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# A Method of Representing Knowledge of Toolkits in a Pervasive Toolroom Maintenance System

A. Mohamed Mydeen, Pallapa Venkataram



***Abstract*****—**The learning process needs to be so pervasive to impart the quality in acquiring the knowledge about a subject by making use of the advancement in the field of information and communication systems. However, pervasive learning paradigms designed so far are system automation types and they lack in factual pervasive realm. Providing factual pervasive realm requires subtle ways of teaching and learning with system intelligence. Augmentation of intelligence with pervasive learning necessitates the most efficient way of representing knowledge for the system in order to give the right learning material to the learner. This paper presents a method of representing knowledge for Pervasive Toolroom Maintenance System (PTMS) in which a learner acquires sublime knowledge about the various kinds of tools kept in the toolroom and also helps for effective maintenance of the toolroom. First, we explicate the generic model of knowledge representation for PTMS. Second, we expound the knowledge representation for specific cases of toolkits in PTMS. We have also presented the conceptual view of knowledge representation using ontology for both generic and specific cases. Third, we have devised the relations for pervasive knowledge in PTMS. Finally, events are identified in PTMS which are then linked with pervasive data of toolkits based on relation formulated. The experimental environment and case studies show the accuracy and efficient knowledge representation of toolkits in PTMS.

***Keywords*****—**Generic knowledge representation, toolkit, toolroom, pervasive computing.

## I. Introduction

With the significant advancement in information and communication technologies, learning nowadays become pivotal activity. People from all walks of life want to educate or to learn or to update themselves through learning environment such as traditional class room teaching, e-learning, m-learning, pervasive or ubiquitous learning environment based on their profession and interests. This has had a huge impact on the design of knowledge representation for information systems belong to e-learning, m-learning, pervasive or ubiquitous learning systems. Moreover, learning using the above information systems especially the pervasive or ubiquitous systems produce the system smarter rather the learner [2], [13], [14]. The learners who use these systems want requirements such as the self learning capability, organizational skills, smart way of learning, etc. These requirements of a learning system need the well adequate design of knowledge representation of information. But the representation of knowledge, storage and their access are also difficult tasks particularly in the pervasive systems. In the present arena of pervasive learning, the well ordered knowledge representation is very much needed to deliver the quality of learning through which the learner can get the right learning material. The proposed research work of this paper will enhance the quality of learning in the pervasive environment by making the learner smarter. They key factor requires to achieve this task is the optimal knowledge representation of a pervasive system.

A. Mohamed Mydeen is with the Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore, 560012, India (e-mail: muhammad@ece.iisc.ernet.in).

Pallapa Venkataram, is with the Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore, 560012, India. (corresponding author, Phone: +91-80-22932747; e-mail: pallapa@ece.iisc.ernet.in).

### *A. PTMS*

The Pervasive Toolroom Maintenance System (PTMS) maintains the toolroom with the different types of toolkits from various fields such as electrical, electronics, mechanical and sports. The objective of PTMS is to provide the learner to attain the following qualities: The absolute knowledge of the tools, the self learning capability, the disciplines to maintain in the toolroom during the learning process, the appropriate guidance for managing several situations during the learning process. The Pervasive Toolroom Maintenance System features the optimal knowledge representation to attain the above said qualities which will bring the new paradigm for ubiquitous and pervasive learning. The PTMS provides the learner the systematic way of learning and improves the learner's smartness.

### *B. Proposed Model of Knowledge Representation*

In this paper, we first propose the generic model of knowledge representation for Pervasive Toolroom Maintenance System (PTMS). The generic knowledge representation covers the various toolkits in the toolroom. Second, we propose the specific cases of knowledge representation for three toolkits in the pervasive toolroom. The both generic and specific pervasive knowledge of tools are also represented using ontology. Third, we formulate the relation for the pervasive knowledge of toolkits in PTMS. We found events happened in PTMS and link these events to the pervasive data of toolkits based on relation formulated.

### *C. Organization of the Paper*

The organization of the rest of the paper is as follows: Section II briefs about the some of the existing works. Section III elaborates about Pervasive Toolroom Maintenance System; and Section IV explores the layout for pervasive data in Pervasive Toolroom Maintenance System. The relation of attributes of pervasive knowledge and linking the events with pervasive knowledge based on relation formulated are discussed in Section V. The experimental environment of the proposed model of knowledge representation is discussed in Section VI. The conclusion and future directions are given in Section VII.

## II. Some of the Existing Works in Pervasive Knowledge Representation

The approach for representing knowledge about scientific concepts that reflects the situated processes of science is argued in [1]. The social construction of knowledge and the emergence and evolution of understanding over time is also resented. A basic framework of power grid knowledge representation using agents is given in [4] which uses BDI theory. In [5] the knowledge representation is done using semantic networks and demonstrated its utility as a basis for the intelligent environment. The ontology based pervasive context aware systems with the collection of places, agents, events and their associated properties are described in [6]. They have used Ontology Web Language for representing the knowledge for context-aware systems. A knowledge representation infrastructure for semantic multimedia content analysis and reasoning is presented in [7] by extending the use of ontologies in order to support automatic content annotation. The survey is made in [8], on the state of the art in representing the knowledge about the context in ubiquitous and pervasive fields. The use of ontologies and their limitations in knowledge representation in computer science are addressed in [9]. The application of ubiquitous computing in aircraft maintenance systems that deals with tool management, safety and documentation process are discussed in [10]. The empirical knowledge is represented using Ontology Web Language (OWL) in [11]. The medical knowledge is presented using ontology in [12]. Integration of ECA rules to make DBMS active and execution model for object oriented active DBMS are discussed in [17].

## III. Pervasive Toolroom Maintenance System

The Pervasive Toolroom Maintenance System maintains various types of tools/toolkits belonging to the different fields such as electrical, electronics, mechanical, civil, biomedical, instrumentation and sports. It provides the quality learning process in the pervasive learning environment. The user from any background can learn about any one toolkit at a time. The pervasive computing technologies such as RFIDs, GPS and different types of sensors and the communication technologies such as Wi-Fi, WiMAX, GSM and 3G are facilitating the system.

