A Framework to Analyse the Approach Adopted in the Information Systems Requirements Engineering Activity

Álvaro Rocha
amrocha@ufp.pt
Faculty of Science and Technology
Fernando Pessoa University
Porto - Portugal

José Braga de Vasconcelos
jvasco@ufp.pt
Faculty of Science and Technology
Fernando Pessoa University
Porto - Portugal

Abstract

The activity of requirements engineering (RE) is the initial stage for the information systems development process. The RE is often developed using an excessive technological-driven approach. This aspect is pointed as a factor for the failure of the RE and consequently to the corresponding information system.

We present an evaluation framework for the requirements engineering activities within organizational settings that can help on analysing how this important activity is carried out in organizations. This framework, designed by RETIS, is composed by three parts. The first part focuses on the organizational domain, the second focuses on the users and information systems' stakeholders, and the third focuses on the underlying methods and techniques.

The initial validation of this investigation was based in the application of the RETIS in five real organizational settings. Organizations that demonstrate higher maturity in their information systems' function presented a less technological-driven RE approach.

Keywords: Requirements Engineering, Information Systems Development, Maturity of the Information Systems Function.

1. Introduction

The RE activity is the initial stage of the IS development where IS requirements are defined and specified. This means describing what the system should do as well as the circumstances in which the system will operate.

The RE is likely to be the more critical activity in the IS development. A misleading requirements definition results in an inadequate IS deployment for the target workplace.

An IS supports work activities. Work activities can be viewed as having different dimensions, namely: technical, social, and organizational. A successful IS should be well conceived technically and should support adequately the social and organizational aspects [4, 6, 13, 14, 18, 23, 34, 35, 37].

Often requirements engineers assume a decision-making role asking the users what type of system should be designed. The users have a consultive and passive role. This work is often developed without social and organizational concerns. The IS implementation in a real setting interferes with the social and organizational structures. These effects should be considered in the requirement engineering activity [17, 24, 25, 31, 34, 36]. This requires that RE should be conducted by requirements engineers with expertise on social and organizational issues. It also requires that requirements engineers promote an active, participative, and responsible involvement of users [5, 16, 31, 33]. The idea is to encourage the representation of users' tacit values, motivations and perspectives [13, 22].

The main maturity models for the IS function [e.g., 10, 15, 21, 26, 27, 28] suggest that less mature organizations tend to emphasize technical aspects. And suggest that more mature organizations pay a balanced attention to both technical and socio-organizational aspects.

Taking into account that RE is usually conducted under a technological-driven tendency [5, 13, 16, 34, 37], this research work aims to tackle other approaches, such as the RE process following a social and organizational tendency. In this context, we raised the following question:

(i) Is it possible to analyse the RE approach?

(ii) What type of RE approach is being followed in a particular organizational setting?

(iii) In what way the maturity of the IS function interferes with the RE tendency?

This paper presents the RETIS framework to assists the analysis of the RE tendency. We present three types of RE approaches. We present some considerations about the tendency of the RE activity, then the RETIS framework for analyse the RE approach. We conclude with some remarks concerning the application of the RETIS in five organizations.

2. Requirements Engineering Approaches

RE activity should give proper attention to all the domain problem aspects. Rocha [30] identified two perspectives: I) a technological perspective and II) a social and organizational perspective. Based on these perspectives, he is presented the following RE approaches:

Technological approach: when RE follows an objective perspective of the domain requirements and emphasizes the IS technical view. This approach is usually named as *hard* or using structured methods.

Socio-organizational approach: when RE follows an inter-subjective vision of the requirements and social aspects that are related to the domain and to the underlying organization and emphasizes a socio-organizational perspective. This approach is usually described as using *soft* or interpretative methods.

Socio-technological approach: when RE combines the two previous approaches. This approach focuses initially on the socio-organizational aspects and then on the technological aspects in a complementary way.

According to suggestions of the main maturity models for the IS area [e.g., 10, 15, 21, 26, 27, 28], the last approach will be the most adequate and coadunate with RE activities of superior maturity. Then, effective RE practices will should be based on a socio-technological approach.

Table 1 resumes the main features of the technological and socio-organizational approaches focusing their principles, focus, models, techniques, strategies, role of the RE engineers and users, strengths and weaknesses.

Table 1: Main features of the technical and socio-organizational approaches.

