

The Context Analysis of Problematic Activities in New Product Development Processes

I-Hsiu Yin, Chao Ou-Yang, and Yeh-Chun Juan

Abstract—New product development (NPD) consisting of multitudinous activities is a big and complicated process. The context analysis, i.e. tracing the influential upstream activities and affected downstream activities, for a problematic activity is important for NPD process management. This research has proposed a three-phased context analysis approach for a problematic activity in NPD processes. First, the NPD process definition phase uses Design Chain Operations Reference-model (DCOR) to describe and determine the scope of a NPD process. Next, the context analysis phase applies the relativity of NPD activities to key performance indices (KPIs) to filter the influential upstream activities and affected downstream activities. Finally, the system implementation phase implements the proposed approach with an ontology tool, Protégé.

Keywords: New product development, context analysis, DCOR, ontology, weapon system

I. INTRODUCTION

THE new product development (NPD) has played an important role in research-intensive enterprises. NPD processes consisting of multitudinous development activities are a big and complicated process. When a problematic NPD activity appears, the context analysis, i.e. tracing the influential upstream activities and affected downstream activities, for the problematic activity becomes important for NPD process management.

To support the design chain planning, Supply-Chain Council (SCC) has proposed the Design Chain Operations Reference-model (DCOR). Besides, the ontology techniques have been proposed and applied to process knowledge management and process reasoning recently.

Therefore, this research has applied DCOR and the ontology techniques to propose a three-phased approach to the context analysis for a problematic activity in NPD processes. First, the NPD process definition phase uses Design Chain Operations Reference-model (DCOR) to describe and determine the scope of NPD process and activities. Next, the context analysis phase applies the relativity of NPD activities to KPIs to filter the influential upstream activities and affected downstream activities. Finally, the system implemen-

¹ Manuscript received January 5, 2013; revised January 26, 2013. This work was supported in part by the National Science Council, Taiwan under project No. NSC 101-2221-E-131-031.

I. H. Yin is with the Department of Industrial Management, National Taiwan University of Science and Technology, Taipei, Taiwan 10607, ROC (e-mail: yin666.michael@gmail.com).

C. Ou-Yang is with the Department of Industrial Management, National Taiwan University of Science and Technology, Taipei, Taiwan 10607, ROC (e-mail: ouyang@mail.ntust.edu.tw).

Y. C. Juan is with the Department of Industrial Engineering and Management, Ming Chi University of Technology, New Taipei City, Taiwan 24301, ROC (To whom correspondence should be addressed. phone: +886-2-2908-9899#3107; fax: +886-2-2908-5900; e-mail: ycjjuan@mail.mcut.edu.tw).

tation phase implements the proposed approach with an ontology tool, Protégé.

II. LITERATURE REVIEW

To provide the basis and context for this research, DCOR and ontology have been outlined below.

A. Design Chain Operations Reference-model (DCOR)

The DCOR for product development [1] shown in Fig. 1 was released by SCC. DCOR framework includes three levels. Level 1 uses five basic management processes, including Plan (P), Research (R), Design (D), Integrate (I) and Amend (A), to define the scope and content of design chain operations. Level 2 classifies the management processes R, D and I into three process categories: Product Refresh (1), New Product (2) and New Technology (3). Level 3 decomposes Level 2's process categories into process elements.

Each Level 3's process element also provides much valuable referable information, including the required input (source) and output (destination), key performance indices (KPIs) and best practices that produce the best-in-class performance [1]. Additionally, each process element in DCOR Level 3 has a code name. For example, D2.1 represents a Design (D) element which is suitable for new product design (2) and is related to receiving, validating and decomposing the design requests (.1).

Therefore, companies can configure their own product development process with DCOR process elements (Level 3).

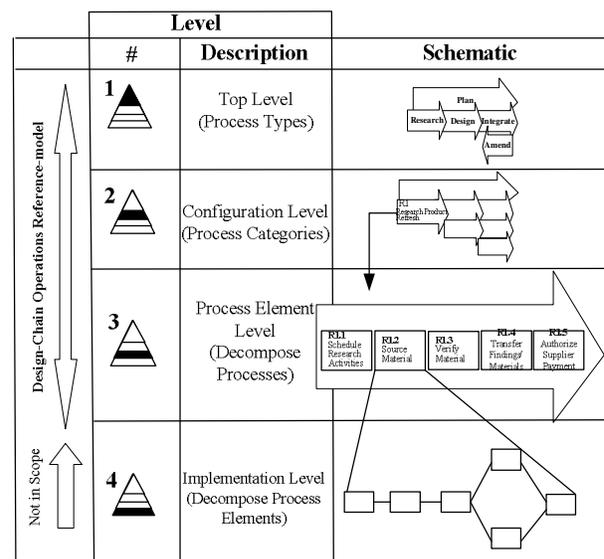


Fig. 1. DCOR framework [1]

Moreover, DCOR suggests that companies should extend their DCOR model to Level 4 using company-specific processes, systems, and practices to achieve competitive advantage and adapt to changing business conditions. But, no standard process notation and convention is defined in DCOR for Level 4.