### A. Toolroom

Toolroom is equipped with several toolkits. We denote T is the set of toolkits. Let T = $\{T_1, T_2, T_3, ..., T_N\}$, where $T_1$ = is the Toolkit 1, $T_2$ = is the Toolkit 2, $T_3$ = is the Toolkit 3 and $T_N$ = is the Toolkit N. The tools, their consumables and the objects to work are kept in the individual workbench in the toolroom. Upon choosing one toolkit, the system will guide the learner for going to the appropriate workbench of the toolkit through the user's one of the mobile devices like laptop, PDA or smart phone. Fig. 1 shows few types of tools in the tool room and tool knowledge is available in PTMS.

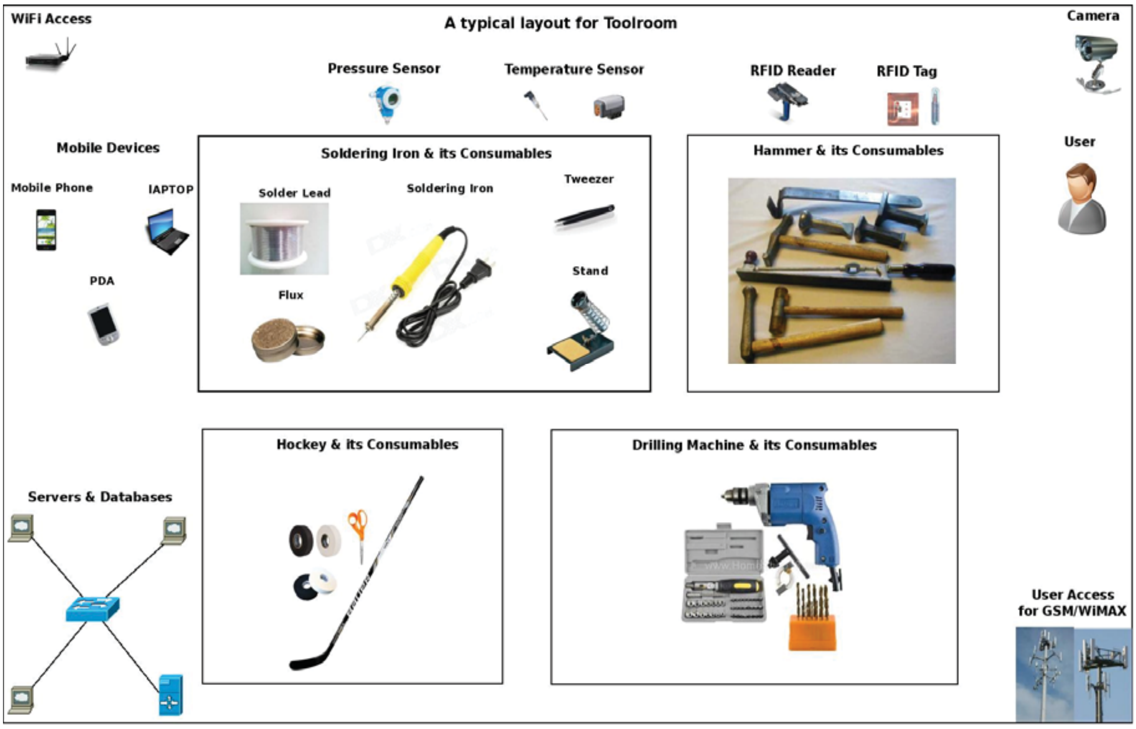


Fig. 1 A typical layout for toolroom

### B. Description of Tools/Toolkits

Toolkit consists of a major tool and its consumables which are used for doing specific purposes. We consider three toolkits $T_1$, $T_2$, $T_3$ given in Table I with their description to discuss the proposed knowledge representation.

TABLE I
KNOWLEDGE DESCRIPTION ABOUT THREE TOOLKITS

| Sl No. | Name of the Toolkit | Description of the tool |
|---|---|---|
| 1 | Soldering Iron, $T_1$ | Soldering Iron Tool is an electronic tool. It requires consumables such as soldering flux, soldering lead, tweezer for the proper operation. Soldering iron tool is used to join two metal objects together by using the heating element. It is used in laboratories in colleges, electronics service centers and in industries. |
| 2 | Hammer, $T_2$ | Hammer Tool is used to drive the nails or to deliver a blow to an object. It is used to set right the iron cables or rods. Hammers are available in different types for different purposes. It is used in houses for maintenance like decorating the houses. It is most effectively utilized in workshops and in industries for making various jobs. Consumables are available with the hammer tool to work safely while operation. |
| 3 | Hockey Stick, $T_3$ | Hockey Tool is used in hockey games. Using this tool, the user can move the ball to the required place of goal or to the targeted place. It is used in school, colleges and hockey teams. There are different hockey tools available based on the type of field. The learner can learn about the tool with the object ball. Consumables are available with hockey tool which is used to provide necessary protection for the hockey tool for longer life. |



## IV. A LAYOUT FOR THE PERVASIVE DATA IN PTMS

In this section, we present the optimal generic knowledge representation for pervasive toolroom maintenance system for the various toolkits. We achieve the optimal knowledge representation by dividing the entire knowledge into levels and then levels into appropriate stages. Here we give some of the definitions which are required for this work.

- Knowledge: It is an abstract term that attempts to capture an individual's understanding of a given subject [15].
- Knowledge Representation: It is the method used to encode knowledge in an intelligent system's knowledge base [15].
- Ontology: It is a formal explicit specification of a shared conceptualization of a domain of interest [3].