	Technological	**Socio-organizational**
Principles	Positivists and objectivists	Interpretativists and subjectivists
Focus	Formal system; data	Informal system; Information; Knowledge
Models	Conceptual model of the current system	Conceptual model of users' perspectives
	Conceptual model of the future system	Conceptual model of the effective features and changes of the real setting
Techniques	Structured and inflexible	Ethnographic, interactive and flexible
Strategy	Divides a problem in parts for individual analysis	Sees a problem as a whole that can be improved
Engineers' role	Driver and decision-maker	Facilitator
Users' role	Consultive and passive	Participative and decision-maker
Strengths	Expected results	Promote the innovation and reengineering of systems
Weaknesses	Promote the repairing and burnishing of old and obsolete systems	Unexpected results

3. Tendency of the RE Activity

The RE should be an activity that addresses simultaneously solving activities of less structured and boundless domain problems, and computer engineering activities that could change the computer system, the IS, and the underlying organizational system [30].

An IS incorporates the technical and socio-organizational components. Some authors [2, 5, 16, 19] claim that the socio-organizational component is often neglected throughout the RE activity. According to [13, 34, 37], a balance between the two approaches should be attempted. Figure 1 illustrates such balance as socio-technological approach.

The *x-axis* represent many ways of conduct the RE activity, varying from a pure technologic approach to a pure socio-organizational approach. The darkest area means the technological emphasis and the lightest means the socio-organizational emphasis.

According to [30], in the practice some aspects are responsibly for a predominance of a technological RE tendency:

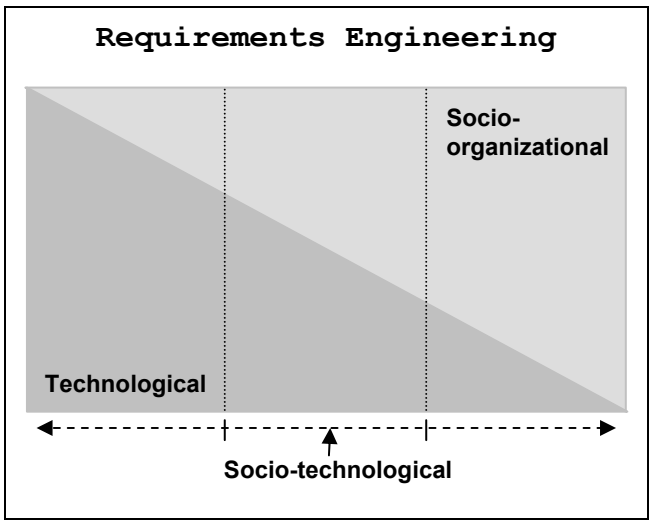

Figure 1: Possible approaches/tendencies of the RE activity

- Software engineers that usually conduct the RE activity have some difficulties to deal with social and organizational components of the IS and related business domain.
- The RE is accomplished with the main aim of constructing computer systems, which are often viewed as a final product, neglecting the view that sees RE as a mean to enhance the IS and the way this supports the organizational processes.
- The importance of users is underestimated, they perform a passive role, and their important viewpoints are ignored.
- The applied methods and techniques stimulate a technological-driven approach.

As the RE is an activity that should simultaneously give attention to both technical and socio-organisational components, we find the need of defining a framework that is able to analyze the approach of the RE activity.

4. RETIS - A framework to analyse the tendency of the RE activity

Next table is based on the aforementioned arguments used to justify the technological predominance in the RE activity and on the main characteristics from each of the three RE approaches. This table includes indicators used in the development of the RETIS framework to evaluate the tendency of RE activity within organizations.

The RETIS framework includes a questionnaire to collect information that is used to produce an evaluation of the RE approach. The questionnaire uses a *Likert* scale and it is structured in three groups of questions (Appendix I).

Table 2: Indicators and arguments used to identify the RE approach.

Indicators	Technological	Socio-technological	Socio-organizational
Who	Software engineer	Requirements engineer	Business or Systems engineer
Aim	Make computer-based information systems	Information systems development	Organizational development
Users' role	Consultive and passive	Representative	Participative and decision-maker
Visions	Objective	Subjective	Inter-subjective
Methods	Structured Analysis SSADM Object Oriented Analysis …	ETHICS Multiview …	SSM …
Techniques	Data analysis Decisions analysis Objects analysis Text analysis Structured interview Reutilization …	Observation of behavior Prototyping Open interviews Cognitive mapping Variances analysis Grid reports Scenarios Futures analysis JAD sessions Conducted by user …	Learning with the user Brainstorming Rich Pictures …

The first group includes a set of questions that allow the inference of the RE level: computing system, information system or organizational system.

The second group includes a set of questions that allow the identification of the user's interference level and their level of participation as well as their concerns, perspectives and social interactions.

