Sap: Self Aware Protocol for Ubiquitous Object Communication

Thyagaraju G.S., Umakanth P. Kulkarni

Abstract— The advances in computing technologies have resulted in an explosive growth in computing systems and applications [ubicomp] that impact all aspects of our life. People have an increasing desire for such ubiquitous access to information, anywhere, anytime. This trend demands for unique protocol to establish a meaningful and useful communication across ubicomp objects. Self awareness property of the object driven automatically without human intervention makes their coexistence meaningful and is a necessary requirement of ubicomp systems. In this paper we are presenting a design and implementation of query language based self-aware protocol for ubicomp objects communication.

Index Terms—self aware, protocol, ubicompobject, query language, bnf, sap.

I. INTRODUCTION

Self Awareness empowers individuals, as it gives them the ability to understand their position in a given system and use that knowledge to operate more effectively. Objects want to be aware of their own presentation, of what is appropriate in the given context, and how others perceive them. Objects produce immense quantities of data about their identity and behavior without an awareness of what that data is. Self awareness is a fundamental concern of the ubiquitous computing community, as awareness is necessary for interaction among the objects present in an environment. Self awareness for an object is all about, providing the complete information like: what the object is, in which environment the object is present ,which all other objects are present in that environment and what the object suppose to do in that environment. Some of the important aspects of self awareness are:

- To make the interactions among the objects possible.
- To make the objects more intelligent.
- To make the computing environment ubiquitous.
- To make the objects have complete information about themselves and about the environment in which they are present.

Language is mode of communication between two people. In the presented work we make the various objects to interact among themselves and with others. For this purpose, we make use of query language, which acts as a mode of communication between these objects. Any interactions among them or between the objects are possible through queries. The proposed query language handles data in the form of tree structure.

Each node in tree represents an object (Ubicomp Object) having different attributes, like Manufacture ID, Object ID, Serial Number and Expiry Date.

The Query Language provides different queries that can be used to manipulate or retrieve data from the tree data base.

II. LITERATURE SURVEY

Different Technologies like RFID [1,5,6] and Electronic Product Code [EPC] used for automatic object identification are considered as the most emerging Ubiquitous Computing Technologies. Today RFID is a generic term for technologies that use radio waves to automatically identify people or objects. There are several methods of identification, the most common of which is to associate the RFID Tag unique identity with an object or person. The EPC system defines technical protocols and creates a data structure for stored information.

In a ubiquitous computing environment, all the objects present in the universe have to be given unique identity. The existing EPC method has some drawbacks [2]. These drawbacks are listed as follows-

- The number of bits allocated for each field in the tag is limited. As the number of objects grows, we need more and more bits to assign unique identifiers to each of these objects.
- There is no scope to add intelligence to the objects.

III. THE PROPOSED SELF AWARE PROTOCOL (SAP)

The proposed SAP (modified and integrated version of our earlier work [2,4]) is realized by addressing the following issues:

1. Object Self Awareness.
2. Object Categorization and unique object identity.
3. Query Language for object communication.

To increase the level of human comfort and security it is indispensable to categorize the objects as ubiquitous objects and assign each and every ubiquitous object a unique Id.

Ubiquitous object can be defined as an intelligent, autonomous computing object which can be accessed by anything at anytime and anywhere. Every ubiquitous object is identified by its unique object id (Ex: RFID tag). Each such ubiquitous object will be responsible for managing its own internal state, behavior and managing its interaction with other ubicomp compliant objects. One object after identifying other ubicomp compliant object near by, stores its identity in knowledge base. Depending on the type of the object and other relevant information the RFID tag indicates, the necessary actions will be initiated by the execution unit [2,4].
Every object can, in some sense, become smart by having RFID labels attached to them i.e. each object could acquire an electronic identity in addition to its physical structure. For example, an intelligent refrigerator may make use of the labels attached to the bottles, which could be useful in hotel rooms. The proposed ID format for RFID label content is shown in Fig1. Table1 gives the details of each field of the format.

