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FORMALIZING CONTEXT AWARE REQUIREMENT PATTERNS USING ONTOLOGY

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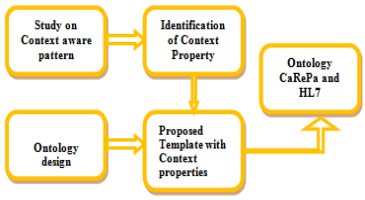
Graphical abstract



Abstract

Requirements patterns for context aware system is challenging due to dynamic and ambiguous nature of context data which remain poorly characterized. A significant amount of research is being done on formalizing context aware systems. However, only few works has been done on requirement patterns which are mandatory to derive complete, consistent and deployable specifications for context data. Since context aware systems with its applications and simulation are still in pilot study. There is a need of formalizing context properties and a methodology to drive the contextual requirements in the system. Further to focus the research problem, empirical study was carried out to investigate context aware pattern properties and different context aware pattern aspects. The contribution of this paper work is to propose ontology based context aware requirement patterns (CaRePa). This CaRePa compared with existing models in context aware patterns. New set of context properties are identified and merged with the CaRePa template. Verification can be performed with the model created using ontology for context aware requirement patterns.

Keywords: Requirement patterns, context aware patterns, pattern template, carepa

1.0 INTRODUCTION

A context-aware system [21] is insistent by the response of individual components and its circumstances. The scope of these applications cooperates with their environments in terms of framework association design normal to pervasive, mobile computing [22], [23].

The contextual environment has a great impact on a specific application segment because the recent needs to adjust in light of changing outside conditions or on the grounds that it depends on assets whose accessibility is liable to persistent change [1].

Context aware system presented in the mid 1990's with the presentation of cell phones. Active Badge [2] utilized infrared correspondence between identifications worn by clients and sensors set in a building to screen clients' location and forward phone calls to them.

In a setting a context aware vehicle application on a roadway collaborates with other vehicle in the same spot/region of a city to gather vehicle movement data. A specific vehicle, driver has no development information about which vehicles will give the activity data; rather the driver knows to gather movement data from other close-by vehicles.

Summed up programming assembled to backing the advancement of connection mindful registering in versatile situations has additionally turned into a center of much more research. The best known among frameworks are the context toolkit [3] and the context fabric [4]. The context toolkit gives deliberations to speaking to connection data through the utilization of setting gadgets. These gadgets gather low-level sensor

data and total it into larger amount data all the more effectively took care of by application designers.

These gadgets structure a library that designers can utilize when developing pervasive applications. The context fabric assaults a comparative issue however utilize a foundation approach. While the context toolkit and context fabric provides greatly for designers to build pieces for developing context based applications.

Requirements patterns [19], [20] were picking up prominence among exploration groups to help researchers in distinguishing, breaking down and organizing necessities of a context aware system framework. At the point when an issue happens again and again in a domain, its summed up arrangement alongside specific strengths that oversee the use of this arrangement is coupled to structure an example. One can reuse design information to take care of repeating issues, while never destroying it the same way twice. Since examples support learning reuse and abstain from reexamining the wheel, they indicate awesome potential to fabricate programming better, speedier and effortlessly.

The dialog above empowers to recognize patterns of contextual frameworks. Patterns use safeguarding of autonomies and interior structures of the information sources joining in the contextual criteria. In patterns the impacts of context are exhibited in wording of context types and recurring information resides it.

In this paper, we formalize context aware systems based on Requirements patterns known as Context aware Requirement Pattern (CaRePa) based on ontology. We start in Section 2 deals about a study of existing architecture models in this area. Section 3 states summary of the context aware requirements patterns. Section 4 identifies common pattern template for context aware systems. Final section provides ontology design for CaRePa and several future works as a concluding remark.

2.0 PATTERNS AND CONTEXT AWARE SYSTEM

There are six works related to context aware system with patterns considered in this section. Among all PABRE, AWARNESS are models then Real time pattern is an approach and Knowledge fusion, CAPOMF are Framework. All these works deals with requirement or design pattern in the context domain. Each of the work discussed in the subsequent subsections.

2.1 PABRE

PABRE (Pattern Based Requirement Elicitation) explore the use of requirement patterns as a method to strengthen early stage of requirements (elicitation) by IT industry professional who work with a client.