B. Ontology

Recently, ontology techniques have been used for process knowledge management (KM) and process reasoning. Koschmider and Oberweis [2] used Web Ontology Language (OWL) combining with other techniques to help coordinate cross-organizational business processes. Martin and Dumitru [3] proposed Semantic Business Process Management (SBPM) to increase the degree of automation in translating the perceptions of organization's processes and available resources. Pedrinaci and Domingue [4] proposed an ontology for process monitoring and mining. Dimitrov et al. [5] proposed a SUPER approach which can be augmented with semantic annotations, so that formal reasoning techniques can be applied for discovery, composition, mediation and execution of business processes. Cabral et al. [6] developed related knowledge representation and reasoning techniques to help the workflows refer to semantically annotated data and services, incorporate heterogeneous data through semantic mappings, and lastly help query these workflows using a reasoning or inference engine.

Ontology is a formal and explicit specification of a shared conceptualization [7], [8] and contains a formal approach, i.e. logical languages that allow for specifying rigorously formalized logical theories and are closed to humans [9]. The conceptualization should express a shared consensus among several parties, rather than an individual viewpoint [10].

Guarino [11] proposed that any conceptual object C can be defined as $C = \langle D, W, R \rangle$, where D indicates such domain knowledge; W is a status set of correlative thing in applied domain; R is a set of concept relation in domain space $\langle D, W \rangle$. Besides, a logical language L , with a vocabulary V , can be defined as a structure $\langle S, I \rangle$, where $S = \langle D, R \rangle$ is a world structure and $I: V \rightarrow D \cup R$ is an interpretation function assigning the elements of D to constant symbols of V and the elements of R to predicate symbols of V .

To implement ontology, Pereira and Freire [12] described the architecture and implementation of a semantic web tool, Semantic Web Editor (SWedt). Gennari et al. [13] developed a software system, Protégé, to provide a flexible, well-supported, and a robust ontology development environment. Protégé is also a free, open source ontology editor. By using Protégé, developers and domain experts can easily build effective knowledge-based systems and explore ideas in a variety of knowledge-based domains.

III. PROPOSED APPROACH AND EMPIRICAL CASE STUDY

Fig. 2 is the framework of the proposed context analysis approach for NPD problematic activities. There are three phases in this framework. First, the NPD process definition phase uses DCOR to describe and determine the scope of NPD process and activities. Next, the context analysis phase applies the relativity of NPD activities to KPIs to filter the influential upstream activities and affected downstream ac-

tivities. Finally, the system implementation phase implements the proposed context analysis approach with Protégé.

To illustrate and verify the proposed approach, an empirical case about the new weapon development for military solar cell system is introduced. The development of military solar cell system requires hundreds of R&D members involved in. Any problematic activity will affect the whole development process. Thus, the context analysis of problematic activities is important for this development process.

A. The NPD Process Definition Phase

This phase is to define the NPD process. As explained in section II.A, DCOR Level 2's New Product process categories are suitable for new product development. So, in this phase, we first use DCOR's New Product process categories (Level 2) and their corresponding process elements (Level 3) to configure the NPD process. Then, the configured DCOR Level 3 model is extended to Level 4 process models by referring to the industry conventions and business rules.

