Easy Integration of MAC/EUI Addresses into New Network Connected Designs

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Evolution of the `Internet of Things´

The 'Internet of Things' is fast becoming a part of everyone's lives. More and more gadgets and devices have the ability to connect to some type of network. For devices without this capability, many system designers are thinking about the limitless possibilities of a connected smart device, whether they connect to the Internet or interact with a local network. Integrating network functionality into future designs is quickly changing from a luxury feature to a must-have system component.

Figure 1. The `Internet of Things´ Continues to Expand

The rapid growth of connected, smart devices is undeniable. Some gadgets being brought to market today did not seem plausible even five years ago, including: livestock monitoring systems, power outlet switches, toaster ovens, pill bottles, plumbing systems, sprinkler systems, bathroom scales, and thermostats to name a few. Imagine the possibilities five years from now!

Market research firms have attempted to forecast the rapid growth of connected devices. IHS iSuppli estimates that by 2015, Internet-enabled consumer devices – connected devices outside the traditional personal computing space of desktops and laptops – will reach 780 million units, significantly exceeding the expected shipment of PCs which is estimated at 480 million units.[1]

There are many challenges to developing a network-connected device, but one common element to every one of these designs is the requirement for a unique hardware address in every device. This hardware address is necessary to properly communicate on the network as it uniquely identifies the incoming and outgoing data from that specific device. Let's examine the challenges of bringing connected devices to market, particularly with respect to the manufacturing flow and ensuring that these products are able to be uniquely identified on the network.

[1] http://www.isuppli.com/home-and-consumer-electronics/news/pages/shipments-of-internet-enabled-consumer-devices-to-exceed-pcs-in-2013.aspx

What are Hardware Addresses?

Hardware addresses must be globally controlled to ensure they are unique. But what actually comprises a hardware address value? There are two types in use today. For networking hardware such as wireless routers, the unique hardware address required for communicating on local networks is 48 bits long and is often referred to as a Media Access Control (MAC) address or abbreviated as MAC-48. In devices with network access such as printers and multimedia equipment, along with software like those used in virtualization technology, the hardware address is called an Extended Unique Identifier (EUI) and can be 48-bits or 64-bits long or abbreviated as EUI-48 or EUI-64. The term "MAC address" is used synonymously with both types of values as they are assigned from the same numbering space.

The range of available MAC/EUI addresses is, in part, controlled by the Institute of Electrical and Electronics Engineers or IEEE. The IEEE will register and assign a 24-bit OUI (Organization Unique Identifier) for a company, and this 24-bit OUI value becomes part of the MAC/EUI address. The fee to register for and be assigned an OUI by IEEE is $1,750. Purchasing a range of addresses from the IEEE represents a fixed cost that must be considered in a development budget. The OUI value is what every MAC/EUI address starts with, followed by a 24- or 40-bit Extension Identifier that, when combined, creates a 48-bit MAC/EUI-48 number or a 64-bit EUI-64 number as seen in figure 2.

One OUI registration will give the registrant about 16 million potential 48-bit values or over 1.1 trillion 64-bit values. To prevent waste of available MAC/EUI addresses, the IEEE will not assign a new OUI value until at least 90 percent of the registrant's original allotted values have been used.

System Design Challenges

One of the first considerations that system designers must make is where they will store the hardware address in the system. The most common choice is either in the nonvolatile memory of a microcontroller or in a secondary nonvolatile memory device such as a Serial EEPROM. When nonvolatile memory is used to store this data, it will often contain other vital manufacturing values such as lot number, system default values, manufacturing location, system serial numbers, etc. The system designer also needs to decide how the hardware address will be protected from being altered. Ideally, a system designer can program the hardware address value during the system production operation and then apply a mechanism that makes it impossible to alter the MAC address for security purposes. Not all systems incorporate such lockout features but adding this capability to the product makes it more secure. However, in a number of applications, the extra level of security provided by ensuring the MAC cannot be altered is not a necessity.

Once an OUI has been procured from the IEEE, the next step is to create a production flow that guarantees that every individual widget has its own unique value. However, there are numerous technical hurdles to consider. Implementing this flow can be a cumbersome task and creates a number of challenges both on the system design side as well in the manufacturing environment. The issue is further complicated if the manufacturing facility isn't experienced in the process of managing a bank of addresses and guaranteeing no duplication of values.