It also examine the pattern catalogue to invent a requirement book to be exploited as a part of require fragile (weak) courses of action for the period of call for tender processes. It is customized to the particular instance of requirement delicate business enterprise [9].

PABRE strengthens knowledge endorsement by approach for a reuse structure in weightless of practice. It is very much adaptable to the particular needs of IT industries and institutes. Apart from all these advantages it has limitations too. PABRE acceptance through validation model not yet addressed. Need more workouts for creating software requirement pattern (SRP) layout and its principles like including new functionalities for searching into the SRP list.

To enrich the SRP framework by including new functionalities for the examination of the SRP need to use information and the development of the pattern. At last irregular requirement of client may affect the pattern exploration which is not addressed [9], [10].

2.2 Real Time Patterns

Konard *et al.* [7, 11] made specification patterns for real time in terms of normally utilized temporal logic's. They organized English grammar that incorporates support for real time properties. Finally they took a case study real-world automotive embedded system: Electronically controlled steering (ECS).

In their work, specification pattern classification as given in the structured English. This grammar significantly assists the understanding of the meaning of a temporal logic property, thereby making this approach more accessible to non-experts in formal methods [11].

2.3 Requirement Patterns in Knowledge Fusion

In this paper, the patterns are utilizing to signify the requirements to the information sources from the frameworks to verify the full frameworks functionality. Here, seven patterns are identified in the decision support system while doing knowledge fusion. They are namely simple fusion, extension, configured fusion, instantiated fusion, flat fusion, and adaptation then fusion history pattern.

Here they observed ontological effects which are a new ontology, a new class and its property, relationship etc., a new ontology type and a new type of knowledge source. Application of the identified system patterns over fire safety system. They did not propose any pattern methodology for context aware decision support system [12].

2.4 AWARENESS

AWARENESS is a model which presents three patterns to be specific the event-control-action, the context sources and managers' hierarchy and the actions patterns that can be connected usefully in the advancement of setting contextual services. These patterns present answers for repeating issues connected with overseeing context data and proactively responding upon changes in context [13].

They discussed four pattern ideas namely problem arise situation, recurring situation considered, the

solution steps for structural/dynamic and benefits of applying pattern. Here they consider sensing, aggregating or fusion, inferring and predicting is the context information processing activities.

To validate the work authors took the mobile health application that backing observing the epileptic seizures and uncontrolled movements in spasticity.

2.5 OpenEHR

OpenEHR combins dissimilar areas like ubiquitous, software agent and interoperability. Here interoperability realized by openEHR archetypes. This work can reveal the viability of creating blueprint and realizing a reusable planning for exchange of message to deal with practical scenarios of pervasive healthcare systems [14].

OpenEHR has agents and pervasive computing, and work with standards of healthcare. The main area needs to be focused in this work is to handle the different situations in which healthcare system users performing their tasks with the heterogeneity of devices [15].

2.6 CAPOMF

CAPOMF is a Context Aware and Pattern Oriented Machine Learning Framework. In this work author claims that they proposed context aware services along with machine learning but machine learning is not addressed in detail. It also utilizes the mobile platform with android hardware using sensors. It addresses the potholes application considering the streets of Mumbai. Thought the potholes they provided safety to the vehicles [16].

The CAPOMF introduces the concept of an agent, but it is not addressed in a detail way. Thus the CAPOMF claims that they provides efficient machine learning capabilities and also context-aware services for the effective development of applications but it is not addressed in the architecture in the extensive way.

Table 1 Provides the summary of all the above discussed context aware patterns and its comparative analysis. In the column specifies the characteristics about the work and the rows specify different authors work towards context aware patterns. There works are combination of analysis and design oriented patterns. Whereas, this summary gives an idea stating the need to formalized model and verify the context aware requirement patterns.

3.0 CaRePa TEMPLATE

The reusability concept of patterns significantly saves time in development and gives freedom in deployment through which the necessity of traditional development process is considerably decreased [18]. In addition, using context attributes and its information creates a new pattern for analyst to resolve the problem to adopt with different situations.

Here Figure 1 shows that context property and its corresponding values. What is a context property value? Why it is required? Who are involved in this study? How to arrive these values? All these questions answered with the context aware system's property study [23, 24].