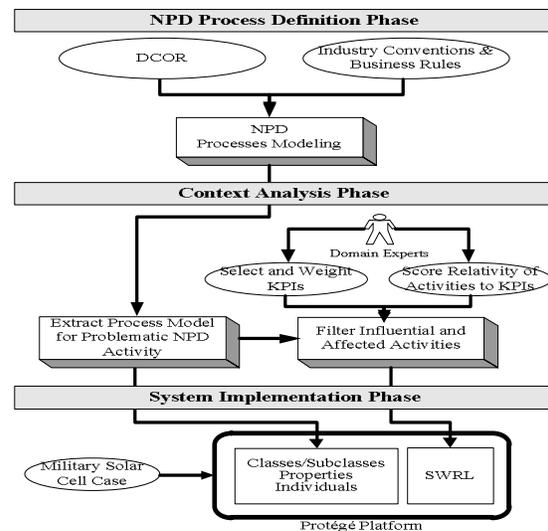


Fig. 2. The proposed approach

Fig. 3 is the NPD process model for the case of military solar cell system. Fig. 3(a) is the NPD process model defined by DCOR Level 2's New Product process categories, including Plan Design (PD), Plan Integrate (PI), Research New Product (R2), Design New Product (D2), Integrate New Product (I2) and Deficient New Product (A2). From Fig. 3(b) to Fig. 3(g), the process categories in Fig. 3(a) are extended to Level 3 process models with their corresponding process elements at DCOR Level 3 and, further, extended to Level 4 by referring to DoD Instruction 5000.2 and the characteristics of the new weapon system. DoD Instruction 5000.2 is the defense acquisition management system released by Department of Defense (DoD), USA, to regulate the operations of the defense acquisition [14], [15]. Its scope covers Material Solution Analysis, Technology Development, Engineering and Manufacturing Development, Production & Deployment and Operations & Support. Nowadays, many countries have adopted DoD Instruction 5000.2 as the guidelines for new weapon development.

