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Process-based evaluation and comparison of OTS software alternatives

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***Abstract*—Many Off-The-Shelf Software (OTSS) assessment techniques have been proposed, most of them using criteria related to standard quality models. However, these techniques are not as useful to evaluate and compare alternative OTSS as solutions to specific process-driven organizational changes. This article proposes PBEC-OTSS (Process-Based Evaluation and Comparison of OTSS), a technique for evaluating and comparing OTSS regarding impact in the organization, based on process models, and using fuzzy decision making systems. The technique was compared with an Ad-Hoc approach (systemized from the literature) in an experimental study with IT professionals, some new to BPM and some experts; the experts obtained similarly good results with either approach, but the novice professionals obtained better results with PBEC-OTSS than with Ad-Hoc. These results suggest that organizations can improve their Business/IT alignment with this technique even if no process experts are available.**

I. Introduction

THE software selection process is a subjective and uncertain decision process [23], where meeting the specific needs of the organization is complex and requires time [8], considering that a company may lose its competitive advantage by investing in wrong alternative technologies or by investing too much time in selecting the right one [18].

In practice, there are numerous organizations that lack a rigorous selection process [11], which is often made under pressure by evaluators who may not have time or the expertise to plan it [8], or that select according to their experience or intuition [20], [21].

A systematic and repeatable selection methodology for *Off-The-Shelf Software* (OTSS), is a crucial need to minimize uncertainty and risk in companies [19]; so, choosing a suitable OTSS, is a non-trivial task for organizations and requires a thorough assessment process. Therefore, the key question seems to remain: how to identify the most appropriate OTSS to meet organizational needs? The recommendation to managers is to choose an appropriate IT infrastructure to facilitate the alignment between strategy and organizational structure, achieving higher performance levels [4]. However, the benefits of an organization's systems are generally known only after some period of use [2].

In the literature, there are studies that emphasize the important relationship between business processes and IT, stating: IT will be used if, and only if, the functions available for the user, support, or fit to their activities [5]. The selection and implementation of proper IT applications, is an important precondition for the efficient execution of business processes [17]. IT will only have a positive effect in the organizational performance, if this fits with the business processes [9].

Therefore, based on the close relationship between business processes and IT, is that this study proposes a new approach to evaluate and compare OTSS, based on processes models and fuzzy decision making systems, which allows:

- Generate alternative reconfigurations of processes models, which serve as input data for processes improvement and processes standardization.
- Identify and measure the potential contribution of the OTSS to the organization, through impact indicators (coverage, automation, and implementation).
- Generate OTSS traceability regarding the processes and activities of the organization.
- Identify collaboration between OTSS, and implemented systems in the organization.

All of which improves decision making, and promotes the Business/IT alignment.

The remainder of this paper is structured as follows: section II presents the Related Work; in Section III the proposed approach, along with an illustrative example; in section IV the Case Study, and finally Section V summarizes and concludes.

II. Related Work

In literature, the software assessment has been a subject of interest of suppliers, and topic of study for academics and professionals, developing and proposing:

- Preliminary proposals, such as: general recommendations for evaluation of commercial software [3], generation of Domain-specific quality model to assess software [7], and approach for determining the software selection strategy [25].
- Proposals for the evaluation of specific types of software, such as: ERP [6], data warehouse system [13], and workflow type software [14], among others.
- Frameworks, methods, and tools of assessment and/or selection of OTSS (see Table I). However, in most of these proposals, criteria are repeated or are similar, and related to standard quality models. Unfortunately, criteria associated to software quality evaluate the product and its interaction with the user, but ignore the importance

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of the contribution that assessed system can make to the organization [1]. Therefore, choosing between a proposal and the other, apparently, depends on the value that is given to: application requirements (time, effort, and tools), evaluation criteria, and the complexity of each.

- Methods of Commercial Off-the-shelf (COTS) Selection, such as [12]: OTSO (1995), PORE (1998), STACE (1999), PECA (2002), and CARE (2004), among others. However, these are specific for components, were created for the software development, and do not seem to be adaptable to the different domains and projects [16].
- Assessment services and online software comparison: TEC[1] and Capterra[2]. Although a comprehensive review is allowed, the evaluation criteria are similar to those of Table I, or are wielded in a generical and superficial manner, as is the case of processes.

