EPC and IPv6 -based discovery services

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Abstract—The concept of "Internet of Things" means extending internet to include objects of the real world. The first step towards this goal is to uniquely identify real world objects in order to have virtual representations of them. A unique identifier called Electronic Product Code (EPC) has been developed for identifying unique objects. EPC numbers are used for uniquely identifying objects. Routing information needed for addressing objects over the internet is achieved by mapping EPC numbers to IPv6 addresses.

I. INTRODUCTION

The term Internet of Things (IoT) relates to the internet as we know it expanding to include real world objects. In order to have virtual representations of physical real world objects, they must first be uniquely identifiable. The term Internet of Things has been claimed to be coined by Kevin Ashton, co-founder of Auto-ID Center which is currently known as Auto-ID Labs [1]. Auto-ID labs is one of the leading players in the research of radio-frequency identification (RFID) technology.

The vision is that in the future virtually all items and even human beings would be tagged with an RFID tag and would also have a virtual representation of themselves. Current research and actual implementation of IoT is not quite that far, though. Currently RFID identification techniques are very popular in the field of logistics. Essentially RFID tags are used to replace EAN barcodes. The difference is that RFID tags are used to uniquely identify every item, EAN barcodes can only identify the product type.

This paper examines two problems related to tracking objects and the information related to them in IoT. The first is related to finding information about a product that is stored in private databases of companies in the logistics supply chain. The second is related to tracking the physical location of physical objects.

II. RADIO-FREQUENCY IDENTIFICATION (RFID) [2]

Radio-frequency Identification (RFID) is a technology that makes wireless identification of objects possible from a distance. Unlike barcodes, reading an RFID tag doesn’t require a line of sight from the reader to the tag. Because of this RFID tags can be read automatically without human assistance. A unique identification number is attached to every RFID tag. Other type of info, such as sensor measurement data, can also be incorporated in RFID tag read events.

RFID tags can be categorized into passive, semi-active and active tags. Semi-active and active tags are connected to external power sources, which allows an operating range of hundreds of meters. Externally powered tags can also have other functionalities such as sensors incorporated in them. Semi-active tags are powered by an integrated battery, which means their lifetime is limited by the lifetime of the battery. Active tags are more expensive and physically bigger than passive tags, which makes them impractical for many applications.

Passive tags are much more common due to their relatively low price and small size. Passive RFID tags get electromagnetic energy from the radio waves of the reader, and backscatter this signal back to the reader device encoded with their unique ID number. The operating length of a passive RFID tag varies from 10 centimeters to a few meters [3].

The identifier incorporated in RFID tags must be unique to each tag. A standard called Electronic Product Code (EPC) has been developed as an identification mechanism for RFID tags. In logistics processes this number can be used to find information associated with the EPC number in private databases of the companies in the supply chain.

III. ELECTRONIC PRODUCT CODE (EPC)

Electronic Product Code (EPC) was developed by Auto-ID Center (currently Auto-ID Labs) at MIT [4]. In the supply chain business case the manufacturer of the product is responsible for issuing a unique EPC number for each RFID tag. The EPC number can be either a 64-bit or 94-bit identifier. EPC is currently managed by EPCglobal [3].

![Fig. 1. Structure of the EPC Numbering Scheme][5]

Figure 1 shows the structure of the EPC numbering scheme. An EPC number consists of four parts. First part is the header which defines the version of the EPC number used. The second part is the identifier of the EPC-Manager that assigns the EPC number to the object. Third part is the object class identifier that essentially defines the product type of the object. The last part is reserved for the unique serial number that identifies the product from other products among the same object class.

IV. EPCGLOBAL NETWORK

A. EPCglobal Architecture Framework [5]

EPCglobal Architecture Framework (EPC Network) is a concept that allows the storing and querying of data related to objects identified with EPC numbers. The structure of the EPC network is shown in figure 2. The data that is stored in local databases consists of EPC read events that are created when an RFID tag is read. The read events typically contain the EPC number of the product with the time and location of
the read event. Other data such as sensor measurement data can be included with the EPC read event as well.

The EPCglobal network consists of three different components:

- Object Name Service (ONS)
- EPC Information Services (EPCIS)
- EPC Discovery Service (EPCDS).

