



Software Process Ontology: A case study of software organisations software process sub domains

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Abstract

In a domain like software process that is intensively knowledge driven, transforming intellectual knowledge by formal representation is an invaluable requirement. An improved use of this knowledge could lead to maximum payoff in software organisations which is key. The purpose of formal representation is to help organisations achieve success by modelling successful organisations. In this paper, Software process knowledge from successful organisations was harvested and formally modelled using ontology. Domain specific knowledge base ontology was produced for core software process subdomain, with its resulting software process ontology produced.

Keywords: Software Process, Software Process Ontology, Ontology, Knowledge, Formal Representation, Knowledge Representation

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1. Introduction

Software process is a knowledge driven and knowledge intensive process that involves several other sub-processes. Software process can be defined as the set of related activities that are used in developing software. Knowledge in Software Engineering (SE) is diverse and organizations have problems capturing, retrieving, and reusing it. An improved use of this knowledge is the basic motivation and driver for Knowledge Management (KM) in SE [1-23].

Harvesting, representing and reusing knowledge within a domain leads to maximum payoff, which is desirable in most organisations [23]. Knowledge Management (KM) is defined as an effort to capture critical knowledge and share it within an organization [3, 17]. It capitalizes on the collective organiza-

tional memory to improve decision making, enhance productivity, and promote innovation [18, 19].

It is also the process of transforming information and intellectual assets into persisting value. KM connects people with the knowledge that they need to take action, when they need it [20]. Knowledge management involves the identification and analysis of available and required knowledge [21] and helps an organization to gain insight and understanding from its own experience. Specific knowledge management activities focus on acquiring, storing and utilizing knowledge for problem solving, dynamic learning, strategic planning and decision making. This prevents intellectual assets from decay, adds to a firm's intelligence and provides increased flexibility [22].

SE comprises several interrelated subdomains such as Requirements, Design, Coding, Testing, Project Management, and Configuration Management. There are several software process models which describe the sequence of activities carried out in developing software. These software process models are a stan-

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standard way of planning and organizing a software process. The major phases are requirement gathering, design and coding, implementation and maintenance. It has been identified that there are few works in literature that aim at developing ontologies covering wide portions of the SE domain, such as [4-6].

A lot of SE domain ontologies model SE subdomains [7-11]. Ref. [12] described these subdomain ontologies as weak or not interrelated, and are often applied in isolation. Thus he made an attempt to provide an integrated solution for better dealing with KM-related problems in SE by means of a Software Engineering Ontology Network (SEON). It was designed with mechanisms for easing the development and integration of SE domain ontologies, covering the main technical software engineering subdomains (i.e requirements, design, coding and testing). However, he only represented a small portion of software engineering ontology. [7], identified that the combination of ontologies of all SE subdomains would result in an ontology of the complete SE domain. He further stated that the reality is that this goal is extremely laborious, not only due to its size, but also due to the numerous problems related to ontology integration and merging, such as overlapping concepts, diverse foundational theories, and different representation and description levels, among others. He concluded that despite the challenges involved, an ontological representation covering a large extension of the SE domain remains a desired solution. This paper represents a software process ontology covering major SE subdomains (i.e. requirement gathering, design and coding, implementation and maintenance).

2. Related Literature

Ontologies have been widely recognized as a key enabling technology for KM. They are used for establishing a common conceptualization of the domain of interest to support knowledge representation, integration, storage, search and communication [2]. A domain ontology identifies the key concepts, objects and entities that exist in some knowledge domain or area of interest and the relationships between them [15, 16]. Ontologies play a significant role for knowledge sharing and as knowledge models in instructional science, technology-enhanced learning, knowledge management and training [15, 14, 13]. Ontologies consist of instances, properties and classes, where instances represent specific project data, properties represent binary relations held among software engineering concepts/instances, and classes represent the software engineering concepts interpreted as sets that contain specific project data [25]. [7], did an extensive review of SE ontologies, where he classified them into generic and specific ontology. Generic SE Ontologies, have the ambitious goal of modeling the complete SE body of knowledge; while Specific SE Ontologies, attempting to conceptualize only part (a subdomain) of this discipline.