Therefore, although there are many evaluation proposals, it can be appreciated that there is no evaluation technique based on process models able to allow assessing and comparing OTSS, which could lead to identify their potential effect in the organization.

III. Process-Based Evaluation and Comparison of OTSS

This section presents the PBEC-OTSS (Process-Based Evaluation and Comparison of OTSS) technique, which consists of five stages, and considers six evaluation criteria (see Figure 1), defined from the process perspective.

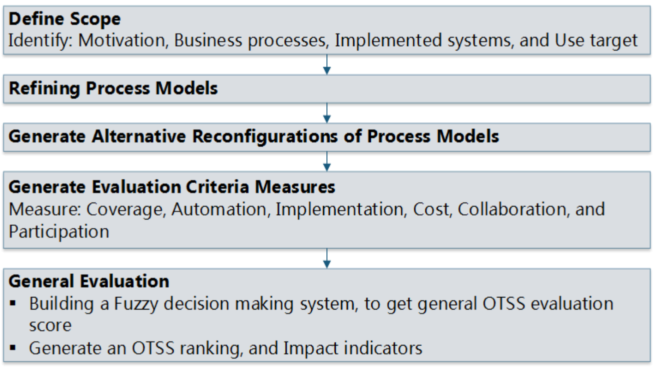

Fig. 1. Process-Based Evaluation and Comparison of OTSS

The details of the stages of the proposal are hereunder described, with an illustrative example, which is based on a real scenario of a Chilean public sector institution, *Solidarity and Social Investment Fund* (FOSIS[3]). The results correspond to evaluation performed by an BPM and IT expert, who was also Case Study expert (see section IV).

A. Define Scope

To establish the assessment dimension, identify: (i)*Motivation*: problems or situations that are intended to be solved or improved, (ii) *Business Processes*, (iii) *Implemented systems*, that participate in the identified processes, and are involved with motivation, and (iv) *Use Target* of each implemented system; i.e., according to the motivation identified, and as a complementary measure, to establish whether to decrease, maintain, or increase current usage level of each implemented system.

Example. (i) *Motivation*: Problems between different areas of the organization with HR, during recruitment. Current Situation: Extensive process cycle, exceeding by 75% the established time limit. Low process standardization, varying its implementation in different regions of the country. High effort, and null automation. High loss information, lack of centralized repository for generated documentation. Low standardization of generated documentation. No versioning of created documents; high dependence of general purpose tools. Therefore, the organization wants to buy a new tool to help them with the problems identified; (ii) *Business process*: Recruitment; (iii) *Implemented systems*: Microsoft Office (Word, Excel, and Access), and e-mail, and (iv) *Use target*: decrease the use of both systems.

B. Refining Process Models

Review process models identified in previous stage. If implemented systems are not specified in process model, or documented as a black box, process model should be refined, specifying for each actor: user's activities, automatic activities, and manual activities (not performed on any system).

Example. Figure. 2 illustrates refined Recruitment process model.

C. Generate Alternative Reconfigurations of Process Models

Review documentation, and identify OTSS functionalities. Subsequently, for each identified process model in previous stage, generate a new process model including OTSS. Each process activities that can cover the OTSS, will exclusively depend on the features identified in the revised documentation. Activities cannot be modified (name and quantity), and automatic activities must be a explicit OTSS feature.

Example. OTSS assessed are PeopleNet Recruitment[4] and Email2DB[5]. Reconfigurations generated are displayed in Figure 3 and 4.

D. Generate Evaluation Criteria Measures

To generate evaluation criteria measures, all models and reconfigurations generated in the previous stages should be considered, and calculate the different types of activities, as specified in Table II.

Example. Table III presents evaluation criteria results, considering Figure 2, 3 and 4.

