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The Virtual Electronic Product Code

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ABSTRACT

The Electronic Produce Code (EPC), as originally conceived, was intended as a method for uniquely identifying physical objects. Coupled with the electronic tags (ETAGS), the Object Name Service (ONS) and the Physical Markup Language (PML), the EPC provided a universal system for automatically identifying products and linking these to networked information. As this simple concept was applied to new areas, such as manufacturing, electronics, healthcare and transportation, the demands and requirements grow along with it. This paper proposes an extension of the EPC concept to address the unique identification of **batch** products, component **types**, and physical **configurations**. Each of these applications shares the same benefits and advantages as the original implementation; that is to provide a simple, and efficient mechanism to connect physical objects to the Internet

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Biography

by David L. Brock
Co-Director

Dr. David Brock received Bachelors degrees in theoretical mathematics and mechanical engineering from MIT, and his Masters and Ph.D. degrees from the Department of Mechanical Engineering at MIT with an affiliation to the Artificial Intelligence Lab. He is currently a Principal Research Scientist in the Laboratory for Manufacturing and Productivity and Co-Director of the MIT Auto-ID Center. Dr. Brock is also the Founder of Brock Rogers Surgical, a manufacturer of robotic medical devices. Dr. Brock has worked with a number of organizations including the Artificial Intelligence Laboratory, the Massachusetts Eye and Ear Infirmary, DARPA, Lockheed-Martin, Loral, BBN and Draper Laboratories.

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Contents

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1. INTRODUCTION

The Electronic Product Code (EPC), as originally conceived, was intended to **uniquely** identify **physical** objects [1]. As such, its development and subsequent implementation were conceptually quite simple. A physical object, such as a box of detergent or a tube of toothpaste, was assigned a single, unique EPC. This EPC was embedded in an electronic tag, affixed to the object and linked to on-line information [2]. The physical item would be thus automatically (and permanently) identified as it moved through the supply chain – from manufacturer through retailer all the way to the consumer and recycling center [3].

This simple implementation had many advantages for supply chain management and inventory control. Other benefits included theft reduction, real-time tracking, automatic restocking, instant checkout and waste management. However, as the vision of a simple mechanism for product identification grew into other domains and applications, its potential – and limitations – grew along with it.

Areas such as manufacturing, electronics, medical devices, defense systems, pharmaceuticals, agriculture, transportation, document control and raw materials could all benefit from a low-cost, automatic identification system, but each extends the demands and requirements of the previously simple system.

Although beyond its original scope, the concept of a unique identification number coupled, automatically, to on-line information has application to many of these domains. The original definition of the EPC code, however, will have to change.

A single EPC embedded in a monolithic object (the box of soap), does not necessarily make sense for small assemblies, such as integrated circuits, nor to common parts in manufactured products, such as standard bolts and rivets. Batches of small, uniform parts, such as ball bearings and electronic resistors may not benefit to individual serialization. It may make sense, however, to assign an EPC to a **batch**, or **lot**, of items, and we may want to use the EPC to describe a particular **type** of common component. The advantages of automatic identification and immediate, on-line data continue under this expanded definition, but the concept of a single EPC for a single object does not.

Temporary arrangements of objects, such as shipments, pallet configurations and assemblies, may also require an identification number. This number, however, comes into existence with the configuration of the components, such as a shipment, and is eliminated (except for historical records) once the configuration is removed. An EPC applied to this case is truly a virtual EPC, since the EPC does not describe any physical object, but simply the configuration of physical objects.

Beyond, batches, types and configurations of objects, it has been suggested the EPC could be used for other purposes, such as for telephone numbers, addresses and geographic location – or even concepts such as patents, meetings and legal decisions. However, given the stated goals of the Auto-ID Center, we will concentrate our efforts on the identification and description of physical objects.

After a brief background section, we will expand on the concept of the Electronic Product Code for batch, type and configuration of physical objects, and provide examples of its potential use and benefit.

