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MULTIOBJECTIVE OPTIMIZATION OF INFORMATION SYSTEM QUALITY ENHANCEMENT

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ABSTRACT

Organizations have to efficiently manage efforts they deploy in order to enhance and ensure information system quality. Unlike other research works addressing this issue, the present proposal handle quality characteristics, such interoperability and security, by taking into account the subsisting complementarity between the different quality factors, their interactions and mutual effects. This paper considers the use of multiobjective optimization techniques in order to plan effectively quality evolution in inter organizational context. To ensure this effectiveness goal, this paper proposes initially a model to represent quality evolution and planning. Quality degrees are evaluated using ratio metrics taking into account all operational assessment aspects. In a second stage, a Multi Objective Particle Swarm optimization (MOPSO) algorithm is used as a heuristic optimization technique to obtain the best efforts distribution in collaborative networks.

Keywords: *Information system quality, Project planning, Effort dispatching, Multi objective optimization, Particle Swarm optimization*

1. INTRODUCTION

Strengthening Information System Quality (ISQ) factors aims at improving organizational performance and promoting synergy and business efficiency. The quality enhancement process appeals project management techniques when planning adequate improvement activities and monitoring their progress. Particularly for inter organizational context, ISQ enhancement involves usually different teams from independent entities. Effort dispatching, in such integration projects, requires advanced negotiations that could lead to divergences. Also, the subsisting complementarity between the different quality factors, their interactions and mutual effects are quite challenging issue to handle in order to plan effectively the improvement efforts.

The present work focuses on external ISQ characteristics that are influenced by environmental parameters. Indeed, the quality levels are evaluated using RatQual [1] assessment approach which uses composite rational metrics taking into account the three main following aspects:

– Internal potentiality corresponding to the quality characteristic maturity level of the environment where the studied information systems are located.

– External compatibility degree regarding the studied quality factor.

– Operational performance of the IT infrastructure that supports these systems.

This work aims to optimize efforts required to improve inter organizational information system quality levels. To do this, multi-objective heuristic optimization techniques are used in the sense that it supports not only one quality factor but two complementary factors such security and interoperability. The used bi-objective approach may be generalized to more than two objectives.

As a heuristic method, it is proposed to use Multi Objective Particle Swarm Optimization (MOPSO) [2] which is known as an efficient approach with a high performance of solving multi objective optimization problems in many research fields. Particle Swarm algorithms are population based stochastic optimization algorithms inspired by the social behaviors of animals like fish schooling and bird flocking.

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This paper is organized as follows: the second section is devoted to information system quality characterization in inter organizational context. The third section reminds the five steps of the used RatQual measurement method. The fourth section describes how RatQual method is coupled with linear modelling in order to monitor external information system quality evolution. The fifth section describes the used MOPSO algorithm. The last section presents results analysis of the proposed contribution.

2. EXTERNAL INFORMATION SYSTEM QUALITY CHARACTERIZATION

2.1 Inter organizational information systems Quality

Inter organizational systems characterize those information systems that cross organizational boundaries linking one or more independent organizations. Such systems can be used to support collaborations and partnerships among organizations for competitive purposes. Indeed, low quality level is a potential failure of cooperation and collaboration. Thus, Organizations make continuous investments to enhance ISQ levels and consequently to improve activities and performance.

Within a collaborative network, ISQ improvement deals with conceptual, organizational and technical barriers between business partners. The stakeholders may belong to different governance subdomains [3]. In this context, studying ISQ implies a specific focus on its external characteristics that are influenced by environmental parameters such as interoperability, security or horizontal alignment ability.

Many efforts are done in order to propose approaches to ensure, manage and control ISQ characteristics. One of the active branches deals with the characterization and the assessment techniques [4]. Many models have been proposed to characterize quality attributes and their relationships. Despite the richness and benefits of these models, they present several disadvantages regarding the consideration of all operational aspects in assessment process [3].