TA: Total of activities of refined models, **TUA:** Total of user's activities of refined models, **TUAr:**Total of user's activities of alternative reconfigurations, **TAA:** Total of automatical

[1]http://www.technologyevaluation.com
[2]http://www.capterra.com
[3]http://www.fosis.gob.cl/
[4]http://www.meta4.com/solutions/105/personnel-selection-recruitment.html
[5]http://www.email2db.com

TABLE I
OTSS FRAMEWORKS, APPROACHES AND ASSESMENT TOOLS

Approach	Input	Assessment Criteria	Output
Expert System for Software Evaluation (ESSE) [23]	(i) Set of OTSS (ii) OTSS documentation	(i) Hardware, (ii) Software, (iii) Legacy software porting,(iv) Network management software, (v) Training, (vi) Maintenance, (vii) Company profile, (viii) Miscellaneous.	(i) Best subset of OTSS, or (ii) Subset of OTSS grouped according to classification, (iii) Ranking of OTSS, or (iv) Formal description of each OTSS (without ranking).
Five-phase COTS selection model [21]	(i) Set of OTSS (ii) OTSS documentation	(i) Cost, (ii) Supplier's support, (iii) Technological risk, (iv) Closeness of fit to the company's business, (v) Easy of implementation, (vi)Flexibility to easy change as the company's business changes, (vii) System integration.	Ranking and qualification of OTSS
Enterprise COTS software analyzer [10], [11]	(i) Set of OTSS (ii) OTSS documentation	(i) Functionality, (ii) Reliability, (iii) Cost, (iv) Ease of customization, (v) Ease of use.	Qualification of each assessed OTSS
Enterprise Software Selection Method (ESSM) [19]	(i) Set of OTSS (ii) OTSS documentation	(i) Functional requeriments, (ii) Non-functional requeriments, related to: Quality characteristics, Technology factors, and Socio-economic factors, (iii) Total cost, (iv) Implementation time.	Selected software
Decision making framework for software selection [8]	(i) Set of OTSS (ii) OTSS documentation	(i) Functional, (ii) Technical, (iii) Quality, (iv) Vendor, (v) Output, (vi) Cost and benefit, (vii) Opinion.	Ranking and qualification of OTSS

TABLE II
EVALUATION CRITERIA MEASURES

Criteria	Measure
Coverage: OTSS user's activities rate	$\frac{(TUA_r)}{TA}x100$
Automation: Variation of Automatic Activities	$\frac{(TAA_r - TAA)}{TA}x100$
Implementation: Variation of Manual Activities	$\frac{(TMA - TMA_r)}{TA}x100$
Cost: Cost Qualification	0 (very low) - 1 (very high)
Collaboration: Average of compliance of implemented systems (equal to 0% if implemented systems do not meet the use target)	$\frac{\sum_{i=1}^{n}\left\| \left[\frac{TUA_r - TUA}{TA}x100\right]_{IS_i}\right\|}{n}$
Participation: Average of non-compliance regarding the use of implemented systems (equal to 0% if implemented systems meet the use target).	$\frac{\sum_{i=1}^{n}\left\| \left[\frac{TUA_r - (TUA+G)}{TA}x100\right]_{IS_i}\right\|}{n}$

TABLE III
EVALUATION CRITERIA RESULTS

Criteria	Measure	
	PeopleNet	Email2DB
Coverage	61%	39%
Automation	39%	30%
Implementation	13%	0%
Cost	0.6	0.6
Collaboration	44%	35%
Participation	0%	0%

activities of refined models, **TAAr**: Total of automatical activities of alternative reconfigurations; **TMA:** Total of manual activities of refined models, **TMAr:** Total of manual activities of alternative reconfigurations; **IS:**for each implemented system (of an n total), **G:** Use target (if it is to decrease = -1; if it is to maintain = 0; if it is to increase = 1)

E. Introduction to Fuzzy Logic and Fuzzy Decision Making System

For a better understanding of last stage of the proposal, it is here presented an introduction to the basic concepts of Fuzzy logic [26] and Fuzzy decision making system [15].

Definition 1. *Fuzzy sets*: The fuzzy set theory was proposed in 1965 by Zadeh, where he defines that a fuzzy set is characterized by a membership function that maps the elements of a universe of X discourse to a unit interval [0,1].

Definition 2. *Linguistic variable*: A linguistic variable is a fuzzy variable whose values are categories represented by fuzzy sets. The value of a linguistic variable is a compound term $T(x) = \{L_1, L_2, \ldots, L_n\}$.

Definition 3. *Membership function*: Any function of the form μ_A:X→[0,1] describes a membership function associated with a fuzzy set A. The shape of the membership function depends on the concept to represent and the context in which it is used.