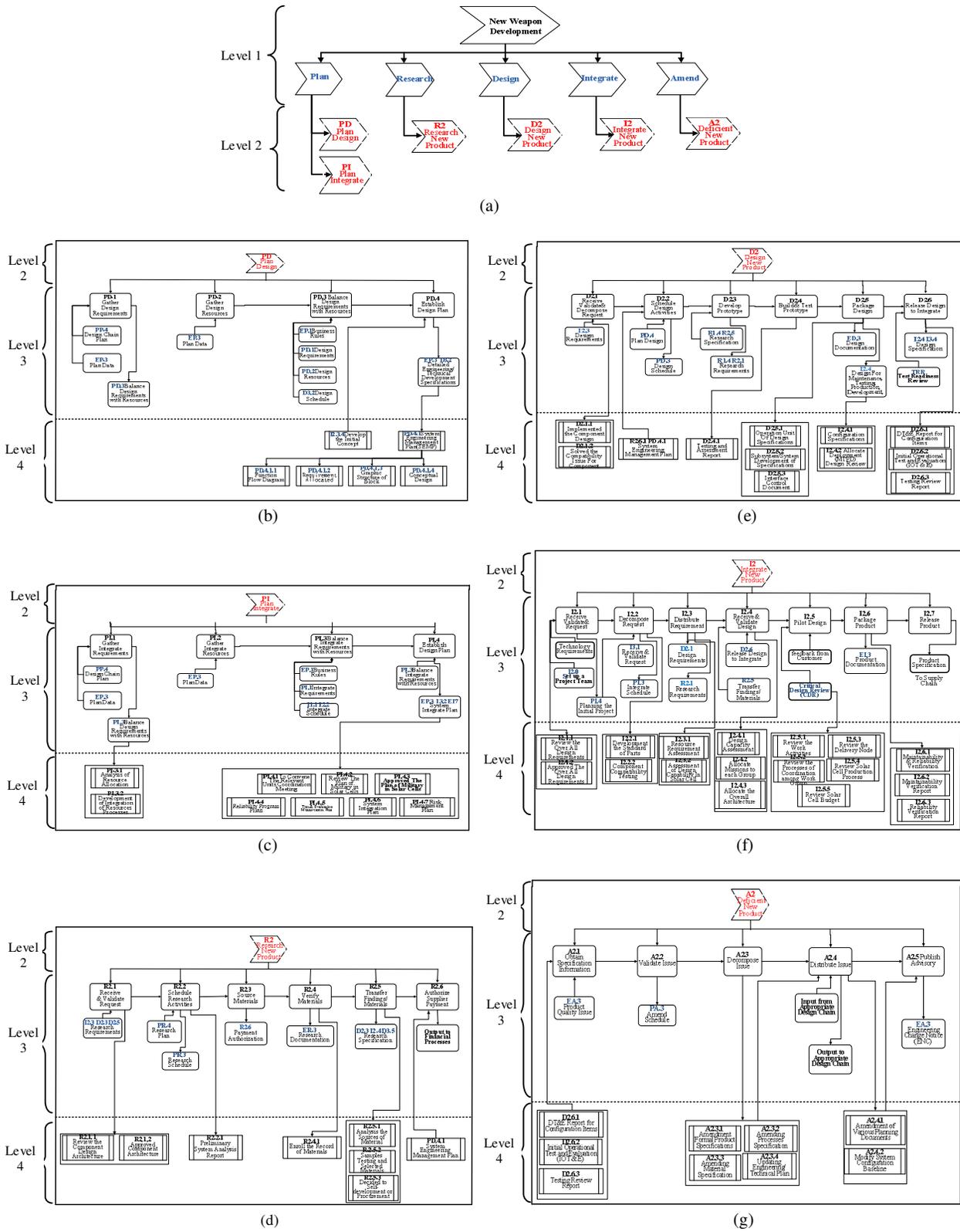


Fig. 3. NPD process model for military solar cell system

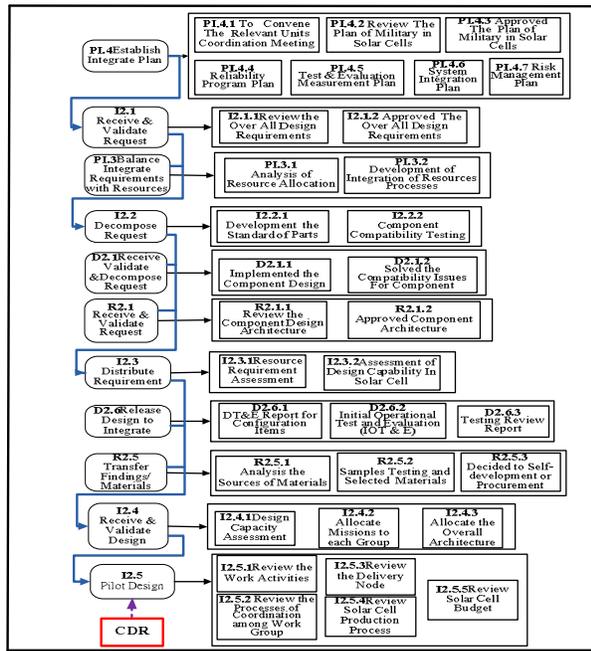


Fig. 4. Critical Design Review (CRD) process model

B. The Context Analysis Phase

This phase develops a context analysis method to analyze and filter the influential upstream activities and affected downstream activities for the problematic NPD activity.

First, the upstream and downstream activities of the problematic NPD activity are extracted from the NPD process model to form a process model of the problematic NPD activity. Assume the activity Critical Design Review (CRD) shown in Fig. 3(f) encounters some problems, the CRD process model shown in Fig. 4 can be extracted from Level 3 and Level 4 shown in Fig. 3.

Then, the influential upstream activities and affected downstream activities are identified from the process model of the problematic NPD activity. As stated in section II.A, DCOR has provided five kinds of key performance indices (KPIs), including Reliability (Rel), Responsiveness (R), Flexibility (F), Costs (C) and Assets (A), for each NPD activities, so this research will determine the influential upstream activities and affected downstream activities according to the relativity of NPD activities and KPIs.

Domain experts first decide which KPIs the context analysis of the problematic activity should focus on and give a weight to each selected KPI according to its importance to the context analysis. Then, domain experts score the relativity of the problematic activity and its upstream and downstream activities in terms of the selected KPIs. The relativity score is between 0.0 and 1.0. In addition, the relativity scores of an upstream/downstream activity for all selected KPIs are summed up to 1. Afterwards, for each upstream/downstream activity, an indicator T is calculated by using (1).

$$T_{activity} = W_{rel} * Rel_{activity} + W_r * R_{activity} + W_f * F_{activity} + W_c * C_{activity} + W_a * A_{activity} \quad (1)$$

where

W_{rel} , W_r , W_f , W_c , and W_a are the weights of KPIs.

$Rel_{activity}$, $R_{activity}$, $F_{activity}$, $C_{activity}$, and $A_{activity}$ are the relativity scores of the upstream/downstream activity for KPIs.

$$Rel_{activity} + R_{activity} + F_{activity} + C_{activity} + A_{activity} = 1.$$

Finally, a threshold is set for identifying the influential upstream activities and affected downstream activities from the process model of the problematic NPD activity. In this research, the averaged T for all upstream/downstream activities of the problematic NPD activity is set as the threshold. The upstream and downstream activities which T is greater than the averaged T are recognized as the influential upstream activities and its downstream activities.

For example, domain experts think that four KPIs, including Responsiveness, Reliability, Flexibility and Cost, are related to the context analysis of activity Critical Design Review (CRD). Furthermore, they give the KPI Responsiveness a weight of 0.6, the KPI Reliability a weight 0.4, the KPI Flexibility a weight 0.3, and the KPI Cost a weight 0.2, respectively.

In addition, domain experts score the relativity for all CDR's upstream/downstream activities shown in Fig. 4 in terms of the selected KPIs at Table I. Hence, all indicators T of the upstream/downstream activities of activity CDR can be calculated. For example, $T_{I2.5} = W_{rel} * Rel_{I2.5} + W_r * R_{I2.5} + W_f * F_{I2.5} + W_c * C_{I2.5} = 0.4 * 0 + 0.6 * 0.6 + 0.3 * 0 + 0.2 * 0.4 = 0.44$. Further, the averaged $T = (T_{I2.5} + \dots + T_{P1.4.7}) / 44 = 0.4$, so the threshold is set at 0.4 to be the norm for filtering the influential upstream activities and affected downstream activities for the problematic NPD activity, CDR. Therefore, the upstream activities of CDR with the T greater than 0.4 are recognized as the influential upstream activities and the downstream activities of CDR with a T greater than 0.4 are recognized as the affected downstream activities.