RatQual approach [1] which is geared towards the assessment of the quality factors among many information systems. RatQual is an assessment oriented model for the characterization of ISQ indicators depending on the inter-organizational environment and influenced by the partners capabilities. This model is interested only on 17 external features classified into 3 main classes, namely "functionality", "adaptability" and "evolutivity" regarding qualitative requirements of processes driven services

Indeed, the first class of characteristics is Functionality. This class refers to the essential purpose of the involved information systems and their components. Functionality characteristics are mainly recognized in the requirements identification stage. This class contains various features among which interoperability, security, compliance and inter-alignment ability.

The other classes we propose are related to quality requirements linked to system change management. Change requests can be classified into two main categories: (i) “Adaptability category” including context dependent change requests, and (ii) “evolutivity category” time dependent change requests.

The former EISQ category entitled “Adaptability” includes Portability, Coexistence, Replace ability, Flexibility and Variability.

The latter category named “Evolutivity” encloses characteristics like Changeability, Maintainability, Stability, Testability, Customizing Ability and Extensibility.

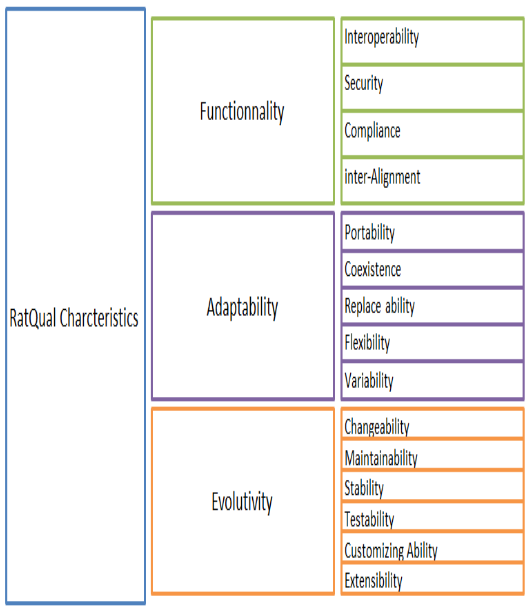

Figure 1 : Quality characteristics supported by RatQual model [1]

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2.2 RatQual Assessment Approach

RatQual is a quality assessment oriented model of business process driven services. This approach combines in the same time à priori as well as à posteriori evaluation elements. RatQual takes in consideration three operational aspects, namely 'internal quality', 'external quality' and 'quality in use' accompanying collaboration based business process driven services. RatQual approach supports the technical, organizational and conceptual considerations while giving importance to architectural elements.

RatQual is a five steps appraisal approach. These steps are as follows (see Figure 2):

1. Delineating the scope of the study.
2. Quantifying the internal aspect: quality characteristic potentiality.
3. Calculating the external aspect: Quality implementation effort.
4. Evaluating the in use aspect: operational quality performance.
5. Aggregating the EISQ RatQual degree based on an adequate aggregation technique.

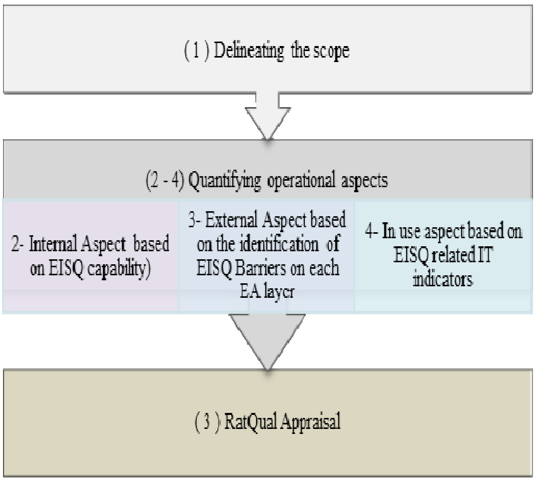

Figure 2 : Ratqual Assessment Approach [1]

2.2.1 Scope delineation

Assessing an external quality characteristic degree of a system requires the knowledge of its environment. In practical terms, the study focuses on a macro business process consisting of a set of sub automated processes among independent business entities. These sub processes are linked together via several interfaces identified in advance. In this case, the preliminary phase consists of identifying the context of the studied automated business process then lists its underlying automated processes. This step includes identifying:

- Organizations involved in the cooperation.
- Sub process within each entity in order to study compatibility.
- Information systems that support automated business processes within each organization.
- Application services that enables sub processes interactions.