Definition 4. *Fuzzy If-then rules*: They have the structure *If* (x is A_i) and (y is a B_j) *then* (z is C_k)

Definition 5. *Fuzzy decision making system*: Corresponds to a system that is responsible for mapping an input space to a determined output space using fuzzy logic. It comprises four components (see Fig. 5), hereunder detailed.

Fuzzification interface. Inputs are identified, and through membership function, it can be established the degree of membership of each input to the relevant fuzzy set.

Knowledge base. A database that consists of the expert

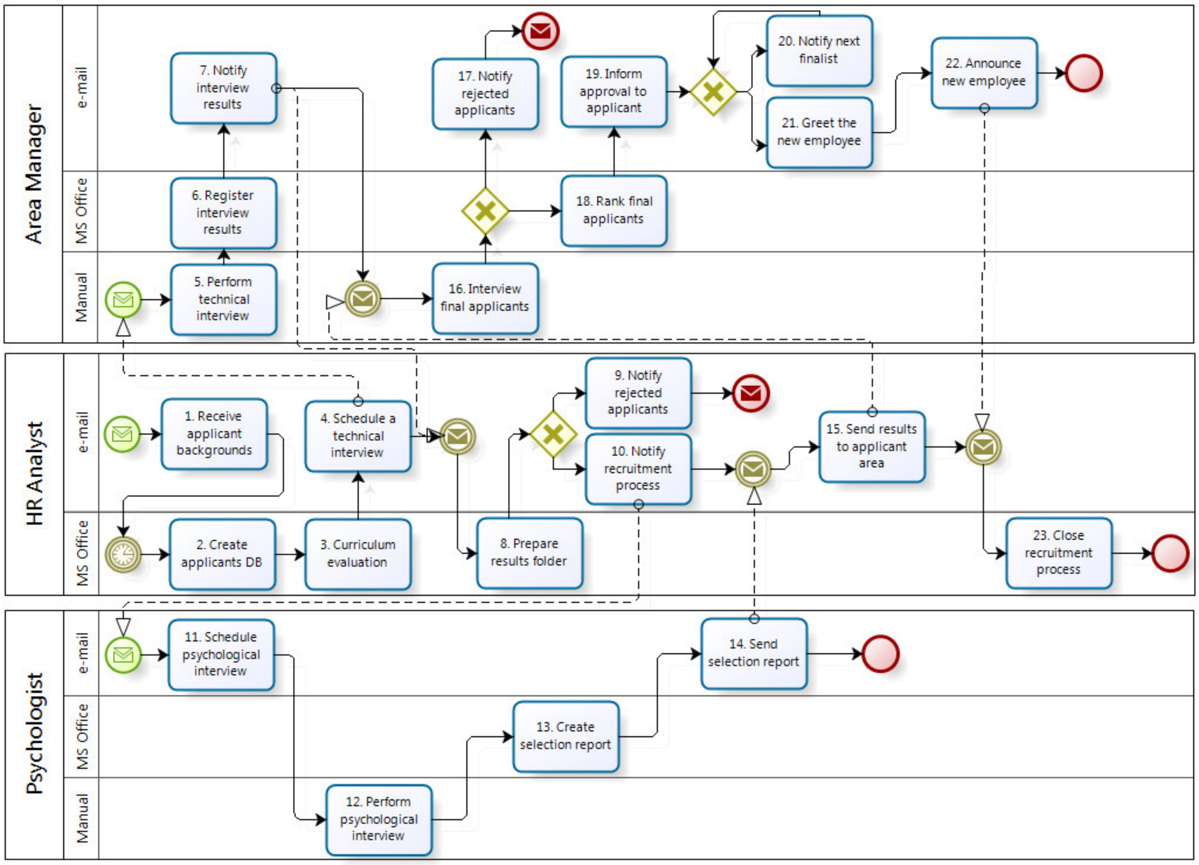

Fig. 2. Refined Recruitment process model

knowledge of the domain in question. In this database are defined the parameters of the membership function, linguistic categories of input and output variables, and set of rules.