C. The System Implementation Phase

As described in section II.B, Protégé provides a flexible, well-supported, and a robust ontology development environment. By using Protégé, developers and domain experts can easily build effective knowledge-based systems and explore ideas in a variety of knowledge-based domains. Besides, Protégé is a free, open source ontology editor due to the ability to support most java-based plug-ins such as SWIR Rules for editing Semantic Web Rule Language (SWRL) rules in Protégé-OWL. Therefore, in this phase, Protégé is used to implement the proposed context analysis approach for problematic NPD activities.

First, the ontology's conceptual model with a format $C = \langle D, W, R \rangle$ is created by retrieving related objects from the NPD process model defined in section III.A. Here, we can define its conceptual model $C = \langle D, W, R \rangle$ as follows:

D = All NPD activities and selected KPIs.

W = the set of possible worlds in NPD process model.

$R = \{\text{Review}^1, \text{Has_factors}^1, \text{Has_weight}^1, \text{Input}^2, \text{Output}^2, \text{Caused_by}^2, \text{Is_affected_by}^2\}$.

R has two types of relations. The first one is the unary relations with a superscript 1 which represent the properties of activities in CDR process model. The second one is the binary relations with a superscript 2 which indicate the relationship of two activities in NPD process model.

TABLE I
THE RELATIVITY SCORE OF CDR ACTIVITIES TO KPIS

KPI/weight \ Activity	I2.5	I2.5.1	I2.5.2	I2.5.3	I2.5.4	I2.5.5	I2.4	I2.4.1	I2.4.2	I2.4.3
Reliability (Rel) / 0.4	0	0.3	0.2	0.3	0.3	0	0	0.5	0	0.3
Responsiveness (R) / 0.6	0.6	0.2	0.3	0.3	0	0.3	0.4	0	0	0.1
Flexibility (F) / 0.3	0	0.5	0.4	0.4	0	0.4	0.4	0	0.6	0.6
Cost (C) / 0.2	0.4	0	0.1	0	0.7	0.3	0.3	0.5	0.4	0
Total	0.44	0.39	0.4	0.42	0.26	0.36	0.42	0.21	0.26	0.36

D2.6	D2.6.1	D2.6.2	D2.6.3	I2.3	I2.3.1	I2.3.2	R2.5	R2.5.1	R2.5.2	R2.5.3	D2.1	D2.1.1	D2.1.2
0.1	0.5	0.3	0.6	0.2	0	0.3	0.2	0.3	0.1	0	0	0.4	0
0.6	0.2	0.3	0.4	0.3	0.4	0.4	0.4	0.3	0.4	0.3	0.4	0.3	0.2
0	0.3	0.4	0	0.5	0.2	0	0	0.1	0	0.2	0.6	0.3	0.5
0.3	0	0	0	0	0.4	0.3	0.4	0.3	0.5	0.5	0	0	0.3
0.46	0.47	0.42	0.48	0.41	0.38	0.42	0.4	0.39	0.38	0.34	0.42	0.43	0.33

I2.2	I2.2.1	I2.2.2	R2.1	R2.1.1	R2.1.2	PI.3	PI.3.1	PI.3.2	I2.1	I2.1.1	I2.1.2	PI.4	PI.4.1
0	0	0.4	0	0.5	0.5	0.3	0.3	0.3	0	0.6	0.5	0.4	0.3
0.6	0.3	0	0.5	0.5	0.5	0.3	0.4	0	0.3	0.2	0.3	0.3	0.3
0.4	0.3	0.3	0.5	0	0	0.4	0	0.3	0.4	0	0	0.3	0.4
0	0.4	0.3	0	0	0	0	0.3	0.4	0.3	0.2	0.2	0	0
0.36	0.38	0.31	0.45	0.5	0.5	0.42	0.42	0.29	0.48	0.4	0.42	0.43	0.42

PI.4.2	PI.4.3	PI.4.4	PI.4.5	PI.4.6	PI.4.7
0.5	0.3	0.7	0.6	0.5	0.5
0.5	0.5	0.3	0	0	0.4
0	0.2	0	0.4	0.5	0.1
0	0	0	0	0	0
0.5	0.48	0.46	0.36	0.35	0.47

TABLE II
CONCEPTUAL MODEL OF FIG. 4'S CDR PROCESS MODEL
 $C = \langle D, W, R \rangle$