2.2.2 Internal potentiality

Appriasing a quality characteristic internal potentiality within the k_{th} organization «QP_k» requires the adoption of a quality maturity models. The organization is classified then on one of the five levels noted QMML (for Quality maturity model level).

Within each organization, the potential is calculated using the following equation

$$QP_k = 0.2 * QMML_k \quad (1)$$

The final quality potentiality across collaboration network is given by Equation 2 below:

$$QP = \min(QP_k) \quad (2)$$

2.2.3 External compatibility

To assess the external aspect degree, the present work uses a compatibility matrix [1].

The compatibility matrix, as presented in Table 2, consists of a combination of the “quality levels perspective” and “quality barriers perspective”.

In practical terms, we enumerate conceptual, technical and organizational barriers in the different layers of collaboration concern: process, service, data and infrastructure.

By noting the elementary degree of quality compatibility «dcij» (i takes values from 1..4, and j takes values from 1..6).

	Conceptual		*Organizational*		*Technology*	
	Syntactic	Semantic	Responsibilities	Organization	Platform	Communication
Process	dc_{11}	dc_{12}	dc_{13}	dc_{14}	dc_{15}	dc_{16}
Service	dc_{21}	dc_{22}	dc_{23}	dc_{24}	dc_{25}	dc_{26}
Data	dc_{31}	dc_{32}	dc_{33}	dc_{34}	dc_{35}	dc_{36}
Infrastructure	dc_{41}	dc_{42}	dc_{43}	dc_{44}	dc_{45}	dc_{46}

Table. 1. Quality Compatibility Matrix

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Therefore, if the criteria in an area marked satisfaction the value 0 is assigned to dc_{ij}; otherwise if a lot of incompatibilities are met, the value 1 is assigned to dc_{ij}.

The degree of compatibility «DC» is given as follows:

$$DC = 1 - \sum (dc_{ij} / 24) \quad (3)$$

2.2.4 Operational performance

By Denoting:

- «DS» the overall availability rate of application servers.
- «QoS» service quality of different networks used for interacting components communication. QoS is represented mainly by the overall availability of networks.
- «TS» end users satisfaction level about interoperation.

Given the cumulative nature of these three rates, the evaluation of operational performance is given by the geometric means the following equation (See Equation 4):

$$PO = \sqrt[3]{(DS * QoS * TS)} \quad (4)$$

2.2.5 RatQual aggregation

The final calculation of RatQual (for ratio of Quality) is by aggregating the three previous indicators using a function f defined in [0,1]3 → [0,1] (See Equation 5)

$$RatQual = f(PQ, DC, PO) \quad (5)$$

Given the independent nature of these three indicators, we opt for the arithmetic mean as follows (See Equation 6):

$$RatQual = (PQ + DC + PO) / 3 \quad (6)$$

In case the collaboration network has elements for pondering each one of these three indicators with different weights (w1, w2, w3), we use the weighted arithmetic mean.

$$RatQual = (w1 * PQ + w2 * DC + w3 * PO) / (w1 + w2 + w3)$$
(6)

3. MULTI PROJECTS RESOURCE ALLOCATION

In project management, project planning deals with many challenges including resources allocation and effort dispatching. Project implementation within a collaboration network and across independent organizations can be seen as a multi-projects environment that targets a unified objective of collaboration but involves different teams in order to interconnect independent information systems [6]. Also, the subsisting complementarity between the different quality factors, their interactions and mutual effects are quite challenging issue to handle in order to plan effectively the improvement efforts. For instance, interconnecting the partners systems and improving the interoperation capabilities in this context imply serious security risks: security incidents occur mainly from the trust zone existing within the collaboration network [4].

In such environment, the challenge considered is resource allocation and effort dispatching in order to effectively establish collaboration on a projected level. The optimal allocation of effort refers to an optimization problem whose objective is to optimize the overall effort and better distribute it in a multi project implementation of collaboration.

