A Data-Centric Approach for Business Process Improvement Based on Decision Theory

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Abstract. An efficient business process redesign is an ambitious research and implementation challenge for both academia and industry. Traditional approaches for business process improvement are based on activity flows, not considering data of business processes. In this paper, we provide an approach to business process improvement, which is based on data and on combining data with decision theory. In particular, subprocesses are formalized as decision activities and analyzed according to techniques from decision theory. We demonstrate the applicability of our research with a use case, where meetings in an enterprise are scheduled.

Keywords: business process improvement, redesign, decision subprocess, process data.

1 Introduction

The prerequisite of successful existence of the enterprise of today is effective business process management. In consequence of technological progress in the last decades, organizations have received not only vast opportunities for the optimization of business processes, but also daunting challenges with regards to applying these innovations in real businesses. With that, the question of how to re-organize the business process in order to use new technologies, represents the challenge of business process redesign which "is often not approached in a systematic way, but rather considered as a purely creative activity" [4].

The majority of existing approaches to business process redesign are activity-centric and they do not consider process model data. However, data-centric approach to modeling business operations and processes "has been evidenced in both academic and industrial researches where it not only provides higher level of flexibility of workflow enactment and evolution, but also facilitates the process of business transformations" [10].

Other factors, which influence the application of business process management in enterprises, are the instability of markets and the necessity of making decisions under the conditions of risk and uncertainty. Even a simple business process, such as scheduling meetings at an enterprise, can have different execution outcomes depending on, for example, the time preferences of the customer. Due to technological development, centralized, calendar-oriented software for

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scheduling meetings is available, which can potentially improve the business process of time management [5]. However, the methodology of redesigning such a business process, considering both the internal structure of the process, and uncertainties of the external environment, does not exist.

The above mentioned factors served as the prerequisite for the development of a methodology for data-centric business process improvement based on the application of decision theory, which we present in this paper. Our fundamental contribution is a presentation of the integrated methodology for the identification of patterns for redesign in process models, redesign guidelines and introduction of process indicators which will allow the effectiveness of the redesigned models to be monitored.

The remainder of the paper is structured as follows. In Section 2 the notions of process models, data and the foundations of decision theory used in our approach are presented. In Section 3 we introduce a special kind of process model, a decision subprocess, which serves as a redesign pattern. Additionally, we present a transformation rule for improvement of such a process model. Section 4 demonstrates the applicability of the developed scheme with a use case, where meetings in an enterprise are scheduled. The related work is then provided in Section 5. Finally, the paper is concluded.

2 Preliminaries

The generic scheme of our approach for business process redesign is presented in Figure 1, the detailed version of which can be found in our previous paper [2].

The first step is to identify if the initial process model P contains patterns for redesign. The example of such a pattern, a decision subprocess, is presented in Section 3. If it is detected that the process model contains such patterns, the transformation of the process model is implemented as the second step of the redesign scheme, which will be explained in detail in Section 3. This transformation yields, as an outcome, an improved process model P'. To verify the effectiveness of the transformation, the third step of the redesign scheme simulates the execution of the improved process model P' with the usage of the key performance indicators, the development of which is planned for future work.

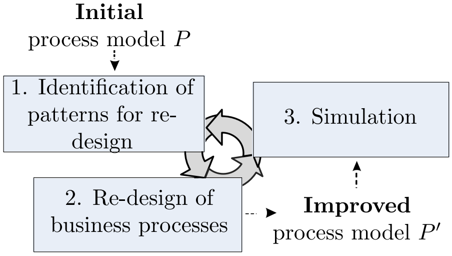


Fig. 1. Scheme for business process improvement

Depending on the simulation results, a conclusion is made, either to accept the improved process model P' and start using it in the enterprise, or to conduct further improvements of the process model. Such a decision can be done, for example, by a business analyst or higher management.

2.1 Process Model and Data

The input and output for our redesign scheme are process models, which can be viewed as blueprints for a set of process instances with a similar structure [15].