$D = \{CDR, I2.5, I2.5.1, I2.5.2, I2.5.3, I2.5.4, I2.4, I2.4.1, I2.4.2, I2.4.3, I2.3, I2.3.1, I2.3.2, D2.6, D2.6.1, D2.6.2, D2.6.3, R2.5, R2.5.1, R2.5.2, R2.5.3, I2.2, I2.2.1, I2.2.2, D2.1, D2.1.1, D2.1.2, R2.1, R2.1.1, R2.1.2, R2.1.3, I2.1, I2.1.1, I2.1.2, PI.3, PI.3.1, PI.3.2, PI.4, PI.4.1, PI.4.2, PI.4.3, PI.4.4, PI.4.5, PI.4.6, PI.4.7, Responsiveness, Reliability, Flexibility, Cost\}$
$W = \{w1, w2, w3, w4, w5, w6, w7, w8, w9, w10, w11\}$ Every set represents one process elements at Level 3.
$R = \{Review^1, Input^2, Output^2, Caused_by^2, Is_affected_by^2, Has_factors^1, Has_weight^1\}$
$Review^1 = CDR$
$Input^2(w) = \{(I2.5, I2.4), (I2.5, I2.5.1), (I2.5, I2.5.2), (I2.5, I2.5.3), (I2.5, I2.5.4), (I2.4, I2.4.1), (I2.4, I2.4.2), (I2.4, I2.4.3), (I2.4, D2.6), (D2.6, D2.6.1), (D2.6, D2.6.2), (D2.6, D2.6.3), (I2.4, I2.3), (I2.3, I2.3.1), (I2.3, I2.3.2) (I2.4, R2.5), (R2.5, R2.5.1), (R2.5, R2.5.2), (R2.5, R2.5.3), (I2.3, D2.1), (D2.1, D2.1.1), (D2.1, D2.1.2), (I2.3, I2.2), (I2.2, I2.2.1), (I2.2, I2.2.2), (I2.3, R2.1), (R2.1, R2.1.1), (R2.1, R2.1.2), (R2.1, R2.1.3), (I2.2, PI.3), (PI.3, PI.3.1), (PI.3, PI.3.2), (I2.2, I2.1), (I2.1, I2.1.1), (I2.1, I2.1.2), (I2.1, PI.4), (PI.4, PI.4.1), (PI.4, PI.4.2), (PI.4, PI.4.3), (PI.4, PI.4.4), (PI.4, PI.4.5), (PI.4, PI.4.6), (PI.4, PI.4.7)\}$
$Output^2(w) = \{(PI.4.1, PI.4), (PI.4.2, PI.4), (PI.4.3, PI.4), (PI.4.4, PI.4), (PI.4.5, PI.4), (PI.4.6, PI.4), (PI.4.7, PI.4), (PI.4, I2.1), (I2.2.1, I2.2), (I2.2.2, I2.2), (I2.1, I2.2), (I2.1.1, I2.1), (I2.1.2, I2.1), (PI.3, I2.2), (PI.3.1, PI.3), (PI.3.2, PI.3), (R2.1, I2.3), (R2.1.1, R2.1), (R2.1.2, R2.1), (R2.1.3, R2.1), (I2.2, I2.3), (I2.2.1, I2.2), (I2.2.2, I2.2), (D2.1, I2.3), (D2.1.1, D2.1), (D2.1.2, D2.1), (R2.5, I2.4), (R2.5.1, R2.5), (R2.5.2, R2.5), (R2.5.3, R2.5), (I2.3, I2.4), (I2.3.1, I2.3), (I2.3.2, I2.3), (D2.6, I2.4), (D2.6.1, D2.6), (D2.6.2, D2.6), (I2.4, I2.5), (I2.4.1, I2.4), (I2.4.2, I2.4), (I2.4.3, I2.4), (I2.5.1, I2.5), (I2.5.2, I2.5), (I2.5.3, I2.5), (I2.5.4, I2.5)\}$
$Caused_by^2(w) = \{(CDR, I2.5)\}$
$Is_affected_by^2(w) = \{(PI.4, I2.1), [(PI.3, I2.1), I2.2], [(D2.1, I2.2, R2.1), I2.3], [(D2.6, I2.3, R2.5), I2.4], (I2.4, I2.5)\}$
$Has_factors^1(f) = \{(I2.5, f1..f4), (I2.4, f1..f4), \dots, (PI.4, f1..f4)\}$ Each activity has 4 relativity scores for KPI Responsiveness, Reliability, Flexibility and Costs, respectively.
$Has_weight^1(t) = \{(f1..f4, 0-1)\}$ Each KPI has a weight from 0.0 to 1.0.