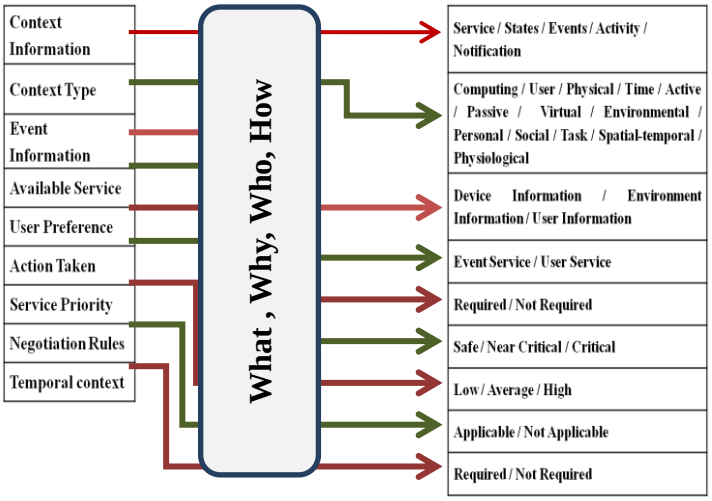


Figure 1 Context property values

In general Gamma *et al*. [6] developed design pattern template then Dwyer *et al*. [5] used to design a requirement pattern based on the design pattern template. Konrad *et al*. [7], [11] and Renault *et al.'s* [9] proposed a requirement pattern template for pervasive system. The proposed pattern template (CaRePa) in this paper, the pattern elements are adopted with Withall's [8] template, the RePa standard template [17], Pattern based requirement elicitation(PABRE) [9], Real time pattern template [11], knowledge fusion patterns and context related attributes based on the common structure we worked out for context aware system. These fields contain semantic description about the patterns as presented in Figure 2 CaRePa context aware pattern template contains the elements and description as given in Figure 2. CaRePa methodology [28] defined in the earlier work was not address the context property in details as mentioned in the Figure 1. So combining the context properties with the earlier work will produce the CaRePa template as given in Figure 2.

Table 1 Summary of Patterns and Context Aware System

Sl. No.	Model	Problem	Methodology	Advantage	Limitation
1	AWARNESS [P. Dockhorn Costa et. al. 2004]	Need solution for recurring problems associated with managing context information and proactively react upon context changes.	Design oriented Pattern	Easy to understand design principle. Help to manage software complexity. Support building complex and heterogeneous architecture.	Need to define condition rules and auto configuration of condition rules. Need of concrete technique to resolve composition of actions.
2	DSS [Alexander Smirnov et. al. 2013]	Pattern identification for knowledge fusion processes in DSS	Fusion	Enable to develop the DSS information requirements. Facilitate solution space for the fusion problem.	Need to address context properties,
3	Reusable Model [Rahul et.al. 2014]	To identify and classify a variety of instances of the different types of reusable patterns.	CAPOMF – Context Aware Pattern Oriented Matching Framework	Ensures scope of reusability, flexibility and maintainability	It address design aspects rather analysis
4	MVC [João Luís Cardoso de Moraes1 *et al*. 2013]	To design architecture which facilitates message exchanging between caregivers of pervasive healthcare systems that available any ware to anyone?	HL7 Standards	Interoperability achieved by message exchange between heterogeneous healthcare information systems.	Performance not addressed Need of improvement in interoperability.
5	No Specific Model [Samuel Renault et. al. 2015]	To select patterns from the catalogue and convert them into real requirements.	PABRE – Pattern Based Requirement Elicitation	Quality addressed using ISO-9126, IEEE830 Reusable and customizable to IT industry need	Quality attributes lacks. Template insufficient to handle context attributes Heaviness of the process
6	Model not specified [Sascha Konrad and Betty Chang 2005]	To address real time specification pattern	Temporal Logic	Timing based requirements. To understand meaning of specification.	Tool support Mobile computing area pattern creation. Context aware methodology which is not addressed.
7	Context 4BPMN [Matthias Wieland et. al. 2006]	To enable modeling and execution of technical production processes with workflow systems.	BPMN Business Process Modeling Notation	Web service approach Context aware workflow modeling	Performance not addressed Context scope Query not addressed

