GuruSKool: An RFID based Smart School Ontological Model with SWRL reasoning

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Abstract: In the present society, safety mechanisms are quite crucial for school going students. There are various technologies available towards providing the solution to this problem of student's safety in schools. RFID (Radio Frequency Identification) is a significant technology, which has drawn the attention of various researchers towards delivering the services of student's safety. There is a need of developing the better models or mechanisms to be proposed for providing the solutions in this direction. In this paper, first concerned technologies along with their concepts have been explored and discussed which includes Pervasive computing, RFID, SWRL, Ontology, Context awareness etc. Second, a related literature survey has been provided. Third, an RFID enabled Smart School OWL Ontological Model (GuruSKool) using SWRL for student's safety has been proposed. Fourth, SWRL scenario based implementation for smart schools has been provided. Fifth, some useful inferences and limitations are provided along with future work and conclusions.

Index Terms - Pervasive computing, Context awareness, Ontology, RFID, SWRL.

I. INTRODUCTION

In today's society, crimes related to students are increasing and therefore, their safety is of prime concern. There is a need of making the educational domain smart and secure where the schools plays a vital role. Towards this, in order to create a secure environment for the students the schools have used various technologies to create a secure environment for the children. The sensor based technology nowadays is trending and is widely being used by the smart educational environment. These sensors provides the information about the user that includes the body accelerations, health related data (example heart rate, breath rate, etc), and the user's location. This paper has mainly focused on the incorporation of two major technologies i.e. pervasive computing and semantic web to accomplish the above mentioned goal. The pervasive computing is the field that uses the relevant contextual information to adapt human behaviors for a given period of time and according to Mark Weiser(in 1991) pervasive computing is a computer based concept that weave itself under the daily life coverage until they are indistinguishable from it[9][2]. Pervasive computing based researches have highlighted the context awareness as an important paradigm, especially the aspect of context modeling. Context-aware based applications are capable of adapting their major operations to the present context without any explicit human intervention and achieve the main goal of effectiveness by considering the environmental context into account [3]. The approach of ontological modeling provides a high expressivity and formal description to define the related concepts and relationships of a particular area of interest [3].

Towards this, the usage of the popular semantic web language called Web Ontology Language (OWL) has provided the base to satisfy the context-aware reasoning. Here, the semantic reasoning approach has been proposed for risk or danger recognition on the basis of the knowledge description provided in OWL and developed rules using SWRL [10].

This paper is divided into following sections:

In Section 1, various concerned technologies and their concepts have been explored and discussed such as Pervasive computing, RFID, SWRL, Ontology, Context awareness etc.

In Section 2, the related literature survey has been provided which discusses various types of reasoning, smart environments, SWRL usage in various applications etc.

In Section 3, An Ontological approach for smart school has been presented which includes: classes and properties, Ontograph, upper-level and domain based ontologies.

In Section 4, the model for "GuruSKool" student security has been proposed where RFID enabled Smart School based OWL Ontological approach has been used using SWRL context based reasoning.

In Section 5, SWRL scenario based implementation for smart schools has been demonstrated which analysis dangerous situations to give appropriate alerts.

In Section 6, conclusions and future work has been provided.

II. BACKGROUND AND LITERATURE SURVEY

2.1. **Context Modeling**

Smart space or environment is the major research area in pervasive computing. Here, the embedded sensors and devices adapt the behavior of the contexts either in dynamic or proactive manner. The term context according to many researchers have different definitions, but the most popular one is suggested by Dey and Abowd, where, the "context" is any information which may be used to characterize the situation of entities and the "entity" refers to the person, place or object that may be relevant to the interaction between a user and an application [6].

The context can either be static or dynamic. The static context refers to a state where the appearance and the provision of the content are user-driven, which ultimately means that the user can control the elements of the system while in dynamic refers to the state where the user depicts the passive behavior and is controlled by the system [2]. This contribution is dealing with the dynamic context and therefore requires a context model for the storage of contextual information. But, the development of a context model is quite difficult task. For this, Strang (2004) has suggested some influential context modeling approaches that represent the contextual information in context aware application, such as Key-Value Models, Graphical Models, Logic Based Models, Markup Scheme Models, and Ontology Based Models [7]. Among above mentioned approaches, the Ontology based modeling is the preferred technique to represent the contextual based information due to its simplicity, genericity and expressiveness as compared to other modeling approaches [7] [8]. According to Gruber's definition, "Ontology is the explicit and formal specification of a conceptualization". The Ontology based modeling approach enables the integration of the heterogeneous information systems and devices to enable the semantic interoperability to support various applications and services. Moreover, it also provides the formalized vocabulary where the concepts and properties can be defined to facilitate the knowledge sharing and reuse.