Next, the inferences rules of the proposed context analysis method are implemented by SWRL rules. The Protégé can implement the ontology's conceptual model according to the following rules:

- Establishing classes and subclasses: All objects in D are transformed into classes and subclasses.

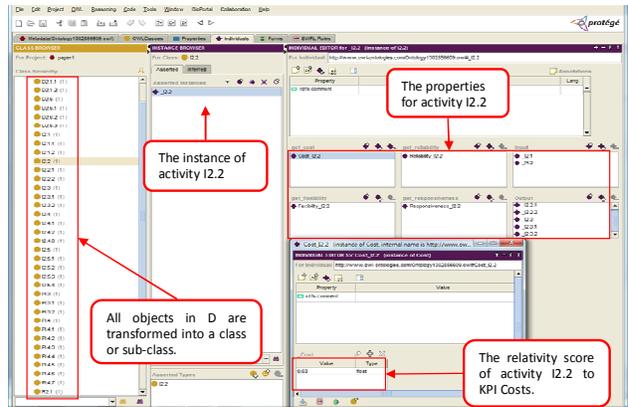


Fig. 5. The Protégé's implementation screen for Table 2's conceptual model

- Creating properties: The properties of objects in D are retrieved and created from R. For example, activity I2.1 is the input of activity I2.1.1 and it has four relativity scores for Reliability, Responsiveness, Flexibility and Costs.
- Setting individuals: According to the structure of classes and properties, create object instances of processes and activities for analyzed new weapon development process model.
- Building SWRL Rule: Build the inference rules of the proposed context analysis for the problematic NPD activity. For example, the syntax notation associated with Costs: $Activities(?x) \wedge get_cost(?x, ?y) \wedge Cost(?y) \wedge _Cost(?y, ?z) \wedge swrlb:greaterThan(?z, 0.25) \rightarrow sqwrl:select(?x)$.

To illustrate the above steps, the CDR process model shown in Fig. 4 is taken as an example. First, it can be transformed into the conceptual model $C = \langle D, W, R \rangle$ as shown in Table II. The information and rules for context analysis, such as the KPI weights, relativity scores, and threshold, etc., are transformed into SWRL rules. Fig. 5 is the Protégé's implementation screen for Table II's conceptual model. Assume now the activity I2.3 in CDR process model encounters a problem. Fig. 6 shows the result of the context analysis implemented by Protégé for activity I2.3. The middle column shows the problematic activity, the KPIs and weights, and the threshold. The left and right columns are the analysis of the influential upstream activities and affected downstream activities, respectively. The triangular exclamation-

tion mark represents the influential and affected activities which indicator T is greater than the threshold while the circular checked mark shows the uninfluential and unaffected activities which indicator T is smaller than the threshold.

IV. CONCLUSION

The context analysis of problematic activities in NPD process is a complex task. Developing an effective context analysis approach is important for NPD process management. The main contributions of this research include:

1. A three-phased context analysis approach for problematic NPD activities has been proposed.
2. An approach applying DCOR to configure a NPD process model has been proposed.
3. An approach applying the relativity of NPD activities in terms of KPIs for filtering the influential upstream activities and affected downstream activities has been proposed.
4. An approach for implementing the proposed context analysis approach by Protégé has been proposed.

REFERENCES

- [1] Supply-Chain Council., *Design Chain Operations Reference-model (DCOR)*, Version 1.0, Supply-Chain Council: Pennsylvania, 2006.
- [2] A. Koschmider and A. Oberweis, "Ontology based business process description," in *Proceedings of the CAiSE'05 Workshops*, vol. 2, 2005, pp. 321-333.
- [3] H. Martin and R. Dumitru, "An ontology framework for semantic business process management," in *Proceedings of Wirtschaftsinformatik*, 2007.
- [4] C. Pedrinaci and J. Domingue, "Towards an ontology for process monitoring and mining," in *Proceedings of the Workshop on Semantic Business Process and Product Lifecycle Management (SBPM)*, Innsbruck, Austria, 2007.
- [5] M. Dimitrov, A. Simov, S. Stein, and M. Konstantinov, "A BPMP based semantic business process modeling environment," in *Proceedings of the Workshop on Semantic Business Process and Product Lifecycle Management (SBPM)*, Innsbruck, Austria, 2007.
- [6] L. Cabral, B. Norton, and J. Domingue, "The business process modeling ontology," in *Proceedings of 4th International Workshop on Semantic Business Process Management*, 2009, pp. 9-16.
- [7] T. R. Gruber, "A Translation approach to portable ontologies," *Knowledge Acquisition*, vol. 5, no. 2, pp. 199-220, 1993.
- [8] R. Studer, B. V. Richard, and D. Fensel, "Knowledge engineering: Principles and methods," *Data & Knowledge Engineering*, vol. 25, pp. 161-197, 1998.
- [9] M. Uschold and M. Grueninger, "Ontologies: Principles, methods and applications," *Knowledge Engineering Review*, vol. 11, no. 2, pp. 93-155, 1996.
- [10] W. Borst, *Construction of Engineering Ontologies*, Ph.D. dissertation, Institute of Telematica and Information Technology University of Twente Enschede The Netherlands, 1997.
- [11] N. Guarino, "Formal ontology and information systems," in *Proceedings of FOIS'98*, Trento, Italy, 1998.
- [12] R. G. Pereira and M. M. Freire, "SWedt: A semantic web editor integrating ontologies and semantic annotations with resource description framework," in *Proceedings of IEEE International Conference on Telecommunications and International Conference on Internet and Web Applications and Services*, 2006, pp. 200.
- [13] J. H. Gennari, M. A. Musen, R. W. Fergerson, W. E. Grosso, M. Crubezy, H. Eriksson, N. F. Noy, and S. W. Tu, "The evolution of Protégé: An environment for knowledge-based systems development," *International Journal of Human-Computer Studies*, vol. 58, pp. 89-123, 2003.
- [14] M. Schwartz, M., "Defense acquisitions: How DOD acquires weapon systems and recent efforts to reform the process," *CRS Report for Congress*, Congressional Research Service, 2010.
- [15] Department of Defense, USA, "Operation of the defense acquisition system," *DOD Instruction 5000.2*, 2008.