### A. Generic Model of Knowledge Representation of Toolkits

The complete knowledge representation for all the toolkits can be denoted by Knowledge (K). In the generic model of knowledge representation, we define the Knowledge (K) as a set of attributes. That is,

$$K = \{k_1, k_2, k_3\} \tag{1}$$

where, $k_1$ = Feature, $k_2$ = Specification, $k_3$ = Operation. In the generic model knowledge representation each attribute in K are modeled with many levels. We consider the elements of K are Level 1 attributes. Each attribute from Level 1is further having set of attributes and these are termed as Level 2 attributes. For example, the attribute k1 consists set of attributes. That is,

$$k_1 = \{k_{1,1}, k_{1,2}, k_{1,3}, k_{1,4}\} \tag{2}$$

where, $k_{1,1}$ = Name, $k_{1,2}$ = Appearance, $k_{1,3}$ = Description, $k_{1,4}$ = Application. We consider the elements of k1 are Level2 attributes. Similarly, each attribute from Level 2 is further having set of attributes and these are termed as Level 3attributes. Similarly, Level 4 and Level 5 attributes can be evolved if required. In our work, we have considered three levels for this generic knowledge representation of toolkits in PTMS. The generic knowledge representation for PTMS, Knowledge (K) with Level 1, Level 2 and Level 3 is given in Table II. Fig. 2 depicts the layout of pervasive toolkit knowledge with different levels in knowledge representation in PTMS.

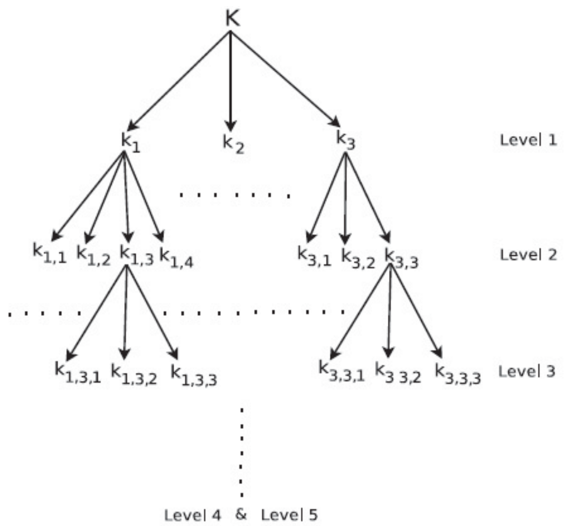


Fig. 2 A layout for pervasive toolkit Knowledge (K) in PTMS

Fig. 3 shows ontology based generic knowledge representation in PTMS with how transition happens from Level 1 to Level 2 and Level 2 to Level 3 by taking the attribute Feature in Level 1 as an example. This figure shows that the generic representation for N number of toolkits available in the toolroom. Transition1 represents how the knowledge represented in Level 1 has evolved into Level 2. Similarly Transition 2 represents how the knowledge represented in Level 2 has evolved into Level 3 Toolkits is a class. Toolkit $T_1$, Toolkit $T_2$, up to Toolkit $T_N$ are subclasses. Some of properties/relations in the ontology given in Fig. 3 are *isA* and *has*.

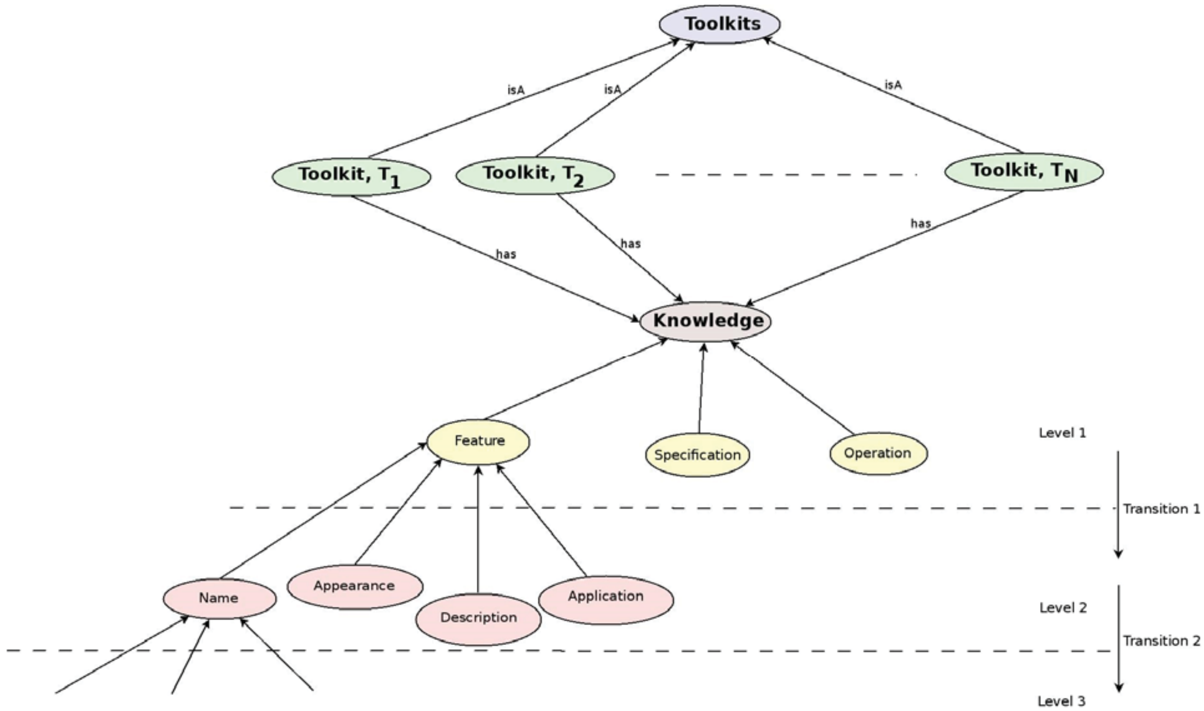


Fig. 3 Ontology based Generic Knowledge Representation in PTMS with Level's Transition for all N Toolkits