The management of knowledge and experience are key means by which systematic software development and process improvement occur. Within the domain of Software Engineering (SE), quality continues to remain an issue of concern. Knowledge Management (KM) gives organizations the opportunity to ap-

preciate the challenges and complexities inherent in software development [24].

Successful organisations continuously improve their processes. Like organisational standard process definition, systematic process improvement is more effective and efficient if it is done guided by process quality models and standards. The purpose of most standards is to help software organisations achieve excellence by following the processes and activities adopted by the most successful organisations [26].

3. Methodology

Two complementary methods were used for data collection. They are: case study and interview methods. For the case study, four (4) Software Development Organizations was studied. For reason of privacy and confidentiality, the organizations studied are not referenced by their names. Table 1 shows the details of the organisations.

From Table 4, the domain concept, the data value/property and the instances are specified. For example the entity domain expert in number 9 has the property: name that can take a data value string, data property domain that can take a data value string and a data property years of experience that can take a data property integer. It also has instances of the class as: business rules and directory of experts. Figure 6 shows the domain concepts and their instances

4. Result

Four main subdomains were identified as knowledge entities in a typical software development process irrespective of the life cycle model adopted: Requirements Definition, Design & Coding, implementation and maintenance. These are core human centric activities performed by developers that create opportunities for sharing tacit knowledge during the software development process. This research used both inductive and deductive analysis by first identifying keywords related to software development process and then grouping the keywords into categories related to requirements definition, coding, implementation and maintenance. For each process activity, a Union of the useful themes obtained each case study was used to determine the useful knowledge constructs for that activity. That is, for each Process Activity (PA), Knowledge Harvested (KH) for the software process is given as

$$KH(PA) = \text{Case 1}(PA) \cup \text{Case 2}(PA) \cup \text{Case 3}(PA) \cup \text{Case 4}(PA) \quad (1)$$

5. Software Process Ontology

There is no globally accepted methodology for Ontology construction [28] but the development is usually an iterative process. A 5-step iterative process from [29, 30] was adopted for the Ontology construction:

Table 1: Details of the organisations

Case Study	Years of existence	Software Area
1	15	Human resources systems, Payroll systems, and portal for schools.
2	22	Banking solutions, Human Resource management systems, Process Control Systems, Payroll Systems, Security systems, Materials management systems
3	10	security solutions, and Web Development
4	12	Human resource Management Systems, Third Party Online Payment Solutions, Payroll and other financial systems