Ontology has played a significant role in CoBrA as it support the server (named as context broker) and shares the contextual information within agents and allows to perform context reasoning [13]. The architecture CoBrA (context broker agent)[13] support the construction of generic context aware systems for various intelligent space such as smart house, smart car, etc. It presents a collection of ontologies called COBRA-ONT to model the contextual information of the intelligent environment. The OWL has been used to model COBRA-ONT where the simple concepts have been defined in association with places, agents and events [13].

Another intelligent environment based application i.e. Service-Oriented Context-Aware Middleware (SOCAM) uses the ontology to provide a typical prototype of context-aware services in an intelligent environment. In this application, the two separate ontologies have been defined (i.e. upper ontology and domain-specific ontology). The upper ontology is collecting the general concepts of the physical world and includes classes, such as, "computational entity", "location", "user" and "activity". While, the domain based ontologies are defining the set of low level ontologies that provides the detailed view of the domain based concepts and relationships [14].

2.2. Context Based Reasoning

Context based reasoning is another important aspect in context based applications as it gives a provision of inferring the new information from the gained knowledge of the physical environment.

Basically, three classifications of context based reasoning techniques are known such as, case based reasoning, rule based reasoning, and collaborative filtering [1]. The case based reasoning is used to provide the required solution to a new problem after the analysis of the similar previous problems of a particular application [9]. But, this approach requires the backup of user related data in advance, otherwise it may generate the inaccurate results. Another approach is the collaborative filtering approach which performs the user personalization by collecting the opinions and reviews in a smart environment. However, it does not require any specific model as that required by other approach and only suggests some relevant services on the basis of the previous similar results. The third approach i.e. the rule based reasoning.

This technique was employed by the Skillen et al. [1], the SWRL based rule based reasoning made the user personalization and knowledge retrieval[12].

The Rule Markup Language (i.e. RuleML) and OWL (Web Ontology Language) integrates to form SWRL. It enables the users to write the rules to reason about OWL based instances and infer the new knowledge from them. A SWRL rule consists of two parts i.e. antecedent part and another is the consequent part. Both these antecedent and consequent have certain positive conjunctions of atoms which indicate: 'if all those atoms present in the antecedent are true, then those in consequent part must also be true'.

2.3. RFID (Radio Frequency Identification)

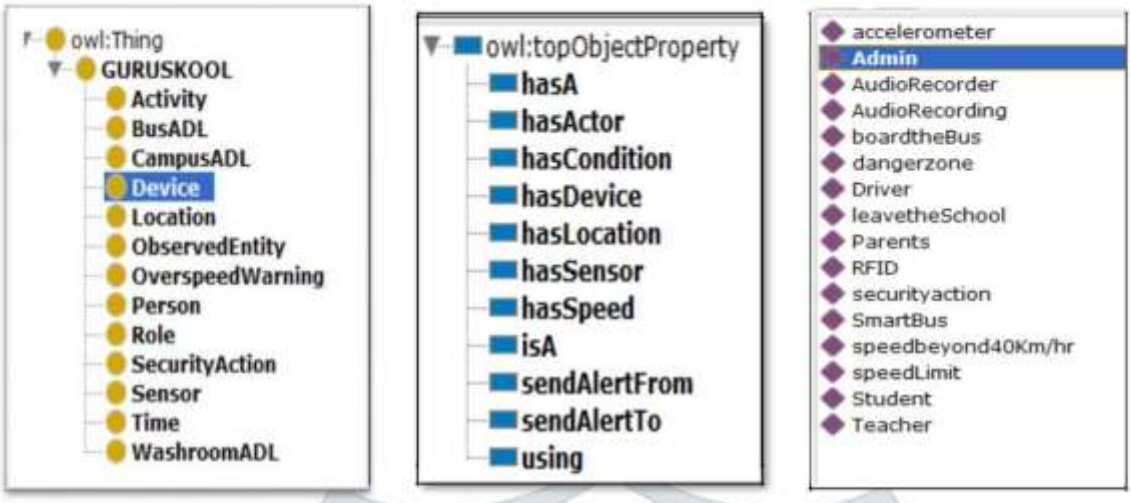
The RFID (Radio Frequency Identification) technology has been used for the identification and location detection of the individuals by many researchers as it provides each object a unique identifier and using which an object can be monitored and identified in any smart environment. The technology basically contains three components, first is the reader, an electronic tag and the antenna. There exists a wireless connection between the tag and the reader. An RFID tag is the combination of a

