مجلة المجد العلمية المتطورة العدد (5) المجلد (5) تموز 2025

نماذج الأهداف المُولَّدة تلقائيًا من المتطلبات: نحو صيغة مُحسَّنة

Automatically Generated Goal Models from Requirements: Toward an Enhanced Formalism

Ahlam Yousef [1 b)], Said Ghoul [1 a)], Mohammad Taye[2 c)]

[1] Research Laboratory on Bio-Inspired Software Engineering

Philadelphia University, Amman, Jordan؛2 Software Engineering Department

تاريخ الاستلام: ٢٠٢٥/٦/٩ تاريخ القبول: ٢٠٢٥ /٦/١٩ تاريخ النشر: ٢٠٢٥/٧/١٥

مجلة المجد العلمية المتطورة العدد (5) المجلد (5) تموز 2025

Automatically Generated Goal Models from Requirements: Toward an Enhanced Formalism

الملخص:

يُعد نموذج الهدف (GM) للبرمجيات أحد المفاهيم المهمة في مواصفات متطلبات البرمجيات، إذ يُساعد في تمثيل أهداف البرمجيات والعلاقات بينها. وقد أُجريت العديد من الأبحاث لتوليد نموذج هدف للبرمجيات من وثيقة متطلباتها. ومع ذلك، فإن نماذج الهدف المُولّدة تدمج جوانب السلوك والأهداف غير المباشرة. وقد أدى هذا الدمج إلى نماذج هدف مُولّدة متشابكة ومعقدة يصعب صيانتها. يقترح العمل المُقدّم في هذه الورقة صيغة نموذج هدف لمعالجة هذا القصور. وهو جزء من مشروع توليد نموذج هدف آلي، حيث يُركّز على نموذج الهدف المُستهدف. وبالتالي، يُحلّل هذا العمل تقنيات حديثة مُختلفة تُولّد نماذج هدف تلقائيًا، ويُبيّن دمجها وتشابكها وتعقيد صيانتها، ويُقترح صيغة نموذج هدف لمواجهة هذه التحديات. يُفصّل العمل الأهداف بوضوح إلى أهداف سلوكية وأهداف غير مباشرة وجوانب مُقيّدة. وتُقدّم دراسة حالة تقييمية، وهي عبارة عن مواصفات جزئية لمتطلبات مجال ملموسة وواقعية. أدى هذا الفصل بين الاهتمامات إلى نتائج قيّمة: تقليل التعقيد، وتحسين قابلية الفهم، وتبسيط الصيانة، وزيادة القدرة على التعبير.

الكلمات المفتاحية: نماذج الأهداف المُولّدة تلقائيًا من المتطلبات: نحو صيغة مُحسّنة

Abstract:

The Goal Model (GM) of software is one of the important concepts in the software requirements specification, as it helps in representing the software goals and the relationships between them. Several research works were conducted to generate GM of software from its requirements document. However, the generated GMs merge behavior and soft goals aspects. This merging leaded to tangled and complex generated GMs that are difficult to maintain. The work presented in this paper proposes a GM formalism handling this insufficiency. It is part of an automated GM generating project where it focuses on the target GM. Thus, in this work, different recent techniques that automatically generate GMs are analyzed, their merging, tangling, and complexity of maintenance were stated, and a GM formalism facing these challenges is proposed. It separates goals clearly into behavior goals, soft goals, and constraints aspects. An evaluating case study, which is a partial concrete and real word domain requirements specification, is presented. This separation of concerns leaded to valuable results: complexity reduction, improvement of the understandability, simplicity of maintenance, and raising up the expressiveness power.

Keywords: Automatically Generated Goal Models from Requirements: Toward an Enhanced Formalism

.

Introduction

Software requirements analysis [6] allows understanding requirements gathered from stakeholders. Often these requirements are complex and extensive. Many requirements specification models have been proposed, such as Goal Model (GM) which specify a set of software goals and relationships between them [3].