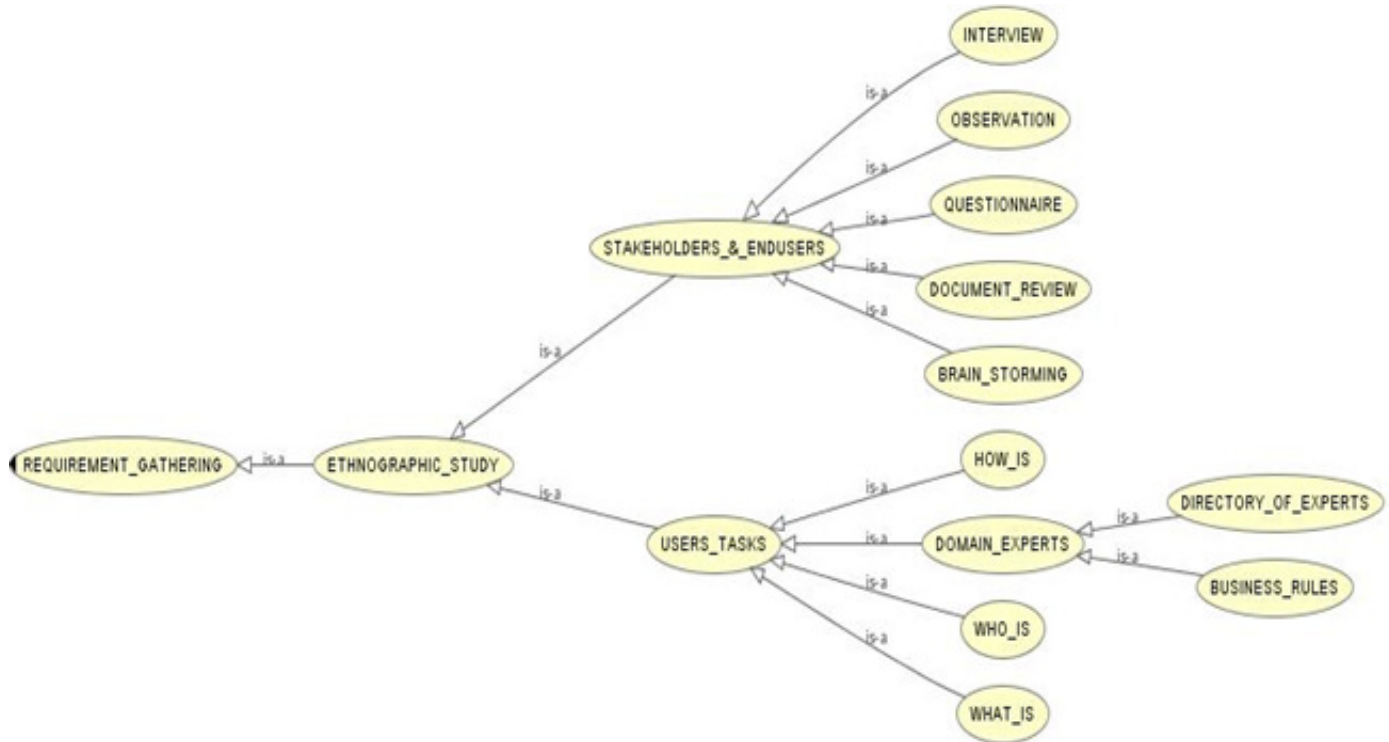


Figure 1: Requirement Definition Sub-domain Ontology Visualization

• Step 1: Identify the key concepts of the domain

The first step in the Ontology building process is to identify the concepts and map them into the relevant knowledge entities. To provide clarity and efficiency in the formal representation of software process knowledge, the concepts from the harvested knowledge were categorized into the four main knowledge entities:

1. Knowledge-Creation
2. Knowledge-transfer
3. Knowledge-sharing
4. Knowledge-documentation.

Each concept (Table 2) connotes a software process activity that describes a task, function, action, strategy, or reasoning process. A Concept is a collection of objects. It is the fundamental element of a domain and usually represents a group or class whose members share common properties [30]

• Step 2: Organisation of the concepts into a hierarchy

The purpose of this categorization is to establish a systematic relationship between the knowledge entities and the specific software development process activities. Competency questions was used here in creating the ontology. Competency questions as defined by some methodologies for ontology engineering describe what kind of knowledge the resulting ontology is supposed to answer. According to [27] one of the ways to determine the scope of the ontology is to sketch a list of questions that a knowledge based on the ontology should be able to answer. The following competency questions were used:

1. Ethnographic study in requirements gathering involves the study of?
2. What are the processes for gathering requirements from stakeholders and end-users?
3. What are the processes of software development?
4. What are the physiological processes for blocks resolution during coding?