![Diagram of the EPCglobal Network](image)

**Fig. 2. Architecture of the EPCglobal Network [5].**

**B. Object Name Service [5]**

The Object Name Service (ONS) is based on Dynamic Name Service (DNS). ONS resolves information sources to an EPC number. Information sources can be websites, web services or EPCIS repositories (see section IV-C). The typical case is that the EPC number is resolved to the EPCIS repository of the manufacturer of the product. The ONS uses the first three parts of the EPC number defined in section III to resolve the information source. This means it does not process the request at the serial number level, which means that the ONS can not be used for retrieving information associated to a specific EPC number.

**C. EPC Information Services (EPCIS) [5]**

EPC Information Services (EPCIS) is essentially a local database for holding the EPC read events for every company in the supply chain. EPCIS also contains a query interface so that EPC read events can be queried using the EPC number. EPCIS serves a simple repository and query interface but they don’t offer any functionality to locate all the information available related to a specific EPC number.

The early specifications of the EPC network specification provided a mechanism for the ONS to resolve all the EPCIS repository addresses given an EPC number. This didn’t take into account any of the privacy concerns related to EPC related data. Because of this a different information system called EPC Discovery Service has been developed for the discovery and confidentiality of data.

When an RFID tag is read, the read event is stored in the local EPCIS repository. The first time a certain EPC number is read at a company, the EPCDS-service is also notified that the EPCIS repository holds data associated with the EPC number.

**D. EPC Discovery Service (EPCDS) [5]**

EPC Discovery Service is the service that allows users to find all the data related to an EPC number. The EPCDS follows a so called Directory of Resources approach where EPCIS repositories register information about the availability of data corresponding to an EPC number at the EPCDS. The EPCDS informs the querying client which EPCIS repositories hold information related to the EPC number. The clients can then directly query the EPCIS repositories for data. In this scenario the EPCDS services also make sure that the querying client is authorized to request information about the given EPC number.

**E. Bootstrapping [5]**

The sheer amount of data in IoT means that it is not viable to have one discovery service that covers all the EPC repositories in the world. A bootstrapping method must be developed that allows clients to find the correct EPCDS-service using just the EPC number of the object for querying. Several solutions have been suggested for this bootstrapping process.

The ONS-service could be used to resolve the EPCDS the product belongs to. The manufacturer of the product would essentially dictate to which EPCDS the product belongs to when issuing an EPC number for it. This is problematic since all companies in the supply chain may not be willing to distribute information to that EPCDS due to technical, political or economical reasons.

Another possible solution for the bootstrapping problem is to build a peer-to-peer overlay network for collaboration of discovery services. This would however complicate the EPC network structure significantly.

**V. MAPPING EPC TO IPv6**

Sometimes it is desirable to access real world objects directly over the internet, for example to retrieve real-time data. Since IoT is a concept of extending internet as we know it into the real world, it would make sense if we could use current technologies on the internet to address objects in the "Internet of Things". EPC numbers are not directly usable for routing on the internet. However, a mechanism for mapping EPC identifier numbers to the existing IPv6-protocol has been suggested [4].

An IPv6 address consists of a 64-bit network prefix and a 64-bit Extended Unique Identifier (EUI-64). EUI-64 is an extension of the MAC addresses in the physical layer of network communication. A simple way to construct an IPv6 address is to use the network prefix in the readers’ network and append the EPC number to it, replacing the EUI-64 part of the IPv6 address.

EPC codes can be used as unique identifiers, but they can not be used as a routing addresses. Equally an IPv6 address can be used as a routing address but not as an item identifier at the same time [6]. Identifier methods based on IPv6 alone have been proposed, but for both unique item identifiers and routing over the internet protocols mapping between EPC and IPv6 is needed.
VI. CONCLUSION

Internet as we know it hopes to expand to the real physical world. The unique identifiers provided by RFID tags and Electronic Product Codes are the basis for building an "Internet of Things". The EPCglobal Architecture network provides a simple structure for distributed storing of data and making it available globally.

EPC numbers provide a way to identify real world objects, but they can not be used to reference objects on the internet. A mapping between EPC numbers and IPv6 addresses has been suggested. Having an IPv6 address gives objects a true virtual representation.

REFERENCES


