Ubiquitous Object Categorization and Identity

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Abstract

The advances in computing technologies have resulted in an explosive growth in computing systems called Ubiquitous Computing Systems [Ubicomp] and also the applications that impact all aspects of our life. Everyday objects communicate with each other and also with the Internet objects available today. People have an increasing desire for such ubiquitous access to information, anywhere, anyplace, and anytime. As ubicomp occurs everywhere, there may be a very large number of objects interacting with each other simultaneously in future. This necessitates the question of how to uniquely provide identity to infinitely growing objects and standard towards the uniformity of the data being exchanged by the various objects. In this paper, author proposes the way of providing uniqueness in scalable object identity, object categorization and standard format for the data being exchanged by various ubicomp compliant objects..

Key words: Ubiquitous computing, Pervasive computing, RFID, Objects.

1. Introduction

Ubiquitous computing [ubicomp] is a compelling vision for the future that is moving closer to realization at an accelerating pace. The combination of global wireless and wired connectivity along with mobile technologies has made the vision of ubiquitous computing much more realistic and feasible. Ubicomp [5] is an intelligent computing, integrated into everyday objects that, it becomes invisible to users. In this world, toys play together, pets converse with their owners, vehicle talk to road signs, refrigerators know when items inside expire. The Ubiquitous computing environment may contain many devices with which the user interacts. Speech gestures, and even physical interaction with the devices can be used as interaction modalities. Behavior by the users may cause actions in the physical world. For example, lying down in an intelligent room can cause the window curtains to close, the lights to dim, and the music to be turned off. Both input and output in ubicomp environment may be distributed. Today, ubicomp applications are diverse in nature, ranging from small applications that help commuters track train and bus schedules, to smart laboratories, smart museums, instrumented classrooms, etc. As ubicomp occurs everywhere, there may be a very large number of Ubicomp compliant objects interacting with each other simultaneously.

2. Ubicomp: Object Categorization and Identity- an issue

2.1. Background

The ultimate goal [7] of ubiquitous computing is to "make it unnecessary to carry around anything with us". In our current day society, we must carry many items of necessity like:

- Watch, Alarm Clock
- Wallet Money, Credit Cards, Membership Cards, Driver's License, Business Cards, Passes, Coupons, Receipts,...
- Cell Phone, Paper
- Laptop Computer, PDA
- (Digital) Camera, Audio Recorder
- Document, Planner
- (Blank) Paper, Pen, Marker, Pencil, Post-it note
- Keys (for houses, cars, offices,...)

If computing becomes ubiquitous and fully connected to its full potential, there will be no need to carry these items at any time. This is made possible with networked computing, sensors, and actuators. Objects can be identified from a distance using

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biometric technologies such as face recognition. This eliminates the need for membership cards, driver's license, and passes etc. With devices connected to the network and identification provided above, there should be no need for money, credit cards, name cards, and keys. With displays and speakers/micro phones already in cars and at places such as home, offices, and hotels, we can get rid of watches, cell phones, PDA's, laptops, and documents.

This leads to following issues and challenges: [7]

1. Categorization of the things around us.
2. Unique Identity for the individual objects.
3. Non –intrusive, distant, and quick identification technology.
4. Scalability of approaches. [3]

The research and development activity in this area is focused on improving the devices and on the technologies they use to communicate [8].