TABLE II
GENERIC KNOWLEDGE REPRESENTATION OF TOOLKITS IN PTMS

| Attributes at Level 1 | Attributes at Level 2 | Attributes at Level 3 | Attributes at Level 4 / Instances of Attributes at Level 3 |
|---|---|---|---|
| 1. Feature($k_1$) | 1.Name($k_{1,1}$)<br>2.Appearance($k_{1,2}$)<br>3.Description($k_{1,3}$)<br>4.Application($k_{1,4}$) | To be evolved if required | |
| 2. Specification($k_2$) | 1.Electrical($k_{2,1}$) | 1.Parameter($k_{2,1,1}$) | {Voltage, Current, Power, Frequency} |
| | | 2.Notation($k_{2,1,2}$) | {V, I, P, F} |
| | | 3.Unit($k_{2,1,3}$) | {Volt, Ampere, Watt, Cycles per Second} |
| | 2.Mechanical($k_{2,2}$) | 1.Property(k2,2,1) | {Young's Modulus, Tensile Strength} |
| | | 2.Measurement($k_{2,2,2}$) | {Length, Width, Height, Weight} |
| | 3.Fabrication($k_{2,3}$) | 1.Material($k_{2,3,1}$) | {Handle, Power Cord, Head Portion, Elemental Part, Bottom Section} |
| 3. Operation($k_3$) | 1.Working ($k_{3,1}$) | 1.Principle($k_{3,1,1}$)<br>2.Fundamental($k_{3,1,2}$)<br>3.Advanced($k_{3,1,3}$) | To be evolved if required |
| | 2.Maintenance($k_{3,3}$) | 1.Preventive($k_{3,3,1}$) | {Testing Electrical Earth, Temperature Examination, Probing Breakage} |
| | | 2.Breakdown($k_{3,3,2}$) | {Alignment, Repairing, Replacement} |
| | 3.Precaution ($k_{3,4}$) | 1.Risk Factor($k_{3,4,1}$) | 1.Improper use ($k_{3,4,1,1}$) |
| | | 2.First Aid($k_{3,4,2}$) | {Pressing Alarm Button, First Aid Provision} |

### *B. Specific Cases of Knowledge Representation*

We present the knowledge representation for the attribute Feature(k1) for three toolkits with three users such as Novice User, Semiskilled User and Professional User. The knowledge representation for the attribute Feature(k1) for Soldering Iron, Hammer and Hockey Stick Toolkits are shown in Table III. We are providing the case studies of specific knowledge representation of three toolkits below.

1. Case 1: Knowledge Representation of Soldering Iron

Consider that a learner in the PTMS wishes to know the features about the soldering iron tool. The features of the tool consist of *Name, Appearance, Description, Application*. These are the subattributes of Feature in the generic knowledge representation. The attributes *Name* and *Appearance* at level 2 are modeled for *Novice User(NU)* only. Because *Semiskilled User(SU)* and *Professional User(PU)*have prior knowledge or experience or they have already visited the PTMS. The instances of these level 2 attributes are shown in Table III. From Table III, the instance of attribute *Name* is *Soldering Iron* and the instance of attribute *Appearance* is *Plastic Handle with Soldering Tip.*

TABLE III
SPECIFIC KNOWLEDGE REPRESENTATION OF THREE TOOLS IN PTMS

| Attributes at Level 1 | Attributes at Level 2 | Instances of Attributes at Level 2 | Type of Learner | Type of Tool |
|---|---|---|---|---|
| 1. Feature($k_1$) | 1.Name($k_{1,1}$) | Soldering Iron | NU | Soldering Iron |
| | 2.Appearance($k_{1,2}$) | Plastic Handle with Soldering Tip | NU | |
| | 3.Description($k_{1,3}$) | Joining alloys with the help of consumables | NU/SSU | |
| | 4.Application($k_{1,4}$) | Laboratories in Educational Institutions | NU/SSU/PU | |
| | 1.Name($k_{1,1}$) | Hammer | NU | Hammer |
| | 2.Appearance($k_{1,2}$) | Wood handle with Iron Head | NU | |
| | 3.Description($k_{1,3}$) | Driving Nails | NU/SSU | |
| | 4.Application($k_{1,4}$) | Workshops and in Industries | NU/SSU/PU | |
| | 1.Name($k_{1,1}$) | Hockey Stick | NU | Hockey Stick |
| | 2.Appearance($k_{1,2}$) | Longwood stick with curved end | NU | |
| | 3.Description($k_{1,3}$) | Move the ball to the target fence | NU/SSU | |
| | 4.Application($k_{1,4}$) | Hockey Games | NU/SSU/PU | |



Since the knowledge about the attribute Description may not be aware by *Semiskilled User*(*SSU*), the instance is modeled or both *Novice User* and *Semiskilled User*. From Table III, the instance of attribute Description for soldering iron tool is *Joining alloys with the help of consumables*. Since *Professional User*(PU) may not be aware of all the applications of the tool, the instance of attribute *Application* is modeled for all three type of learners. The instance of attribute *Application* for soldering iron tool is *Laboratories in Educational Institutions*.

2. Case 2: Knowledge Representation of Hammer

Consider that a learner in the PTMS wishes to know the features about the hammer tool. The knowledge model for this attribute *Feature* is shown in Table III. Like in the case of Soldering Iron tool, the instance for the attribute *Name* and *Appearance* are modeled for the *Novice User* only. The instance for the attribute *Name* is *Hammer* and the instance for the attribute *Appearance* is *Wood handle with Iron Head*. The instance for the attribute *Description* is modeled for both *Novice User* and *Semiskilled User*. From Table III, the instance for the attribute *Description is Driving Nails*. The attribute *Application* is modeled for all three type of users. The instance for this attribute is *Workshops and in Industries*.

3. Case 3: Knowledge Representation of Hockey Stick

Like in previous two cases, we have modeled the specific knowledge representation for the Hockey Tool. The first and second attribute *Name* and *Appearance* are modeled for *Novice User* only. The instances for these two attributes are given in Table III. Similarly, the third attribute and its instance are *Description* and *Move the ball to the target fence* which is modeled for both *Novice* and *Semiskilled* users. The last attribute *Application* and its instance *Hockey Games* are modeled for all three types of users.