2. BACKGROUND

The Electronic Product Code (EPC) is a 96-bit identifier divided into four (4) partitions, as shown in Figure 1. The code includes a fixed, 8-bit header. This header defines the number, type and length of all subsequent data partitions. Thus, the single byte provides 256 possible partitioning schemes.

The first scheme, EPC Type I, is intended as a public object identification number. It will be used in the same way as the current Uniform Product Code (UPC), as well as UCC.EAN Shipping Container Codes.

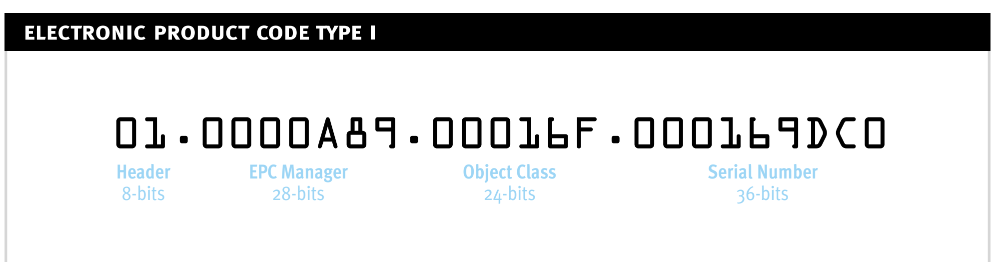
The EPC Type I has three data partitions, shown in the figure. The first data partition identifies the EPC manager; that is the manufacturer, or entity, responsible for maintaining the subsequent codes. The EPC manager is responsible for maintaining the object type codes and serial numbers in their domain. The EPC manager must also ensure reliable operation of the Object Naming Service and for maintaining and publishing associate product documents.

The EPC manager partition spans a 28-bit section, encoding a maximum of 2^{28} = 268,435,456, or approximately 268 million, manufacturers. This exceeds the 100,000 managers possible with the UPC-12 and the 1,000,000 for the EAN-13.

The next partition, object class, occupies the next 24-bits. The object class may be considered the product skew or stock keeping unit (SKU). It may also be used for lot number, or any other object grouping scheme developed by the EPC manager. Since each manufacturer is allowed more than 16 million object types, this partition could encode all the current UPC SKUs, as well as many other object classes.

The final partition encodes a unique object identification number. For all objects of a similar type, the EPC serial number provides 36-bits, or 2^{36} = 68,719,476,736, unique identifiers. Together with the product code, this provides each manufacturer with 1.1 x 10^{18} unique item numbers – currently beyond the range of all identified products.

Figure 1: The EPC Type 1 encodes is a unique object identification number



3. BATCH

Many manufactured and agricultural products are produced in lots, or batches. Usually a single lot number is assign to the entire group. In this case, the number does not refer to a particular item nor to the arrangement of items (since product may be distributed, but the batch number remains valid). Here the batch number simply refers to all objects within a particular grouping. Thus objects with the same batch number are, for all intents and purposes, absolutely **identical**.

Objects that are **indistinguishable** from each other, in both form and function, cannot be assigned a unique EPC. We said **both** form and function. Products that share the same form, such as the box of soap described earlier are indistinct from other boxes of the same type, but have different functions. They are bought and used by different consumers. Other objects with the same function, such as a computer modem, may have different forms, in that they are produced by different manufactures.

Although the objects in a batch are indistinct, they may, however, be assigned a unique EPC number, that designates the entire lot. In some cases, it may be feasible to embed this batch EPC number directly on the product. However, individual object traceability and the benefits of serialization are lost for these items. For many products of this type, it is unnecessary and cost prohibitive to consider individually tagging. The electronic tag and the corresponding EPC number, in these cases, will be attached to the container – whether bin, box or bag.