In this section, we try to obtain the optimum distribution of effort in order to establish a specific organizational collaboration situation.

RatQual is a centric assessment approach that aims to quantify on a scalar form quality degree of an information system within its ecosystem.

RatQual stipulates that external quality improvement of an information system is obtained by implementing changes in its supporting system and also bringing improvement on the external interfaces of the interlinked systems.

Coupling *RatQual* method with linear modeling tends to characterize the evolution of the overall quality degree of a set of interconnected information systems. It monitors the efforts needed to improve quality degree of the collaboration network.

To illustrate this, let's take a set of "n" systems (Stm_1, Stm_2,…, Stm_n). We suppose:

– Each system is ensured within one organization.

– Each information system is automated and supported by exactly one IT infrastructure.

– Each system may interact with any other systems.

– The IT systems have the ability to interoperate in a homogeneous way with the environment.

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We associate to each system A_i two ratios representing interoperability and security degrees within its ecosystem.

- I_i=RatQual(Stm_i,"Interoperability")
- S_i= RatQual(Stm_i, "Security") ;

We aim to monitor the evolution of this indicator in a macroscopic way.

The vector $A(A_1,..,A_n)$ evolves in accordance with the effort made to adapt the internetworked system from current As-is state to the target To-Be state in terms of the enterprise architecture vision.

By denoting:

$A=(a_i)$ represents the current quality vector (interoperability or security).

$A'= (a'_i)$ represents the target quality vector.

We have for each a system Stm_i

$$a'_i = \sum E_{ij} a_j. \quad (7)$$

Eij represents the effort to make on the A_i system in order to improve the A_j system.

$E=(E_{ij})$ the matrix effort to make in order to reach the target quality.

Scenario 1 : differentiated efforts

$$A' = E.A \quad (8)$$

(two different efforts matrixes one for A=I another for A=S)

Scenario 2 : consolidated efforts

$$A' = E.A \quad (8)$$

(the same matrix for A=I and for A=S)

with

$$\begin{pmatrix} E_{11} & E_{12} & \cdots & E_{1n} \\ E_{21} & E_{22} & \cdots & E_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ E_{n1} & E_{n2} & \cdots & E_{nn} \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \\ \cdots \\ \cdots \\ a_n \end{pmatrix} = \begin{pmatrix} a'_1 \\ a'_2 \\ \cdots \\ \cdots \\ a'_n \end{pmatrix}$$

If each system Stm_i is compatible with all other systems and there is no explicit barrier that impedes interaction, E_{ij} is equivalent to the ratio of workload N_{ij} (workload allocated to the improvement of the external interfaces of Stm_i to facilitate the Stm_j RatIop) over the overall workload allocated to collaboration enhancement [6].

$$E_{ij}=N_{ij}/N_{overall} \quad (9)$$

In this case, our goal is to find the optimal effort to reach the targeted interoperability vector. So, the objective function to minimize is :

$$a'_i - \sum_i \sum_j E_{ij} \cdot a_i \leq 0 \quad (10)$$

The constraints are for each j:

$$\sum_i E_{ij} \leq 100\% \quad (11)$$

E_{ij} is to be multiplied with $N_i/N_{overall}$ with $Ni=\sum N_{ij}$

To optimize the objective function (10) with respecting the constraints in (11) it is possible to use deterministic techniques such the gradient function. But with problems with large dimensions these techniques remains inefficient in terms of performance. Heuristic algorithms such Particle Swarm Optimization [5] is a promising discipline to explore in this area.

4. MULTI OBJECTIVE PARTICLE SWARM OPTIMIZATION

Multi-objective optimization involves the simultaneous optimization of several incommensurable and often competing objectives. In the absence of any preference information, a non-dominated set of solutions is obtained, instead of a single optimal solution. These optimal solutions are termed as Pareto optimal solutions. Simply put, Pareto optimal sets are the solutions that cannot be improved in one objective function without deteriorating their performance in at least one of the rest. In general, a multi-objective problem consists of a vector-valued objective function to be minimized, and of some equality or inequality constraints.