### *C. Ontology based Knowledge Representation for Specific Toolkits in PTMS*

We have presented the ontology based knowledge representation for the generic model of the attribute Knowledge (K) in PTMS with an example of the attribute *Feature*. The prominent design of knowledge representation for PTMS is clearly depicted by using ontology with first two levels. The concept *Knowledge* is the primary attribute. The attribute *Feature* is one of the attributes at the first level. The attribute *Feature* is also called as *Concept* in Ontology theory. The subattributes of *Feature* are Level 2 attributes. The Level2 attributes are also called as *Concepts* at Level 2. Every concept from Level 2 has *instances* or *individuals*. For example, the concept *Name* has individuals such as *Soldering Iron*, *Hammer*, *Hockey Stick*. Fig. 4 shows that the other concepts *Appearance, Description, and Application* have also instances.

## V. RELATIONS OF ATTRIBUTES AND EVENT LINKING WITH PERVASIVE KNOWLEDGE OF TOOLKITS IN PTMS

We have formulated the relations of attributes modeled for pervasive knowledge of toolkits in PTMS. We give some of the events happened in PTMS. Using the Event-Condition-Action (ECA) Scheme, events are linked with pervasive knowledge of toolkits.

### *A. Relations of Attributes of Pervasive Knowledge in PTMS*

The relations are formulated for the pervasive knowledge of toolkits in PTMS. The relations are formed based on the generic knowledge representation of toolkits described in Section IV. Table IV shows relation for some of the attributes described in generic knowledge representation of toolkits. The specific cases are given in Table V. The ontology in Fig. 5 shows the relation *appearsAs* among the attribute *Name* and *Appearance*. The instances of *Name* and *Appearance* are also shown in Fig. 5.

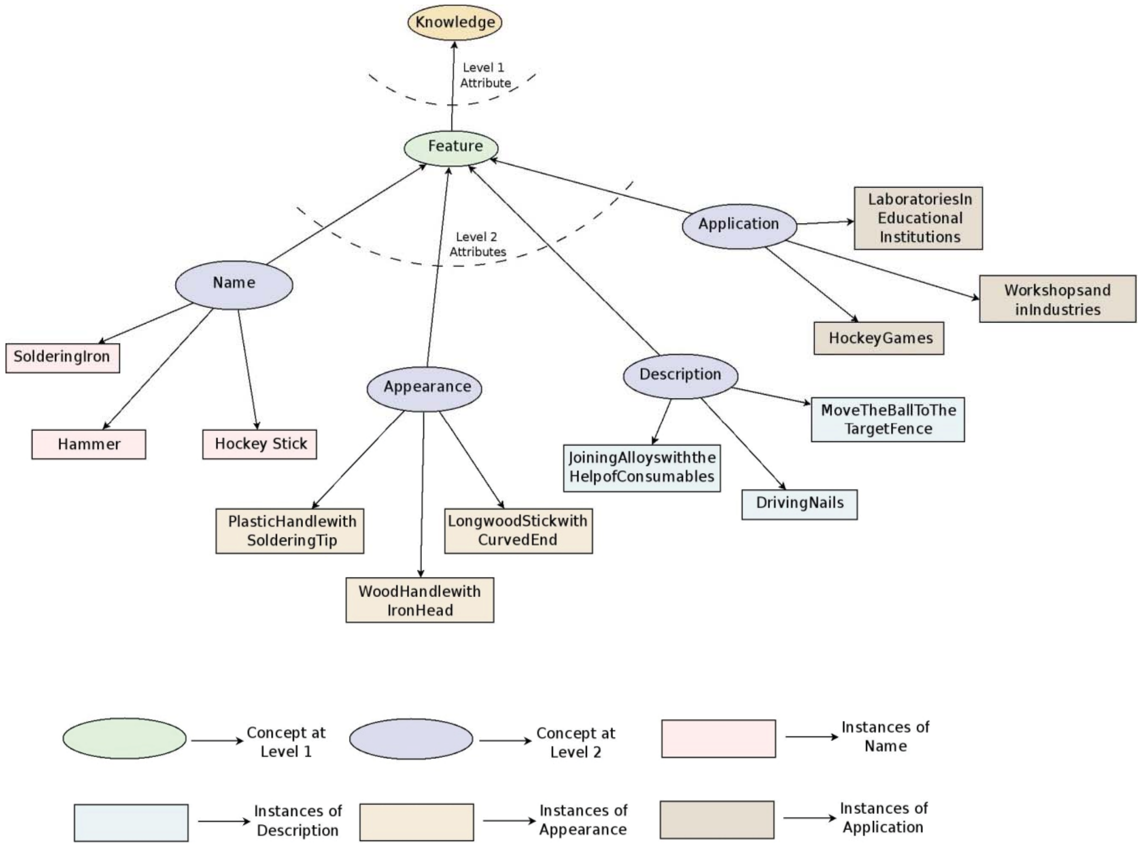


Fig. 4 Ontology based knowledge representation for the specific cases with an example of the attribute Feature at level 1 of Knowledge (K) with all three toolkits

TABLE IV
RELATION OF SOME OF THE ATTRIBUTES OF PERVASIVE KNOWLEDGE IN PTMS

| Generic Knowledge | Relation | Generic Knowledge |
|---|---|---|
| Name | appearsAs | Appearance |
| | Prescribes | Specification |
| | describesAs | Description |
| | appliesIn | Application |

TABLE V
SPECIFIC CASES APPLIED IN RELATION OF PERVASIVE KNOWLEDGE OF DIFFERENT TOOLS IN PTMS

| Instances of Generic Knowledge | Relation | Instances of Generic Knowledge |
|---|---|---|
| Soldering Iron | appearsAs | PlasticHandlewithSolderingTip |
| | Prescribes | ElectricalSpecification |
| | describesAs | JoiningAlloyswiththeHelpofConsumables |
| | appliesIn | LaboratoriesInEducationalInstitutions |
| Hammer | appearsAs | WoodhandlewithIronHead |
| | Prescribes | MechanicalSpecification |
| | describesAs | DrivingNails |
| | appliesIn | WorkshopsAndInIndustries |
| Hockey Stick | appearsAs | LongwoodStickwithCurvedEnd |
| | Prescribes | MechanicalSpecification |
| | describesAs | MovetheBallintheField |
| | appliesIn | HockeyGames |