transponder (combination of transmitter and responder) and the antenna. In the RFID based process, first the reader passes a radio signal to read an RFID tag and as a consequence the transponder gets activated, this then sends data back to the transceiver. And the moment the transponder enters the read zone, the reader then captures the data which then transferred using the standard interfaces to a host computer, or programmable logic controller for database storage or action [11].

III. ONTOLOGICAL MODEL/APPROACH FOR SMART SCHOOL

An RFID based Smart School Ontological Model has been presented in this paper. The main goal of this contribution is to provide a better security management of the school going children. Here, the RFID tags are embedded in the school children's id-cards, and the RFID readers with antenna are placed in the school buses and the school campus to facilitate the tag scanning as well as location checking. In order to meet the requirement from the student's security perspective, the GuruSKool's service has provided the unambiguous clear expression in daily life of students, the decision support for safety service and the accurate contextual based reasoning [10].

The famous ontological editor i.e. Protégé 5.2.0 has been used to perform the formal conceptualization of the relevant concepts related to the smart school domain. Figure 1 demonstrates the related classes, properties and instances.



a. Classes b. Properties c. Instances

Figure 1: Illustration of the Classes, Properties and Instances of GuruSKool

GuruSKool is the main class that contains *'Activity', 'BusADL', 'CampusADL', 'Device', 'Location', 'ObservedEntity', 'OverspeedWarning', 'Person', 'Role', 'SecurityAction', 'Sensor', 'Time', 'WashroomADL'* as its subclasses. The classes such as *'Activity', 'Location', 'Person', 'Sensor', 'Role', 'Time'* represents the core concepts of any smart space. The same can be visualized using the Protégé 5.2.0 plugin called 'Ontograph'.

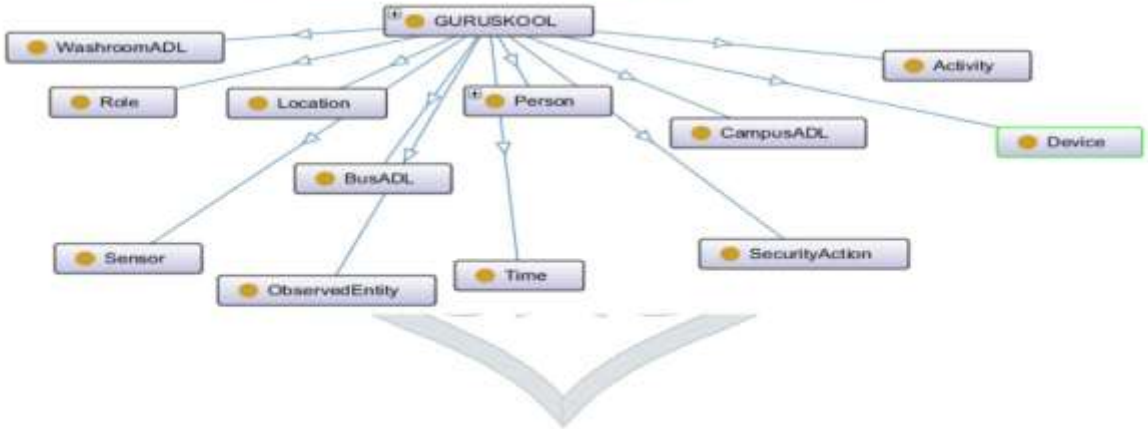


Figure 2: Visualization of the Smart core concepts in 'OmtoGraph'.

The same ontology can have two separate levels i.e upper level and lower level, the upper level core concepts with their interrelationships have been depicted in figure 3.