Accelerated multi-objective particle swarm optimization MOPSO is an efficient approach because it gives rapid and important results in a small amount of time. This approach incorporates vector function as objective function and uses matrix computation to develop the "Pareto front". The general idea of MOPSO algorithms is to start with some initial solutions: initial population and then try to improve performance toward some optimal solutions. The process of searching terminates when predefined criteria are satisfied. In the absence of a priori information about the solution, we always start with a random guess.

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4.1 Partical Swarm Optimisation PSO.

The Particle Swarm Optimization (PSO), developed by Kennedy and Eberharts in 1995, is an approximation algorithm method proposed for the optimization problem of finding the global minimum [5]. Since then, it has been improved by many searchers. The principal of this algorithm is based on the movement of birds searching for a food in a flock; this animal behavior is simulated to the optimization research. This method generates a group of particles, each one search for the minimum of the fitness by their own knowledge and movement, and is influenced by the search of his neighbors. If a particle finds a good site, all the others can become aware of it more or less directly, in order to take advantage of it.

In Particle Swarm Optimization algorithm (PSO), each particle i is treated as a point in a space with dimension D, a position X_i, a velocity V_i and a personal best position X_{besti}. The personal best position associated with a particle i is the best position that the particle has visited. The best positions of all particles in the swarm are represented by the vector X_{gbest} [7].

$X_i = (x_{i1}, x_{i2},\ldots,x_{id})$ is the position of the particle.

$V_i = (v_{i1}, v_{i2},\ldots,v_{id})$ is the velocity of the particle.

$X_{besti} = (p_{i1}, p_{i2},\ldots\ldots,p_{id})$ is the best personal position.

$X_{gbest} = (p_{g1}, p_{g2},\ldots\ldots,p_{gd})$ is the best global position of the swarm.

$1 \le i \le n$: n is the dimension of the problem representing the position X_i

$1 \le d \le D$: D is the space dimension of the swarm (Number of particles)

$$V_{id}(t+1) = \chi\,(V_{id}(t) + \rho_1(X_{besti}(t) - X_i(t)) + \rho_2\,(X_{gbest}(t) - X_i(t))) \quad (12)$$

$$X_{id}(t+1) = X_{id}(t) + V_{id}(t+1) \quad (13)$$

Where $\rho_1 = c_1r_1$ and $\rho_2 = c_2r_2$

c_1 and c_2 : positive acceleration components called social parameter.

r_1 and r_2 : Independent random number in the rang (0; 1).

χ: constriction coefficient.

We modified the velocity function by using a new term X_{Nbest} in the Eq.12 defined as:

$X_{Nbest} = (p_{n1}, p_{n2}\ldots\ldots\ldots p_{nd})$ the best position of the neighborhood.

The Eq.12 becomes:

$$V_{id}(t+1) = \chi\,(V_{id}(t) + \rho 1\,(X_{besti}(t) - X_i(t)) + \rho 2\,(X_{gbest}(t) - X_i(t)) + \rho 3\,(X_{Nbest}(t) - X_i(t))) \quad (14)$$

Where $\rho_3 = c_3r_3$

c_3: positive acceleration components called social parameter.

r_3: Independent random number in rang (0; 1).

The initialization of the swarm and velocities are usually performed randomly in the search space, following a uniform distribution. The best positions are initially set equal to the initial swarm. After the first time increment, the particles moved by the velocity V_i in Eq. 14. Then the algorithm searches for optima by updating generations.

