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Galois Theory and Quality of Service Driven Knowledge Extraction within an Enterprise

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Abstract: In Enterprises, knowledge is used in the execution of workflow tasks by users. This knowledge is held by employees involved in the workflow. With the instability of employees, quality of service is not always guaranteed. However, due to competitiveness, enterprises are forced to improve their quality of service to satisfy their customers. The method generally used consists to build a knowledge base that identifies the knowledge to optimize employee's performance to ensure optimal quality of service. But the existence of a knowledge base does not always guarantee the achievement of quality of services requested by customers. This raises the problem of extraction of knowledge in the execution of business process to achieve a quality of service requested by a customer. In this paper, we present a method based on Galois Theory, to extract, from the knowledge base, relevant knowledge needed for the execution of business process to achieve a given quality of service.

Keywords: Business process and workflow modeling, Customer satisfaction, Galois theory, Knowledge base, Knowledge management, Process abstraction, Quality of service.

I. Introduction

The enterprise places great importance on the diffusion and use of information and knowledge as well as its creation. The determinants of success of enterprises, and of national economies as a whole, is ever more reliant upon their effectiveness in gathering and utilizing knowledge [4, 8, 19]. The preservation of knowledge is an important building block within the concept of knowledge management [12, 19]. This is why efforts are being made today in the development of knowledge base in enterprise [12, 10, 14]. We can describe knowledge base as a system of knowledge and capabilities that preserves and stores perceptions, actions and experiences over time and secures the possibility of recall for the future.

During the knowledge base development processing, there is a first knowledge extraction which is done in order to select useful knowledge to be included in the knowledge base [13]. The second type of extraction is involved by employees to have any knowledge in the knowledge base previously built [17]. Several algorithms have been defined for these two types of extractions [1, 15, 4, 20]. Furthermore, various models exist in the literature on business process and workflow modeling, which integrate the knowledge aspects in different levels of abstraction. However, these models and algorithms do not take into consideration the knowledge selection that may occur during the execution of business process, aiming for a given quality of service, to select relevant knowledge to be used to achieve this quality of service [1, 4, 7, 8].

In this paper, we present a method based on Galois Theory, to extract from the knowledge base, knowledge needed for the execution of business process to achieve quality of service previously requested by a customer. This issue is particularly relevant to the extent that enterprises have focused their efforts on meeting the expectations of their customers in recent years [9, 11, 12]. Expectations expressed behind a set of qualities factor for the services expected. This makes it important to use these knowledge bases in the sense of knowledge to be selected for a given quality of service.

The rest of paper is organized as follows: Section II provides a summary of the theory of business processes and workflows modeling; Section III presents a summary of Galois Theory; Section IV deals with the Galois Theory and QoS driven knowledge extraction approach; and Section V concludes the work and highlighting some perspectives as future works.

II. Business Process and Workflow Theory

In this section we present, in an incremental manner, concepts that are borrowed for the theory proposed by Atsa *et al.* [1, 2, 3, 4] for the modeling of business process and workflows within an organization in order to manage the satisfaction of different stakeholders. We then move from basic to complex concepts. Those concepts are suitable to tackle the knowledge extraction.

A. Knowledge Model

In [16], a knowledge or knowledge bit is defined as a tuple $<k,Ag,Ex,y,w,l,d,v>$ where: k is the name of the knowledge;

Ag is the name of the agent who expressed the knowledge; *Ex* is the experience level of *Ag*; *y* the context in which the goal is defined; *w* is the goal; *l* the business rule; *d* execution constraints; *v* the level of importance of the goal.

Let $Kb_1 = (k_1, Ag_1, \Psi_1, \omega_1, \lambda_1, \delta_1, \gamma_1)$ and $Kb_2 = (k_2, Ag_2, \Psi_2, \omega_2, \lambda_2, \delta_2, \gamma_2)$ two Knowledge. Kb_1 and Kb_2 are compatible denote by $Kb_1 \Delta Kb_2$, if and only if $\Psi_1 = \Psi_2$ and $\lambda_1 = \lambda_2$. When Kb_1 and Kb_2 are compatible, Kb_2 is better than Kb_1 denote $Kb_1 \subseteq Kb_2$, if and only if $\gamma_1 \text{--} \gamma_2$. $(\Omega, \subseteq)$ is used to denote the partial ordered set of compatible knowledge.

