

SCP-Trust Reasoning Strategy Based on Preference and Its Service Composition Process of Context-Aware Process

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Received May 2014

Abstract

Before providing services to the user, user preference considerations are the key conditions to achieve the self-adaptive decision-making about service selection and composition process, which is the flexible concerned aspect provided by massive cloud computing environment data. Mean-while, during the whole services' providing process, achieving the capturing and forming of service aggregation units' topology logic, building the context environment's process-aware of service composition, ensuring the trust and adaptation among service aggregation units, which are the important reasons to express timely requirement preference. This paper designs SCP-Trust Reasoning strategy about the integration of user preference and trust, with process algebra, it is to achieve the context process-aware logic for service composition process, in order to improve the autonomous optimization and evolution of service implementation system.

Keywords

Preferences, Trust Reasoning, Context-Aware Process, Service Composition, Service Aggregation Unit

1. Introduction

1.1. Service and Cloud Technology

With the rapid development of service and cloud computing, the business organization and topology building based Web services have gotten attention extensively [1]-[4]. The integration of the two technologies make cloud services more rich, there are a large number of service resources in cloud, while it is difficult to select services for timely user requirements according to preferences, how to adaptively make out the countermeasures and topology implementation sequences by effectively analyzing preferences is the achievement goal of autonomous service selection and composition. However, the information interaction between users and service resource pool, some information will often be missed or ignored as noise, which might cause imperfect requirement conditions about service selection and composition, and does not fully reflect the trust and preferences, and even deviate from the real requirement substance, leading to the topological implementation results are not re-

How to cite this paper: Xia, X.N., Yu, J.G. and Cao, B.X. (2014) SCP-Trust Reasoning Strategy Based on Preference and Its Service Composition Process of Context-Aware Process. *Journal of Computer and Communications*, **2**, 38-45. http://dx.doi.org/10.4236/jcc.2014.29006 quired by users, seriously, it causes the lack of information and destruction.

1.2. Related Work

Zeng *et al.* [4] proposed a global optimization method based on integer rules, with the help of context requirement, one optimal implementation path was selected; Ardagna and Pernic [5] concerned the global and local issues about services selection; Yu and Lin [6] used the requirement optimization and result of knapsack problem to achieve composition services selection; Korkmaz and Krunz [7] put forward a kind of heuristic composition services selection options; Driven by architecture implementation goal, Canfora *et al.* [8] used genetic algorithms to solve services selection process; Fan Xiaoqin *et al.* [9] designed a kind of discrete particle swarm algorithm to improve services' response capacity about timely requirement.

2. Preferences Requirement Principle

Based on the preference right re-determine method of rough sets [10] [11], capturing preference process is built in the platform, and does the grasping and learning timely during the interaction between users and services, that is the pre-conditions about preferences and services.

Definition 1 (Preference Knowledge Supporting System). Four-tuple pS = (U, A, V, f) stands for this system. *U* is the non-empty finite object set; *A* is the non-empty finite attribute set, $A = C \cup D$, $C \cap D = \phi \cdot C$ is the condition attribute set, *D* is decision-making supporting attribute set; $V = \bigcup_{\alpha \in A} V_{\alpha}$, V_{α} is range of α $(\alpha \in A)$; $f: U \times A \to V$ is a information function, it might give the information domain for every preference attribute.

Definition 2 (Weight Re-measure of Preference attribute): Supposing $X \subset U$ is one subset of attribute, $x_i \in U$ is a specific description, after adding specific value x_i in X, the weight of service selection is improved, the greater of improving degree, x_i is more important for X preferences, the important degree of attribute of x_i for

X is defined as:
$$pSig_{x_i}(x_i) = 1 \frac{|pos_{x_i}(U)|}{|pos_X(U)|}$$

If *P* and *Q* is the equivalence relationship in *U*, the positive domain of *P* for *Q* is denoted as posp(Q), $posp(Q) = \bigcup_{X \subset U/Q} PX$, *P* means that all classified results might be collected in the preference object sets of rela-

tionship Q according to U/P.

Objective preference weight is described as:

$$pG_{i} = \frac{pSig(x_{i})}{\sum_{i=1}^{n} pSig_{x_{i}}(x_{i})}$$

Objective weight is basic value, the comprehensive weight will be gotten:

$$pI(\omega) = \alpha Q(\omega) + (1-\alpha) pG(\omega), \quad 0 \le \alpha \le 1$$

 α is experience factor of preference, $0 \le \alpha \le 1$ expresses the preference degree for subjective and objective weight in selecting services, the greater α , the more important is the ensured requirement branch; the smaller α , the implementation of requirement cares for objective weight more. When $\alpha = 1$, the selection process only thinks about current requirement goals, does not do the cognitive exhibition; if $\alpha = 0$, it is needed to consider objective weight and be aware of the learning and evolution analysis about requirement goals.

3. Preference-Driven Trust Relationship and Evaluation

In order to extend and deepen the cognitive range of service customer *SC*, thereby enhancing complex synergy and the accuracy of service scheduling in different platforms, and increasing cross-organizational the effective-ness of service selection and composition.

Assume that service provider of SP about service customer A of SC is $[SP_1, SP_2, \dots, SP_m]$, if the number of service customers interacting with m SP is n, under the premise of not involving preferences, its interactive evaluation records might be expressed as follows matrix structure:

$$SQ_{A,1..m}^{1..n} = \begin{bmatrix} SQ_{1,1}^{r} & SQ_{1,2}^{r} & SQ_{1,3}^{r} & \dots & SQ_{1,m}^{r} \\ SQ_{2,1}^{r} & SQ_{2,2}^{r} & SQ_{2,3}^{r} & \dots & SQ_{2,m}^{r} \\ \dots & \dots & \dots & \dots & \dots \\ SQ_{i,1}^{r} & SQ_{i,2}^{r} & SQ_{i,3}^{r} & \dots & SQ_{i,m}^{r} \\ \dots & \dots & \dots & \dots & \dots \\ SQ_{n,1}^{r} & SQ_{n,2}^{r} & SQ_{n,3}^{r} & \dots & SQ_{n,m}^{r} \end{bmatrix}$$
(1)

Every element in matrix $SQ_{A,B}^r$ is the evaluation vector of the different service times, which is equivalent to $SQ_{A,B}^r = \left[SQ_{A,B}^{(1)}, SQ_{A,B}^{(r2)}, SQ_{A,B}^{(r3)}, \cdots, SQ_{A,B}^{(rx)}\right]$, the same time, every element of vector $SQ_{A,B}^r$ is also a multidimensional vector, when it is expressed as $SQ_{A,B}^{ij} = \left[SQ_{A,B}^{1,(ij)}, SQ_{A,B}^{2,(ij)}, SQ_{A,B}^{3,(ij)}, \cdots, SQ_{A,B}^{\nu,(ij)}\right]$, represents that $SQ_{A,B}^{ij}$ is one *v*-dimensional vector.

In matrix $SQ_{A,1.m}^{1..n}$, $[SQ_{j,1}^r, SQ_{j,2}^r, SQ_{j,3}^r, \dots, SQ_{j,m}^r]$ express QoS of *m* service provider entities for this set of values might be recognized as *m SP* service providers in line with the actual target values, it might verify whether other SC service customer reflect QoS of SP service providers, furthermore, it might reduce its trust values:

$$SQ_{A,B}^{r} = \left[SQ_{A,B}^{(t1)}, SQ_{A,B}^{(t2)}, SQ_{A,B}^{(t3)}, \cdots, SQ_{A,B}^{(tx)} \right]$$

This formula represents QoS of SC service entity A for SP service provider B. Take any one element from $SQ_{A,1.m}^{l.n}$, $SQ_{C,B}^{r} = \left[SQ_{C,B}^{(t1)}, SQ_{C,B}^{(t2)}, SQ_{C,B}^{(t3)}, \dots, SQ_{C,B}^{(tx)}\right]$, this formula QoS of SC service customer C for SP service provider B, because SC service customer C really completes its own evaluation, so that, it might justify the trust of SC service customer C according to the differences' evaluation of SC service customer for SP service provider B. From $SQ_{A,B}^{r}$ and $SQ_{C,B}^{r}$, the evaluation vector of SC service customer A and SC entity C for SP service provider B about tj moment:

$$SQ_{A,B}^{ij} = \left[SQ_{A,B}^{1,(ij)}, SQ_{A,B}^{2,(ij)}, SQ_{A,B}^{3,(ij)}, \cdots, SQ_{A,B}^{\nu,(ij)} \right]$$
(2)

$$SQ_{C,B}^{ij} = \left[SQ_{C,B}^{1,(ij)}, SQ_{C,B}^{2,(ij)}, SQ_{C,B}^{3,(ij)}, \cdots, SQ_{C,B}^{\nu,(ij)}\right]$$
(3)

Combining with the preferences analysis of the second part, the evaluation difference based on preferences is derive:

$$\Delta_{A,C}^{B,(ij)} = \Delta(A,C,B,tj) = pI(\omega) \cdot \sum_{k=1}^{\nu} \tilde{\omega}_m \left| Q_{A,B}^{k,ij} - Q_{C,B}^{k,ij} \right|$$
(4)

Further, the ratio of the difference in value of the trust might be calculated as:

$$\varphi_{A,C}^{B,(ij)} = \Delta_{A,C}^{B,(ij)} / \sum_{k=1}^{\nu} \tilde{\omega}_m Q_{A,B}^{k,ij}$$

$$\tag{5}$$

$$C_{A,C}^{B,(ij)} = 1 + \left\lceil \Lambda - \psi_{A,C}^{B,(ij)} \right\rceil \cdot \hat{\mathcal{O}}$$
(6)

In Formula (6), ∂ represents the component of gradient, " $\lceil \rceil$ " expresses arithmetic modulo, Λ is constant value. When difference is smaller that threshold constant Λ , it means credible, the smaller the difference value, the higher the trust. When the difference value is greater than Λ , it means incredible, its trust values is negative. Thus through *SP* entity *B*, about *SP* service provider *SC* entity *C*, the trust evaluation of *SP* service customer *A* has the information evaluation vector:

$$C_{A,C}^{B} = \left[C_{A,C}^{B,(t1)}, C_{A,C}^{B,(t2)}, \cdots, C_{A,C}^{B,(tx)}\right]$$
(7)

Through the trust level method, if the trust evaluation $C_{A,C}^{B,(j)} \ge 0$, trust density value is 1, and 0 otherwise. requirement preference is the premise, the trust evaluation $f_{A,C}^B$ of other *n SC* is equivalent to $pI(\omega) \cdot f(\alpha_{A,C}^B, \beta_{A,C}^B, \gamma_{A,C}^B)$, it is refined as the following matrix structure:

$$f_{A,1..m}^{1..n} = \begin{bmatrix} f_{j,1}^1 & f_{j,1}^2 & f_{j,1}^3 & \cdots & f_{j,1}^m \\ f_{j,2}^1 & f_{j,2}^2 & f_{j,2}^3 & \cdots & f_{j,2}^m \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ f_{j,j}^1 & f_{j,j}^2 & f_{j,j}^3 & \cdots & f_{j,j}^m \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ f_{j,m}^1 & f_{j,m}^2 & f_{j,m}^3 & \cdots & f_{j,n}^n \end{bmatrix}$$
(8)

4. SCP-TP (Service Composition Preference-Trust Reasoning)

SCP-TP is described as the follows: according to goal's preferences, service entity *SA* might reduces its own trust relationship, which is showed as the interaction relationship between *SA* and *SC*₀, the whole interaction accepts the preference-driven effect of *PIG* (Platform Implementation Goal). *SA* is one set of *SP* entities interacted with *SC* entities *A*, *SC*₀ is one set of *SC* entities interacted with *SP* entities in *SA* set. Because the preference implementation condition led by goal's changing is the trust logic of *SP* of *SP*_k in **Figure 1**, which might gotten by the indirect trust relationship by *PIG*.

Trust reasoning and process-aware in Figure 1 is described as follows:

1) Preferences of platform goal and real-time user requirement is mapped for *PIG* (related characterization described in the paper has been assigned), *PIG* realization is attributed to cluster logic set of *SC* service customer entity *A*. The serialization process of *A* is submitted by SP_0 , and does a series of reasoning that SC_0 cluster set is the starting point, to get the trust value for SP_1 cluster set.

2) Besides SC_0 cluster set, SC interacted with SP_1 cluster also introduces the reasoning and process-aware with SC_1 cluster. Contrasting SC_0 cluster and SC_1 cluster about the difference of SP_1 cluster, reduces the trust results of SC_1 . In this process, SP cluster entity is viewed as the reference of SC trust evaluation and reduces SC_1 trust. In this way, trust reasoning and service goal might reduce SP_1 cluster and SC_1 cluster.

3) According to the second step of this process, further reasoning, it might get QoS weight of SP_k cluster that its trust coincides with preferences.

 SC_0 driven by *PIG* has *n* entities, there are *z* entities in SC_1 , SP_0 has *m* entities, SP_1 is with *y* entities. Preference *QoS* evaluation matrix of SP_1 set related to *PIG* is described as:



Figure 1. Trust reasoning and process-aware of SCP-TP.

$$Q_{0,1..n}^{1..y} = \begin{bmatrix} Q_{1,1}^{r} & Q_{1,2}^{r} & f_{1,3}^{r} & \dots & Q_{1,y}^{r} \\ Q_{2,1}^{r} & f_{2,2}^{r} & f_{2,3}^{r} & \dots & f_{2,y}^{r} \\ \dots & \dots & \dots & \dots & \dots \\ Q_{j,1}^{r} & f_{j,2}^{r} & f_{j,3}^{r} & \dots & f_{j,y}^{r} \\ \dots & \dots & \dots & \dots & \dots \\ f_{n,1}^{r} & f_{n,2}^{r} & f_{n,3}^{r} & \dots & f_{n,y}^{r} \end{bmatrix}$$
(9)

Corresponding to QoS of SP entities adjusted by PIG, it might get the trust evaluation of n SC entities in SC₀ set according to above reasoning and aware:

$$T_{0,1..n}^{1..y} = \begin{bmatrix} f\left(\alpha_{1,1}, \beta_{1,1}, \gamma_{1,1}\right) & f\left(\alpha_{1,2}, \beta_{1,2}, \gamma_{1,2}\right) & \dots & f\left(\alpha_{1,y}, \beta_{1,y}, \gamma_{1,y}\right) \\ f\left(\alpha_{2,1}, \beta_{2,1}, \gamma_{2,1}\right) & f\left(\alpha_{2,2}, \beta_{2,2}, \gamma_{2,2}\right) & \dots & f\left(\alpha_{2,y}, \beta_{2,y}, \gamma_{2,y}\right) \\ \dots & \dots & \dots & \dots \\ f\left(\alpha_{i,1}, \beta_{i,1}, \gamma_{i,1}\right) & f\left(\alpha_{i,2}, \beta_{i,2}, \gamma_{i,2}\right) & \dots & f\left(\alpha_{i,2}, \beta_{i,2}, \gamma_{i,y}\right) \\ \dots & \dots & \dots & \dots \\ f\left(\alpha_{n,1}, \beta_{n,1}, \gamma_{n,1}\right) & f\left(\alpha_{n,2}, \beta_{n,2}, \gamma_{n,2}\right) & \dots & f\left(\alpha_{n,2}, \beta_{n,2}, \gamma_{n,y}\right) \end{bmatrix}$$
(10)