Pseudo-code of Particle Swarm Optimization

Initialization
X_i ← Generate the initial particles of the swarm randomly.
V_i ← Generate the initial velocity of the particles randomly.
X_{besti} ← X_i Set the best positions to a randomized particle position.
X_{gbest} ← X_i Set the best positions of the swarm to a randomized particle position.
X_{Nbest} ← X_i Set the best positions of the neighbour to a randomized particle position.
Repeat
    For *i = 1 : N (All particles in the Swarm)*
    Fitnessi(t) ← Evaluate Fitness(Xi)
    if *Fitnessi(t) < Fitness(X_{besti})(t)*
    Xbesti ← Xi particle attractor
    end
    For *j = 1 : M (M number of neighbours in the Swarm)*
    $X_{Nbest(j)}$ ← defining the best position in every neighbour.
    End For
    if *Fitnessi(t) < Fitness(X_{gbest})(t)*
    X_{gesti} ← Xi swarm attractor
    end
    Update velocity $V_{id}(t+1)$ in Eq 14
    Update position $X_{id}(t+1)$ in Eq 13
    if *$X_{id}(t+1)$ < Xmin OR $X_{id}(t+1)$ > Xmax*
    $X_{id}(t+1)$ ← Xrandom Xrandom ∈[XminXmax]
    end
    End For
Until *Stop criterion*

Figure 3: Pseudo Code Of PSO Algorithm

The acceleration constants c_1, c_2 and c_3 in Eq. 14 represent the weighting of the stochastic acceleration terms that pull each particle towards

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X_{besti}, X_{gbest} and X_{Nbest} positions. c_1 represents the confidence that the particle has in itself, c_2 represents the confidence that the particle has in the swarm and c_3 represents the confidence that the particle has in his neighbor.

In most cases, the acceleration parameters c_1, c_2 and c_3 are affected to 1, however, if we want to eliminate the particle's own experience we take $c_1 = 0$; $c_2 = 1$ and $c_3 = 1$ or eliminate the influence of the best of the swarm we take $c_1 = 1$; $c_2 = 0$ and $c_3 = 1$ or we eliminate the influence of the best of the neighbor we take $c_1 = 1$; $c_2 = 1$ and $c_3 = 0$. Depending on the problems to resolve we can make the appropriate choices for these parameters to modify the velocity and to promote convergence.

The search procedure of a population-based algorithm such as PSO consists on the concept of neighborhood; the information regarding the best position of each neighborhood is gradually communicated to the rest of the particles through their neighbors in the ring topology. We have neighborhoods that consist of particles belong to different partitions. In this case, particles with different behaviors can interact by sharing information through their neighborhoods.

All particles in a neighbor share the same value of X_{Nbest} and each neighbor has a different value of X_{Nbest}. It is important to respect the number of particles that comprise the neighborhoods, therefore, in our experiments the swarm was divided into 7 partitions. In general there is no formal procedure to determine the optimal number or the size of the neighbor but case by case depending on the problems to resolve [7].

4.2 Accelerated multi Objective PSO Algorithm. Initialization techniques:

Good initialization of the population can increase the convergence speed and sometimes improve the final results. But if no information about the solution is available, then random initialization is the most commonly used method to generate initial population. In our case we use the semi-random initialization, described as followed.

$P(x_1, x_2... x_n)$ is a point in n-dimensional space,

xi in [ai; bi]. The opposite point of P is defined by P_(x_1,x_2,…; x_n) where : $x\_{i} = a_i + b_i - x_i$

The Multi-Objective Particle Swarm Optimization algorithms are described:

- we initialize the swarm which includes both the positions and velocities of the two populations X_{mobest} and X_{part} using the initialization techniques that we explained above.
- We evaluate the objective functions that optimize the problem we are dealing with.
- We compare between improvement of the population of the best positions, denoted X_{mobest}, which will converge toward the Pareto optimal set and the population in developing X_{part} that will benefitt from the experiences of the entire developed population.
- We update both populations.
- The algorithm stops if the criteria is satisfied if not then we update the population X_{part} and we restart from the step 2. We keep following these steps until we get efficient positions or solutions to the multiobjective problem suggested.