The third group contains the questions that allow the identifications of the methods and techniques used during the RE activity.

In each of the questions are presented some possible use cases, and each of these cases is associated to a specific type of RE tendency. The respondents need to mark one of five choices representing the practical level of occurrence: never, rarely, sometimes, frequently, or always. To finalize each question the respondent can introduce some open-ended comments. Each choice was classified using a percent grade (0%, 25%, 50%, 75%, and 100%) in order to quantify the influence of each use case in the RE approach.

The use cases presented in each question were determined to assist the identification of the RE approach. The use cases were applied in different places in order to avoid the adulteration of the questionnaire responses.

The questionnaire should be answered by managers of requirements engineering activities with presence of the responsible for the approach analysis.

A reflection is necessary in case of not following a socio-technological approach. We claim that this approach should be tackled as standard effort in normal situations.

4.1 Evaluation schema

For each group of questions and according the choices marked in the use cases, we briefly explain the way to detect the approach followed in the RE.

I) Involvement level

RE should be conducted following the dynamics of the organization. The RE activity can change the computing system, the information system or the organizational system. In the first case we consider that RE follows a technological approach, in the second case we consider that RE follows a socio-technological approach, and in the third case we consider that RE follows a socio-organizational approach. The underlying questions are:

a) Who performs the RE activity?

The RE activity usually deals with ill-defined and unbound domain problems (business engineering) as well as with the analysis of the related computer systems (software engineering) [Doyle 12]. Firstly, the concern is focused on the organizational aspects and then the focus is on the technological aspects.

A key factor that influences the RE tendency concerns the people's profiles [5, 16, 19]. In the questionnaire we consider three possibilities: (i) Software engineers, (ii) System/Business engineers, (iii) Requirements engineers.

b) What levels of requirements modeling are considered?

IS development and implementation in a real setting interferes both in the technological and in the socio-organizational infrastructures. This occurs either if the information system is developed internally, externally (outsourcing) or acquired (a software package) [17, 24, 25, 36]. Therefore, it is necessary to consider the impact of these factors before building or acquiring the computer system. In the questionnaire we consider three possibilities: (i) Organizational, (ii) Information system, (iii) Technological (computer system).

II) The role and significance of the users

The requirements engineer activity and his interaction with the different stakeholders promotes different users' roles, attitudes and perspectives. This issue is fundamental to ensure the proper requirements definition. The aim of this set of questions is to evaluate the user's roles and their perspectives and motivations. We consider the following questions:

a) What is the role performed by the users?

The users' involvement is a key issue in all the IS development process [9], specifically in the RE activity [29]. The participation level has a direct impact on their satisfaction [1]. In the questionnaire we consider the following user involvement types: (i) Passive or consultive, (ii) Representative, (iii) Participative or decision-maker.

b) What requirements visions are considered?

Depending on the existing RE involvement, there are different users' views that could determine the requirements definition. According to Iivari e Hirschheim [17], there are three visions that distinguish the definition of users' requirements: (i) objective, (ii) subjective, (iii) inter-subjective. The first addresses a functional view of the domain. The second emphasizes the users' personal features, and the requirements are defined following their preferences. The third emphasizes the user's voluntarism and organizational relationships. In this context, the requirements definition emerges from the dynamics of the organization. In the questionnaire we consider these three visions.

III) Used Methods and Techniques

The RE activity involves a combination of principles, methods, and related techniques. The adopted methods and techniques promote different RE attitudes and results. These set of questions aims to identify different methods and techniques used during the RE activity. The underlying questions are:

a) What types of methods are used?

Although the objectives concerning the existing methods for the RE orientation and support seemed to be similar, there are specific features that allow some kind of categorization. According to the main objective of this research that is the identification of the RE approach within the organization, and the related evaluation framework, we have considered three types of methods in conjunction with the existing RE approaches: (i) Traditional/hard (e.g.: Structured Analysis [38]), (ii) Soft (e.g.: Soft System Methodology [8], (iii) Socio-technological (e.g. Multiview [3]).

b) What types of techniques are used to acquire and model the requirements?

There are several techniques to support the collection and the definition of different requirements categories [7, 11]. The questionnaire includes a set of nineteen techniques. These techniques are based on the analysis performed by Rocha [30] that includes a categorization schema to classify the techniques according to the stimulated RE tendency. In the questionnaire we consider the following categories: (i) Technological (e.g.: text analysis, structured interviews) (ii) Socio-technological (e.g.: behaviour observation, cognitive mapping), (iii) Socio-organizational (e.g.: brainstorming, rich pictures).