A useful object classification scheme is necessary so that, the individual objects represent unique instances of larger classes and generic classes. The classification should also allow an active object to focus on the level of specificity that best suits its purpose. The proposed classification schema has the following features like scalability, consistent, complete, and responsive and supports drill down and roll-up features.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mfgId</td>
<td>Variable length- Unique ID for Manufacturer. This is to be given by Designated Competent Authority.</td>
</tr>
<tr>
<td>objId</td>
<td>Variable length- Unique ID for objects Type. Ex- Food, Data Storage Device, Computational Device etc.…This is to be given by Designated Competent Authority.</td>
</tr>
<tr>
<td>serNo</td>
<td>Unique serial number of that particular Object.</td>
</tr>
<tr>
<td>expDate</td>
<td>Object’s expiry date.</td>
</tr>
</tbody>
</table>

The proposed object type consists of five level hierarchies for object classification and is:

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 common use.
5. **Object**: A group of common functionalities.

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The ‘expDate’ is the programmable information, which determines the expiry date of ubicomp compliant objects under particular category. For example, a soft drink under object category of “liquid food item with Expiry Date” may contain the tag <Exp>13-06-2013</Exp> indicating the expiry date. Similarly many other standard tags may be defined as indicated in the Table2 which facilitates the inter Ubicomp compliant object communication.

As an illustration assume that we have three ubicomp compliant objects namely PenDrive, Soft drink and Medicine with RFIDs as:

1) PenDrive#1.1.3.4#aabbcc#<expDate>12-07-2011</expdate>, and
2) Pepsi#1.0.2.3#mmnnoo#<expDate>21-03-2014</expdate>, and
3) Crocin#1.0.3.2#eeffgg#<expDate>16-07-2015</expdate>.

These items 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 RFIDs 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.
Table 2: Few other tags that can be included.

<table>
<thead>
<tr>
<th>Tags/Commands</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;warDate&gt; date</td>
<td>Indicates warranty date</td>
</tr>
<tr>
<td>&lt;SnI&gt;</td>
<td>Switch on the device Immediately</td>
</tr>
<tr>
<td>&lt;SoI&gt;</td>
<td>Switch off the Tag Immediately</td>
</tr>
<tr>
<td>&lt;Ds&gt; signature</td>
<td>Indicates the digital signature for security purpose</td>
</tr>
<tr>
<td>&lt;SoA&gt; date/time</td>
<td>Switch off the Devices at specified date and time</td>
</tr>
</tbody>
</table>

Query Language acts as a mode of communication between the objects. Any interaction among or between the objects is possible through queries. The Query Language provides different queries that can be used to manipulate or retrieve data from the tree data base. The query is parsed using the lexer (lex program) and parser (yacc program)[3,4].

Here the grammar for yacc program is implementation of the BNF grammar given below:

```
QL_statement ::= getInfo_statement | add_statement | delete_statement
getInfo_statement ::= getparent_clause | getdetails_clause | getsiblingcount_clause | getsiblingdetails_clause | getchildren_clause | getlevel_clause | getdepth_clause | getleafnodes_clause;
add_clause ::= ADD '(' STRING ',' STRING ',' STRING ', DATE ')' ';'
delete_clause ::= DELETE del_where_clause ';'
getparent_clause ::= GETP WHERE NAME EQ STRING ';
getdetails_clause ::= GETD WHERE predicate ';
getsiblingcount_clause ::= GETSC WHERE NAME EQ STRING ';
getsiblingdetails_clause ::= GETSD WHERE NAME EQ STRING ';
getchildren_clause ::= GETC WHERE NAME EQ STRING ';
getlevel_clause ::= GETL WHERE NAME EQ STRING ';
getdepth_clause ::= GETDT WHERE NAME EQ STRING ';
getleafnodes_clause ::= GETLN WHERE NAME EQ STRING ';
where_clause ::= WHERE search_condition;
del_where_clause ::= WHERE search_condition;
search_condition ::= predicate;
predicate ::= NAME EQ STRING | ED COMPARISION DATE | ED EQ DATE;
ADD ::= ADD | add | Add
DELETE ::= DELETE | delete
GETP ::= GETPARENT | Getparent | getParent | getparent
GETD ::= GETDETAILS | Getdetails | getdetails | getdetails
GETSC ::= GETSIBLINGCOUNT | GetSiblingcount | getSiblingcount | getsiblingcount
GETSD ::= GETSIBLINGDETAILS | GetSiblingdetails | getSiblingdetails | getsiblingdetails
GETC ::= GETCHILDREN | Getchildren | getChildren | getchildren
GETL ::= GetLevel | getLevel | getlevel
GETDT ::= GETDEPTH | Getdepth | getDepth | getdepth
GETLN ::= GETLEAFNODES | GetLeafnodes | getLeafnodes | getleafnodes
WHERE ::= WHERE | where
```

Table below illustrates some examples how to write the queries in order to establish the communication between ubiquitous objects.