Decision making unit. Simulates human decision making, by performing inference using the *fuzzy If-then rules*. For this purpose, first are identified the antecedents of each rule and their relationship; i.e., the various values that every input can take are identified, and related to each other, through logical operators. Subsequently, each antecedent is related to a particular consequent (fuzzy set represented by membership function), by implication operators. Finally, the fuzzy sets representing the output of each rule are grouped in a single fuzzy set.

Defuzzification interface. To the fuzzy set resulting from the previous stage, it is applied a defuzzification method to obtain a single value, which corresponds to the final result.

F. General Evaluation

Building a Fuzzy decision making system, to get general OTSS evaluation score. Following is part of used structure.

Fuzzification interface and Knowledge base. The inputs correspond to evaluation criteria results obtained in the previous stage. Based on the knowledge and experience of two BPM experts, it was defined for each input, linguistic terms, their membership functions, and domain (see Table IV).

Decision making unit. Antecedents of fuzzy rules are: Coverage and Automation and Cost; Coverage and Automation and Implementation; Implementation and Cost; Collaboration and Participation. Consequent for all rules is Evaluation.

Defuzzification interface. Defuzzication method used is centroid, and output corresponds to OTSS evaluation result. Finally, according to OTSS evaluation result, generate an OTSS ranking, indicating percentages obtained by Coverage, Automation, and Implementation criteria, which together correspond to *Impact Indicators*.

Example. Table V presents OTSS evaluation result, delivered by fuzzy decision making system, considering as input the evaluation criteria results of Table III.

G. PBEC-OTSS Benefits

The main benefits of PBEC-OTSS are: (i) favors Business/IT alignment, (ii) improves decision making, i.e., decision making is well informed, and with less uncertainty, (iii) provides new information, which can serve as an antecedent for reducing time and efforts.

IV. Case Study

The purpose of the case study was to evaluate quality of results, duration, and use satisfaction, of PBEC-OTSS. In this regard, it was compared with an Ad-Hoc approach,

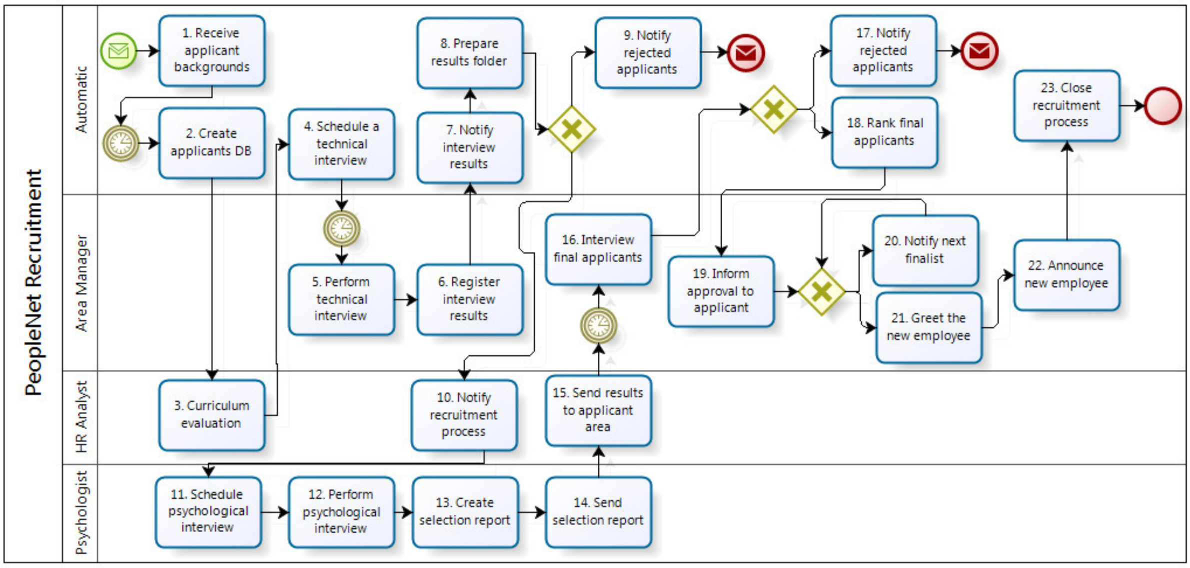

Fig. 3. Reconfiguration of Recruitment process model including PeopleNet Recruitment