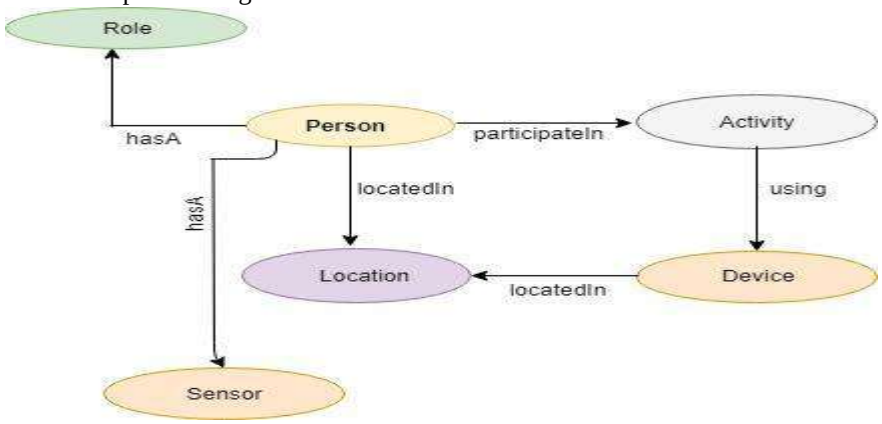


Figure 3: The Upper level Ontological approach

The above figure (Figure 3) ontology demonstrates the upper level ontology of the GuruSKool's service along with its properties. While in the figure 4, the key concepts of the smart school based ontology has been defined and hence called as domain based ontology of GuruSKool.

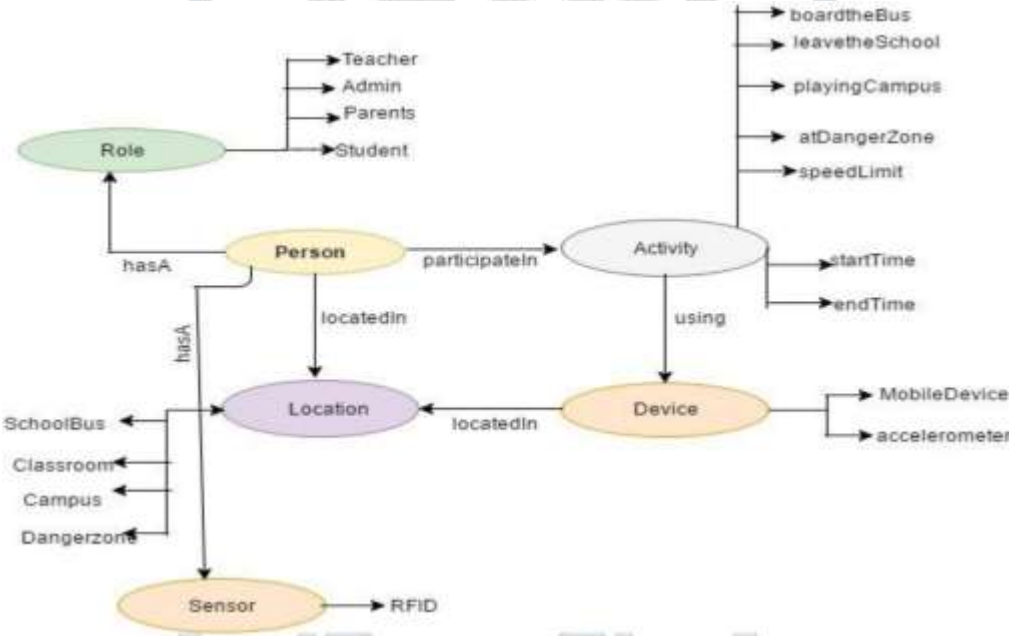


Figure 4: The GuruSKool's Ontology

In order to develop a child security service, the interaction among the persons such as Student, Parents, Admin and Teacher is an important point of concern. For example, the Student regularly goes to the school and is associated with other classes of the ontology such as Location and Activity as children are mobile are involved with some activity. The Location class is the generic term used for all types of locations in a school and contains *School Bus, Classroom, Campus and Dangerzone* as its individuals. The Device class contains *accelerometer* and Mobile Device as its individuals. Moreover, each student at a particular time is involved with a particular activity and same thing has been depicted in the ontological approach. This ontological model later on will be attached to the proposed model that has been described in the next section.