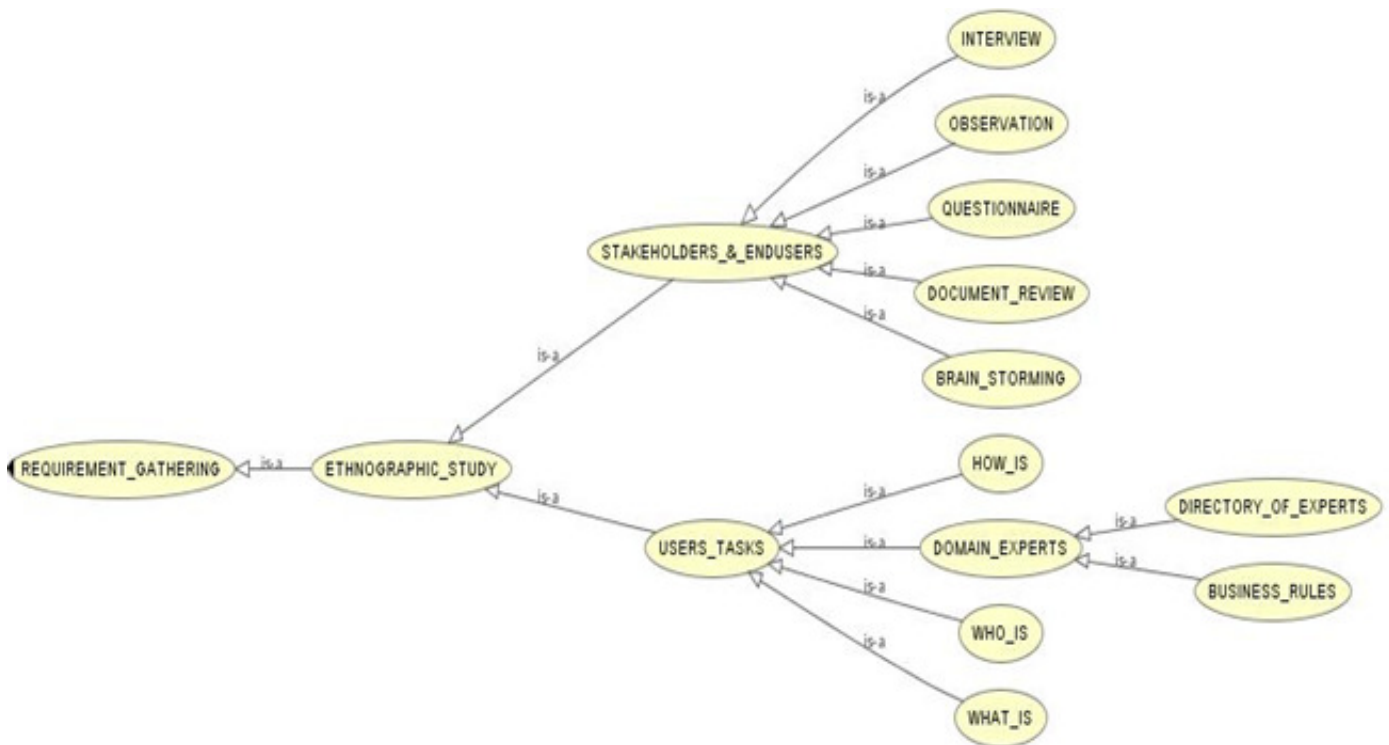


Figure 2: Design and Coding Sub-domain Ontology Visualization

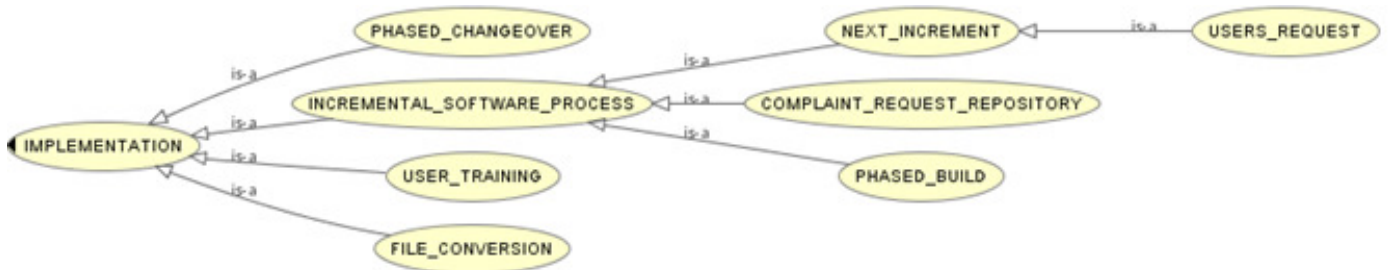


Figure 3: Implementation Sub-domain Ontology Visualization

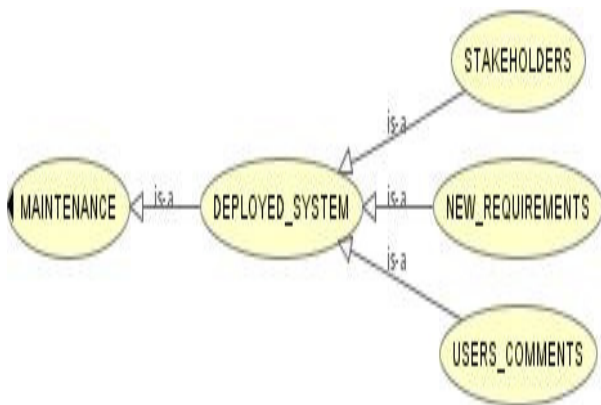


Figure 4: Maintenance Sub-domain Ontology Visualization

5. What are the appropriate approach to software design?
6. What are the people and processes involved in user tasks?
7. What are the tools used in ethnographic study of stakeholders and end-users?
8. What are the stages involved in implementation?
9. What does a deployed system need for maintenance?
10. Who can business rules be obtained from in a domain?
11. How can low bus factor issues be handled in coding?
12. How can code ownership issues be resolved in coding?
13. How can knowledge be shared in software process?
14. How can knowledge be transferred in software process?