Whether the batch number is physically placed on the object or affixed to the container, all objects in the lot inherent the same number. The other components of the Auto-ID system – the Object Name Service and Physical Markup Language – apply equally well to batch products [4,5]. The system simply identifies the characteristics of the batch and provides traceability up to the resolution of the lot.

4. TYPE

Another extension of the basic EPC concept is its application to the **type** of object. This is distinct from batch or lot number described above, in that the EPC identifies the general characteristics of a **class** of objects. This is a wholly new use of the EPC – essentially as an index into a classification system.

Objects such as small bearings, fasteners, lubricants, and adhesives may be identified in an assembly for a manufactured product, but never enumerated individually or even recognized by lot number. A standard method and system for identifying these types of components would be greatly beneficial in the manufacuting design, development and production process, as well as providing cost savings through common languages and tools – such as those provided by the Auto-ID Center. Today manufacturers, nearly universally, "reinvent" some properitary process to perform this identification function, and would be open to the efficiency and ease of a standardized approach.

Beyond the identification of small, identical parts for mechanical assemblies, a universal, globally recognized classification-referencing system would, of course, have enormous application across a wide range of disciplines. The classification of objects – components, materials, fluids, produce, finishes, diseases, pharmaceuticals, etc. – is applied in all disciplines and industries. Today there is no universal mechanism to index into these disparate classification systems. The EPC and associated services could be used as such as mechanism. Methods of classification and the use of the EPC as an index is an area of current research.

5. CONFIGURATION

The final extension of the EPC we will consider in this paper is its use for identifying the **configuration**, **arrangement** or **assembly** of mechanical systems. A shipment, for example, may consist of a number of containers on a pallet. Each component – in this case the pallet and boxes – may have an EPC number, but the assembly, that is the pallet load, may also require a unique identification number. Certainly many packing slips, shipment orders and invoices require such a number, and its utility is obvious for supply chain management.

Mechanical assemblies are also particular arrangements of physical components. These arrangements may be more permanent, as in the case of an appliance, or mutable, as in the configuration of computer peripherals. What is common is that all these assemblies are perceived as unified wholes to the user and as such require a method for naming and identfication.

The EPC concept may be applied to both permanent and ephermal configurations. The EPC number may be assigned and attached **virtually**; that is in a computer database, or physically, as an additional electronic tag on the assembly. In either case, the EPC will still reference an associated Physical Markup Language (PML) file through the Object Name Service (ONS), and will still be serve as an indentification and indexing number to on-line information.

6. CONCLUSION

The extensions to the original EPC concept that we've introduced in this paper are natural applications and enhancements to the fundamental idea – that is to provide a standard method for enumerating objects and to link these to networked information. The same advantages and benefits exist in the extended applications as in the original; that is to reduce cost and to increase the reliability of inventory and tracking, and to provide a simple, standard mechanism for associating data with a physical object.

7. REFERENCES

1. **Brock, D. L, "The Electronic Product Code – A Naming Scheme for Physical Objects,"**
Auto-ID White Paper, WH-002, Jan 2001.
http://auto-id.mit.edu/pdf/MIT-AUTOID-WH-002.pdf

2. **Radio Frequency Identification (RFID) summary from the AIM Global Network**
http://www.aimglobal.org
http://www.aimglobal.org/technologies/rfid/

3. **The Object Naming Service (ONS) summary from the MIT Auto-ID Laboratory**
http://auto-id.mit.edu/research/naming.html

4. **"The Networked Physical World – Proposal for Engineering the Next Generation of Computing, Commerce and Automatic-Identification,"**
Auto-ID White Paper, WH-001, Dec 2000.
http://auto-id.mit.edu/pdf/MIT-AUTOID-WH-001.pdf

5. **Brock, D. L, "The Physical Markup Language – A Universal Language for Physical Objects,"**
Auto-ID White Paper, WH-003, Feb 2001.
http://auto-id.mit.edu/pdf/MIT-AUTOID-WH-003.pdf

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