IV. PROPOSED MODEL FOR SMART SCHOOL'S SECURITY

In recent years, the crime against children is increasing day by day all over the world and therefore, it is the high time to offer the safety support system to the school going children. This paper focuses on delivering the smart solution to the children tracking system of every child attending school. In the above architecture, several components can be observed and among these the GuruSKool's database is the component whose working depends on its sub components such as the pellet reasoner, an OWL based ontological model/approach and SWRL reasoning rules. The GuruSKool's application takes the input from RFID sensors where an RFID tag has

been attached to the id cards of each student and when the RFID tag are scanned by the RFID reader (placed either at the smart school bus or in several zones of the smart school campus), then the entire student's related information stored in that electronic tag gets transferred via server to the GuruSKool's database.

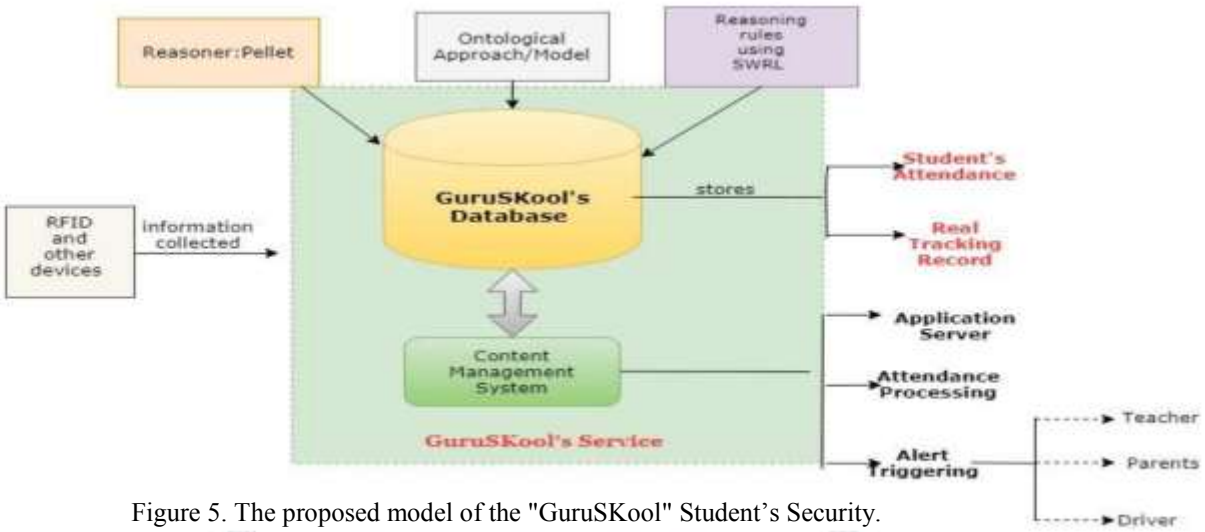


Figure 5. The proposed model of the "GuruSKool" Student's Security.

And, this database then can be accessed by the attached content management system which supports the two main tasks first is *Attendance Processing* and the second is *Alert Triggering.* The *Attendance Processing* module as its name suggests will deal with the automatic attendance of the students. And, the *Alert Triggering* on the other hand, on the basis of the real time collected data sends the real time updates to the various care takers of the children (i.e. Teacher, Parents and Driver). Furthermore, the database has facilitated the records of student's attendance and real time tracking records for future reference.

Parents while sending their wards to the schools often found doubtful about the safety of their children and demands for the adequate measures from the school management to resolve the child's security [15]. This paper is concerned with the same problem and therefore has proposed a smart school based service called GuruSKool's service whose fundamental architecture has sbeen provided in figure 5. The student security otology is enabled with the RFID technology and some other devices such as accelerometer, GPS and audio recorder etc. Each student is carrying an RFID tag which has been placed at each identity card of the student. Whenever this RFID tag is scanned by the RFID reader (placed at the door of the school bus, or at the entrance of the school campus and classroom) the student related information programmed in that tag get transferred to the GuruSKool's database via server. Thus, the service then acknowledges the location of the students and accordingly sends the alert update to the parents and also marks the attendance of the students. Further, the main component of the GuruSKool's database that support the working of the whole mechanism includes the SWRL rules, application server, and the reasoner. The SWRL are used for sending the personalized alerts after the analysis of certain conditions. The reasoner (such as Pellet [1]) has been attached as a key component and is used to reason about the information in the knowledge base to accomplish the ultimate purpose of formulating the new conclusions or inferring new concepts [1]. Moreover, in order to improve the capability of the reasoning that is built into the Ontology that is quite insufficient in terms of expressivity, particularly when used alone. The OWL or RDF are incapable of representing the additional things therefore, the SWRL has been used [1]. The SWRL-based rules are made up of an antecedent and a consequent; these rules can be used together with OWL constructors to ensure the decidability, soundness and completeness in reasoning [5]. Additionally, it can be observed from the figure 5 that the content management system has been attached to the GuruSKool's database and whenever the RFID tag get detected by the RFID reader which then automatically marks the student's attendance by collecting the relevant information of the student from the database and accordingly sends scenario based alerts.