B. QoS Model

The quality of service denoted by QoS represents the performances of the service which determine the level of satisfaction projected for the recipients of the services [1, 4]. The level of satisfaction is defined as a set of properties, criteria, characteristics and performances of the services delivered to the customers.

Let *Cr* be a set of criteria considered in the evaluation of the quality of service, Val the set of values that can be assigned to these criteria, and *f* a map defined by $f: C \rightarrow Val$, the QoS is defined by (C, Val, f) [4].

Given two QoS *q1* and *q2* such that $q1 = (Cr1, Val1, f1)$ and $q2 = (Cr2, Val2, f2)$, $q1$ and *q2* are compatible and denote by $q1 \Delta q2$ if and only if $C1 = C2$ and $Val1 = Val2$. When *q1* and *q2* are compatible, *q1* is better than *q2* and denote $q1 \subseteq q2$ if and only if $\forall c \in C1, f1(c) \leq f2(c)$. $(\Phi, \subseteq)$ is used to denote the partial ordered set of compatible qualities of services [4].

C. Task Model

A task is an atomic activity that cannot be split into smaller activities [1, 2, 3, 4]. The performance or execution of a task transforms the state of the environment into another state. A task is therefore an action within a state of an environment. Before a task can be executed, the state of the environment should satisfy a specific condition called pre condition, and when this execution is completed another condition, called post condition is satisfied. For a task to be executed within an organization which will be defined later, the knowledge required for its performance is captured. This knowledge depends on the context within which the execution can take place. For each of the associated contexts, is defined a set of knowledge bits and quality of service to obtain after the execution of a task. In [4], a task is formally defined by a tuple $<nt, PP, f_m, g_m, Cx, KBx, Qx>$ where *nt* denotes the name of the task, $PP = Pre \times Post$ where Pre denotes the non empty set of preconditions within which its execution can be carried out, and $Post$ the set of post conditions that are obtained after the execution, Cx a non empty set of contexts within which the task can be executed, KBx a non empty set of knowledge bits used for the better understanding and performance of the task, Qx is a quality of service to be reach after the execution of nt. f_m, and g_m are maps defined respectively by:

$$\begin{cases} f_m : Cx \rightarrow PP \\ g_m : Cx \rightarrow KBx \end{cases}$$

If *c* denotes a context of Cx, then *c* is a restriction of the environmentΘ, that is $c \subseteq \Theta$. The action of a task within an environment is to transform its current state into a new one. When $<nt, PP, fm, gm, Cx, KBx>$ is a task, *s* a given state where the precondition $pre(PP)$ is satisfied i.e $s(pre(PP)) = true$, the action of *t* in the state *s* is the new state $t(s)$ which satisfies the post condition $post(PP)$ i.e $t(s)(post(PP)) = true$ *e*. In general, the action of a task *t* within the state *s* is characterized by the observers of *s* whose value has been modified [2, 4].

Definition 2.1 (Task Action)

Let $E = \langle \Theta, S, val \rangle$ be an environment, *s* a given state and *t* a task whose pre condition is satisfied in *s*, then the action of *t* in *s* denoted by t_s and is specified by $t_s = \{ o : \Theta, s(o) \neq t(s)(o) \}$ [4].

When there will be no ambiguity, a task will be represented by its name *t* and $pre(t)$ respectively $post(t)$ will denote respectively its pre and post condition. Based on the post condition of a task *t*, and the state *s* where $s(post(t)) = true$, we conjecture that $t_s = +post(t) \cup -post(t)$ [1].

Definition 2.2 (Chain)

A chain is an execution path of tasks, according to their actions in states and their triggering conditions is denoted by $P = \prod_{i=1}^{n} Sht_i$, and is specified as a finite sequence of shifts where *n* represents the length of the sequence [4].

