPC STANDRAD

With establishment of EPC global organization, an intermediate means was developed which specifies which information can be collected and applied. Generally, the global EPC, as an intermediate, provides commercial benefits and great security for the users.

Currently, EPC exists in 64 bits, 96-bit, 128-bit, 256-bit, etc. sizes. The 96-bit codes are among the most common EPCs, and since one can detect an infinite number of objects by 96 bits (up to trillion), thus 96 bits can be adequate. EPC has Pure Identity EPC URI and EPC Tag URI forms, which generally have four sections: Header determines the EPC format; Manager Number specifies the object's manufacturer company; Object Class represents which type of objects use this EPC; and eventually, serial number determines the unique code of that object. Fig. 2 demonstrates these components. Also, Table 1 summarizes different common and practical EPC standards [10].

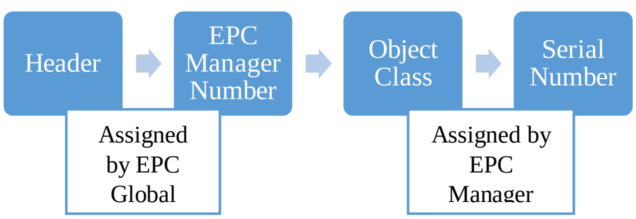

Figure. 2. The structure of EPC general form [10]

III. RELATED WORKS

IPv6 has a high capacity in addressing and can connect an infinite number of devices to the Internet [12]. The structure of IPv6 as defined in [13], is in the form of 2^{128} Bits, where 2^{64} Bits are allocated to the network address and the other 2^{64} Bits is assigned to the Host ID.

A middleware system has been proposed in [3] between reader and RFID applications based on EPC mapping. This middleware stores the server information and its database. The presented method uses the combination of 64 bits of network prefix with 64 bits of EPC (instead of EUI). This method is hierarchical and increases the interaction of internet and RFID tag. But the performance of the presented method will decrease when facing with long EPCs.

The addressing method has been presented based on EPC using XOR operator according to [14]. In this method, after converting to binary, EPC will have one the three states including less than 64 bits, equal to 64 bits, and greater than 64 bits. In the first state, a number of zeros (0) are added to the left side (left zero padding). In the second state, the same binary number is directly used for the next step. Finally, in the third state, hash and compression functions are used to obtain the 64 bits. Then, XOR operator is used to alter the bits obtained from the previous states. Eventually, in the last step, an IPv6 address is generated. This method is useful for simple and inexpensive implementation. Nevertheless, its problem is that if it uses compression and hash functions, temporal complexity grows and the mechanism performance declines.

TABLE I. TYPES OF EPC SCHEMS [10]

EPC Class	**EPC schemes defined in the EPC Tag Data Standard**	
	Tag Encodings	***Typical Use***
ADI	ADI -var	Aerospace and defense – aircraft and other parts and items
CPID	CPID -96	Component / part
GDTI	GDTI -96	Document
GIAI	GIAI -96	Fixed asset
GID	GID -96	Unspecified
GRAI	GRAI -96	Returnable/reusable asset
GSRN	GSRN -96	Service relation (e.g., loyalty card)
GSRNP	GSRNP -96	Service relation (e.g., loyalty card)
SGCN	SGCN -96	Coupon
SGLN	SGLN -96	Location
SGTIN	SGTIN -96	General Trade item
SSCC	SSCC -96	Pallet load or other logistics unit load
USDOD	USDOD -96	US Dept. of Defense supply chain

A method similar to [14] has been presented in [15]. This method uses EPC and performs all steps of the previous method, the only difference being that instead of XOR operator, it uses OR (+) operator and after computations, it generates IPv6 address. This method has the advantage of being simple. On the other hand, it employs hash and compression functions for long EPCs, thus increasing temporal complexity. Further, this method can only be implemented for ID-based objects.

Proposed method in [16] is an addressing method based on Cryptographically Generated Addresses(CGAs). This mechanism uses 64 bits of EPC (as Host ID) with 64 bits of Net ID for generating IPv6 addresses. It is also uses compression strategies for long EPCs which increase computational overhead. This method uses EM4100 tags for implementation scenario.