Pseudo-code of Multi-Objective Particle Swarm Optimisation

Initialization
For each particle :i = 1,….N initialize :
The particle's position with an opposition-based optimization method
The population's best known position to its initial position : X_{mobest}, X_{parti}, f_{mo} *and* f_{mobest}
The particle's velocity : v
The pareto ← *1*
EndFor Until a termination criterion is met,
Repeat
  For *each particle i = 1,….., S do :*
   $\omega \leftarrow rand()$ $\rho_p \leftarrow rand()$
   Update the particle's velocity :
   $V(t) = V(t-1) + \Sigma \rho_k (A_N(X_{mobestk}(t-1)) - X_{part}(t-1))$
   Update the particle's position : Xi ← *Xi + vi*
   If $fmo(:, t) < f_{mobest}(:, r)$
   $fmobest(:, r) \leftarrow rand()$
   $X_{mobest}(:, r) \leftarrow X_{part}(:, t)$
   flag ← *1*
   EndIf
   If $fmo(:, t) > f_{mobest}(:, r)$
    flag ← *2*
   EndIf
  EndFor
    If flag == 0
     $X_{mobest} \leftarrow [X_{mobest}; Xpart(:,t)]$
     $f_{mobest} \leftarrow [f_{mobest}; fmo(:, t)]$
     Pareto ← *Pareto + 1*
    EndIf
EndUntil
Return X_{mobest}

Figure 4: Pseudo Code Of MOPSO Algorithm

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20,7%	0%	4,77%	74,53%
45,64%	0%	17,73%	36,63%
25,7%	1%	3,3%	70%
53,9%	1%	11,4%	33,7%

5. CASE STUDY AND RESULTS

To well illustrate the application of optimization method that couples *RatQual* and PSO and MOPSO, we take the case of four information systems that interact within a collaboration network (See Figure 4).

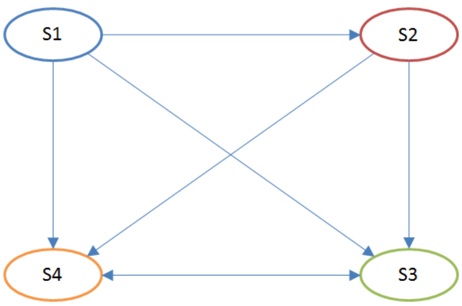

Figure 5: Interaction Model Of Involved IS

After an initial assessment of interoperability and security degrees of each cited system, we notice that they have respectively reached the values of: I(0.7, 0.55, 0.8, 0.85) and S(0.8, 0.6, 0.58, 0.7).

System	As-Is		To-Be	
	Interoperability (I)	Security (S)	Interoperability (I')	Security (S')
S1	0.7	0.8	0.77	0.86
S2	0.55	0.6	0.66	0.9
S3	0.8	0.58	0.9	0.75
S4	0.85	0.7	0.9	0.75

Figure 6 : Interaction Model Of Involved IS

Information System actors in accordance with business teams, target for the coming semester to improve interoperability degree of this collaboration situation and define the objective to reach respectively the values of: I'(0.77, 0.66, 0.9, 0.9) and S'(0.86, 0.9, 0.75, 0.75).

Scenario1: Team manager decides to reserve 30% of effort to security improvement and 70% of effort to interoperability enhancement. We have two independent optimization problems. When improving interoperability we do not care about security and vice versa. In this case, we apply PSO algorithm to find the optimum matrix of effort that minimize the objective function and comply with the constraints in equation (11).

For interoperability enhancement, optimal effort distribution E_{ij} is represented as follow (See fig. 7) :

Figure 7 : Optimal Dispatching Of Interoperability Enhancement (Using Mono-Objective PSO)

For security implementation, optimal effort dispatching E_{ij} is given by next matrix (See fig. 8) :

18,45%	0%	27,85%	53,7%
7,1%	1,36%	23,16%	68,38%
5,7%	0%	21,3%	73%
4,27%	6,57%	39,06%	50,1%

Figure 8 : Optimal Effort Distribution Owing To Security Improvement (Using Mono Objective PSO)

Scenario2: Team manager decides to use multiobjective optimization using MOPSO. We have a same context. We optimize both interoperability and security of inter organizational information system supporting the collaboration.

So, in our case, the optimal multi objective effort Eij is represented in the following matrix in fig 9 :

55,3%	7,45%	1,61%	35,64%
58,25%	4,8%	8,1%	28,85%
59,69%	1,33%	3,3%	35,68%
55,56%	4,26%	1,93%	38,25%

Figure 9: Optimal Dispatching For Multi Objective Security And Interoperability Evolution (Using MOPSO)

5.1 Results analysis

Previous authors work addresses "optimization of interoperability planning" [6]. It is a mono objective optimization issue of one quality factor enhancement (interoperability).