5. Final Remarks

This research focused in the RETIS framework definition for analyse the tendency of the RE activity. The main goal of this framework is to enhance the reflection of the RE participants and consequently to enhance the RE activity results, namely the validity and the expressiveness of the domain requirements to be acquired.

The need of such framework is related with the fact that the RE activity is mainly developed using a technological-driven approach, which have resulted in some failures during the related IS development and implementation.

Although the questionnaire included in the RETIS framework was applied only in five organizational settings, the multiple-case study described in Rocha [30] have validated the aforementioned framework. Within the organizations under investigation, we did not find difficulties concerning the application of this framework. It is demonstrated that these organizations have followed a technological-driven RE practice, and these was more evident in organizations that presented low levels of their IS maturity.

Future work need to be developed in order to enhance this framework. In the context of evaluating the RE tendency, new case studies should be considered. Therefore, we are going to apply this questionnaire in other organizations to refine or introduce (if applicable) new variables, indicators, and arguments used in the existing framework. The idea is to turn the RETIS framework more extensive and concise allowing us its application in the emergent knowledge-intensive organizations.

6. References

[1] Amoako-Gyampah, K. and White, K., "User involvement and user satisfaction: An exploratory contingency model", *Information & Management*, 25 (1993), pp. 1-10.

[2] Andriole, S., *Managing Systems Requirements: methods, tools and cases*, McGraw-Hill, 1996.

[3] Avison, D. and Wood-Harper, A., *Multiview: An Exploration in Information Systems Development*, Blackwell Scientific Publication, 1990.

[4] Avison, D. and Fitzgerald, G., "Information systems, education and research", *Journal of Information Systems*, 1, 1 (1991), pp. 5-17.

[5] Bate, R., "Do systems engineering? Who, me?", *IEEE Software*, Julho/Agosto (1998), pp. 65-66.

[6] Benbasat, I., Dexter, A. and Mantha, R., "Impact of organizational maturity on information system skill needs", *MIS Quarterly*, 4, 1 (1980), pp. 21-34.

[7] Byrd, T., Cossick, K., and Zmud, R., "A synthesis of research on requirements analysis and knowledge acquisitions techniques", *MIS Quarterly*, 16 (1992), pp. 117-138.

[8] Checkland, P., *Systems Thinking, Systems Practice*, Wiley, 1981.

[9] Clavadetscher, C. and Lawrence, B., "User involvement key to success/Designers must do the modeling", *IEEE Software*, Março/Abril (1998), p. 30-33.

[10] CMMI, *Capability Maturity Model Integration*, Version 1.1, Continuous Representation, Software Engineering Institute, CMU/SEI-2002-TR-001/ESC-TR-2002-001, 2002.

[11] Darke, P. and Shanks, G., "User viewpoint modelling: understanding and representing user viewpoints during

requirement definition", *Information Systems Journal*, 8, 1 (1997), pp. 213-239.

[12] Doyle, K., Wood, J. and Wood-Harper, A., "Soft systems and engineering: on the use of conceptual model in information systems development", *Journal of Information Systems*, 3 (1993), pp. 187-198.

[13] Flynn, D. and Jazi, D., "Constructing user requirements: a social process for a social context", *Information Systems Journal*, 8 (1998), pp. 53-83.

[14] Galliers, R., "Towards a flexible information architecture: integration business strategies, information systems strategies and business process redesign", *Journal of Information Systems*, 3, (1993), pp. 199-213.

[15] Galliers, R. and Sutherland, A., "Information systems management and strategy formulation: the ´stages of growth´ model revisited", *Journal of Information Systems*, 1, 2 (1991), pp. 89-94.

[16] Hanseth, O. and Monteiro, E., "Navigation future research: judging the relevance of information systems development research", *Accounting, Management and Information Technologies*, 6, 1-2 (1996), pp. 77-85.

[17] Hirschheim, R., Klein, H. and Lyytinen, K., "Exploring intellectual structures of information systems development: a social action theoretic analysis", *Accounting, Management and Information Technologies*, 6, 1-2 (1996), pp. 1-64.

[18] Hooks, Ivy., *Writing good requirements*, artigo apresentado ao Fourth INCOSE Symposium, 1999a.

[19] Hooks, Ivy., *Management requirements*, artigo de trabalho, 1999b.

[20] Iivari, J. and Hirschheim, R., "Analysing Information Systems Development: A Comparison and Analysis of Eight IS Development Approaches", *Information Systems*, 21, 7 (1996), pp. 551-575.