TABLE IV
KNOWLEDGE BASE

Input	Linguistic term	Membership function	Domain
Coverage	Very low	Trapezoidal	0% - 21%
	Low	Trapezoidal	19% - 41%
	Medium	Trapezoidal	39% - 61%
	High	Trapezoidal	59% - 81%
	Very high	Trapezoidal	79% - 100%
Automation	Very high decrease	Trapezoidal	-100% - -29%
	High decrease	Trapezoidal	-31% - -19%
	Medium decrease	Trapezoidal	-21% - -9%
	Low decrease	Trapezoidal	-11% - 0%
	Equivalent	Triangular	-2% - 2%
	Low increase	Trapezoidal	0% - 11%
	Medium increase	Trapezoidal	9% - 21%
	High increase	Trapezoidal	19% - 31%
	Very high increase	Trapezoidal	29% - 100%
Implementation	High decrease	Trapezoidal	-100% - -29%
	Medium decrease	Trapezoidal	-31% - -14%
	Low decrease	Trapezoidal	-16% - 0%
	Equivalent	Triangular	-2% - 2%
	Low increase	Trapezoidal	0% - 16%
	Medium increase	Trapezoidal	14% - 31%
	High increase	Trapezoidal	29% - 100%
Cost	Very low	Trapezoidal	0 - 0.21
	Low	Trapezoidal	0.19 - 0.41
	Medium	Trapezoidal	0.39 - 0.61
	High	Trapezoidal	0.59 - 0.81
	Very high	Trapezoidal	0.79 - 1
Collaboration Participation	Null	Triangular	0% - 1%
	Low	Trapezoidal	1% - 10%
	Medium	Trapezoidal	11% - 40%
	High	Trapezoidal	41% - 100%

TABLE V
OTSS EVALUATION RESULTS

No.	OTSS	Impact Indicators
1	PeopleNet **82.5**	**61%** Coverage, **39%** Automation, **13%** Implementation
2	Email2DB **73.5**	**39%** Coverage, **30%** Automation, **0%** Implementation

through an experimental study, where to each approach was simultaneously applied [24].

A. Approaches to Experimental Study

PBEC-OTSS. The aim of this approach is to evaluate and compare OTSS using processes models, and fuzzy decision making systems. The result is OTSS ranking, and impact indicators.

Ad-Hoc Approach. The objective of this [10], [11] is to evaluate OTSS through five criteria (Functionality, Reliability, Cost, Ease of customization, and Ease of use). The result is a score for each OTSS analyzed.

B. Experimental Study Design

Experimental study was designed to be done by professionals who finished a *Diploma in Process Management and IT* (196 hrs. postgraduate program taught by a Chilean university). Of all participants, two groups were formed. Simultaneously, one group applied PBEC-OTSS and other applied Ad-hoc approach. The assignment to each group was random, but mark and professional experience of each participant were considered. Thus, they sought the greatest homogeneity between groups, and prevented the influence on the results of factors such as experience or knowledge.

C. Instrumentation

Materials used by participants of both groups were the same: Instructive, Personal Data Questionnaire, Problem Definition,