A lot of ongoing research works dealing with GM generation from requirements document have been conducted [1, 4, 5, 11, 12, 13, 17, 18, 19]. Some ones are for specific business domain and others are business domain free. Some works used UML [2, 14, 16] diagrams as input whereas others used natural language techniques [20]. iStar 2.0 is used in [19] to generate goal models from requirements document presented with natural language. In [11] an approach based on asking questions and answering them was used. Through these answers, goals and relationships can be determined. Extraction rules are used in [18] to directly manipulate the requirements document using these rules to generate a parsing tree, defining objectives and relationships. Graphviz tool was used to draw goal models. Used stories are applied in [4] as input to the generation process based on NLP technique and multiple goal models were generated, in the form of heuristics. Reviews of an application is used in [17] as input to construct GM and hierarchical clustering.

From the current works, it was noted that researches on generating GM face challenges in complexity, understandability, maintainability, and expressiveness power. This is due to the fact that behavior goals aspect, soft goals aspect, and constraints aspect are presented without any distinction in a same GM. This tangling is a serious handicap for GM maintenance. The work presented in this paper proposes a GM formalism handling this insufficiency. It is part of an automated GM generating project where it focuses on the target GM. It aims to propose a powerful GM formalism which could be the target of automated process generating GM. For that, in this work, different recent techniques that automatically generate GMs are analyzed, their merging, tangling, and complexity of maintenance was stated, and a GM formalism, splitting goals clearly into behavior goals aspect, soft goals aspect, and constraints aspects is proposed. An evaluating case study, which is a partial concrete and real word domain requirements specification, is presented. This separation of concerns leaded to valuable results: complexity reduction, improvement of the understandability, simplicity of maintenance, and rising up the expressiveness power.

1- ANALYSIS OF GM GENERATION IN SOME ONGOING RESEARCHES

Research Method

In summary, large number of research papers was selected according to their relevance to the GM generation (inputs, processes, and output) and which are up to date. These papers were analyzed, and generated GMs were evaluated. Some insufficiencies related goals engineering were highlighted, especially that related to separating concerns [8] and maintenance [7,10].

Research works analysis

Many recent researches have introduced different methods of creating GM with different inputs models, different generation processes, and different generated output GM [1, 4, 5, 11, 12, 13, 17, 18, 19].

https://scopmajd.com/ « ISI: (0.841) « ISSN (Online): 3005-2033

In [19] the researcher used a two-stage method; the first stage is to analyze the requirements document using NLP, and in the second stage he draws models using syntax concepts and relationships in iStar language, and it has been observed that the relationships are defined in this language.

In [11], the authors used a semi-automatic method that relies on a tool that enables the analyst to ask questions and receive answers, and through these answers, goals and relationships can be determined. A theory, has been imposed by the authors, that controls the identification of these questions, but the authors have noticed that there is a weakness in this method as it defines the relationships between the objectives as (and).

Through [18], the authors used extraction rules that deal with the requirements document directly. These rules generate a parsing tree through which the analyst determines the goals and then uses the Graphviz tool to draw the goal models. The intentional tree is often complex and difficult to understand.

In [4] the authors used user stories as input. The entries are written in the natural language. The pipeline technology is used to deal with language keys and the NLP is used to analyze sentences to define goals and relationships. The generated model is based on heuristics.

Likewise, when looking at [17], the entries were in the form of reviews of an application, written in natural language, and a two-stage process was used. The first stage deals with names of clustering, and the second stage deals with the title description definition.