From an implementation standpoint, one must decide whether the allotment of MAC/EUI values should be issued sequentially or at random. Another decision is how the

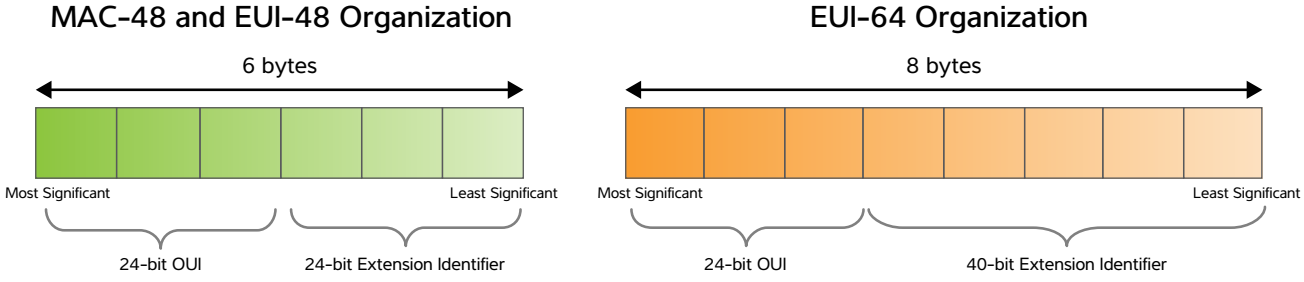

Figure 2. MAC and EUI Address Construction

database of values will be architected and how the database system that issues the MAC/EUI value confirms whether a value has been previously used. Special considerations also need to be made to handle situations where production devices must be reworked or scrapped, including how the recovery and reuse of the MAC/EUI values should be handled when applicable, all the while guaranteeing 100% uniqueness. These issues are further compounded if there are multiple manufacturing locations that have to share the same allotment of addresses.

From an execution standpoint, one must determine how the values be transferred from the database into the actual product. Numerous examples can be found on how to accomplish this. One example is to have the MAC address assigned for a given unit and then printed on a label and attached to the documentation that accompanies the unit through the production process. Later in the production process, an operator will read the label and then manually enter the value into the test equipment which will subsequently write the MAC/EUI value into system memory. This is usually in a microcontroller or Serial EEPROM. While this method can be viable, there is a significant risk of human typographical errors. When an error like this occurs, the most common result is that the incorrect MAC/EUI address will be a duplicate value of another valid address. The problem can be magnified if the duplication is not identified until the product gets into the field.

Considering the difficulty and required experience necessary in creating and maintaining a production flow that guarantees the uniqueness of the value, particularly over multiple manufacturing locations and projects, these intangible costs can quickly surpass the fixed costs of registering an OUI with the IEEE. The combined costs of adding a MAC/EUI address can be significant, particularly in low to medium-volume programs.

Atmel®, however, has introduced a new series of products that solves this problem and eliminates the headaches associated with procuring and managing a bank of addresses. The new Atmel AT24MAC family of Serial EEPROM devices eliminates the need to manage complex MAC/EUI databases by providing system manufacturers with devices that contain pre-programmed, guaranteed unique 48-bit or 64-bit MAC/EUI addresses. The AT24MAC devices contain a standard, fully user-accessible EEPROM array and a separate special read-only memory area where the MAC/EUI address is stored. The devices also include the ability for the customer to permanently write-protect a portion of the standard EEPROM array to store other factory or production process critical data and then permanently prevent it from being altered. These features make it simpler, faster, and less expensive to develop Internet-connected products of all types.

Atmel's AT24MAC devices can be used in a variety of connected products in various market segments including consumer, white goods, industrial, medical, communications, media, lighting, home automation, computing, telecom, and security. Concerns of system manufacturers trying to manage their own database of MAC/EUI values can be solved by utilizing an AT24MAC series device. Because the AT24MAC devices have globally unique hardware addresses embedded in a read-only memory region, system manufacturers no longer need to absorb the management costs and time associated with acquiring, using and managing an allotment of MAC/EUI addresses.

Figure 3. AT24MAC Devices Are Available in a Wide Range of Packages

With time to market for product introduction being extremely critical, the AT24MAC series of products helps system designers by making the task of integrating unique hardware addresses into their network connected devices easy. These products simplify and speed the development of new network connected products, further adding an enhanced level of quality to the production process by ensuring that no outgoing products end up with the same MAC address.

Atmel MAC/Serial Number Products Home Page

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