V. SCENARIO BASED IMPLEMENTATION

The scenarios presented below are demonstrating the inferences for the GuruSKool‟s student security management system. Several possible situations have been discussed so that the security of the school going children could by tracked and when they found in certain dangerous situations, then activity monitoring system will generate the appropriate alert and notification to various care-takers(parents, teacher and students).

SCENARIO 1: ADMIN TO PARENT NOTIFICATION

The first scenario performs the security action by sending the real time alert to the parents of the children. Each student of GuruSKool carries a RFID tag with them, and whenever that tag (carries the student profile with information such as name, gender, class etc.) get read by the RFID reader (placed at the door of the smart bus), then all the student‟s information get transmitted to GuruSKool‟s database. The database then performs activity recognition to identify the current activity of the student, and then accordingly sends a notification to the parents saying, “Your ward has boarded the bus successfully”. Following is the SWRL rule describing the above mentioned scenario.

```
BusADL(?ba)^hasSensor(?ba,RFID)^hasLocation(?ba,SmartBus)^hasActor(?ba,Student)
 ->ObservedEntity(boardtheBus)^SecurityAction(securityaction)^
sendAlertFrom(securityaction,Admin)^sendAlertTo(securityaction,Parents)
```

Figure 6. SWRL rule to send notification from GuruSKool’s admin to parents.

The above rule for sending the alert from admin to parents has been provided where first the instance of the class BusADL has been created as “ba” and along with that some properties and instances have been used that matches the attributes mentioned in scenario1. And, accordingly the RHS of the above rule performs the transmission of alert from admin to parent.

SCENARIO 2 : ADMIN TO TEACHER NOTIFICATION

There‟s a situation comes where the students while playing in playground by accidently reaches the dangerous areas of the school, in that scenario the RFID readers and other sensors placed at different locations of the school tracks the student‟s real time location and send it to the administrator‟s database and as a consequence the GuruSKool’s system then immediately sends the alert to the respective teacher/faculty of the student for immediate help as shown in the figure 7.

```
CampusADL(?ca)^hasSensor(?ca,RFID)^hasLocation(?ca,dangerzone)^hasActor(?ca,Student)
   ->SecurityAction(securityaction)^sendAlertFrom(securityaction,Admin)^sendAlertTo(securityaction,Teacher)
```

Figure 7. SWRL rule to send notification from GuruSKool’s admin to teacher.

SCENARIO 3 : ADMIN TO SMART BUS DRIVER NOTIFICATION

The following rule in figure Fig. 8 is applicable in the areas where slow speed i.e. up to 40 Km/hr is required to be maintained. So, the accelerometers sense the speed of the bus and then accordingly, the alert will get send to the driver to slow down the speed of the bus.

```
BusADL(?bl) ^ hasSensor(?bl, accelerometer) ^ using(?bl, SmartBus) ^ hasCondition(?bl, speedbeyond40Km/hr) ->
SecurityAction(securityaction) ^ sendAlertFrom(securityaction, Admin) ^ sendAlertTo(securityaction, Driver)
```

Figure 8. SWRL rule to send notification from GuruSKool’s admin to bus driver.

VI. CONCLUSION AND FUTURE WORK

Student's safety in schools is of prime concern and various technologies towards this have been explored and discussed like Pervasive computing, RFID, SWRL, Ontology, Context awareness etc. The paper has presented that how ontology can be used to perform the context modelling in a smart school domain to improve the school's security management. Also, some simple scenarios have been illustrated using the context based reasoning with SWRL rules. An RFID enabled Smart School OWL Ontological Model (GuruSKool) using SWRL for student's safety has been proposed. This model may be useful in providing a secure environment for the school going children.

In future, similar models or related algorithms may be proposed along with temporal reasoning concepts.

Ideas from this paper may be further extended to different domains.

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