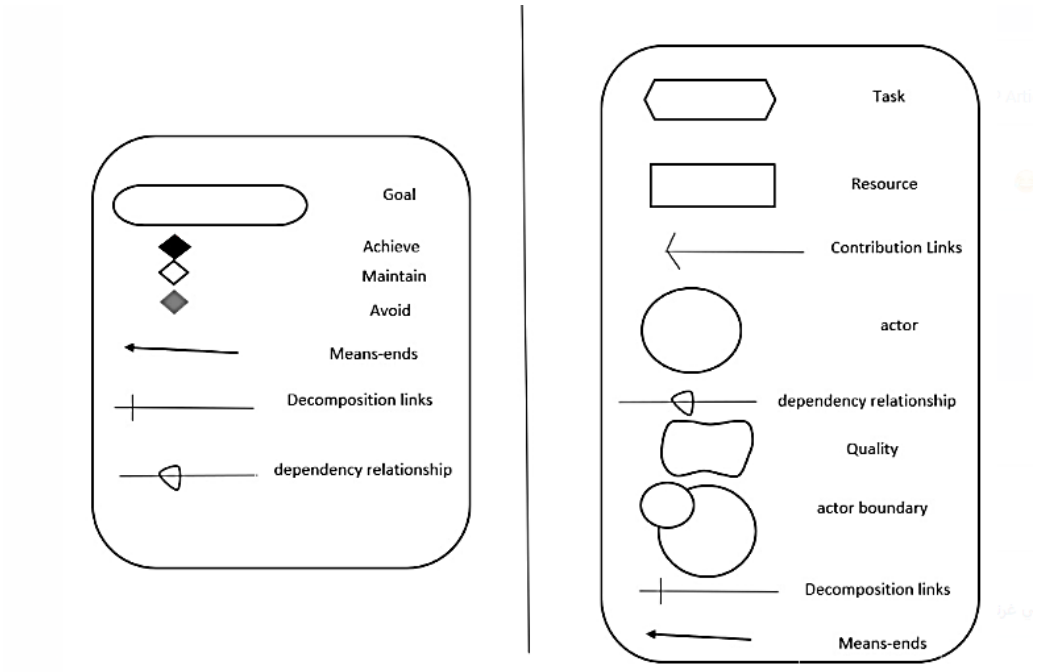
Results

In conclusion, the above works and others did not a distinction, in the generated GM, between behavior goals, soft goals, and constraints aspects, but merged them in a tangled model leading to large complexity, difficult understandability and maintenance [7, 10], and to limited expressiveness. This paper proposes a solution to this insufficiency by providing a formalism cleaning up target GM, by separating the three aspects, for any automated generation process.

2- A TARGET AUTOMATICALLY GENERATED GM FORMALISM

Current research works specify GMs based on the following concepts and relationships between them: Functional goal, task, role, quality, resource, actor, and actor boundary. Some of these concepts concern behavior goals (like functional goal, task, role, quality, ..., etc). Others concern soft goal (like any non-functional goal: Actor, resource, ..., etc.). These concepts, despite their heterogeneous nature are tangled together in a single model.

The proposed target GM formalism splits a GM into three aspects [8]: The behavior goals aspect, the soft goals aspect, and the constraints aspect which are relations between the two others aspects. The figure 1 depicts the notations of each aspect.



(a) (b)

FIGURE 1. (a). Behavior goals aspect notations, (b). Soft goals aspect notations

3- AN EVALUATION CASE STUDY

In order to evaluate the feasibility, the complexity and understandability of the proposed target GM formalism, we applied it on a partial concrete and real word domain requirements specification: Simplified Internet Shop Management System adapted from [9]. The case study is limited to orders aspect.

The functional requirements (behavior goals) state the following goals: Internet shop managed which is composed conjunctively of Process internet orders, Internet orders handled, and Item searching handled. The goal shopping cart is optional participating to the achievement of the goal internet orders handled. It is conjunctively composed of the goal Item to be selected, and Identification details collected.

All these goals are to be achieved by the actor IntShop, having a view on the hole system. Any goal could be achieved by tasks having quality attributes and using resources. The task internet shop managed, for example, collaborates in achieving internet searching handled, internet order handled, and process internet orders goals. This task has security, adaptability, and availability quality attributes.

The (figure 2) shows the traditional tangled generated GM from Internet Shop Management System requirements; whereas the figure 3 shows the proposed generated GM with separated aspects for the same requirements. The difference between the two GMs is valuable.