Definition 1 (Process model). $P = (N, E, D, F, R, \psi, \gamma)$ is a *process model* if it consists of a finite non-empty set N of nodes, and a finite set E of edges. Herewith, $N = N_A \cup N_E \cup N_G$ is a union of the mutually disjoint sets N_A (an nonempty set of activities), N_E (a set of events), and N_G (a set of gateways). With that, E is a set of directed edges between nodes, such that $E \subseteq N \times N$, representing control flow. Further, F is a set of edges representing data flow relations: $F \subseteq (N_A \times D) \cup (D \times N_A)$. R is a set of resources. $\psi : N_A \longrightarrow R$ is a function assigning to each activity a corresponding resource. $\gamma : N_G \longrightarrow \{xor, and\}$ is a function assigning to each gateway a corresponding control flow construct. ◇

In Definition 1, we take into account the resources which are involved in the execution of a business process. It is also assumed in the definition, that the activities of process models operate on an integrated set D of data nodes, which represent application data, created, modified, and deleted during the execution of a process model. The term data flow refers to data dependencies between process activities and data.

In our work we use the distinction of process data into data classes and data nodes (see Figure 2), which can be viewed as analogous to the object-oriented programming paradigm. *Data class*, used in a process model, serves as an abstract data type, which describes the properties of *data nodes*. The data nodes can be viewed as instances of the data classes at the modeling level. Data nodes are associated with exactly one data class in a process model, in a way that the particular values of data class properties are assigned to the data node associated with it.

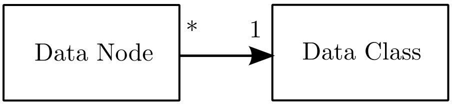


Fig. 2. Relations between data entitites

Definition 2 (Data class). *Data class* $D_c = (name, S, Q_c)$ is a tuple, where:

- $name$ is a constant which serves as a unique identifier for the data class D_c;
- S is a finite non-empty set of data states;
- Q_c is a finite set of attributes, which are properties representing data fields containing values of an arbitrary type. ◇

Definition 3 (Data node). Let D_c be a data class, used in a process model. A tuple $D_n = (name, s, \delta, \tau, \varphi, Q)$ is a *data node*, related to the corresponding data class D_c, with the following parameters:

- $name$ is a constant labeling data node D_n, which serves as a reference to the corresponding data class D_c;

- $s \in S$ is a variable reflecting the state assigned to D_n, where S is the set of data states of D_c;
- $\delta : D_n \longrightarrow \{singlinst, multinst\}$ is a function indicating if the data is a collection (singlinst) or not (multinst);
- $\tau : D_n \longrightarrow \{input; output; default\}$ is a function indicating if D_n is an input data node (existed before the start of the process), ouput data node (will exist after termination of the process) or none of these (default);
- $\varphi : D_n \longrightarrow R$ is a function indicating the resource allocated for D_n;
- $Q \in Q_c$ is a set of attributes assigned to D_n, where Q_c is the set of attributes of D_c. ◇

To be definite, we assume that the resource of a process model, allocated for the data node, is the same as the resource allocated to the activity, which accesses this data node. Thus, the value of the function ψ (from Definition 1), mapping the activity a to the resource R , is equal to the value of the function φ (from Definition 3), mapping the data node D_n, with which a is in a data flow relation, to the same resource R. More specifically, $\varphi(D_n) = \psi(a)$, where $a \in N_A$, and $(a, D_n) \in F \vee (D_n, a) \in F$. Also, as it can be seen from Definition 3, the set of attributes Q store the context data relevant to the business process, i.e. the particular characteristics of the data class.

2.2 Definitions from Decision Theory

As it was mentioned in the introduction, many business processes face the uncertainties of the business environment and decision theory is a tool which is focused on dealing with such challenges. Below we provide the notions used in our approach, with regards to the foundations of decision theory [9,11].

The core setting of decision theory is an occurrence of a subject *decision maker* whose aim is to make an optimal choice between a set of n *alternatives*: $X = \{x_i\}, i = 1, \ldots, n$, with a possible *outcome* event O. The main assumption is that any realization of the alternatives resulting from a decision can be compared, which is described by the *preference relations* of the decision makers, represented by the $\succcurlyeq$ sign.

Definition 4 (Preference relation). A *preference relation* $\succcurlyeq$ is a subset of the binary relation $X \times X$, that satisfies two principles :

1. *Completeness.* $\forall x_i, x_j \in X$: either $x_i \succcurlyeq x_j$, or $x_j \succcurlyeq x_i$, or both.
2. *Transitivity.* $\forall x_i, x_j, x_k \in X$: if $x_i \succcurlyeq x_j$ and $x_j \succcurlyeq x_k$ then $x_i \succcurlyeq x_k$. ◇

Definition 5 (Lottery). A *lottery* L is a finite vector $(p_1, \ldots, p_n)$, where p_i is the probability that the alternative x_i will be realized, such that $\sum_{i=1}^{n} p_i = 1$, $p_i \geq 0$. ◇

Another assumption of decision theory is that a decision maker is making a choice in a rational way, which is expressed by a *utility function* assigned to the decision maker.

Definition 6 (Utility Function). A *utility function* u is a function which assigns a real number to any given choice of the alternatives, $u : X \longrightarrow \mathbb{R}$ where $\mathbb{R}$ is a set of real numbers. A utility function u is said to represent a *preference relation* $\succcurlyeq$ if and only if $\forall x_i \in X, \forall x_j \in X, u(x_i) \geq u(x_j) \Leftrightarrow x_i \succcurlyeq x_j$ ◇

The value of the utility function is a *payoff*. For comparing the alternatives in a decision making process, a notion of *expected payoff* is used:

Definition 7 (Expected Payoff of the Lottery). An *expected payoff* E of the lottery is the average of payoffs which the decision maker gets from the assumed realization of the alternative, weighted by the probability of such a realization: $E(L) := \sum_{i=1}^{n} p_i u(x_i)$ ◇

In terms of the introduced definitions, the assumption of rational behavior is the following: the goal of each decision maker is to maximize the expected payoff of the lottery.

3 Redesign of the Decision Subprocess

Searching for ways to improve business processes led us to consider the typical challenges of the business environment, such as turbulence of markets and making decisions under conditions of risks and limited resources. In order to provide an effective mechanism for dealing with the uncertainties in business environment, in this section we provide a mapping between the decision theory and business process management, and devise how to use it for the business process redesign.

3.1 Process Model as a Decision Subprocess

The notions of decision theory, presented in Section 2, provides the premise for defining a special kind of business process models, which we refer to as *decision subprocesses.*

The generic structure of a decision subprocess is shown in Figure 3. The decision subprocess represents a process model, the internal logic of which is hidden inside the collapsed subprocess. As it can be seen from the figure, the set of alternatives in the decision subprocess is presented as the collection input data node D_n^i, and the final decision is presented as the collection output data node D_n^o, so that $\tau^i = \{input\}$, $\tau^o = \{output\}$. The decision subprocess should reflect the process of decision making, therefore it is assumed that the data represented by the output data

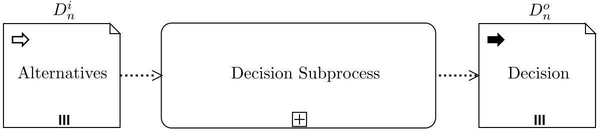


Fig. 3. Structure of a decision subprocess

node "Decision" is a subset of the data represented by the input data node "Alternatives".

Based on the above mentioned considerations, the decision subprocesses can be defined formally, based on following conditions. Let P be a process model, which consists of K data nodes, including the input data node D_n^i and the output data node D_n^o , which are bound to J data classes.

Condition 1. Set of alternatives is represented by the set of attributes Q^i of the input data node D_n^i.

Condition 2. Final decision is represented by the set of attributes Q^o of the output data node D_n^o. The set of attributes Q_c^o of data class D_c^o, which is assigned to the *output* data node D_n^o, is a subset of the set of attributes Q_c^i of data class D_c^i, which is assigned to the *input* data node D_n^i: $Q_c^o \subseteq Q_c^i$.

Condition 3. Decision makers are represented by a function φ, indicating resources allocated for data nodes D_n (see Definition 3).

Condition 4. Decision making process consists of decision makers choosing alternatives, so that each set of attributes Q of data class D_c assigned correspondingly to any data node D_n is a subset of the set of attributes Q_c^i of data class D_c^i assigned to the input data node D_n^i: $\forall Q_c : Q_c \subseteq Q_c^i$.

Definition 8 (Decision subprocess). If a given process model P satisfies conditions 1-4, then such a process model represents a *decision subprocess*. ◇

3.2 Scheme of Business Process Improvement

The introduction of the decision subprocess enables us to suggest an approach for the improvement of such a process model. Below we present the detailed approach, which consists of three consequent phases, corresponding to three stages of the scheme for business process improvement (see Figure 1):

S1 (a). Analysis of Business Process Model. The business process improvement scheme is launched when a business analyst of the enterprise decides that the current business process is not efficient.

S1 (b). Detection of Decision Subprocess. It is identified if the current process model P represents a decision subprocess, according to Definition 8.

S2 (a). Definition of Payoff Function. The improvement of the internal structure of the decision subprocess (i.e., the collapsed subprocess in Figure 3) can be done by the application of the decision theory methods. The persons, or other resources, involved in the execution of the decision subprocess, can be viewed as decision makers. Additionally, according to the assumption of rational behavior of decision makers, their goal is to maximize the *expected payoff* for the decision subprocess. Therefore, the assigned goal of this stage is to set the payoff function of the decision subprocess. The example of the payoff function could be the time saved by participants, to agree on the decision.

S2 (b). Optimization of Decision Subprocess. In such a way, we reduced the challenge of business process improvement to the task of maximizing the expected payoff for the decision subprocess. To solve this task, we propose the following transformation, which consists of two steps:

1. All the data classes D_c of the decision subprocess are consolidated into one data class $D_c^{'}$. Such transformation preserves the business context of the process model, as, according to Condition 4 of Definition 8, each set of attributes of any data class in a decision subprocess is a subset of the set of attributes of the data class assigned to the input data node.
2. The access management of resources is changed in such a way that within the decision subprocess, all the resources should have access to all the data nodes assigned to the consolidated data class $D_c^{'}$.

The output of such a transformation is a process model P', which is different from the initial process model P only in a way, that it contains a set of K data nodes $D_n^{'}$, all of which are assigned to one consolidated data class $D_c^{'} = (name', S', Q_c^{'})$, where

- *name'* reflects the consolidated nature of the data class,. *name'* can be assigned by a business analyst;
- $S' = \{S_j\}, j = 1, \ldots, J$ is the set of states retrieved as a maximal subset of the sets of states of data classes $D_c^j, j = 1, \ldots, J$ assigned to the initial process model P;
- $Q_c^{'}$ is the consolidated set of attributes retrieved as a maximal subset of the sets of attributes for all data classes in the initial process model P.

The data nodes $D_n^{'}$ of the transformed model P' are different from the corresponding data nodes D_n of the initial model P only in a way, that the value of the parameter *name'* for each data node $D_n^{'}$ is equal to the value of the corresponding parameter of the consolidated data class $D_c^{'}$.

S3. Simulation of Redesigned Process Model. In order to assess the efficiency of the transformation, we plan to develop a set of indicators and conduct a simulation of the process model for estimating the values of these indicators. This is the final step of the improvement scheme. Depending on the results of the simulation, a conclusion is made, to either accept the improved process model P' and start using it in the enterprise, or to conduct further improvements of the process model. Such a decision can be done, for example, by a business analyst or higher management.

4 Use Case

In this section, we demonstrate the applicability of our approach to business process improvement with a use case, which incorporates the decision making process.

4.1 Setting of Use Case

Context Statement. *In the enterprise, there is a group of people* $\{person_j\}$, $j = 1, \ldots, N_{people}$ *for whom a meeting should be organized. The meeting should be held on a specific date, with a minimum number of people* N_{minp} *participating in it. A preliminary set of dates* $\{date_i\}, i = 1, \ldots, N_{dates}$ *is given, out of which each participant should choose one.*

We investigate two possible scenarios for the realization of this process:

1. The organization of the scheduling of meetings is being done by a secretary who writes a personal e-mail to every participant of the meeting, collects the responses, selects the date, for which the majority of participants have voted, and sends it back to participants for confirmation. If less than the required minimum N_{minp} of people confirm their participation, the process repeats. If more than N_{minp} people confirm this date, the secretary fixes it and sends a final e-mail to all the participants with the chosen date. This scenario represents the case of a so called closed scheduling system, where the participants make decisions without knowing each others choices.
2. The second scenario considers the scheduling of the meeting date with the help of a software platform, which serves as an agent, collecting the opinions of participants. An example of such a platform could be the online scheduling platform "Doodle" [1]. Such an approach represents the case of a so called open scheduling system, where the participants make choices, knowing each others choices.

4.2 Application of Scheme of Business Process Redesign

The application of our step-by-step approach for the improvement of business process for the use case, described in Section 3, is discussed next.

S1 (a). Analysis of Business Process Model. We assume, that a closed scheduling system is used in an enterprise (first scenario). After reviewing the context of this scenario, the business analyst comes to a conclusion that the scheduling of a meeting by a secretary involves a large number of created data artifacts (e-mails).

S1 (b). Detection of Decision Task. As the goal of the business process is to choose one final date for a meeting, it can therefore be considered as a decision subprocess. The formal mapping of the notions from the decision theory is presented in Table 1.

As shown in the table, the decision makers are the participants of the scheduling business process. With that, the set of alternatives is a set of dates, from which one date should be chosen as a final date for the meeting. Thus, the choice of alternatives can be represented by the following set of trials:

Table 1. Definitions from decision theory and corresponding elements of a business process in the scheduling use case

Definitions of Decision Theory	**Corresponding Elements of the Use Case**
Decision makers	Set of participants for the business process $\{person_j\}, j = 1, \ldots, N_{people}$
Set of alternatives	Set of dates $\{date_i\}, i = 1, \ldots, N_{dates}$
Choice of alternatives	Set of trials which represent the voting of participants $I = \{I_k\}, k = 1, ..., N_{people}$
Outcome	Event S_i / Event F_i - Success or Failure of $date_i$, $i = 1, ..., N_{dates}$
Utility function	$U(S_i) = 1$ and $U(F_i) = 0, i = 1, ..., N_{dates}$

Event $I_j \longrightarrow$ The first person from the group of participants $p_1 \in \{person_j\}, j = 1, ..., N_{people}$ **accepted** the date $date_j$

Event $\overline{I_j} \longrightarrow$ The first person from the group of participants $p_1 \in \{person_j\}, j = 1, ..., N_{people}$ **rejected** the date $date_j$

Furthermore, two outcomes for each alternative date are possible:

Event $S_i \longrightarrow$ "Success", each participant made a choice, and **not less** then N_{minp} voted for the $date_i, i = 1, ..., N_{dates}$

Event $F_i \longrightarrow$ "Failure", each participant made a choice, and **less** then N_{minp} voted for the $date_i, i = 1, ..., N_{dates}$

According to the logic of the business process, each participant will prefer at most that the meeting **will** take place, at any date. Therefore we assign the following values to the utility function: $U(S_i) = 1$ and $U(F_i) = 0, i = 1, ..., N_{dates}$, as presented in Table 1.

In such a way, the business analyst can come to the conclusion that the business process of scheduling the meeting at the enterprise, with the help of a secretary represents the decision subprocess.

S2 (a). Definition of Payoff Function. Recall, that at this stage of the scheme for business process improvement, the payoff function of the decision subprocess should be identified. From the second scenario it is known that the potential improvement of the scheduling business process can be provided by special software, which provides the participants with the possibility to view the choices of each other. Therefore, we propose to view the payoff function as an expected payoff of the choice of participants. Below we provide the comparison of the expected payoff of a choice in the general case and in both scenarios of closed and open scheduling systems.

General Formula for Expected Payoff of the Choice. According to Definition 7, the expected payoff for the participant from choosing the date is the following: $E(date) = P(S_i) * U(S_i) + P(F_i) * U(F_i)$. We showed in Table 1, that $U(S_i) = 0$ and $U(F_i) = 0$, therefore the equation for expected payoff is simplified as follows:

$$E = P(S) \tag{1}$$

When a participant chooses if he accepts a particular date, the answer is either "Yes" or "No". In such a way, we can view the sequence of the decisions made in the use case as a finite sequence of binary random variables with two possible outcomes: 0 or 1. Such process represents the *Bernoulli process* [3]:

Definition 9 (Bernoulli Process). The *Bernoulli process* is a sequence X_1, X_2, ... of independent random variables X_i, such that $P(X_i = 1) = P\{$success at the i-th trial$\} = p$, and $P(X_i = 0) = P\{$failure at the i-th trial$\} = 1 - p$, for each i. ◇

For the Bernoulli process, the formula of success in n trials, not less than k_1 times, and not more than k_2 times, is the following:

$$P\{k_1 \leq k \leq k_2\} = \sum_{k=k_1}^{k_2} C_n^k p^k q^{n-k} \tag{2}$$

Here, p and $q = 1 - p$ are the corresponding possibilities of success and failure of trials. It is assumed, that the choices of the people are random, so that the probability, that a participant will accept or reject the date, is equal: $P(I_1) = P(\overline{I_j}) = 0.5, j = 1, \ldots, N_{people}$. Therefore, according to Formula 2, $p = q = 0.5$. This formula is applicable in our use case for calculating the probability of the outcome $S_i, i = 1, ..., N_{dates}$.

Expected payoff of the choice in the scenario of a closed scheduling system. In this scenario, on any step of the decision subprocess, represented by trials $I = \{I_k\}, k = 1, ..., N_{people}$, the estimation by the participant of the probability of the success outcome for a particular date is always the same and can be calculated by Formula 2:

$$E(date) = P\{N_{minp} \leq k \leq N_{people}\} = \sum_{k=N_{minp}}^{N_{people}} C_{N_{people}}^k p^k q^{N_{people}-k} \tag{3}$$

Expected payoff of the choice in the scenario of an open scheduling system. Assume that only the first participant made a choice (trial I_1 or $\overline{I_1}$ was realized). As this participant does not know the preferences of others, he evaluates the probability of the final success event in the same way, as in the secretary scenario, using Formula 3. Now, when the second participant chooses a date (trial I_2 or $\overline{I_2}$), if he knows the choice of the first participant (trial I_1 or $\overline{I_1}$), his evaluation of the outcome can be estimated by considering the conditional probability of the final event in formula 2: $E(date) = (S|I_1)$. Thus, the required number of the participants for choosing a particular date, is less by 1 in formula 2:

$$E(date) = P\{N_{minp} - 1 \leq k \leq N_{people}\} = \sum_{k=N_{minp}-1}^{N_{people}} C_{N_{people}}^k p^k q^{N_{people}-k} \tag{4}$$

Formula 3 and Formula 4 are also applicable, if the participant is given a set of dates to choose: $\{date_i\}, i = 1, ..., N_{dates}$. In such a case, the participant evaluates all the conditional probabilities of the success of dates, taking into account the choices of the previous participants.

Comparison of expected payoffs of the choices in two scenarios. The comparison of Formula 3 and Formula 4 leads us to the conclusion that two options are possible. In the case that the event I_1 is realized, the expected payoff of the choice for the second participant in the second ("Doodle") scenario is greater, than in the first ("Secretary") scenario, by a positive summand added to the positive sum. If the event $\overline{I_1}$ is realized, the expected payoff is equal in both scenarios. According to the assumption of rational behavior of the decision maker, the second participant will make such a choice, which maximizes his expected payoff. Thus, he will more likely choose the date which was already chosen by other participants. This will increase the probability of a particular date to be chosen by the third participant and so on. The overall benefit for the whole process will be the decreasing in the time spent on decision making and, therefore, raising the effectiveness of the whole business process.

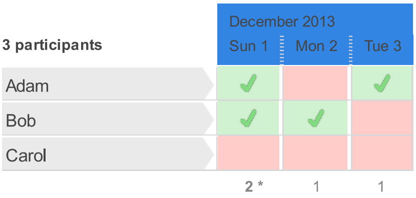
Numerical Example. Assume that 4 workers in the company are required to organize a meeting and they have to choose among three meeting dates, so that: $N_{people} = 4$; $\{date_i\}, i = 1, 2, 3$; $N_{minp} = 3$. The two scenarios can be presented as follows.

"Secretary" scenario. In this scenario, when the participants make the choice of dates, their estimation of the probability of the success for a date can be done using Formula 2:

$$P(S) = \sum_{k=3}^{4} C_4^k * 0.5^4 = C_4^3 * 0.5^4 + C_4^4 * 0.5^4 = 1/16 * (4 + 1) = 0.3125 \quad (5)$$

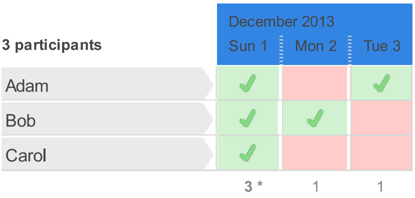
This probability stays the same at any step of choosing the dates by participants, because the participants do not receive any additional information which can influence their decision.

"Doodle" scenario. Assume that 2 people (Adam and Bob) have made choices according to Figure 4:



3 participants	December 2013 Sun 1	Mon 2	Tue 3
Adam	✓		✓
Bob	✓	✓	
Carol			
	2 *	1	1

Fig. 4. Carol needs to make a choice



3 participants	December 2013 Sun 1	Mon 2	Tue 3
Adam	✓		✓
Bob	✓	✓	
Carol	✓		
	3 *	1	1

Fig. 5. Carol made a choice

Now assume that the third worker, Carol, needs to make a choice. For her, the probabilities of dates to be chosen, estimated by Formula 2, are the following:

$$\text{“Sun 1”} \longrightarrow P(S) = \sum_{k=1}^{4} C_4^k * 0.5^4 = 0.5^4 * (C_4^1 + C_4^2 + C_4^3 + C_4^4) = 0.9375 \quad (6)$$

$$\text{“Mon 2”} \longrightarrow P(S) = \sum_{k=2}^{4} C_4^k * 0.5^4 = 0.5^4 * (C_4^2 + C_4^3 + C_4^4) = 0.6875 \quad (7)$$

$$\text{“Tue 3”} \longrightarrow P(S) = \sum_{k=2}^{4} C_4^k * 0.5^4 = 0.5^4 * (C_4^2 + C_4^3 + C_4^4) = 0.6875 \quad (8)$$

We assume that Carol was initially hesitating between “Sun 1” and “Tue 3”. By looking at the Doodle poll (see Figure 4), she estimates that the possibility that the date “Sun 1” will be chosen is greater than for the date “Tue 3” (from Equations 6 and 8: $0.9375 > 0.6875$). She chooses the first date, and the meeting date is found, since three people have voted for the date (see Figure 5).

Simultaneously, if the system would be closed and Carol could only guess which decisions the other participants have made, the probability of success for all three dates from her point of view would be the same and its value could be calculated according to Equation 6. The difference in the expected payoffs of Equation 6 and Equation 5 is Carol's benefit for using the open scheduling system or *expected utility of knowing additional information* and its value is equal to $0.9375 - 0.3125 = 0.625$.

In the examples presented above we have demonstrated, with the help of decision theory, that for the scheduling decision subprocess, the open scheduling business process is more efficient than the closed scheduling business process. In the following subsection we present the possible transformation for the use case scenario of the closed scheduling system.

S2 (b). Optimization of the Decision Task. In order to implement the transformation rule, in this subsection we provide the simplified view at the process model in the case of a closed scheduling system, presented in Figure 6.

Thus, the process model consists of the following data classes with corresponding sets of parametres, as shown in Table 2. The presented use case satisfies the conditions of the decision subprocess with the following parametres:

Table 2. Data classes and corresponding sets of parametres in the use case

Data Class	**Corresponding Set of Parametres**
table with dates	$Q_1 := N_{minp}$, $Q_2 := listDates = \{date_i\}, i = 1, ..., N_{dates}$, $Q_3 := listPeople = \{people_j\}, j = 1, ..., N_{people}$;
confirmation request	$Q_1 := date$; $Q_2 := listPeople = \{people_j\}, j = 1, ..., N_{people}$;
response	$Q_1 := response$;
final date	$Q_1 := date$;

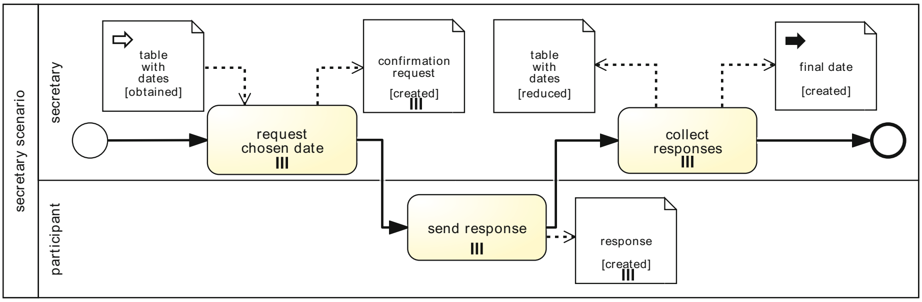


Fig. 6. Example of pattern for re-design of the use case, Secretary scenario

1. The set of alternatives is represented by the set of attributes of the input data node "table with dates": $listDates = \{date_i\}, i = 1, ..., N_{dates}$;
2. The final decision is represented by the set of attributes of the data class assigned to the output data node "final date" which is the subset of the set of attributes of the data class, assigned to the input data node $date \in \{date_i\}, i = 1, ..., N_{dates}$;
3. Decision makers are represented by initiating organizational unit "Secretary' as a resource R_1 and unit "Participant" as a resource R_2;
4. The set of attributes Q of each data class is a subset of the set of attributes of the data class assigned to the input data node: $\forall Q_c : Q_c \subseteq Q_c^i$.

As the scenario satisfies the conditions of a decision subprocess, a transformation rule to the initial process model P can be applied. All data nodes from the above mentioned scenario are replaced with one data node "Document" with different states. The transformed process model P' is presented in Figure 7. The set of attributes Q of the consolidated data class assigned to each data node in the process model P' is retrieved as a maximal subset of the sets of attributes for all data classes in the initial process model P: $Q_1 := N_{minp}$, and $Q_2 := listDates = \{date_i\}, i = 1, ..., N_{dates}$, and $Q_3 := listPeople = \{people_j\}, j = 1, ..., N_{people}$.

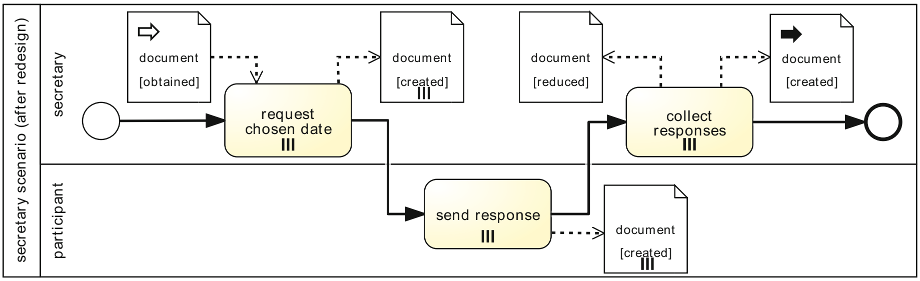


Fig. 7. Example of pattern after re-design of the use case

At the final phase of the investigation for the possibilities of business process improvement, the business analyst can decide how exactly to implement the redesigned data object “Document”. In our case the business analyst finds out that the Doodle poll can replace all the data nodes of the “Secretary” scenario.

5 Related Work

In contrast to the topic of process modeling, process redesign has not received so much attention from the scientific community [4]. A fundamental approach for business-process re-design based on best practices of successful redesign heuristics was presented in 2005 in [12]. In this paper the authors are introducing best practices, which can support the technical challenge of the business process re-design challenge in four dimensions: time, cost, quality and flexibility. This approach was applied, for example, in the healthcare domain for the reduction of throughput and service times of medical management processes, as described in [7]. As well, a number of different automation platforms supporting business process re-design were presented to the public, such as a framework based on Petri-nets [14] or, for example, software based on process mining techniques [8].

However, the above mentioned approaches are based on traditional activity flows and most of them do not consider data or business artifacts presented in the models. In our work we suggest an integrated approach which considers both activities, and the data of process models. Similar work was presented in IBM’s artifact-centric process modeling approach [6]. Also, the artifact-based approach was developed at Eindhoven University of Technology in cooperation with a Dutch consultancy company [13]. However, the above mentioned approaches provide company-specific redesign patterns. In contrast, in our work we provide a generic hybrid scheme for business process re-engineering, based on the application of techniques from decision theory.

6 Conclusion

In the paper we provided an approach for business process improvement, according to the scheme, consisting of the identification of specific patterns in process models and the redesigning of these models in order to increase its efficiency. We presented a decision subprocess, as such a redesign pattern, which incorporates the mapping of decision theory and the business process model at the modeling level. We introduced an approach for improving the internal structure of the decision subprocess by introducing and maximizing the payoff function. In future, we plan to present further redesign patterns for business process improvement.

We demonstrated the applicability of our research by improving a business process for the use case of scheduling meetings in an enterprise. In future, we plan to apply our approach to a broader class of business processes incorporating decision making. For instance, we could extend the use case used in this paper, to the integrated time management in the enterprise.

The limitation of our approach is that our scheme for business process improvement is bound to the dependencies between the data attributes of the data nodes at the modeling level. Nevertheless, in future we plan to enhance the approach with the data execution semantics.

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