This method supports RFID technology for addressing and there is no need to additional hardware for implementation and it is also a hierarchical method.

A simple yet practical method for EPC has been presented in [9]. In this method, serial number part has been

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used in EPC and converts it to binary. After this conversion, two states occur: less than 64 bits and equal to 64 bits. In the first state, a number of ones (1) are added to the left side of the binary number (left one padding). In the second state, the same obtained binary numbers are used in subsequent steps of the mechanism without direct manipulation. Eventually, after being combined with net ID, an IPv6 address is generated. This method is simple and hierarchical and has low implementation costs and supports all EPC schemes for addressing. Further, unlike previous methods, due to not using hash and compression functions, it has less of temporal complexity, though it cannot be used for non-ID objects.

In [17], RFID & Mobile integration is provided to reduce transmission and conversion of data to multiple servers. This mechanism combines the 64 bits of network with 64 bits of EPC to construct a unique IPv6 address. In this method, a mobile phone is able to read the tag data and avoid the data transfer to servers which reduces both energy and time consumption. however, connecting the mobile phone to an unknown device require authentication operation. Thus, it takes time as well as this mechanism is applicable only for mobile phones that support IPv6.

An EPC mapping technique is presented in [18] for identifying home appliances using IoT. In order to translate the mapped EPC to IPv6 in this method, communication with devices takes place through codes (e.g. XML) via sensors (e.g. ZigBee). The circuits communicate with users through mobile phone software interfaces and give the necessary information from the environment to the users. Consequently, the performance of this method is low in large areas and also it is not usable in heterogeneous environments.

The RFID Agent (RA) is presented in [17]. RA performs two operations which are storing information and sending them to the DHCP. The Net ID is generated by DHCP and the Host ID generated by RA. The combination of these two, creates a new IPv6 address. RA and home agent are responsible for managing the tags and storing their location. Although, this method provides the mobility feature for tags. Nonetheless, it is not usable for None-ID objects and therefore, the scalability of this method is low.

IV. Proposed Method

As shown in fig. 3, in the mechanism proposed for generating a unique IPv6 address, EPC and ONS IP combination (high bits) which is connected to the reader of interest is used. EPC is presented in 64-bit, 96-bit, 128-bit, and 256-bit and other forms. Our proposed method covers all of its forms.

Concerning the addressing procedure, first EPC is converted to a binary form and in four-number groups. The obtained numbers are either less than or equal to 64 bits or are greater than 64 bits. The obtained number represents our bit of interest from ONS IP. For example, in an EPC with 45 bits, 128-45=83; we combine 83 bits of the high-order bits of IP ONS with 45 bits of the EPC code. As displayed in Fig. 3, in the EPC code, there is a part called serial number and another is called ID, which consists of a limited number of figures.

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Figure. 3. Combination of EPC with ONS IPv6

For EPC greater than 64 bits, we use ID part in URI or the numerical number of the EPC serial number. In this regard, the number of ID bits in the serial number is subtracted from 128 bits, and obtain the resulting number from ONS IP (see Fig. 4, Fig.5, and Fig. 6). Algorithm 1 describes the proposed mechanism in detail.