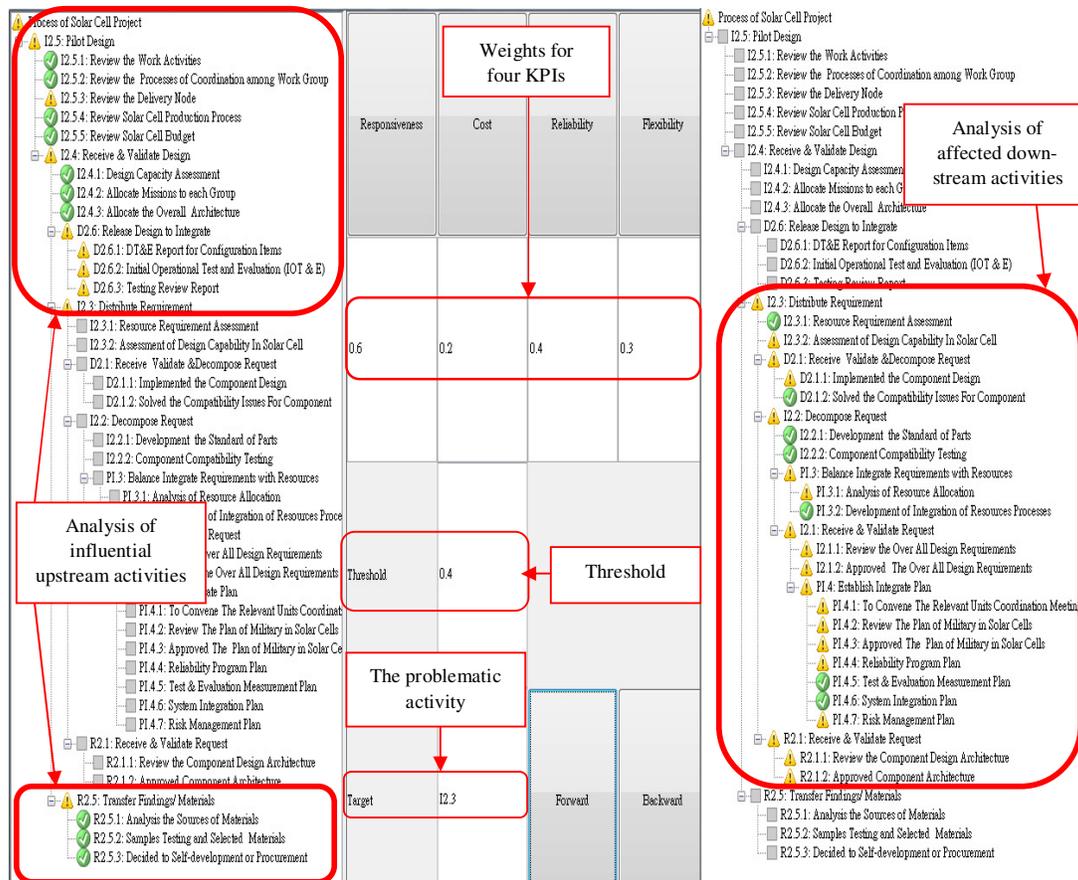


Fig. 6. The Protégé's context analysis for activity I2.3 in CDR process