[21] Khandelwal, V. and Ferguson, J., Critical Success Factors (CSFs) and the Growth of IT in Selected Geographic Regions, *Proceedings of 32nd Hawaii International Conference on Systems Sciences* (HICSS-32), USA, 1999.

[22] Leifer, R., Lee, S. and Durgee, J., "Deep Structures: Real information requirements determination", *Information & Management*, 27 (1994), pp. 275-285.

[23] Mansell, G., "Action research in information systems development", *Journal of Information Systems*, 1 (1991), pp. 29-40.

[24] Mathiassen, L., "Information systems development: reflections on a discipline", *Accounting, Management and Information Technologies*, 6, 1-2 (1996), pp. 115-125.

[25] Mumford, E., "Defining system requirements to meet business needs: a case study example", *The Computer Journal*, 28 (1985), 97-104.

[26] Mutsaers, E., Zee, H. and Giertz, H., "The Evolution of Information Technology", BIK-Blad (Nolan Norton & Co., Utrecht), Vol. 2, nº 2 (1997), pp. 15-23.

[27] Nolan, R., "Managing the crisis in data processing", *Harvard Business Review*, 57, 2 (1979), pp. 115-126.

[28] Paulk, M., Curtis, B., Chrissis, M. and Weber, C., *Capability Maturity Model for Software*, Version 1.1, Software Engineering Institute, Carnegie Mellon University, CMU/SEI-93-TR-024, 1993.

[29] Purvis, R. and Sambamurthy, V., "An examination of designer and user perceptions of JAD and the traditional IS design methodology", *Information & Management*, 32, 3 (1997), pp. 123-135.

[30] Rocha, A., *Influência da Maturidade da Função Sistema de Informação na Abordagem à Engenharia de Requisitos*, Tese de Doutoramento, Universidade do Minho, 2000. (In Portuguese)

[31] Stowell, F., "Towards client-led development of information systems", *Journal of Information Systems*, 1 (1991), pp. 173-189.

[31] Sutcliffe, A. and Minocha, S., *Linking business modelling to socio-technical system design*, CREWS Report 98-35, 1998.

[33] Vasconcelos, J., *An Ontology-Driven Organizational Memory for Managing Group Competencies*, PhD Thesis, University of York, Department of Computer Science, 2001.

[34] Vidgen, R., "Stakeholders, soft systems and technology: separation and mediation in the analysis of information systems requirements", *Information Systems Journal*, 7, 1 (1997), pp. 21-46.

[35] Vitalari, N., *Knowledge as a basis for expertise in systems analysis: an empirical study,* MIS Quarterly, 9, 3 (1985), pp. 221-241.

[36] Walsham, G., "Exploring the intellectual structures of information systems development: a short critique", *Accounting, Management and Information Technologies*, 6, 1-2 (1996), pp. 133-138.

[37] Wastell, D. and Newman, M., "Information system design, stress and organizational change in the ambulance services: a tale of two cities", *Accounting, Management and Information Technologies*, 6, 4 (1996), pp. 283-300.

[38] Yourdon, E., *Análise Estruturada Moderna*, Editora Campus, 1992. (In Portuguese)

APPENDIX I – Condensed Questionnaire of Measures the Requirements Engineering Tendency.

1. Intervention: Level/system where requirements engineering intervenes.

1.1 Who performs the requirements engineering activity?

Software Engineers. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Systems/Business Engineers ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Requirements Engineers. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Comments:

1.2 What levels of requirements modeling are considered?

Organizational. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Information System. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Technological/Software. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Comments:

2. Users. The importance given to the users, their degree of participation and their perspectives and social interactions.

2.1 What is the role performed by the users?

Passive/consultive. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Representative. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Participative/decision-maker. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Comments:

2.2 What requirements visions are considered?

Objective. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Subjective. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Inter-subjective. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Comments:

3. Methods and techniques. Types of methods and techniques used in the requirements engineering activity.

3.1 What types of methods are used?

Traditional/Hard. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Soft. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Socio-technological. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Comments:

3.1 What types of techniques are used to acquire and model the requirements?

Data Analysis. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Decision Analysis. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Objects Analysis. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Text Analysis. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Structured Interviews. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Reutilization. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Observation of Behavior. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Prototyping. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Open Interviews. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Cognitive Mapping ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Analysis of Variances. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Grid Reports. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Scenarios. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Future Analyse. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
JAD Sessions. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Conducted by User. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Learning with the User. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Brainstorming. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Rich Pictures. ☐*never* ☐*rarely* ☐*sometimes* ☐*frequently* ☐*always*
Comments: