CONCEPTUAL OPTIMISATION IN BUSINESS PROCESS MANAGEMENT

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Abstract: To optimise business processes is a very complex task. The goal is double: to improve productivity and quality. The method, developed in this paper, is composed of 4 steps : the first one is the Modelling step (to describe the business process in a very rigorous way), then a conceptual optimisation (supported by evaluation and simulation tools) to improve the business process structure (to make it more consistent, to normalise it), then an operational optimisation to improve the business process performing (to make it more efficient) by providing to each operation the necessary resources and at last a global optimisation (to take into account all the business processes of the company under study). This method is the result of three years research achieved for the French organism "Caisses d'Allocations Familiales: CAF". It was validated on the business processes of the CAF, which deal with information (files and documents), but it can also be applied on industrial business processes (dealing with products and materials).

1 INTRODUCTION

Business process optimisation is one of the major issues of any company. The main goals are to improve processes quality and to improve their productivity, by increasing the number of output flows and/or by decreasing the quantity of necessary resources [Rolland 1996, Butler 1999, Aalst 2002, Aler 2002, Borrajo 2001, Estin 1996, Jonkers 1999, Jensen 2001, Krajewski 2001, Drabble 2002, Nareyek 2001, Haslum 2000, Williamson 1994]. The method presented in this paper starts with a previous modelling step followed by three main steps:

- <u>the Modelling step</u> makes it possible to represent BP with a model which has the usual guarantees of any good model: readability, normalisation, genericity, and which induces an optimisation more rigorous, more consistent and less hazardous. Modelling was decided for all these reasons in order to avoid an empirical optimisation consisting in improving each BP from clues based on its behaviour, by trying to find out local solutions.
- <u>the Conceptual optimisation step</u> which does not take into account resources; it is a structural and static optimisation.
- <u>the Operational optimisation step</u> which consists in optimising the performing of the BP by taking into account resources, which means by locating them the best way as possible. It is a dynamic optimisation since the goal is to optimise performances.
- <u>the Multi-BP optimisation step</u> which is used to optimise (in the operational way) several BP simultaneously.

2 MODELLING

Four concepts are necessary to model business processes: operation, flow, resources and competencies.

<u>Operations</u>: an operation is a task of a business process. Each operation can be mandatory or optional. A mandatory operation has to be used systematically (always), which means it is necessary for the right performing of the BP. An optional operation may not be used depending on the decided options.

<u>Flows</u>: A flow is a set of homogeneous elements passing through the BP and treated by operations. An optional flow is a flow associated to an optional operation. <u>Resources and Competencies</u>: These 2 concepts are linked. A resource is a group of persons having the same set of competencies. A resource possesses one or several competencies. A

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competency can be associated to several resources (N: M link). The set of resources is a partition of the persons set.
We consider that each operation is one-competency. The chosen model is directly inspired from the UML activity diagrams. In order to build activity diagrams, we can use any tool supporting UML notations. We can choose either a full UML environment like RATIONAL ROSE or DESCRIBE or a graphic modelling tool like VISIO or SMARTDRAW. DESCRIBE was finally chosen, because it is the tool which satisfy the better these criteria.

3 OPTIMISING

The modelling step provides a diagram of the BP (by using the previous concepts) in order to evaluate it (with simulation and evaluation tools) and to optimise it in the right directions.

3.1 Collecting information

3.1.1 Indicators

Indicators are used to evaluate a BP. They are of 2 kinds: model indicators and BP indicators.

Model indicators: they are used to evaluate the consistency of a BP independently of its finality. They are theorical indicators (in opposition to BP indicators). They provide an evaluation of the diagram quality and make it possible to check that diagrams are satisfying the norms given by the model. In others words, to check that the conceptual optimisation step delivers well built
diagrams. Examples of model indicators are following:
maximum number of input and output flows in each operation, average number of flows per operation, number of operations, number of loops, cyclomatic number (number of bows-number of nodes + 2), diagram density (number of bows/maximum number of bows), average number of operations per competency.
BP indicators: they are used to evaluate performances and dysfunction of a BP. Their values are useful to determine the optimisation priorities.
The modelling step and the objectives graph (see Fig. 2) step make it possible to find out (for a given BP) the list of the useful indicators.
Fig. 1 shows some examples of BP indicators in a specific BP from the CAF.

NODES OF THE GRAPH	INDICATORS	FORMAT	WAY TO OBTAIN
READABILITY OF DOCUMENTS	I1 : SATISFACTION PER DOCUMENT	VECTOR	OBSERVATION
DECREASE RATE REJECT	I2 : % REJECT PER OPERATION	VECTOR	SIMULATION
DEMATERIALISATION	I3 : % DEMATERIALISATION	NUMBER	OBSERVATION

Figure 1: Examples of BP indicators

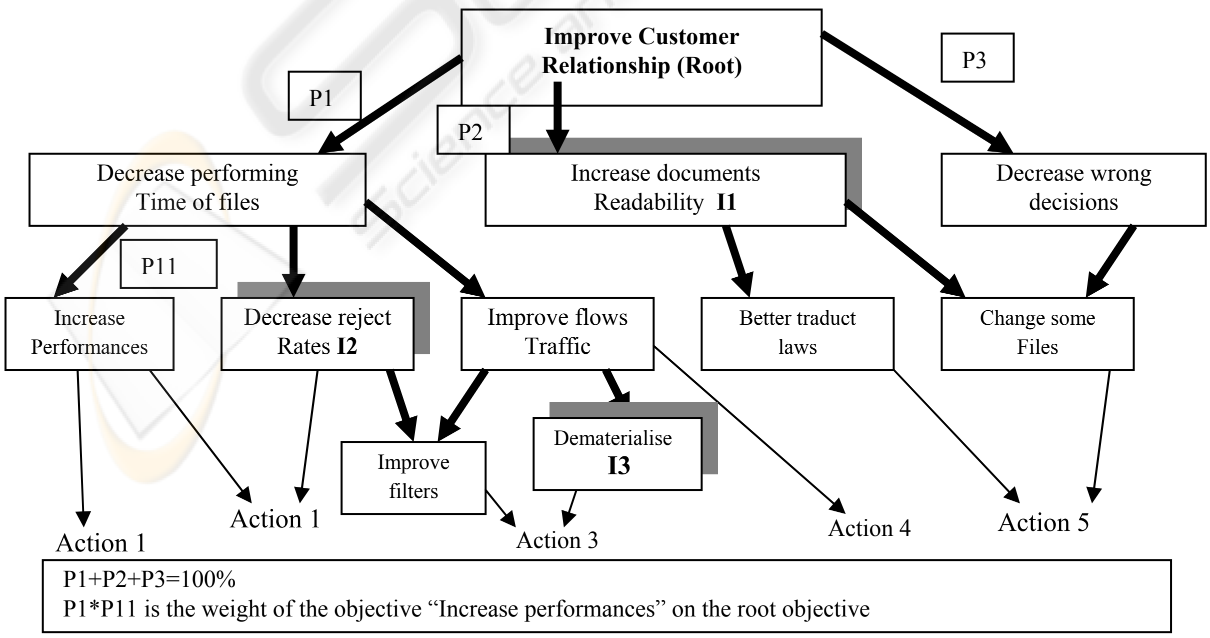

Figure 2: Example of hierarchical objectives graph

3.1.2 Hierarchical Objectives Graph

It is necessary to build a hierarchy of optimisation objectives and to identify precisely those which are means compare to the others. Thus, we propose to build a "hierarchical objectives graph" (HOG). This kind of graph makes it possible to show clearly the hierarchical relationships between objectives.

If the graph is well built and exhaustive, all its leaves are the actions to perform in order to optimise the BP. More precisely, the graph is built by connecting (if possible) to each node (objective) some indicators, values of which will be provided by evaluation and simulation steps (in the example I1, I2 and I3).

The graph is helpful to build an optimise BP because it gives the hierarchical links between objectives and then optimisation priorities. Each BP has its own graph. The bows of the graph have to be valuated (with percentages) in order to give the satisfaction weight of an objective to another one (higher in the hierarchy) and to guide the process optimisation.

Simulation

This step is dedicated to the study of the BP behaviour in order to find out some of the possible improvements (addition or deleting operations and/or flows, detection of wrong cycles, detection of congestion points,…). Obviously, this step requires a simulation tool (SIMPROCESS was chosen).

The simulation step is also used to give values to indicators, such as the reject ratio per operation.

3.2 Building the best BP

The conceptual optimisation of a BP is achieved from information provided by evaluation step, simulation step and objectives graph step. The goal is to build the best BP as possible (in regards to norms, indicators, objectives hierarchy). It is a very tough step (totally hand made) which requires to take into account simultaneously a very large number of information and a great know how. Thus, values of some model indicators will induce creation or suppression of some operations and/or flows, values of some BP indicators will generate creation of some new paths in the diagram (by validating or deleting optional operations) or creation of new documents, analysis of the objectives graph make it possible to identify the parts of the BP which have to be optimised in priority.

Conceptual optimisation is totally guided by the objectives graph: weights are used to know priorities and indicators are used to decide if the nodes are easy to optimise or not. In the example, we can decide to give a priority to the objective "decrease the time to perform a file" if the values of I2 are too high and if the weight of this objective in regards to the root objective is high. In this case, we have to (following the graph) modify some resources and add some operations. In opposition, if the value of I1 is too low and if the weight of the objective "to increase readability of documents" is high, then we have to design new documents.

Actually, the conceptual optimisation of a BP is achieved by a lot of improvements (defined in the leaves of the graph) performed on its diagram, in regards to the objectives graph which gives the right directions. But the diagram's improvement has to be done in respect of concepts. For this reason, we have defined the exhaustive list of generic actions (meta-actions) which are possible to do. Each leaf of the graph has to be obviously an instance of one meta-action.

Examples of meta-actions: to add a new operation, to automate partially an operation, to split an operation (in 2 or more) to add a new flow, to merge 2 or more flows into 1, to modify a flow, to add a new competency, to change the destination operation of a flow.

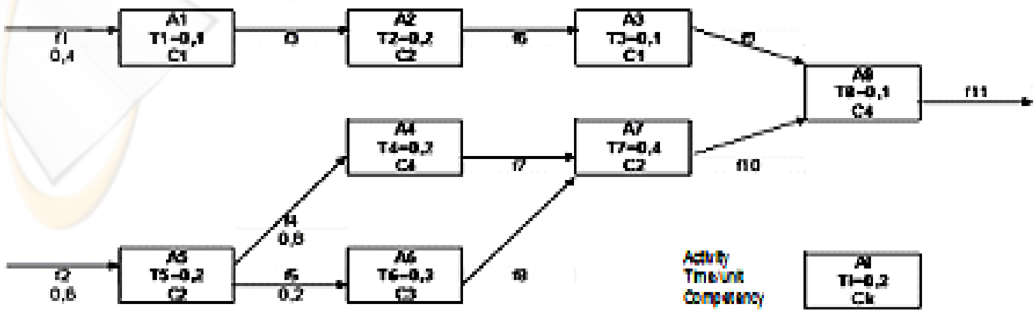

Figure 3: An example of BP

RESOURCE	COMPETENCY	AVAILABILITY/ PERIOD
R1	C2	TR1=35
R2	C1, C2	TR2=35
R3	C3	TR3=35
R4	C1, C4	TR4=35
R5	C4	TR5=35
R6	C2, C3	TR6=35
R7	C2	TR7=35
R8	C2	TR8=17.5
R9	C1	TR9=17.5

Figure 4: Table resources/competencies.

FLOWS	STOCKS
f1	29
f2	58
f3	6
f4	2
f5	6
f6	4
f7	4
f8	2
f9	4
f10	8
f11	0

Figure 5: Table of flows stocks.

3.3 Predicting the best affectation of resources

This step consists in giving to each operation of a BP, resources and competencies, in order to maximise output flows. Actually, the final goal is to provide a command tool to predict the best resources affectation as possible, by taking into account different hypothesis of degraded performing (for example absenteeism) as well as flows stocks (flows which have not been treated).

This third step is divided in two distinct issues:

Issue 1: Searching optimum of outputs flows (by an optimised affectation of resources and competencies to operations (linear optimisation).

Issue 2: Locating resources and competencies on each operation at the right time (non linear optimisation).

To illustrate this step, let's take an example of BP given in Fig. 3.

This BP is composed of 8 operations (A1, A2,.., A8) and 9 resources (R1, R2,…, R9). The relationships between resources and competencies are given in Fig. 4, the stocks of flows are given in Fig. 5. Let fp be the number of units of flow p treated and wjk be the used time of the resource Rj for its competency Ck (during the chosen period).

Issue 1 consists in giving resources and competencies to each operation (by finding out optimal values of fp and wjk) (who does what?) and in computing the maximum number of output flow units. The equations system to solve is following; it corresponds to using conditions of competencies on the period.

Competency C1 $T1*f3 + T3*f9 = w21 + w41 + w91$

Competency C2 $T2*f6 + T5*(f4+f5) + T7*f10 = w12 + w22 + w62 + w72 + + w82$

Competency C3 $T6*f8 = w33 + w63$

Competency C4 $T4*f7 + T8*f11 = w44 + w54$

The first legs of these equations are the total used time of competencies. For example, competency C1 which is used in operations A1 and A3 is engaged for a time T1*f3 in A1 and T3*f9 in A3. The second legs correspond to the used time of competencies in regards to resources. For example, competency C1 is provided for a time w21 by resource R2, for a time w41 by resource R4 and for a time w91 by resource R9.

To solve the system we also have to take into account two types of constraints:

Availability constraints of resources:

For each resource Rj, total used time should not be higher than available time. There are 9 constraints of this kind:

R1: $w12 \leq TR1$ R2: $w21 + w22 \leq TR2$
R3: $w33 \leq TR3$ R4: $w41 + w44 \leq TR4$

R5: $w54 \leq TR5$ R6: $w62 + w63 \leq TR6$
R7: $w72 \leq TR7$ R8: $w82 \leq TR8$
R9: $w91 \leq TR9$

Pouring constraints on flows: Input and output flows can be multiple. To express that input flow f2 is approximately 60% of the total input flow (f1+f2), we write one constraint on the flow from f1 and on the flow from f2: $f2 \geq 1.4 * f1$ and $f2 \leq 1.6 * f1$.

To express that output flow f4 is approximately 80% of the total output flow (f4+f5), we write one constraint on the flow from f4 and on the flow from f5; we write a similar constraint on the flows f7 and f8: $f4 \geq 3.9 * f5$ and
$f4 \leq 4.1 * f5$, $f7 \geq 3.9 * f8$ and $f7 \leq 4.1 * f8$.

For each operation, the sum of output flows has to be inferior to the sum of input flows: $f11 \leq f9 + f10$, $f9 \leq f6$, $f6 \leq f3$, $f3 \leq f1$, $f10 \leq f7 + f8$, $f7 \leq f4$, $f8 \leq f5$, $f4 + f5 \leq f2$

The solver provides values of fp and wjk which optimise output flows. The results are given in the next tables

RESOURCE			$\sum_k$wjk	AVAILABLE TIME
R1	w12 : 28		28	7
R2	w21 : 10.5	w22 : 21	31.5	3.5
R3	w33 : 17.5		17.5	17.5
R4	w41: 3.5	w44 : 31.5	35	0
R5	w54 : 21		21	14
R6	w62 : 28	w63 : 3.5	31.5	3.5
R7	w72 : 31.5		31.5	3.5
R8	w82 : 17.5		17.5	0
R9	w91 : 17.5		17.5	0
TOTAL			231	49

Figure 6: Table of competencies used time

Input flows	
f1	95
f2	176
Stocks	123
Total (input + stocks)	394
Output flows (f11)	280
Non treated flows	114

Figure 7: Flows results

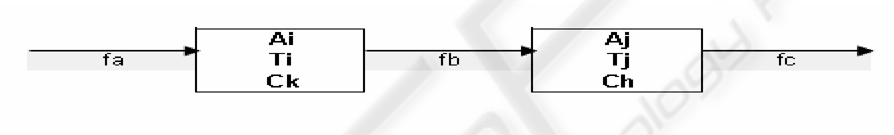

Figure 8: Evolution of flows

Issue 2 consists in searching dated resources locations. (Who does what and when?). For this reason, we have to split the period (35 hours in the example) in 10 slices of same length D (3,5 h in the example), and we have to find out quantities of resources to give to each operation in each slice. The result will be the used resources and competencies for each slice.

For this issue, the system solving has to take into account 3 types of constraints:

Exclusivity constraints on competencies. For each multiple competency resource, at most one competency is used in each slice. As we have 9 resources and 10 slices, we have 90 constraints of this kind. If we name{Cjk} $_{k\in\ 1..p}$ the set of competencies associated to resource Rj, the constraint may be expressed in the following way:

$\forall$ (Resource Rj, slice t) $\exists$ at most one k $\in$ 1..p such that Cjk is used in slice t.