 $Q_{0,1..n}^{1..y}$ matrix represents QoS evaluation of SC_0 about SP_1 , $Q_{1,1..z}^{1..y}$ matrix represents QoS evaluation of SC_1 about SP_1 . Further might be obtained:

$$Q_{1,1,z}^{1,...y} = \begin{bmatrix} Q_{1,1}^{r} & Q_{1,2}^{r} & Q_{1,3}^{r} & \dots & Q_{1,y}^{r} \\ Q_{2,1}^{r} & Q_{2,2}^{r} & Q_{2,3}^{r} & \dots & Q_{2,y}^{r} \\ \dots & \dots & \dots & \dots & \dots \\ Q_{i,1}^{r} & Q_{i,2}^{r} & Q_{i,3}^{r} & \dots & Q_{i,y}^{r} \\ \dots & \dots & \dots & \dots & \dots \\ Q_{z,1}^{r} & Q_{z,2}^{r} & Q_{z,3}^{r} & \dots & Q_{z,y}^{r} \end{bmatrix}$$
(11)

This process is described as:

Step 1: Calculate the evaluation values of E and F for SP entity H, then reduce the trust of E about F, the evaluation difference value of H at t_i moment is

$$\eta_{E,F}^{H(t_i)} = \eta(E, F, H, t_i) = \sum_{k=1}^{u} \varpi_m \left| Q_{E,H}^{k,t_i} - Q_{F,H}^{k,t_i} \right|$$
(12)

Step 2: According to the above reasoning and *PIG* adjustment of *SC* and *SP*, it might reduce and get the trust about services' participation:

$$\varphi_{E,F}^{H(t_i)} = PIG \cdot \eta_{E,F}^{H(t_I)} / \sum_{k=1}^{u} \tilde{\varpi}_m Q_{E,H}^{k,t_i}$$

$$\tag{13}$$

$$T_{E,F}^{H(t_{I})} = 1 + \left\lceil \Lambda - \varphi_{E,F}^{H(t_{i})} \right\rceil \cdot \sigma$$
(14)

The goal trust of service entity E and F during selecting and compositing of SP entity H scheduling by PIG is:

$$T_{E,F}^{H} = \left[T_{E,F}^{H(t_1)}, T_{E,F}^{H(t_2)}, T_{E,F}^{H(t_3)}, \cdots, T_{E,F}^{H(t_v)} \right]$$
(15)

$$f_{E,F}^{H}(\alpha,\beta,\gamma) = \left[f_{E,F}^{1}(\alpha,\beta,\gamma), f_{E,F}^{2}(\alpha,\beta,\gamma), f_{E,F}^{3}(\alpha,\beta,\gamma), \cdots, f_{E,F}^{y}(\alpha,\beta,\gamma)\right]$$
(16)

Further might get every SC_1 service entity's information evaluation of SC_0 service entity E by SP_1 set. Every participation entity's trust evaluation of SC_1 about SC service entity in SC_0 is expressed in the left part of Formula (17). j line of Formula (17) expresses the trust evaluation of j SC_1 entity that service entity E has completed to refer different service provider SP_1 , then it might also get the trust evaluation process of E about every SC_1 entity, it is showed as the right matrix structure in Formula (17).