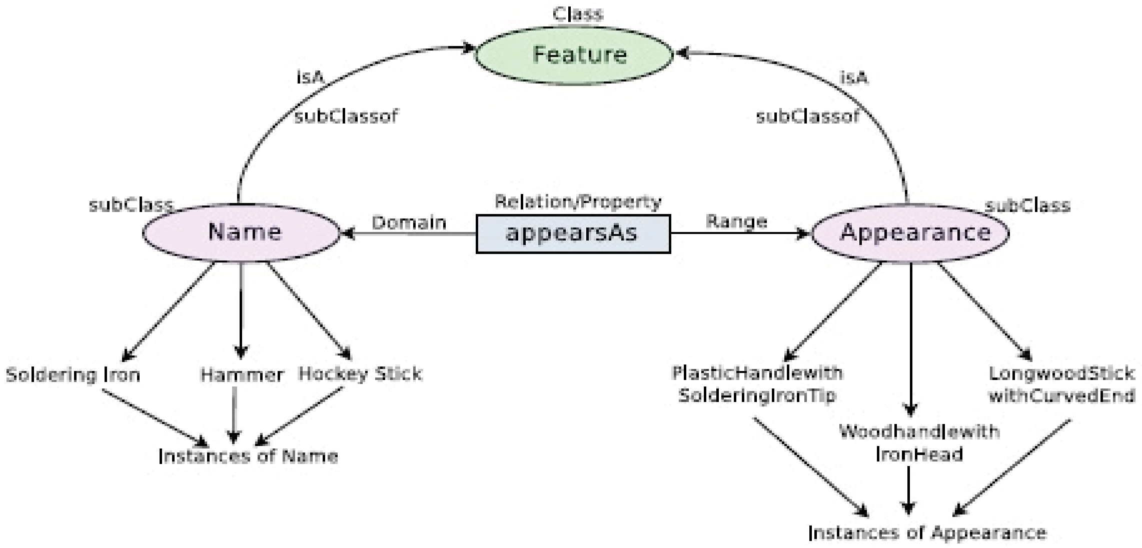


Fig. 5 Ontology for relation *appearsAs* with its attributes/concepts

*B. Events with Pervasive Data in PTMS*

We have given some events happened in PTMS. We link these events with the modeled pervasive data based on the relation. We use Event Condition Action (ECA) Scheme [17]. We give definitions for Event, Condition and Actions [17]. An *event* is an indicator of a happening which can be either primitive or composite. The *condition* can be a simple or complex. An *action* specifies the operation to be performed when an event has occurred and the condition evaluates to true. The logical structure of ECA Rule is as follows:

**When (Event happened)**
**If (Condition Statements)**
**then (Actions to be performed)**

1. Events-Conditions-Actions-Pervasive Data

The identified events need to be related to the pervasive data of toolkits in PTMS. Based on relation derived from context of a learner, the system evaluates the condition. If the condition holds true then the action will be linked to the pervasive data of toolkits. Fig. 6 shows the simple logical structure of events, actions with pervasive data in PTMS.

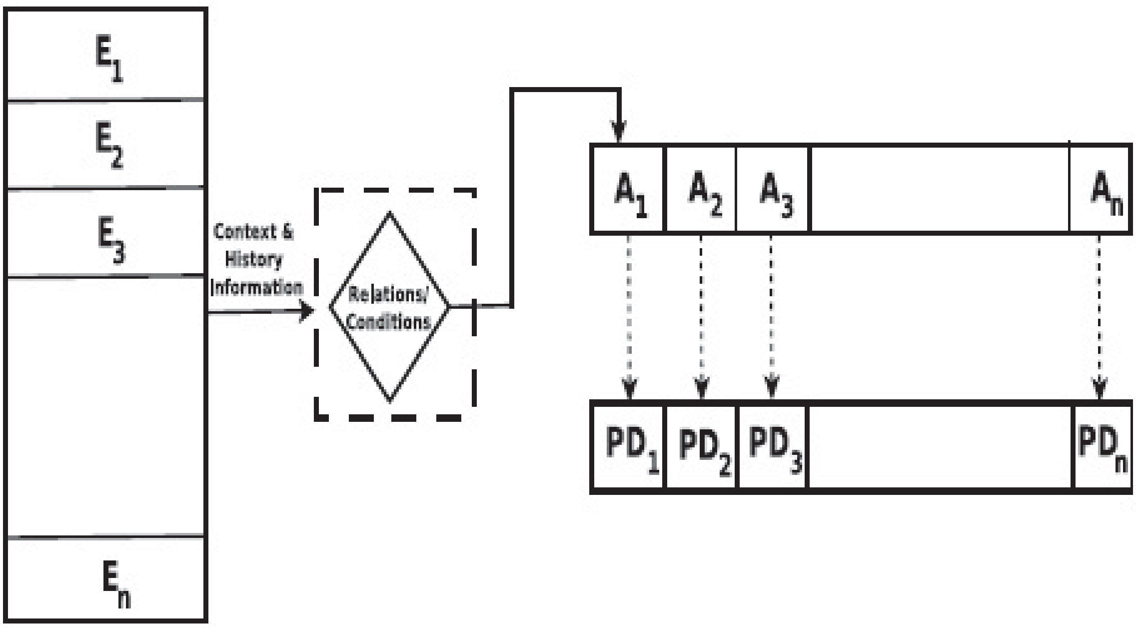


Fig. 6 Logical Structure of Events, Actions with Pervasive Data in PTMS

2. List of Example Events Identified in PTMS:

We consider here the some of the example events found in PTMS.

- Example: Soldering Iron Tool
- *Event: Looking* for the features of the tool at the workbench of soldering iron tool.