Pattern Elements	Description	
Name	Name of the context aware pattern which serves as a usage of pattern and describe the nature of a pattern	
Context	**RE Activity**	Elicitation / Specification / Validation / All
	Pattern Type	Process / Product
	Stakeholders	Persons that are relevant to this pattern
Problem	Knowledge source of the problem discussed. Problem occurred in the context aware system.	
Forces	Describe conflicting concerns balanced by the pattern type and these potentially conflicting concerns are goals, side-effects, tradeoff, constraints and rationale.	
Solution	Knowledge target of the problem discussed in the context aware system.	
Application and Example	Sample instance of the pattern provided as example and describe the common situation where it can be used.	
Context aware system attributes	**Context Information**	Service / States / Events / Activity / Notification
	Context Type	Computing / User / Physical / Time / Active / Passive / Virtual / Environmental / Personal / Social / Task / Spatio-temporal / Physiological
	Event Information	Device Information / Environment Information / User Information
	Available Service	Event Service / User Service
	User Preference	Required / Not Required
	Action Taken	Safe / Near Critical / Critical
	Service Priority	Low / Average / High
	Negotiation Rules	Applicable / Not Applicable
	Temporal context	Required / Not Required

Figure 2 CaRePa template

4.0 ONTOLOGY AND HL7 IMPLIMENTATION

Study on context aware system provides ideas to identify context properties. The identified properties and ontology design are used to propose a pattern for context aware system-CaRePa. Finally, the ontology for CaRePa and HL7 standard are constructed as given in Figure 3.

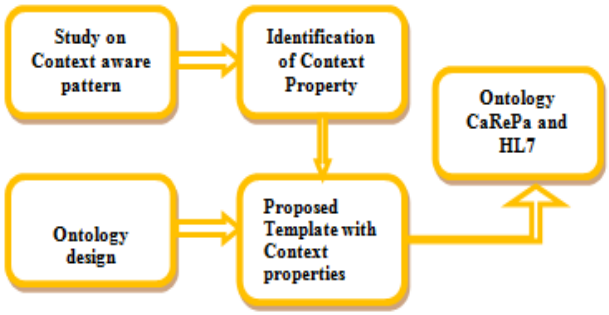


Figure 3 Design process of CaRePa-ontology

This section explains about the usage of the CaRePa template into the real existence. A pattern for selection of contextual domain is represented in subsection 4.1. Then the CaRePa ontology discussed in subsection 4.2. Finally, usage of HL7 standard is discussed with the help of Caristix reader tool [27].

4.1 A Sub Pattern of CaRePa

Here, domain pattern discussed with the use of pattern template proposed in the section 3.

Pattern Elements	Description	
Name	Contextual domain selection	
Context	**RE Activity**	Elicitation
	Pattern Type	Process
	Stakeholders	Requirements Engineer, Analyst
Problem	To select the contextual domain	
Forces	Select a domain where there is a crucial problem for the organization or, by side effect, in other domains of interest for the organization. A side-effect is that the analyst may worry overmuch about contextual information of the domain not present.	
Solution	The domain that is important for the organization or the society, its importance, and the need to smooth things.	
Application and Example	Any application must explicitly request the domain selection, for example the healthcare System.	
Context aware system attributes	**Context Information**	Service
	Context Type	Environmental
	Event Information	Environment Information
	Available Service	User Service
	User Preference	Required
	Action Taken	Not Applicable
	Service Priority	Low
	Negotiation Rules	Not Applicable
	Temporal context	Required

Figure 4 Domain Pattern

4.2 CaRePa Ontology

There is some discussion regarding ontology's and software engineering concepts however both match along, and how each community will learn from one another. As a [24] contribution to the current process, Authors tend to given some of the patterns that use ontology in a engineering context during this paper [25], [26].

Here is the ontology graphical design for the CaRePa. This can be converted from Resource Description Framework file which can be validated and uploaded into the server. Then the verification of the model is conducted with SPARQL query analyzer to ensure the performance. SPARQL in the Fuski server can enhance the context aware property and performance of the CaRePa can be the help of query analysis.