2.2. A brief History

One of the Major problems in Ubiquitous Computing is the Identification of the Objects [9,10]. The barcode technology was most popular technique and has the drawback of visibility of the barcode pasted on the objects and scalability of the code used. Radio Frequency Identification [RFID] tags are the newer and feasible concepts for identifying the objects [11] as an alternative to the bar code in business sector. One of the earliest papers exploring RFID is a landmark paper by Harry Stockman "Communication by Means of Reflected Power" published in 1948. This came on the heals of the Radar and Radio research undertaken during the second World War. According to the survey [15], in 1960s, various inventors and researchers developed prototype systems. Some commercial systems were launched with the Electronic Article Surveillance (EAS) equipment used as an anti-theft device. These systems used 1-bit tags detecting the presence or absence of a tag and were used in retail stores attached to high valued items and clothing. In the 1970s, there was a great deal of interest in RFID from researchers, developers and academic institutions including such organizations as Los Alamos Scientific Laboratory and the Swedish Microwave Institute Foundation. There was much development work in this period and such applications as animal tagging became commercial viable. In 1980s, RFID applications extended into a number of areas. In Europe, animal-tracking systems became wide spread and Toll roads in Italy, France, Spain and such other countries were RFID equipped. In the 1990s, there were significant and wide spread adoptions of Electronic Toll collection in the United States. In 1991, an electronic tolling system opened in Oklahoma where vehicle could pass toll collection points at high way speeds (No Toll Booths). In Europe, there was also considerable interest in RFID applications including Toll Collections, Rail Applications and Access Control. RFID tolling and Rail applications appeared in many countries. Developments continued in the 1990s with integrated circuit development and size reduction until microwave RFID tags were reduced to a single integrated circuit. Currently, there is considerable work being undertaken in the rationalization of frequency spectrum allocation between countries, development of standards and the introduction of many commercial applications. The lack of standardization and lack of harmonization of frequency allocation are hampering growth in this industry. There is a proliferation of incompatible standards with major RFID vendors offering proprietary systems. ANSI and ISO have been working to develop RFID standards and some have been adopted for such applications as Animal tracking (ISO 11784 and 11785) and supply chain goods tracking (ISO 18000-3 and 18000-6). The principle advantages of RFID system are the non-contact, non-line-of-site characteristics of the technology. Tags can be read through a variety of visually and environmentally challenging conditions such as ice, snow, fog, paint, grime, inside containers and vehicles and while in storage. With a response time of less than 100ms, an RFID reader can read many Tags virtually instantaneously. Tags coupled with sensors can provide important information such as the status of the goods. For example, refrigerated goods can be monitored for temperature, problem areas can be identified. According to the survey [15], though RFID usage is limited at present, Evans Data Corporation, an IT market research organization, is predicting that RFID usage will increase by 450% in 2005 and a further 96% in 2006. The RFID market is segmented into low-end and high-end tags. Low-end passive tags have approximately 32 bytes of local storage and are powered by the RF field generated by the readers. High-end tags can have full-blown micro controllers and multiple interfaces to the environment, with local batteries to power them.

Some current applications of RFID include:

- Access control: RFID tags are embedded into personal ID cards.
- Baggage ID: Passive tags embedded in paper luggage tags.
- Automotive systems: Keyless entry and Immobilization systems.
- Document tracking: Passive tags affixed to

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documents.
- Express-parcel tracking.
- Library checkout and check-in: Passive tags in books.
- Livestock or pet tracking: Tags injected into pets, aiding recovery when they are lost.
- Logistics and supply chain: Container and product tracking.

2.3. Standards

Appropriate standards allowing numerous companies to create interoperable products are a key prerequisite to widespread use of RFID tags. ISO 15693, accepted in 2000, is one such standard. It is titled "Identification Cards—Contact less Integrated Circuit(s) Cards— Vicinity Cards" and has three parts: physical characteristics, air interface and initialization, and anticollision and transmission protocol. It specifies a 13.56-MHz RFID protocol, originally proposed by Texas Instruments and Philips Semiconductors in 1998, defining data exchange between RF tags and readers, and collision mediation when multiple tags are in a reader's RF field. Compliance guarantees that RF tags and readers using the ISO 15693-2 protocol will be compatible across companies and geographies. These are typically passive tags powered only by the reader's RF field, making them easy to manufacture and free of battery life limitations.

The Electronic Product Code(EPC) defines technical protocols and creates data structure for stored information [15]. The EPC system was researched and developed at the Auto-ID center at the Massachusetts Institute of Technology (MIT) and in November 2003, responsibility for the commercialization and management of the EPC system was transferred to EPCglobal Inc. The EPC specifications have defined five tag classes based on functionality as shown in the figure 1. The current version of Electronic Product Code (EPC) tag data standard specifies the format for encoding and reading data from 64- and 96-bit RFID tags as shown in figure 2 and figure 3.

The above standards have the following limitations with respect to Ubiquitous Computing Systems.

- The bits allocated to each field of the tag i.e. EPC manager, Object classes and Serial number are not scalable in the context of Pervasive Computing.
- It does not include object awareness and intelligence components to interact with other ubiquitous objects.
- The intelligence to offer variable services to other ubiquitous objects cannot be incorporated.

Class	Nick Name	Memory	Power Source	Features
0	Anti-Shoplift Tags	None	Passive	Article Surveillance
1	EPC	Read-only	Any	Identification-only
2	EPC	Read-write	Any	Data logging
3	Sensor Tags	Read-write	Semi-passive or active	Environmental sensors
4	Smart dust	Read-write	Active	Ad-hoc networking

Figure 1: Tag Classes

EPC TYPE	HEADER SIZE	FIRST BIT	DOMAIN MANAGER	OBJECT CLASS	SERIAL NUMBER	TOTAL
64-bit type I	2	01	21	17	24	64
64-bit type II	2	10	15	13	34	64
64-bit type III	2	11	26	13	23	64
96-bit and more	8	00	28	24	36	96