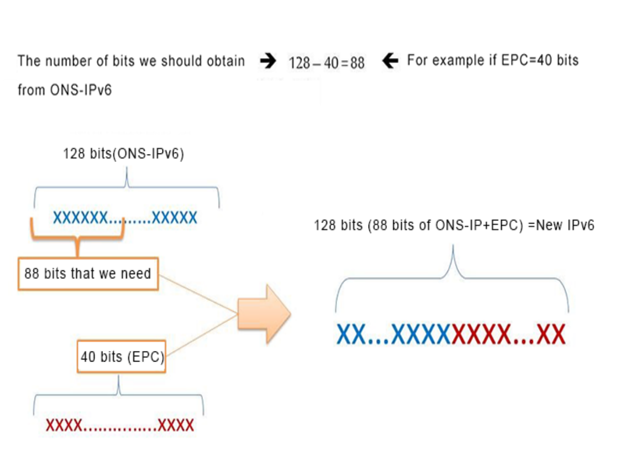

Figure. 4. Combination of EPC < 64 bit with ONS IP

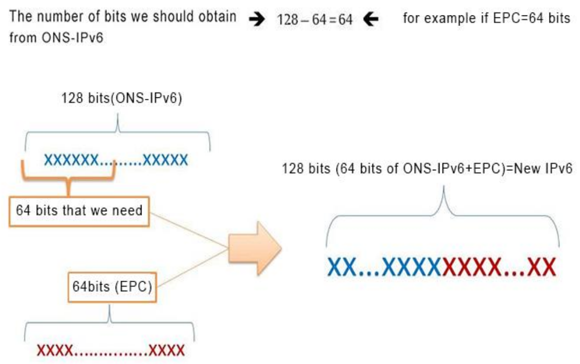

Figure. 5. Combination of EPC = 64 bit with ONS IP

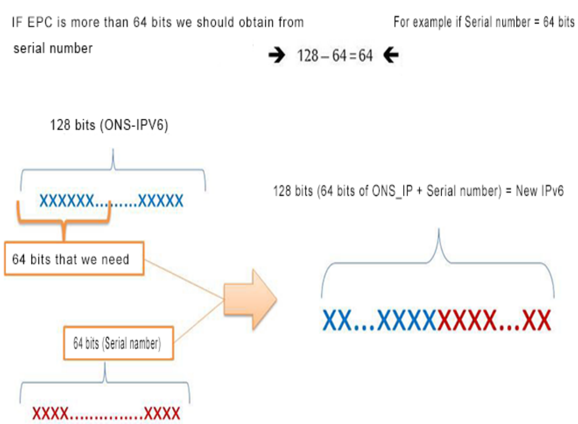

Figure. 6. Combination of EPC > 64 bit with ONS IP

Since the proposed mechanism does not need extra hardware, it will have a higher speed and far lower computational overhead compared to other methods. This method functions the same for EPCs with different number of bits, and at EPCs greater than 64 bits, it does not need compression functions. Fig. 7 provides the simulation results of proposed approach in Python.

V. Conclusion

The aim of presenting this paper has been connecting objects through the Internet, proper performance, and gaining a better control over the surroundings. The proposed mechanism is a hybrid addressing which can develop unique addresses for objects. This method does not need extra hardware, computational overhead, and complex operations for using EPC with different number of bits in addressing objects. It's simple functioning contributes to saving costs and time, enabling us to address objects by EPC.

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===========For EPC <= 64 Bits =============
EPC is :  9611683854154598
ONS's IP is :
3ffe:ffff:4004:1952:0000:7251:bc9b:a73f
Unique New IPv6 :
3ffe:ffff:4004:1952:22:25c6:89d1:fb66

===========For EPC > 64 Bits ==============
Serial number is :  37375918425780
ONS's IP is :
3ffe:ffff:4004:1952:0000:7251:bc9b:a73f
Unique New IPv6 is :
3ffe:ffff:4004:1952:0: 61fe:4257:46b4
```

Figure. 7. Results of proposed mechanism

Algorithm. 1. The pseudo code of the proposed addressing method

```
Read the EPC by reader
#Read the serial number by reader
#get the ONS ipv6
#for EX EPC is 32
EPC = 32
serial_number=0
shortage_of_bits =0
address_list = list()
for i in range(128)
   address_list[i]= ipv6 of Ons
need_list = list()
if EPC <=64:
shortage_of_bits = 128 – EPC
for i in range(shortage_of_bits):
  need_list[i] = adresslist[i]
new_ip =  need_list + EPC
else:
#serial_number = serial number of product
   shortage_of_bits = 128 - serial_number
for i in range(shortage_of_bits) :
  need_list[i]=adresslist[i]
new_ip = need_list + serial_number
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