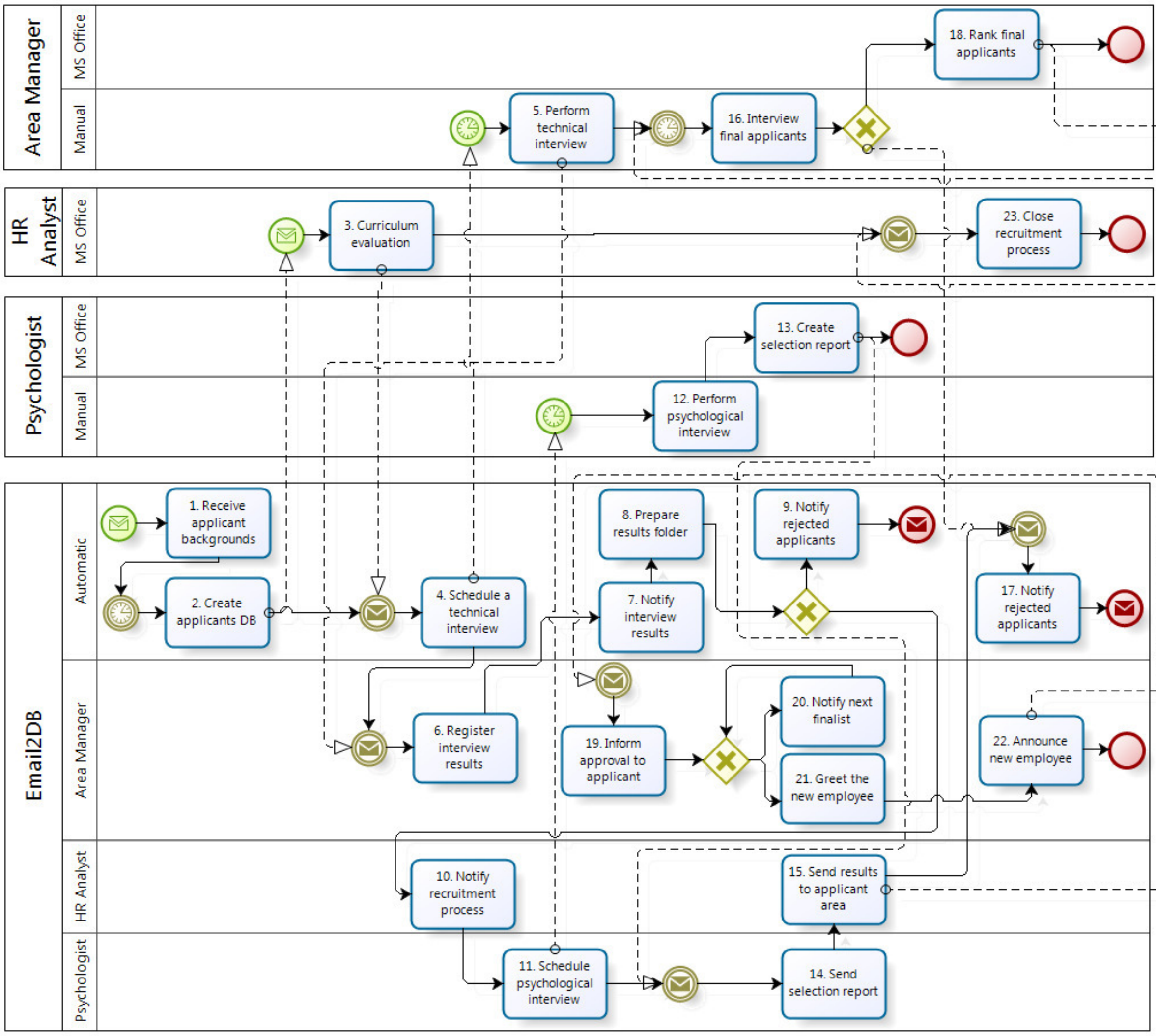

Fig. 4. Reconfiguration of Recruitment process model including Email2DB

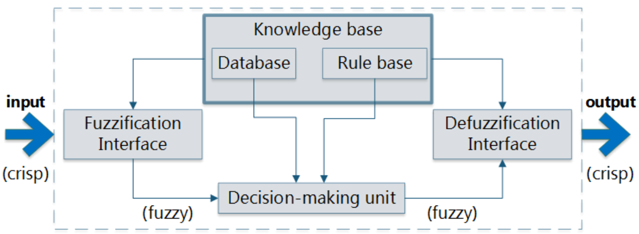

Fig. 5. Fuzzy decision making system [22]

Recruitment Process Description and Model, OTSS Documentation, How-to approach, Questionnaire on applied assessment approach. For both approaches, the problems, process, and OTSS to evaluate were the same as those presented in Section III example, which was adapted to be resolved in a maximum of two hours (time calibrated by previous execution of a pilot experiment). In addition, the OTSS real name was omitted, to avoid influence on the results, due by possible foreknowledge of these.

D. Experimental Study Execution

The participants were 13 Chilean IT professionals, who held positions as Software Engineer, Project Manager, Process Engineer, or Consultant, and Area Assistant Manager. Six of these used PBEC-OTSS, and seven Ad-hoc approach. None of them had previous experience in any of two approaches. Table VI presents group and expert characteristics (in average years).

Each group was trained in its respective approach. The training was conducted in parallel, same day and time, but in different rooms and with different instructors. The results of each approach were compared with results obtained by an BPM and IT expert, who performed the same experiment (see results in Section III example).