Figure 2: Tag Structure

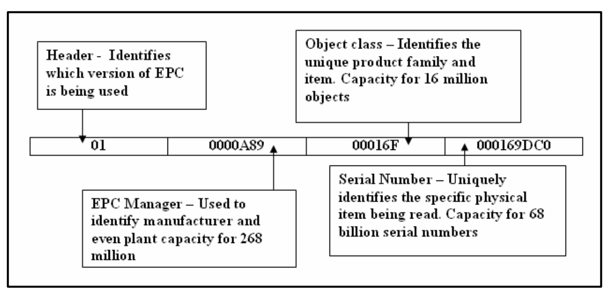

Figure 3: Tag Content

The paper [14] proposes a concept and requirements of Ubiquitous service using a RFID tag reader on a mobile terminal, mentioning the use of RFID tag for:

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- Identify objects in first phase.
- Used as a portal, in second phase, to various virtual contents / services. A user will get various information and service offered by a RFID tag attached with an object.

It also mentions the need for the universal information, which is semantically described, including kinds, attributes, names, serial numbers etc, for efficient reorganization and retrieval of necessary and variable information from various kinds of RFID.

2.4. Proposed Concept

Everyday objects can, in some sense, become smart by having RFID labels attached to them i.e. each object could acquire an electronic identity and variable intelligence in addition to its physical structure. These intelligent autonomous objects might then interact with a virtual world independently from the physical world. More and more physical world becoming "smart" necessitates the setting up the universal standard for object identity (Ubicomp compliant Objects) and categorization, so that interactions with one object will not affect another object. For example, an intelligent refrigerator may make use of the labels attached to the bottles, which could be useful in hotel rooms. Even more interesting are the scenarios where prescriptions and drugs talk to a home medicine cabinet, allowing the cabinet to say which of those items should not be taken together, in order to avoid harmful interactions or even irrelevant.

The structure of a Ubiquitous object is shown in the figure 4. Each such object will be responsible for managing its own internal state, behavior and managing its interactions with other Ubicomp compliant objects. One Object after identifying the other Ubicomp Compliant Object near by, stores its Identity in its knowledge base. Depending on the type of the object and other relevant information the RFID tag indicates, the necessary actions are to be initiated by the Execution unit. Each Object's RFID tag needs to follow certain standard to be called as Ubicomp Compliant Objects. It should provide unique scalable ID for all things in the universe. The proposed ID format for RFID tag is shown in figure 5 and the details of each fields are shown in the Table: 1.

The 'ObT' field represents the Object Classification. A useful object classification scheme is necessary so that, the individual objects represent unique instances of larger classes and generic classes.

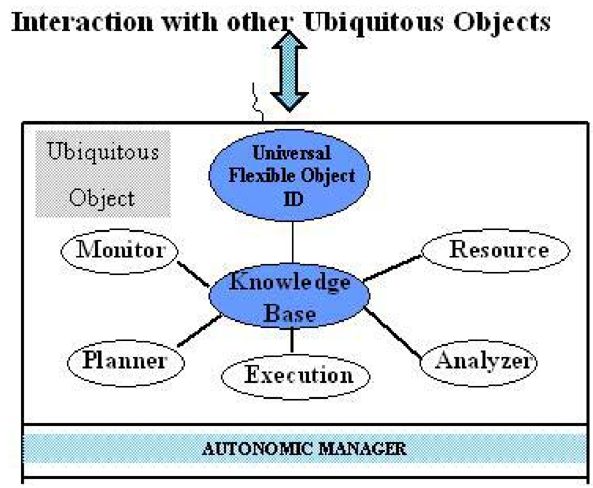

Figure: 4. Structure of Ubiquitous Object.

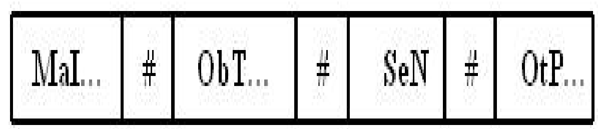

Figure: 5. Structure of RFID data content Format For Ubicomp Compliant Objects.

RFID Field	Description
MaI	Variable length -Unique ID for Manufacturer. This is to be given by Designated Competent Authority
ObT	Variable length -Unique ID for Objects Type, Ex- Food, Data Storage Device, Computational Device etc…. This is to be given by Designated Competent Authority
SeN	Unique serial number of that particular Object. Format: YYYY: MM: DD: hh:mm:ss Representing Manufacturing Date/time.
OtP	Object's other related programmable Information. Ex: Expiry date for the Medicine.

Table 1**: ID** Field details

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The classification should also allow an active object to focus on the level of specificity that best suits its purpose. Current research work does not address this as an important issue which facilitates the search analysis and object awareness.