- *Relation: appearsAs*, prescribes, describesAs, appliesIn
- *Condition:* (Learner's location in the toolroom) ^ (Learner's Education Background is Electrical) ^ (Learner's Interest from history is Soldering Iron Tool) ^ (Learner's Application interest is Printed Circuit Board (PCB)).
- *Action:* Delivering the Features of Soldering Iron: Displaying Name, Appearance, Description, Application.
- *Action-linking attribute in the knowledge representation:* Table VI shows the list of other events identified and the linking attribute for a learner in PTMS.

TABLE VI
EVENTS, CONDITIONS, ACTIONS AND ACTION-LINKING ATTRIBUTE IN THE KNOWLEDGE REPRESENTATION OF TOOLS IN PTMS

| Events | Conditions | Actions | Action-Linking attribute in Knowledge Representation of tools | Toolname |
|---|---|---|---|---|
| Handling Electrical PowerCord with the Electrical Tester | Near the plug point& electrical cable is not inserted | Check for the electrical earth | The instance electrical earth of the attribute Preventive Maintenance ($k_{3,3,1}$) | Soldering Iron Tool |
| PowerCord of SI is broken | Electrical cord should be removed from the electrical plug point | Provide Insulation in the broken area | The instance Repairing(Insulation) of the attribute Breakdown Maintenance ($k_{3,3,2}$) | Soldering Iron Tool |
| Concrete wall was hit using jumper | Wood piece should be inserted in the hole | Drive nail into the concrete wall with a repeated impact | The instance of the attribute fundamental ($k_{3,1,2}$) working operation: Drive nail into the concrete wall with a repeated impact | Hammer Tool |

## VI. Experimental Environment

In the experimental environment, we have stored around 10000 attributes and instances of the represented knowledge out of which around 60 attributes are shown here. We have verified our ontology based knowledge representation using Protege [16] Ontology editor. The attribute is considered as class and subattribute is considered as subclass. The instance of an attribute is considered as an individual. The ontologies built can be stored using the standard Web Ontology Language (OWL) format. The OntoGraf visualization plugin in Protege shows the relation between the instances and relation between instances and their values for the specific case of Soldering Iron tool as shown in Fig. 7.

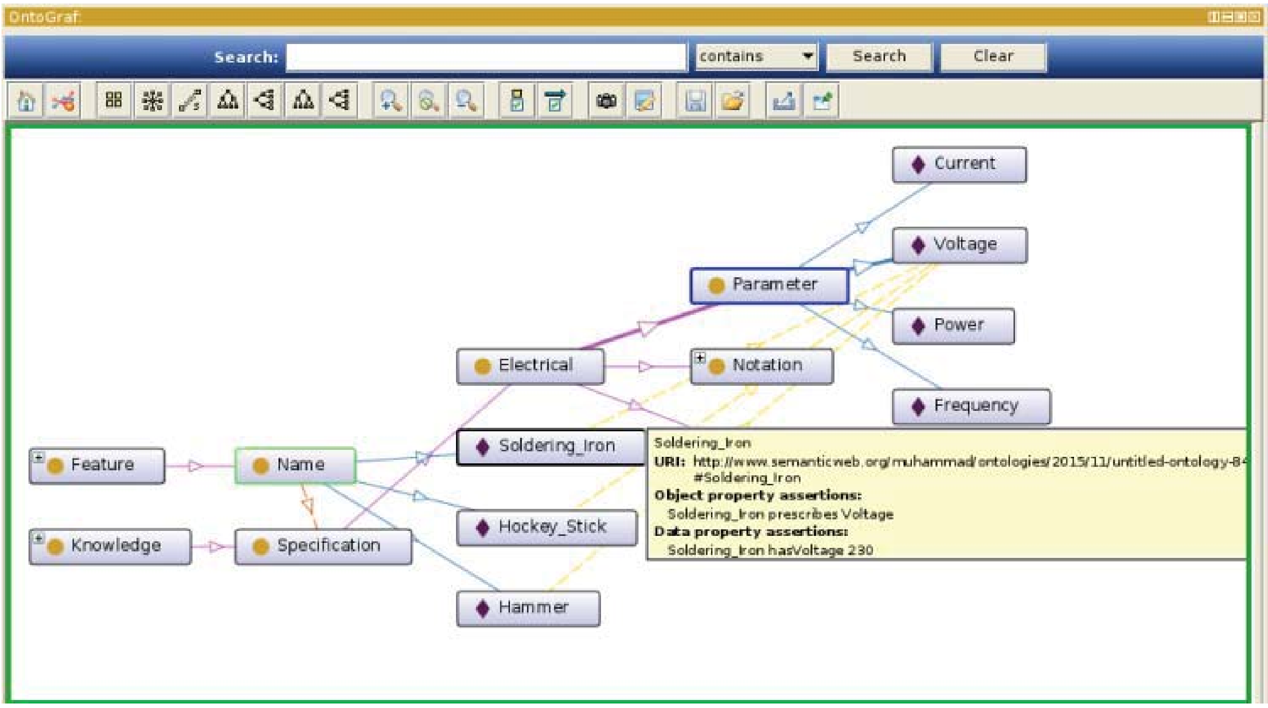


Fig. 7 OntoGraf Visualization of Generic Knowledge Representation with Soldering Iron Tool as Specific Case for PTMS

## VII. Conclusion

We have proposed the knowledge representation for Pervasive Toolroom Maintenance System that has various toolkits for learning purpose in the pervasive environment. We have first proposed the generic model of knowledge representation for various toolkits and we have considered three tools as specific cases to represent knowledge for our PTMS. We have formed the relation for represented knowledge of toolkits in PTMS. We found some of the events and linked with the pervasive data using ECA Scheme. The proposed knowledge representation for both generic and specific cases has given complete knowledge about the tools maintenance by the learner in PTMS. The accuracy and the effectiveness of the represented knowledge are confirmed through the experimental environment and the case studies. We assure that this method of knowledge representation of toolkits will pave the way for the pervasive learning space to be unique and effective and it will produce the learner with the enhanced quality of learning in a pervasive learning environment. We are planning to design the access methods for the knowledge represented for the Pervasive Toolroom Maintenance System.

## REFERENCES


[1] William Pike, Mark Gahegan, *Beyond ontologies: Toward situated representations of scientific knowledge*, In International Journal of Human-Computer Studies, pp. 659-673, Elsevier 2007.