Table 3: Syntax and examples of few queries

<table>
<thead>
<tr>
<th>Query</th>
<th>Syntax</th>
<th>Example</th>
</tr>
</thead>
</table>
| Add   | Add NghbObjectInfoague | Add Nghb "% %", "apple", "% %", "2012", "12-31-2011)"
| Delete| Delete where conditions         | Delete where conditions                  |
| GetDta | GetDetails where condition       | GetDetails where condition                |
| GetSib | GetSiblingCount where condition  | GetSiblingCount where condition            |
| GetSibD | GetSiblingDetails where condition | GetSiblingDetails where condition    |
| GetChi | GetChildren where condition      | GetChildren where condition               |
| GetLev | GetLevel where condition         | GetLevel where condition                  |
| GetDel | GetDepth where condition         | GetDepth where condition                  |
| GetLi | GetLeafNodes where condition     | GetLeafNodes where condition              |

IV. MODELING AND DESIGN OF PROPOSED ARCHITECTURE

Various system components and their coexistence along with their behavior is shown in Fig4.

Agent Creator: Allows creation of various objects and assigns the property
Protocol & OMIB (Object Management Information Base ) Unit : Standard hierarchical storage and operation on storage. Tag Repository and usage in the specific protocol version.
Simulation Room : Meeting place for all Objects and exercise the protocol capabilities under simulated environment
Coordination Environment- GUI : Main program which encapsulate underlying all system capabilities.
Object Querying System: Subsystem to simulate querying and information retrieval features.
Fig5 illustrates the working of SAP. The protocol is validated using three agents’ refrigerator, owner and passive objects.Fig6 and fig7 shows the use cases of owner and refrigerator objects.Fig8 illustrates the different classes and their association used for implementing SAP.
V. IMPLEMENTATION AND EXPERIMENTAL STUDY

The simulator for the proposed system is implemented using Java Software Development Kit, Eclipse and Linux Platform (Fedora version 14). The proposed SAP is validated using refrigerator, owner object and passive objects.

**Refrigerator**: The refrigerator object is a active object which can communicate to owner all the details about the objects present in it making use of its knowledge base. The refrigerator object periodically accepts the RFID signals emitted by the objects and processes these RFID signals and depending upon the result of the processed information it sends various messages to its owner object. The refrigerator object can also receive messages from the owner object. The simulated refrigerator GUI is shown in fig9, which includes dialog boxes to create objects, delete objects, view object details and to view the various activities that are going inside it like messages sent to owner object and the messages received from the owner object.

**Owner Object**: The owner object is also a active object which can communicate with refrigerator object. Fig10 illustrates the GUI of owner object which includes the dialog boxes to know the objects present in the refrigerator, to submit a query and to display the received messages. It can send messages to the refrigerator like get Count-to get the number of objects of a specified type, get alternative-to get an alternative for a specified object, get Objects- to get the objects hierarchy in the application.
Passive Object: This class only emits RFID signals. The RFID signals contain various self information about the object like Manufacture ID, Object ID, and serial no. and expiry date. As this object does not do any other work, no GUI is provided for this object.

Experiment was conducted by considering different category of objects like domestic and industrial. In domestic category we considered perishable (food items , fruits, vegetables, grains, milk products, green leaves, bakery items, beverages, medicines, cosmetics and cleansing agents), non perishable (electronic appliances, plastics, toys and ornaments). In industrial category we considered objects like chemical and daily usable objects. In Total about 50 passive objects was considered .Using SAP communication was established among these objects. Table 4 gives the list of messages that was communicated successfully among the objects.

VI. CONCLUSION

The protocol designed facilitates a communication of very basic details of the object (like name, id , expiry date and compatibility) . The SAP can be further improved by adding more programming related attributes like temperature at which objects can be kept, calorie contents of the object, warranty date of the object, user registration, human health factor, etc. More query commands can be added to the Query Language to enhance the efficiency of interaction among the objects.

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REFERENCES

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