It could be easily stated from the figure 3 that the proposed GM formalism is:

- Feasible. Having supporting GM tools and Aspect-programming theory.
- Less complex. The separation of the three aspects leads to small GM units, more readable and easier to maintain.
- Understandable. This is due to complexity reduction

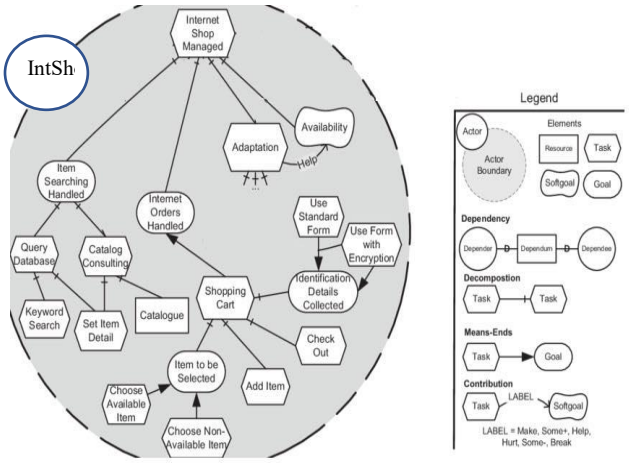
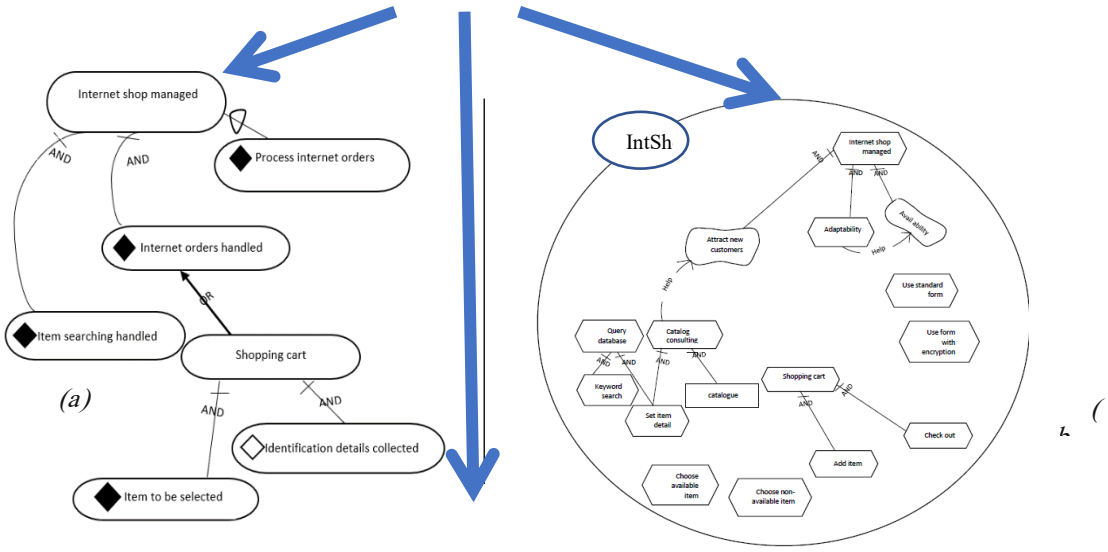


FIGURE 2. A traditional GM adapted from [9]



Constraints aspect *(c)*

- Item to be selected Uses Choose Available item ∨ Choose non-available Item.
- Item Searching Handled Has Query Database ∧ Catalog Consulting.
- Identification Details Collected Uses use standard form ∨ use form with encryption.
- Media shop Depends process internet orders.

FIGURE 3. *Proposed GM with separated aspects: (a). behavior goals, (b). Soft goals, and (c). constraints*

The GM automatic generating processes face several challenges, especially their output (the generated GM) is far to be simple, complete, and accurate and easy to maintain. In fact behavior goals and soft goals aspects are presented without any distinction in a same GM. This tangling increased the GM complexity, limited its understandability, entangled its maintenance, and limited its expressiveness power. The work presented, in this paper, analyzed different automatically produced GMs, identified their common weaknesses and proposes a GM formalism avoiding them. The proposed GM formalism splits goals clearly into behavioral goals aspect, soft goals aspect, and constraints aspects. An evaluating case study is presented. This separation of concerns leaded to complexity reduction, improvement of the understandability and maintenance, and raising up the expressiveness power.