[2] Vinu P.V., Sherimon P.C., Reshmy Krishnan, *Towards pervasive mobile learning - the vision of 21st century*, In 3rd World Conference on Educational Sciences, vol. 15, pp. 3067-3073, Elsevier 2011.

[3] Stephen Grimm, Pascal Hitzler, Andreas Abecker, *Knowledge Representation and Ontologies: Logic, Ontologies and Semantic Web Languages*.

[4] YAN Lei, WANG Xinying, DONG Junlei, A power grid knowledge representation using agent based representation in pervasive computing, In Information Management and Engineering (ICIME), The 2nd IEEE International Conference on pp. 297-300. IEEE 2010.

[5] Stephen Peters, Howard E. Shrobe, Using Semantic Networks for Knowledge Representation in an Intelligent Environment, The 1st IEEE Conference on Pervasive Computing and Communications (PerCom 2003), pp. 323-329, IEEE 2003.

[6] Harry Chen, Tim Finin, Anupam Joshi, An Ontology for Context Aware Pervasive Computing Environments, In The Knowledge Engineering Review, Vol. 18:3, pp. 197-207, Cambridge University Press, 2004.

[7] Petridis. K, Kompatsiaris. I, Strintzis. M.G., Knowledge Representation for Semantic Multimedia Content Analysis and Reasoning, EWIMT, 2004.

[8] Mikko Perttunen, Jukka Riekki, Ora Lassila, Context Representation and Reasoning in Pervasive Computing: A Review, In International Journal of Multimedia and Ubiquitous Engineering, Vol. No.4, October 2009.

[9] Christopher Brewster, Kieron O'Hara, Knowledge Representation with Ontologies: Present challenges Future possibilities, In International Journal of Human-Computer Studies, pp. 563-568, Elsevier, 2007.

[10] Matthias Lampe, Martin Strassner, Elgar Fleisch, *A Ubiquitous Computing Environment for Aircraft Maintenance, In Symposium on Applied Computing, ACM 2004.*

[11] Yuh-Jen Chen, Development of a method for ontology-based empirical knowledge representation and reasoning, In Decision Support Systems, Elsevier 2010.

[12] Alan Jovic, Marin Prcela, Dragan Gamberger, Ontologies in Medical Knowledge Representation, In 29th International Conference on Information Technology Interfaces, 2007.

[13] Sabine Graf, Kathryn Mac Callum, Tzu-Chien Liu, Maiga Chang, Dunwei Wen, Qing Tan, Jon Dron, Fuhua Lin, Nian-Shing Chen, Rory McGreal, Kinshuk, An Infrastructure for Developing Pervasive Learning Environments, In Pervasive Computing and Communications, 2008. 6th International Conference on, pp. 389-394. IEEE 2008.

[14] Yuvan Pete, Benjamin Barbry, Thomas Vantroys, Philippe Laporte, Sylvie Lerouge, Design and Evaluation of Pervasive Workplace Learning System for Retail Stores, In Advanced Learning Technologies, 12th International Conference on, pp. 202-204, IEEE 2012.

[15] Habil.sc.ing, Anis Grundspenkis, Fundamentals of Artificial Intelligence.

[16] http://protege.stanford.edu/, Software from online from this web page, downloaded on June 2014.

[17] S. Chakravarthy, V. Krishnaprasad, Z. Tamizuddin, R. H. Badani, ECA Rule Integration into an OODBMS: Architecture and Implementation, In Data Engineering, 11th International Conference on, pp.341-348, IEEE, 1995.


**Mohamed Mydeen A** received his B.E. in Electronics and Communication Engineering from Arulmigu Kalasalingam College of Engineering, Krishnankoil, which is affiliated to Madurai Kamaraj University, Madurai, Tamilnadu, India, and M.E. Degree in Communication Systems from College of Engineering Guindy, Anna University, Chennai, Tamilnadu, India, in 2000 and 2006 respectively. Currently, He is pursuing his Ph.D Degree on issues in Pervasive Computing under the guidance of Prof. Pallpa Venkataram in the Department of Electrical Communication Engineering at Indian Institute of Science, Bangalore, India. His research interests are in the areas of Pervasive Networks and Systems, Knowledge Representation, Fuzzy Logic and Systems, and Agents Technology in Pervasive Systems. He is a student member of IEEE.

**Pallapa Venkataram** received his Ph.D. Degree in Information Sciences from the University of Sheffield, England, in 1986. He was the chairman for center for continuing education, and also a Professor in the Department of Electrical Communication Engineering, Indian Institute of Science, Bangalore, India. Dr. Pallapa's research interests are in the areas of Wireless Ubiquitous Networks, Communication Protocols, Computation Intelligence applications in Communication Networks and Multimedia Systems. Dr. Pallapa is the holder of a Distinguished Visitor Diploma from the Orrego University, Trujillo, PERU. He has published over 150 papers in International/national Journals/conferences. Written three books: Mobile and wireless application security, Tata McGraw-Hill, Communication Protocol Engineering, Prentice-Hall of India (PHI), New Delhi, 2004 (Co-author: Sunil Manvi), and Multimedia: Concepts & Communication, Darling Kinderley (India) Pvt. Ltd., licensees of Pearson Education in South Asia, 2006. Edited two books: Wireless Communications for Next Millennium, McGraw-Hill, 1998, and Mobile Wireless Networks& Integrated Services, John Wiley & Sons(Asia) Pvt. Ltd., 2006 (Co-editors: L.M. Patnaik & Sajal K. Das). Written chapters for two different books, and a guest editor to the IISc Journal for a special issue on Multimedia Wireless Networks. He has received best paper awards at GLOBECOM'93 and INM'95and also CDIL (Communication 39 Performance Analysis of a Priority based Resource Allocation Scheme Gochhayat and Pallapa Devices India Ltd) fora paper published in IETE Journal. He is a Fellow of IEE (England), Fellow of IETE (India) and a Senior member of IEEE Computer Society.