TABLE VI
GROUP AND EXPERT CHARACTERISTICS

Characteristic	PBEC-OTSS	Ad-Hoc	Expert
Age	32.3	30.6	56
Professional experience (total)	6.8	6.6	26
Process modeling experience	2.2	2.6	20
Experience about IT decision	1.3	1.4	15

E. Experimental Results and Analysis

Table VII presents participants and expert results. Table VIII shows average duration and average rating of the application of each approach (where 1 is very low and 5 is very high).

TABLE VII
PARTICIPANTS AND EXPERT EXPERIMENTAL RESULTS

	PeopleNet Recruitment		Email2DB	
	PBEC-OTSS	**Ad-Hoc**	**PBEC-OTSS**	**Ad-Hoc**
Subject 1	82.5	72.9	82.5	57.2
Subject 2	82.5	78.4	79.5	69.1
Subject 3	85.5	78.7	73.5	45.2
Subject 4	82.5	75.5	79.5	42.4
Subject 5	73.5	80.3	67.5	58.3
Subject 6	82.5	78.7	82.5	34.7
Subject 7	-	79.2	-	66.8
Average	81.5	77.7	77.5	53.4
Standard Deviation	4.1	2.6	5.9	12.9
Expert	**82.5**	**79.4**	**73.5**	**71.0**

TABLE VIII
DURATION AND QUALIFICATION OF APPROACHES

	PBEC-OTSS	Ad-Hoc
Duration	56.8 minutes	45.7 minutes
Difficulty	3.67 points	3.71 points
Satisfaction	3.67 points	3.57 points
Recommendation	100% yes	86% yes, 14% no

The results in Table VII and VIII show that:

- For PeopleNet Recruitment, both approaches generated similar results with respect to expert, with an acceptable variation of 1% for PBEC-OTSS, and variation of 2% for Ad-Hoc.
- For Email2DB, approaches differ, PBEC-OTSS presents better results than Ad-hoc approach. Respect to expert, PBEC-OTSS has 5% variation, while Ad-hoc approach has 25% variation.
- Regarding duration, PBEC-OTSS takes 11 minutes more than Ad-Hoc, this could be due to greater degree of PBEC-OTSS difficulty. Despite this, average satisfaction qualification, and recommendation rate is higher for PBEC-OTSS.
- Comparing both approaches, expert results are similar, this could be due both techniques have a expert knowledge base. PBEC-OTSS uses fuzzy decision making systems built with parameters identified by two BPM specialists (different to case study expert), and Ad-Hoc approach was based on a survey of MIS managers.

Therefore, for complex cases (Email2DB), PBEC-OTSS reduces the risk of an inadequate evaluation, by presenting reasonable results and close to an expert. While for simple cases (PeopleNet Recruitment), both approaches are similar.

V. CONCLUSION

It was proposed PBEC-OTSS technique, that allows evaluate and compare OTSS, measuring its possible contribution to an organization. This proposal considers six criteria (Coverage, Automation, Implementation, Cost, Collaboration, and Participation), based on process models and fuzzy decision making systems. The main benefits of PBEC-OTSS are: favors the Business/IT alignment, and improves decision making.

PBEC-OTSS was compared with an Ad-Hoc approach, in an experimental study, based on real scenario of a Chilean public sector institution. 13 IT professionals participated, and a BPM and IT expert. The professionals results showed that for simple cases PBEC-OTSS is similar to Ad-hoc approach, while for complex cases, the techniques differ, being PBEC-OTSS the best. Additionally, it was observed that when applying both approaches (PBEC-OTSS and Ad-Hoc) by an expert, the results were very similar, which could infer that PBEC-OTSS results, appear to be comparable with a technique from the literature. Although experimental study was conducted with two specific software, PBEC-OTSS is applicable to other types of software, and in any type of organization, because PBEC-OTSS focuses on Business/IT alignment.

Finally, based on the study and analysis fulfilled, we identified the following topics of interest to perform as future work: adaptation of the technique proposed so that the assessment to include different levels of activities importance, inclusion of new experts to redefine Fuzzy decision making system configuration parameters, and new experimental study with a greater number of professionals, experts, and other real scenario of an public or private sector institution.

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