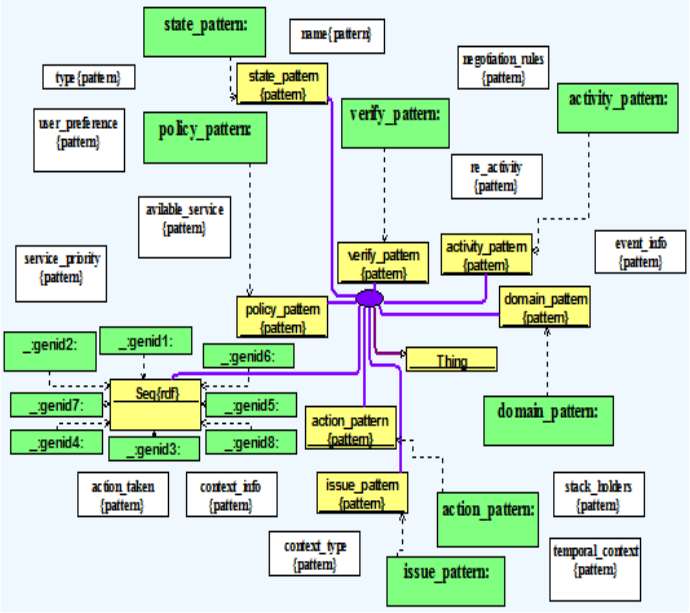


Figure 5 Graphical diagram of CaRePa Ontology

4.3 HL7 Std. (Carstix)

In the domain of healthcare, Health Level 7 (HL7) have developed meta data standards for handling electronic health information to facilitate interoperable communication.

As a way of illustration a screenshot of caristix reader showing the applied metadata standard that will be used as design for CaRePa catalog.

Pattern based health care architecture consist of several levels. Each level address the corresponding major functionalities used in that level. Figure 6 depicts the levels and its role in health care system. Over all levels it shows how health records shared to other systems and users with the help of HL7 standard.

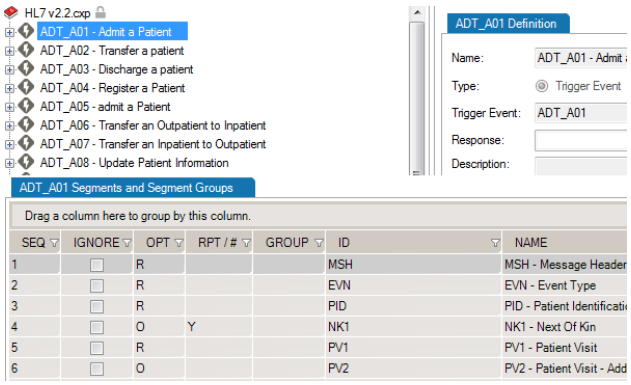


Figure 6 HL7 Carstix Tool

5.0 SUMMARY AND CONCLUDING REMARKS

In section2, we have discussed six different works related to patterns in context aware systems. These works are summarized based on three major categories which have metrics to measure.

The categories are pattern type, usage of pattern and evaluation. The metrics in the pattern category is requirement pattern or design pattern. Then the usage of context aware methods has four metrics namely context, agents, fusion and interoperability. Finally, evaluation category has a metrics application based evaluation and validation/verification based evaluation. The above discussed patterns and context aware system with pattern categorized based on the metrics which are presented in the Figure 7. Comparatively CaRePa has satisfied more metrics by the way of providing necessary usage of pattern and evaluation method adopted in the system model.

Patterns and Context Aware Systems	Pattern		Usage				Evaluation	
	Require -ment	Design	Context	Agents	Fusion	Interoper ability	Application Based	Validation / Verification Based
PABRE [9]	✓					✓	✓	✓
Real time Specification pattern [11]	✓		✓			✓	✓	✓
Fusion Method [12]	✓		✓		✓	✓	✓	
AWARENESS [13]		✓	✓	✓			✓	
OpenEHR [14]		✓	✓			✓	✓	
CAPMOF [16]		✓	✓	✓		✓	✓	
CaRePa	✓		✓	✓	✓	✓	✓	✓

Figure 7 Comparison of CaRePa with existing system

The significance of proposed CaRePa template has its ability in providing requirement patterns and handling richness of contextual data. The template is introduced based on the existing work and the surveyed models. It is of relevance to review supplementary context-aware pattern based systems to fit them into the presented pattern template or even determine whether they fit into the pattern template. It can be visualized with additions or even changes might prove useful, although we believe that the introduced pattern template will fit most of the context aware systems.

In future CaRePa have to be built for a specific context aware system like health care system, context based vehicular system etc. Then the implementation architecture produced based on the identified context aware requirement patterns. There is a need of CaRePa process method which provides unique process steps to achieve requirements to implementation in the context aware systems.

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