The present work describes the use of novel means for multi objective optimization issue in order to efficiently dispatch resource allocation of multi project implementation. It proposes to deal with two complementary qualities factors: interoperability and security.

From a project management perspective, there is an overall workload that needs to be dispatched regarding each quality objective. We have two complementary quality factors (interoperability and security) to enhance. For project planning, there is a need to optimize resources dispatching. This work

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proposes two optimization scenarios. In each scenario, we use adequate particle swarm based technique. The first scenario uses mono objective optimization method. The second scenario uses a multi objective technique. In both scenarios, we have the optimal resource allocation to reach efficiently the quality targets.

For the **first scenario**, the hypothesis made implies the resolution of two PSO independent problems: the first one use a swarm to optimize the distribution of interoperability enhancement effort within the collaborative network. The second swarm is used to optimize the distribution of security improvement effort. For the **second scenario** we use MOPSO algorithm and consequently a unique swarm to have the optimal distribution of effort to enhance in the same time interoperability and security. The swarm algorithm during its iterations makes compromises between the two qualities. This compromise is continuously improved.

To plan efficiently quality enhancement, the present work uses:

- RatQual metric as project indicator.

- Linear modeling to trace the evolution from "as-is" state and "to-be" state.

- Metaheuristic techniques as simulation and optimization tools.

The **first scenario** transforms the "quality improvement multi project" on two Independent sub-projects (each one is focused on one quality factor enhancement). Correlation between the two quality factors is not considered. The problem is simplified and beforehand well defined: we have 2 separated mono objective mathematic resolutions regarding simplification hypothesis.

The **second scenario** uses a Multi-objective mathematic resolution. Correlation between the two quality factors is considered. This scenario is more time machine consuming due to heuristic iterations. In this paper we have presented an efficient approach for effort distribution optimization method for interoperability and security enhancement. First of all, we assess interoperability and security degrees of an information systems network using the *RatQual* metric. Secondly, we define a desired interoperability and security degrees to achieve. The proposed Enhanced *RatQual* method is able to optimize the system and propose a theoretical optimum effort required to reach the objective. This distribution is to be compared with the integration architects proposals regarding the estimation of effort needed to interface the involved information systems. Indeed, if architects propose an estimate close to our theoretical result so this proposal can be accepted. Otherwise, the project manager invites architects to rethink their estimates.

5.2 Interoperability and security optimal control

The proposed result provides a visibility on the optimum configuration in the field of possible solutions.

It helps multidisciplinary teams (project manager, enterprise architects, and security administrators) to converge towards the proposed optimal theoretical solution. The result may not be realistic in practice although it respects the constraints. This can still be used by integration architects and security managers to approach the solution. The performance improvement is always possible: All we need is to adjust the target qualities vectors and the system generates a new effort matrix. The optimization system is fully configurable; it can run as many times as necessary.

The size of interoperability and security vectors in the practical case is 4 (number of information system to interact effectively). When the dimension is large enough (it may exceed 20), the prediction of the optimal effort matrix in a manual way becomes almost impossible. Our system is very well suited to large problems and offer optimal solutions within the constraints, and can be continually improved.

6. CONCLUSION

Multiobjective Optimization concerning Resource allocation and effort dispatching of quality enhancement is a key requirement to effectively setup, develop and evolve intra and inter organizational collaboration. This paper studies interoperability and security as quality characteristics of information systems interaction. It proposes a novel linear model to describe workload needed to enhance and secure interoperability implementation. This linear model is coupled with mono and multi objective Particle Swarm Optimization algorithms in order to propose optimum effort distribution of collaboration situation. Throughout this proposal, the present proposal handle quality characteristics, such interoperability and security, by taking into account the subsisting complementarity between the different quality factors, their interactions and mutual effects.

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Many Analyses are listed in order to achieve an optimal control of interoperability implementation. We also intend to extend the proposed optimization model to more than two objectives and, by consequence, targeting three EISQ on the same multi project.

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