Using constraints of resources in operations. They are equality constraints. For each slice and for each competency, there is equality between quantities of competencies used by operations and quantities of competencies taken in resources. In the example, there are four competencies and 10 slices; we have then 40 constraints of this kind.

If we name {aik(t)} $_{k\in\ 1..p}$ the set of used times of competency Ck for the operation Ai on the slice t and {w'jk(t)} $_{k\in\ 1..q}$ the set of used times of resource Rj for its competency Ck on the same slice, the constraint may be expressed in the following way: $\sum_i$ aik(t) = $\sum_j$ w'jk (t) where aik(t) = αik(t) * D ; αik(t) representing the number of times competency Ck is used for operation Ai on the slice t (that is the number of used resources).

Evolution constraints on flows. We assume that flows evolve in a discontinuous way. After each slice, flows evolve in regards to resources provided to operations and available flows of the previous slice. Let's take a basic example of Fig. 8.

The formula which gives flow fb after slice t is:

Flux(b,t) = Flux(b,t-1) + Min(Flux(a,t-1), αik(t)*D/Ti) - Min(Flux(b,t-1), αjk(t)*D/Tj) where αik(t) represents the number of times competency Ck is used for operation Ai on the slice t.

It is necessary to adapt this formula if operation Ai or Aj are preceded and/or followed by several operations.

An additional table is used to give quantities of input flows on each slice (in regards to the chosen arrival law)

OPERATION	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	*COMPETENCY*
A1	1	0	1	0	0	1	0	0	0	0	A1
A2	0	1	0	0	0	1	3	1	0	0	A2
A3	0	0	0	0	1	1	0	2	2	0	A3
A4	0	1	1	1	1	2	1	0	0	0	A4
A5	3	3	5	0	0	0	0	0	0	0	A5
A6	0	0	1	2	1	1	0	1	0	0	A6
A7	0	0	0	4	5	3	1	3	3	0	A7
A8	0	0	0	0	1	0	1	2	2	2	A8

Figure 9: Table of competency/operation affectation for each slice

The solver provides values of αik(t) which optimise the repartition of resources and competencies on each sliceand associated flows.

The table of Fig. 9 shows, the number of times αik(t) competency Ck is used for operation Ai for the slice t. For example, on the first slice, three resources of competency C2 are given to operation A5 and on the fourth slice two resources of competency C3 are given to operation A6.

4 MULTI-BP OPTIMISATION

As indicated by its name, multi-BP optimisation consists in optimising simultaneously several BP. Obviously, this step does not involve conceptual optimisation (which is, by definition, made on one BP, independently from the others) but only operational optimisation in the case where resources and competencies are shared by several BP. If so, the persons in charge of the business processes have to define priorities between BPs and constraints on resources and competencies which will be given to BPs and operations.

When priorities and constraints are defined, the solver can be run (one to N times) by deleting one by one constraints (from the bottom of the list) while objectives are not satisfied. The multi-BP optimisation step is, thus, a generalisation of the operational optimisation step, using the same tool and being done several times in a row. The final goal is to achieve a full and global command of all the BPs of the company.

5 CONCLUSION

The optimisation method presented in this paper is composed of 4 steps: Modelling step, conceptual optimisation step, operational optimisation step, multi-BP optimisation step. Its originality consists in separating clearly issues related to modelling and issues connected to optimisation. The first step (Modelling step) is necessary to model BPs under study and so necessary for the 3 others steps. The second one (conceptual optimisation step) make it possible to build the best BPs as possible, consistent and normalised (in regards to norms, objectives and indicators). The third one (operational optimisation) is probably the main one. Its goal is to improve the performances and behaviour of BPs by optimising resources and competencies locations.

This method was validated on administrative BPs. It also works on industrial BPs, under condition to take into account (during the operational optimisation) issues of breakdowns and maintenance of machines (by using complementary tools), issues which were not presented in this paper. This research is going to be extended by introducing data mining techniques in the conceptual step in order to find out more efficient optimising rules. We would like to thank the CNEDI 06 and more particularly M.P. Bourgeot who made this research possible.

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