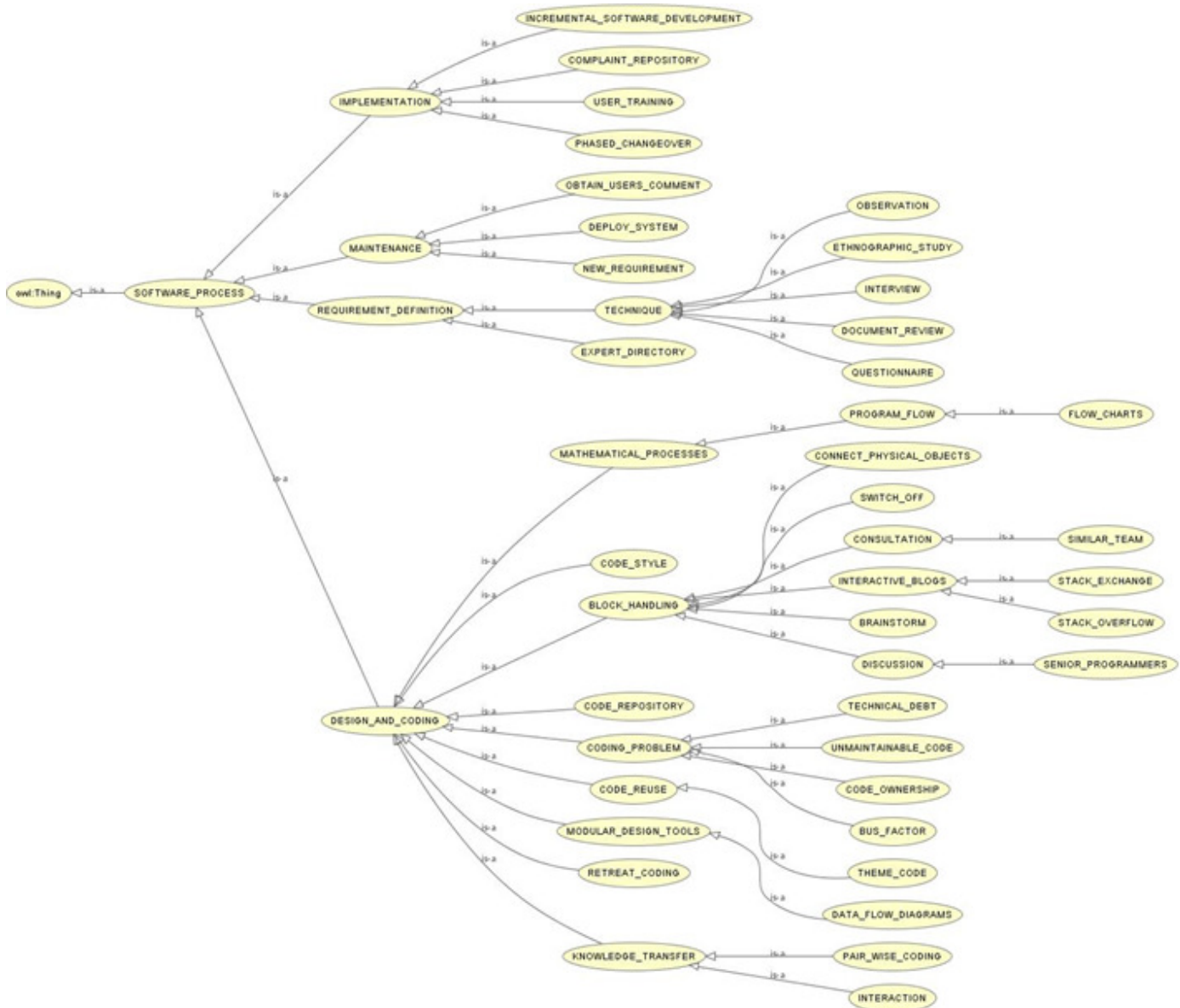


Figure 5: Software Process Ontology Visualization

- **Step 3: Determine the properties of each class**

Every objects have both data property and object property. The object property shows the relationship between classes or instances, and the data property shows the relationship between instances and the data value. It provides a logical relationship between objects. Tables 3 and 4 present sample Object and Data property defined for some objects in the software process ontology.

- **Step 4: Add logical expressions**

Axioms represent assertions formulated in a logical form that together comprise the core knowledge that the ontology describes in its domain of application. They are used to model sentences that are always true. They provide a powerful way to add logical expressions to ontology and they are used to verify the consistency of the ontology.

Axioms are usually added by default in protege.

- **Step 5: Create the ontology**

Protégé 5.0 was then used to build the software process knowledge ontology, with its subdomains as shown in Figure 1-5

6. Discussion

The requirements definition (figure 1) is the first stage in software development process. It is a very critical phase. A major finding from the organizations studied is that Ethnography study was used to obtain the software requirements. It involves studying the organization's culture to understand the key elements and observable patterns of behaviour. This usually requires interaction between stakeholders from the software de-

Table 2: Knowledge Entities and software process Concepts

Knowledge Entities	Software Process Concept
Knowledge Creation	Ethnographic study Stakeholders -New requirement - Users comment Exit interviews Domain experts -Business rules Questionnaire Document Review Block resolution Users Request
Knowledge Transfer	Knowledge Retention Business rules User Training Mentoring Pair wise coding Code review Interactive blogs
Knowledge Sharing	Experienced programmers Team interaction Bus factor User tasks Code ownership Version control What-is Who-is How-is
Knowledge Documentation	Directory of experts Requirements document Code repository

improvements to this paper.

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Table 3: Object Property