5- REFERENCES

1. An Lai, Y; Gupta, A; Zhang, Y. “Goal-Embedded Dual Hierarchical Model for Task-Oriented Dialogue Generation”, Conference on Computational Natural Language Learning, 3(4): 798–811. (2019).
2. Deryugina, O., Nikulchev, E. “Methods, Algorithms and Software for the UML Class Diagram Refactoring”, Communications in Computer and Information Science 1204 CCIS, pp. 179-191, (2021)
3. Essayed, I; Nasr, Z. “Goal Modeling Techniques in Requirements Engineering: A Systematic Literature Review”, Journal of Computer Science, 13 (9): 430.439. (2017)
4. Gunes, T; Aydemir, F. “Automated Goal Model Extraction from User stories using NLP”, (2020).
5. Gupta, I; Eugenio, B: Ziebart, B; Liu, B. “Modeling Health Coaching Dialogues for Behavioral Goal Extraction”, IEEE International Conference on Bioinformatics and Biomedicine, 7(2): 1188-1190. (2019).
6. D. Inkermann, T.Huth,,T.Vietor, A.Grewe, C.Knieke, A.Rausch. “Model-Based requirement Engineering to Support Development of Complex Systems”, Procedia CIRP Volume 84, Pages 239-244 (2019).
7. Jang, K. A., Kim, W. J. “A method of activity-based software maintenance cost estimation for package software”, Journal of Supercomputing 77(8), pp. 8151-8171. 2021
8. Kuraj, I., Solar-Lezama, A. “Aspect-oriented language for reactive distributed applications at the edge”. EdgeSys 2020 - Proceedings of the 3rd ACM International Workshop on Edge Systems, Analytics and Networking, Part of EuroSys 2020. pp. 67-72. (2020)

9. Lucena, M; Castro, J; Silva, C. “Stream: A strategy for transition between requirements models and architectural models, Resercgate”, 10(1): 21-24. (2014).
10. Majumdar, S., Bansal, A., Das, P.P., Datta, K., Ghosh, S.K. “Automated evaluation of comments to aid software maintenance”. Journal of Software: Evolution and Process. Article in Press, (2022)
11. Nakagawa, H; Tsuchiya, T. “Interactive Goal Model Construction Based on a Flow of Questions”, IEICE TRANS, 3(6): 1309-1313. (2020).
12. Polanco, F. Fernandez, D. Borrego, S. (2018). Learning-driven Goal Generation, AI Communications, 2(3): 2-19.
13. Ren, Z; Dong, K. “Exploration via Hindsight Goal Generation. Conference on Neural Information Processing Systems”, 12(2): 1-17. (2019).
14. Reuter, R., Stark, T., Sedelmaier, Y., Mottok, J., Wolff, C. “Insights in students' problems during UML modeling”. IEEE Global Engineering Education Conference, EDUCON. 2020, pp. 592-600. (2020)
15. Sabatucci, l; Cossentino, M. “Supporting Dynamic Workflows with Automatic Extraction of Goals from BPMN”, ACM Transactions on Autonomous and Adaptive Systems, 2(4): 12-19. (2019).
16. Shaikh, A., Hafeez, A., Wagan, A.A., Alghamdi, A., Reshan, M.S.A. “More Than Two Decades of Research on Verification of UML Class Models: A Systematic Literature Review”, IEEE Access. 9, pp. 142461. (2021)
17. Shimada, H; Nakagawa, H. “Goal Model Construction Based on User Review Classification, Copying permitted for private and academic purposes”, 1(1): 2-6. (2019).
18. Shimada, H; Nakagawa, H; Touchily, T. “Constructing a Goal Model from Requirements Descriptions Based on Extraction Rules”, Communications in Computer and Information Science. 8(14): 978-98. (2018).
19. Zhang, CH; “Toward Automatic Generation of Goal Models using Natural Language Processing”, github /amgrubb, 12(1): 1-6. (2019).
20. Zhuang, W. “Architecture of Knowledge Extraction System based on NLP”. ACM International Conference Proceeding Series. pp. 294-297. 2021