Let P be a path of length $n > 1$, and $sh_k = \langle s_k, st_k \rangle$, $sh_{k+1} = \langle s_{k+1}, st_{k+1} \rangle$ notes respectively the shift in the range k and $k+1$, the state s_{k+1} is the resulting state after the execution of the set of tasks st_k i.e $s_{k+1} = \$_k(s_k)$. When there will be no ambiguity, the shift of the range k of the path P will be denoted by $P(k)$.

Let $Sht_k = \langle S_k, S \circ T_k \rangle$ and $Sht_{k+1} = \langle S_{k+1}, S \circ T_{k+1} \rangle$ be two shifts where $Sht_k = S \circ T_k(s_k)$, the difference between the states s_k and s_{k+1} is denoted by $\overline{s_k + s_{k+1}}$ and is defined as follows: $\overline{s_k + s_{k+1}} = S \circ T_k(s_k)$.

Definition 2.3 (Ordering of Tasks)

Let *T* be a set of tasks, and t_1 and t_2 be two tasks of *T*, we write $t1 \trianglelefteq t2$ if and only if for all chain CH such that if n_{t1} and n_{t2} denote respectively the maximum range of *t1* and *t2* in CH, then $n_{t1} \leq n_{t2}$. This relation has the following properties:

- Reflexivity: $t \trianglerighteq t$ this simply means that the task *t* belongs to the chain CH;
- Antisymetric: if $t1 \trianglerighteq t2$ and $t2 \trianglerighteq t1$ in the chain *D* then $t_1 = t_2$. By convention, there will always exist a path from each task to itself;
- Transitivity: obviously if in the chain CH, $t1 \trianglerighteq t2$ and $t2 \trianglerighteq t3$ then $t1 \trianglerighteq t3$.

Palette

Let E be an environment, and S be a set of different states that E may reach according to the actions of tasks T, then a palette P is a couple $<E,S \to S>$ [4].

Given a palette P, according to the environment changes within organizations and the different executions of tasks that can take place, different ways in which tasks can be executed have to be captured. $SP_{\mathbf{P}}$ is use to specify the set of execution paths that can be obtained from a palette P.

D. Business Process Model

A business process is a collection of activities or tasks designed to produce a specific output for customers [1, 2]. It implies a strong emphasis on how work is done within an organization in order to deliver a particular service. A process is thus a specific order of work activities across time and space, with a beginning, an end, and clearly defined inputs and outputs. The output is the reason the organization does this work and is defined in terms of the benefits this process has for the organization as a whole.

The model of a business process is defined as a couple $<P,G>$ where P is a palette and G the service to be achieved [1, 3, 4].

E. Workflow Model

A workflow is defined by $(Ts, Es, Ps, h, f_{em}, Q)$+ where Ts is the set of none conflicting tasks, Es the set of employees dealing with the processing of Ts within the time intervals Ps to obtain the quality of service Q, h is the map $Ts \to Ps$ which defines for each task t, its time interval $h(t)$ within which it is processed, and f a map that gives for each task t the employee $f_{em}(t)$ who is charge of its processing. The two maps h and f are required to be two isomorphism as each task is required to be associated to a time interval within which its execution will take place, and should also be assigned to a specific employee for this performance [1, 2, 16]. The quality of service Q is such that: $Q = \sum_{i=1}^{n} q_i$ where q_i is the quality of service obtain after the execution of task $t_i \in Ts$ and n the number of task in Ts .

Based on the fact that the satisfaction of customers is one of the challenges that enterprises are required to guarantee, in the modeling of the workflow, it is required that employees who are involved in the processing of tasks have the necessary knowledge to carry out these tasks. Therefore, if t is a task to be carried out by the employee $f_{em}(t)$, and $kb_{em}(t, f_{em}(t))$ his knowledge associated for the processing of *t,* there will exist at least a context c within which t can be processed such that the knowledge $bk(t,c)$ required for its processing verifies the following constraint $bk(t,c) \subseteq kb_{em}(t, f_{em}(t))$.

F. Task Processing

Based on the assignment of tasks done by the resource manager within an organization for the achievement a given customer goal, employees process these assigned tasks based on their own experience and the knowledge associated to these tasks [1, 2, 4]. According to the context within which the performance of the tasks is taking place, the processing can be done straightforward if the knowledge related to the task is adequate for its processing within this context. The processing sometime will not be done straightforward as the knowledge related to the performance of the task is not enough. When it is the case, the employee will use his tacit knowledge, on the one received from more experimented employees, in order to process the task. In order to keep track of this new way of carrying out this task, the defined information should be stored for further use. For this end, the knowledge of the so called task should be updated. In order to take this into consideration, the modeling of workflow must take into account the processing of tasks by employees. Let tk be a task that is processed by an employee using the knowledge kb in the context cx , the task tk change the state after its performance based on the fact that, the knowledge associated to this context is updated by the knowledge used for its processing i.e. $gm(cx,tk)=gm(cx,tk')\cup kb$ where $gm(cx,tk)$ denotes the set of knowledge required for the processing of the task tk [4].

III. Galois Theory

In this section, we define parts of Galois Theory that are suitable in handling our proposed approach. Most importantly, the properties of Galois connections are presented in terms of relation between adjoints, fixed points and closures, and order-isomorphic.

A. Galois Connections

In mathematics, especially in order theory, a Galois connection is a particular correspondence between two partially ordered sets (posets) [6, 13, 18].

Let E and F be two Hilbert spaces and T ∈ L(E, F). The unique linear application T*∈ L(F, E) such that for any x ∈ E, y ∈ F we have: $\langle T(x), y\rangle = \langle x, T^*(y)\rangle$ is called the adjoin of T [21].

Let $\mathscr{P} = \langle P, \preceq \rangle$ and $\mathscr{Z} = \langle Q, \sqsubseteq \rangle$ be partial order set; and suppose $f_*: P \to Q$ Q and $f^*: Q \to P$ are a pair of functions such that for all $p \in P$ and all $q \in Q$, (G) $\quad f_*(p) \sqsubseteq q$ iff $p \preceq f^*(q)$, then the pair $\langle f_*, f^* \rangle$ form a Galois connection between $\mathscr{P}$ and $\mathscr{Z}$.

If $\langle f_*, f^* \rangle$ is such a connection, f_* is said to be the *left adjoint* of the corresponding f^* , and f^* is *the right adjoint* of f_* .

f_* appears to the left of its order sign in (G), and f^* to the right of its order sign. Alternatively, the terminology `lower adjoint' vs `upper adjoint' is used (i.e. f_* appears on the lower side of its ordering sign, and f^* on the upper side).

Theorem 3.1.1: Let $\mathscr{P} = \langle P, \preceq \rangle$, $\mathscr{L} = \langle Q, \sqsubseteq \rangle$, and $\mathscr{R} = \langle R, \sqsubseteq \rangle$ be posets. Let suppose $\langle f_*, f^* \rangle$ is a Galois connections between $\mathscr{P}$ and $\mathscr{L}$, and $\langle g_*, g^* \rangle$ is a Galois connections between $\mathscr{L}$ and $\mathscr{R}$. Then $\langle g_* \circ f_*, f^* \circ g^* \rangle$ is a Galois connection between $\mathscr{P}$ and $\mathscr{R}$ [18].

Theorem 3.1.2: Suppose $\mathscr{P} = \langle P, \preceq \rangle$ and $\mathscr{L} = \langle Q, \sqsubseteq \rangle$ are posets, and $f_* : P \rightarrow Q$ and $f^* : Q \rightarrow P$ are a pair of functions between their carrier sets. Then $\langle f_*, f^* \rangle$ is a Galois connection if and only if:

(i) f_*, f^* are both monotone, and

(ii) for all $p \in P$, $q \in Q$, $p \preceq f^*\left(f_*(p)\right)$ and $f_*\left(f^*(q)\right) \sqsubseteq q$.

B. The Relation between Adjoints

The next theorem tells that the relation between the adjoint members of a Galois connection is rigid in the sense that if $\langle f_*, f^* \rangle$ is to be a connection, then f_* fixes what f^* uniquely has to be, and conversely f^* fixes what f_* has to be.

Theorem 3.2.1: If $\langle f_*, f^1 \rangle$ and $\langle f_*, f^2 \rangle$ are Galois connections between $\langle\ ,\ \_ \rangle$ and $\langle Q, \sqsubseteq \rangle$, then $f^1 = f^2$. Likewise, if $\langle f_1, f^* \rangle$ and $\langle f_2, f^* \rangle$ are Galois connections between the same posets, then $f_1 = f_2$ [6].

Theorem 3.2.2: If $\langle f_*, f^* \rangle$ is a Galois connection between $\langle P, \preceq \rangle$ and $\langle Q, \sqsubseteq \rangle$, then

(i) $f^*(q) =$ the maximum of $\left\{ p \in P \middle| f_*(p) \sqsubseteq q \right\}$

(ii) $f_*(p) =$ the minimum of $\left\{ q \in Q \middle| p \preceq f^*(q) \right\}$

C. Fixed Points and Closures

Recall again that we use $f(P)$ for the image of the set P under f, i.e. $f(P) = \left\{ f(p) \middle| p \in P \right\}$. And p is a fixed point of a function f if $f(p) = p$. Then we have the following:

Theorem 3.3.1: If $\langle f_*, f^* \rangle$ is a Galois connection between $\langle P, \preceq \rangle$ and $\langle Q, \sqsubseteq \rangle$, then

(i) $f_* \circ f^* \circ f_* = f_*$ and $f^* \circ f_* \circ f^* = f^*$,

(ii) $p \in f^*(Q)$ if and only if p is a fixed point of $f^* \circ f_*$; and $q \in f_*(P)$ if and only if q is a fixed point of $f_* \circ f^*$.

(iii) $f^*(Q) = f^*\left(f_*(P)\right)$ and $f_*(P) = f_*\left(f^*(Q)\right)$.

Definition 3.3.1: Given a Galois connection between $\mathscr{P} = \langle P, \preceq \rangle$ and $\mathscr{L} = \langle Q, \sqsubseteq \rangle$, let $\mathscr{P}^f$ be ‘s sub-poset $\langle f^*(f_*(P)), \preceq \rangle$, where $\preceq$ here is $\mathscr{P}$ ‘s order relation restricted to $f^*(f_*(P))$. Similarly, put $\mathscr{L}_f$ for the corresponding sub-poset $\langle f_*\left(f^*(P)\right), \sqsubseteq \rangle$.

Then the last theorem can be used to prove a more consequential one [6].

Theorem 3.3.2: If $\langle f_*, f^* \rangle$ is a Galois connection between $\mathscr{P} = \langle P, \preceq \rangle$ and $\mathscr{L} = \langle Q, \sqsubseteq \rangle$, then $\mathscr{P}^f$ and $\mathscr{L}_f$ are order-isomorphic.

Definition 3.3.2: Suppose $\mathscr{P} = \langle P, \preceq \rangle$ is a poset; then a closure function for $\mathscr{P}$ is a function c such that, for all $p, p' \in P$,

(i) $p \preceq c(p)$;

(ii) if $p \preceq p'$, then $c(p) \preceq c(p')$, i.e. c is monotone;

(ii) $c(c(p)) \preceq c(p)$ i.e. c is `idempotent’.

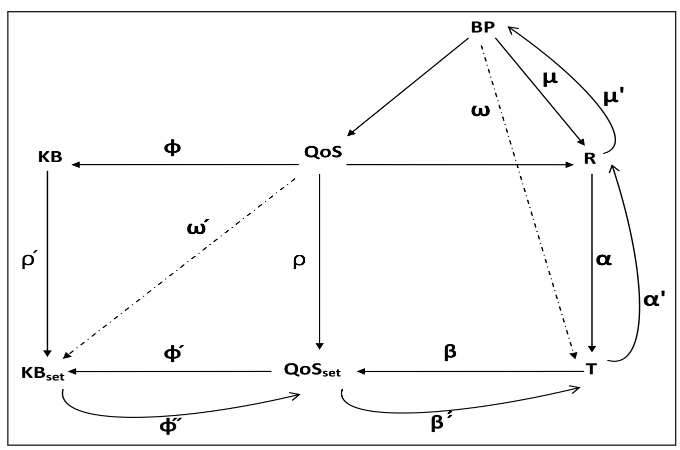
Theorem 3.3.3: If $\langle f_*, f^* \rangle$ is a Galois connection between $\mathscr{P} = \langle P, \preceq \rangle$ and some poset, then $f^* \circ f_*$ is a closure function for $\mathscr{P}$ [6].

Definition 3.3.3: Suppose γ, δ are sets, and let R be any relation between their elements. Define a function f_R from subsets of γ to subsets of δ as follows: if $\alpha \in \gamma$, then $f_R(\alpha)$ is the set of things which are R-related to everything in α. In other words, $f_R(\alpha) = \left\{ b \middle| \forall a \in \alpha \rightarrow aRb \right\}$. And define a corresponding function f^R back from subsets of δ to subsets of γ like this: if *if* $\beta \subseteq \delta$ *then* $f^R(\beta) = \left\{ a \middle| \forall b (b \in \beta \rightarrow aRb) \right\}$.

Then $\langle f_R, f^R \rangle$ is a Galois connection between the inclusion posets $\langle \rho(\gamma), \subseteq \rangle$ and $\langle \rho(\delta), \supseteq \rangle$ [13].

IV. The Galois Theory and QoS Driven Knowledge Extraction Approach

In this section, we present our approach based on Galois connections to extract the knowledge required for the satisfaction of a quality of service previously requested by a client. This approach is summarized by the following model:



The interpretation of this model is based on a number of steps:

Step 1: Request for a QoS by a Service

This step starts the extraction process. For this, the request is made by the client by presenting a quality of service in relation to a product or service in a company. This assume that the request meets the QoS model presented above i.e. the client submits a set of criteria or quality factors in relation to a service.

Step 2: The Deduction of Business Processes

Because the client specifies the requested service, it is obvious from the definition and business process model to find the BP to implement in order to achieve this QoS.

Step 3: Obtaining the Execution Path of BP

A BP is a tuple (P, S), that is a set of tasks required to provide a service, we deduce from the definition of a BP the set of tasks and therefore, the execution path required to provide the service requested. Conversely, from an execution path, we get the BP in question.

Step 4: Selection Knowledge Required to Achieve the Defined QoS

The previous steps enable the determination of the execution path of BP required to achieve the service for which a certain quality was requested by a customer. We know that service quality is defined by the QoS standard. This is an aggregation of QoS is obtained after partial execution of tasks. From a partial QoS is associated, according to the theory of BP, the knowledge kb required to achieve it after the execution of a task t. But the quality of service standard may be different from the QoS requested by a client and therefore, standard knowledge shall not achieve this quality of service. This is why a new selection of knowledge must be made to obtain the requested QoS. This assumes that each task of a BP, one must associate a pair (q_i, k_i) to satisfy the customer. The determination of these couple will be done by applying the properties of Galois connections to the extraction context that we shall first define.

Step 5: Definition of the Context of Extraction

Within this work, we shall define a context called *K* extraction context, as a tuple *((T, QoS), KB,W)* where *T* is the set of tasks of a *BP*, the set partial *QoS, KB* the set of knowledge to be required to achieve the partial *QoS* and *W* a binary relation $W \subseteq (BP, QoS_{set})xKB_{set}$;

Step 6: Determination of the Couple Quality of Service-Knowledge Associated with Each Task in BP Execution Path

From the BP theorie, (KB_{set},$\subseteq$) ; (QoS_{set},$\subseteq$) ; (T,$\subseteq$) ; (BP,$\subseteq$) et (R,$\subseteq$) are posets

$$QoS_{set} = \bigcup_{i=1}^{k} q_i \;\; ; \;\; BP = \bigcup_{k=1}^{m} t_k \;\; ; \; KB_{set} = \bigcup_{j=1}^{n} kb_j$$

The functions $\phi, \rho, \rho', \phi', \phi'', \beta, \beta', \alpha, \alpha', \mu, \mu'$ are defined as follows:

$$\rho : QoS \rightarrow QoS_{set} \; ; \; \rho' : KB \rightarrow KB_{set} \;\; \phi : QoS \rightarrow KB$$
$$\phi' : QoS_{set} \rightarrow KB_{set} \; ; \; \phi'' : KB_{set} \rightarrow QoS_{set} \; ; \; \beta : T \rightarrow QoS_{set} \; ;$$
$$\beta' : QoS_{set} \rightarrow T \; ; \; \alpha : R \rightarrow T \; ; \; \alpha' : T \rightarrow R \; ;$$
$$\mu : BP \rightarrow R \; ; \; \mu' : R \rightarrow BP$$

In addition:

- $\forall q \in QoS_{set}, \; \forall k \in KB_{set} , \; \phi'(q) \subseteq k$ *iff* $q \subseteq \phi''(k)$
- $\forall t \in T, \; \forall q \in QoS_{set}, \; \beta(t) \subseteq q$ *iff* $t \subseteq \beta'(q)$
- $\forall r \in R, \; \forall t \in T, \; \alpha(r) \subseteq t$ *iff* $r \subseteq \alpha'(q)$
- $\forall bp \in BP, \; \forall r \in R, \; \mu(bp) \subseteq r$ *iff* $bp \subseteq \mu'(r)$

From above, we deduce that: $\langle \phi', \phi'' \rangle, \langle \beta, \beta' \rangle, \langle \alpha, \alpha' \rangle$, $\langle \mu, \mu' \rangle$ are the Galois connections between QoS_{set} and KB_{set}, *T* and QoS_{set}, *R* and *T, BP* and R respectively. From the definition of a Galois connection, we deduce that:

ϕ' is the *left adjoint* of the corresponding ϕ'', and ϕ'' is *the right adjoint* of ϕ'

b is the *left adjoint* of the corresponding *b'*, and *b'* is *the right adjoint* of *b*

a is the *left adjoint* of the corresponding *a'*, and *a'* is *the right adjoint* of *a*

m is the *left adjoint* of the corresponding *m'*, and *m'* is *the right adjoint* of *m*

Since $\langle \phi', \phi'' \rangle$ is a Galois connection between KB_{set} and QoS_{set}, *and* $\langle \beta, \beta' \rangle$ a Galois connection between QoS_{set} and *T,* then $\langle \beta o \phi', \beta' o \phi'' \rangle$ a Galois connection between KB_{set} and *T.*

In a similar manner, $\langle \mu o \alpha, \mu' o \alpha' \rangle$ is a Galois connection between *T and BP.*

From the Theorem 3.1.2, we deduce that:

(i)

- ϕ', ϕ'' are both monotone; - *b,b'* are both monotone; - *a,a'* are both monotone;

- *m,m'* are both monotone, and

(ii)

for all $q \in QoS_{set}$, $k \in KB_{set}$, $q \subseteq \phi''(\phi'(q))$ and $\phi'(\phi''(k)) \subseteq k$;

for all $t \in T$, $q \in QoS_{set}$, $t \subseteq \beta'(\beta(t))$ and $\beta(\beta'(q)) \subseteq q$

for all $r \in R$, $t \in T$, $r \subseteq \alpha'(\alpha(r))$ and $\alpha(\alpha'(t)) \subseteq t$

for all $bp \in BP$, $r \in R$, $bp \subseteq \mu'(\mu(bp))$ and $\mu(\mu'(r)) \subseteq r$

Then we conclude that from a given *QoS*, we obtain the set of tasks required to achieve it and therefore, all the partial *QoS* related to the performance of each task. In addition, from this set of partial *QoS*, we obtain the set of knowledge required to achieve these partial *QoS* and therefore the set of tuple *(qi, ki)* used to achieve the requested *QoS*.

V. Conclusion

The main technical content of this paper is to present a method, based on Galois Theory, which extract from the knowledge base, relevant knowledge needed for the execution of business process to achieve a given quality of service. This amounts to determine, for a given quality of service, the set of tuples quality of service, knowledge and task that form the execution path of the business process to achieve this quality of service. For this end, we have shown that these tuples can be obtained by applying Galois Connection Properties from our defined extraction context. We believe that the application of the resulting method in daily work will improve quality of service in enterprises in order to deal with the competitive pressure of the network economy. However, the next step in this work, which is in progress, addresses the incompleteness problem of knowledge and natural language processing method for the extraction of part of a text or document.

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