An individual object codes that have no relation to other codes do not exist. Object Classification Scheme must:

- Be scalable, that is, it must accommodate new infinite objects of future.
- Be responsible to the ubicomp product manufacturers and code assignments should be impartial.
- Support Drill Down and Roll Up Features: i.e. the coding scheme should allow searchers to drill down among the vast group of objects to precisely find the required object. Roll up facility should also exist for general analysis.
- Be consistent, i.e. Single item must be identified at only one place. It should allow aggregation/segregation to appropriate levels without sacrificing accuracy.
- Be complete, i.e. a good scheme identifies all the objects that are ubicomp compatible.
- Be responsive i.e. it should accommodate new emerging products and discontinue with obsolete products.

The 'ÓbT' consists of five level hierarchy for object classification and are:

1. **Logical Aggregate**: The logical aggregation of generic classes for analytical purpose.
2. **Category**: A collection of generic classes.
3. **Generic Class**: A commonly recognized group of interrelated classes.
4. **Class**: A group of objects sharing a common use.
5. **Object**: A group of common functionalities.

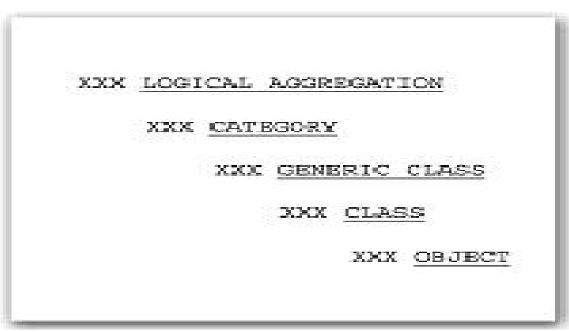

Figure 6: Hierarchical Object Classification

The scheme indicated in figure 6 makes the active objects more intelligent. It provides the active objects with a capability to reason, analyze apparent relationships between objects in the hierarchy and hence facilitates the active objects in the decision making process. Consider a situation where a user of an ubicomp compatible mobile enquires the ubicomp compatible refrigerator about the availability of a cold drink. If the cold drink is not available the active object will be able to inform the user that the cold drink is not available and will be able to provide an acceptable alternative, like available juice or milk.

The 'OtP' i.e. other Programmable Information includes the set of standard tags/Commands to be used by the various Ubicomp compliant objects under particular category to interact with other Ubicomp compliant objects of same category or others. For example a soft drink under Object category of " Liquid Food item with Expiry Date" may contain the OtP:tag <Exp-B>20060110<Exp-E> indicating the expiry date. Similarly many other standard tags need to be defined as indicated in table-2, which facilitates the inter Ubicomp compliant object communication. As an illustration assume three Ubicomp Compliant Objects namely Pen Drive, Soft Drink and a Medicine with RFIDs as:

- 1#1.2.3.4.5#20060110# <War-B>20080110<War-E>,
- 1001#1.2.4.103#20060110#<Exp-B> 20080110 <Exp-E>, and
- 123#1.2.5.12#20060105##<Exp-B> 20080110 <Exp-E>,

respectively, are placed in an Ubicomp compliant refrigerator, a smart intelligent element with the power of processing, here after termed as "active" ubicomp element. On the other hand pen drive, Soft drink and medicine are "passive" without any processing power. They only transmit their details to other objects. The refrigerator after reading RFID's and identifying the object types of all three elements, may send message to the owner, informing that it is not right to place pen drive in it or may inform the other details like expiry dates of the items or it may detect which of those items should not be taken together, in order to avoid harmful interactions or even irrelevant.

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OtP: TAGS/Commands	Meaning
<Exp-B> date <Exp-E>	Indicates Expiry date.
<War-B> date <War-E>	Indicates warranty date
<Ds-B> signature <Ds-E>	Indicates the digital signature for security purpose.
<SnI>	Switch on the Device Immediately
<SnA> date/time <SnA-E>	Switch on the Device at specified date and time
<SoI>	Switch Off the Device Immediately
<SoA> date/time <SoA-E>	Switch off the Device at specified date and time
Etc……….	

Table-2 : Illustration of **OtP**: Tags/Commands

3. Conclusion

There is necessity of uniformity of the data being exchanged by the various objects (Object Types/classification – illustrated in Fig: 6) manufactured by different vendors across the world, in order to be truly pervasive world. Compliance guarantees that future ubicomp compliant objects will be compatible across companies and geographies. There should be competent authority to assign these ID's for the manufacturer and for objects to avoid contradictions and confusions among the Ubiquitous objects' operation. The proposed concept is tested in a simulation environment implemented in laboratory using Mobile agents (IBM's Tahiti Server: Aglet). Agents are used to represent either active Ubicomp compliant object or passive. They also incorporate some processing power for illustration.

Based on above work and concepts developed, we infer that; the hierarchical classification (ObT Field) has an advantage that facilitates object relationship, object awareness along with object identification. It also makes the system more intelligent and scalable.

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