s/n	Object Property	Domain	Range
1	Identifies	Ethnographic study	Stakeholders, Users tasks
2	Todetermine	Users tasks	Who is, What is, How is
3	Require	Maintenance	Deployed system
4	ToObtain	Domain experts	Business rules
5	Through	Implementation	Incremental Software Process, Phased changeover
6	Using	Design	Modular design, Mathematical process
7	With	Modular design	Data flow diagram
8	ByGoingTo	Block Resolution	Senior and experienced programmers, Problem domain, Physical objects, Interactive blogs, Definition and design, User requirements
9	ObtainedFrom	Deployed System	Users comments, Stakeholders
10	RequirementElicitationThrough	Stakeholders and Endusers	Observation, Interview, Document review, Brainstorming, Questionnaire
11	TransfersKnowledgeThrough	Coding	Code review, Pairwise coding

Table 4: Data Property

S/N	Domain Concept	Property/Data Value	Instances
1	Ethnographic study	Purpose(string), target(string), finding(string)	Stakeholders and EndUsers, User tasks
2	Coding	Title (String), Phase(string)	Code Review, Knowledge Retention, Generic application, Unique code, Pairwise coding, Block resolution
3	Design	Name(string), Model (string)	Modular design, Mathematical Process
4	Users tasks	Name(string), specification(string)	Domain experts, Who is, What is, How is
5	Maintenance	Date(date), details(string)	Deployed System
6	Implementation	Title(string), purpose(string), finding(string) Name(string)	User Training, File conversion, Incremental Software Process, Phased changeover
7	Deployed system	(integer), date(date)	New Requirement, Users comments
8	Incremental Software Process	process no(string), date(date)	Next increment, Phased build, Complaint request repository
9	Domain Experts	Name(string), domain(string), years of experience (integer)	Business rules, Directory of experts
10	Stakeholders and end users	Name(string), organisation (string), portfolio (string), domain (string)	Observation, Interview
11	Block resolution	Definition and design (string), problem domain (string), experience programmers (string), interactive blogs (string), physical objects (string)	Document review, brainstorming, senior and experienced programmers, problem domain, physical objects, interactive blogs, definition and design

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