$$\begin{bmatrix} f_{j,1}^{1} & f_{j,2}^{2} & \cdots & f_{j,1}^{\nu} \\ f_{j,2}^{1} & f_{j,2}^{2} & \cdots & f_{j,2}^{\nu} \\ \cdots & \cdots & \cdots & \cdots \\ f_{j,j-1}^{1} & f_{j,j-1}^{2} & \cdots & f_{j,j-1}^{\nu} \\ \cdots & \cdots & \cdots & \cdots \\ f_{j,z}^{1} & f_{j,z}^{2} & \cdots & f_{j,z}^{\nu} \end{bmatrix} \Rightarrow \begin{bmatrix} f\left(\alpha_{j,1}^{idir}, \beta_{j,1}^{idir}, \gamma_{j,1}^{idir}\right) \\ f\left(\alpha_{j,2}^{idir}, \beta_{j,2}^{idir}, \gamma_{j,2}^{idir}\right) \\ \cdots \\ f\left(\alpha_{j,j-1}^{idir}, \beta_{j,j-1}^{idir}, \gamma_{j,j-1}^{idir}\right) \\ \cdots \\ f\left(\alpha_{j,z}^{idir}, \beta_{j,z}^{idir}, \gamma_{j,z}^{idir}\right) \end{bmatrix}$$
(17)

Based on the above results, the trust calculation reasoning model driven by preferences between service providers and service customers about *PIG* is Formula (18):

$$\begin{bmatrix} f\left(\alpha_{1,1}^{idir}, \beta_{1,1}^{idir}, \gamma_{1,1}^{idir}\right), & f\left(\alpha_{1,2}^{idir}, \beta_{1,2}^{idir}, \gamma_{1,2}^{idir}\right), & \cdots, & f\left(\alpha_{1,z}^{idir}, \beta_{1,z}^{idir}, \gamma_{1,z}^{idir}\right) \\ f\left(\alpha_{2,1}^{idir}, \beta_{2,1}^{idir}, \gamma_{2,1}^{idir}\right), & f\left(\alpha_{2,2}^{idir}, \beta_{2,2}^{idir}, \gamma_{2,2}^{idir}\right), & \cdots, & f\left(\alpha_{2,z}^{idir}, \beta_{2,z}^{idir}, \gamma_{2,z}^{idir}\right) \\ & \cdots & \cdots \\ f\left(\alpha_{n,1}^{idir}, \beta_{n,1}^{idir}, \gamma_{n,1}^{idir}\right), & \left(\alpha_{n,2}^{idir}, \beta_{n,2}^{idir}, \gamma_{n,2}^{idir}\right), & \cdots, & \left(\alpha_{n,z}^{idir}, \beta_{n,z}^{idir}, \gamma_{n,z}^{idir}\right) \end{bmatrix}$$
(18)

The first line of Formula (18) is corresponding to the first column of the right part in Formula (18), that expresses the corresponding trust evaluation of some service customer entity SC for every entity in SC_1 set. According to the above logical derivation process, SC_0 is the starting point, SP_1 deduces trust value of SC_0 for SC_1 , then, SC_0 is as the starting point, SP_2 deduces trust value for SC_2 , it might get the trust about SC_k in **Figure 1**.

Through the above derivation process, we might obtain the *QoS* acquisition approach of *QoS* that there *SP* interacted with *SC* indirectly, and *QoS* evaluation model that direct interaction trust is precondition and user preferences are the important factors adjusted by *PIG*.

The trust and process-aware in **Figure 1**, according the above analysis and argumentation, temporary indirect trust about service selection and composition might get the transformation and indirect transition in **Figure 2**. This process might be described as: first, *SC* entity *S* might get the trust relationship of SC_0 . Secondly, according to the forward reasoning, it might get SP_0 entity *D* adjusted by *PIG*. Based on service composition and *PIG*, transition relationship of trust in **Figure 2** achieves other indirect transition routing of trust.

5. Service Composition Process Based on Process-Aware

Process topology and implementation semantic logic of CAPT, this part gives CCML description.

<CCML: Composition>

<CCML: sequence>

<!--read channel-->

<!--get PIG implementation decision-making-->

<CCML: Capture the activities about PIG, which are managed in some way>

<!--read service transition channel based on the goal of some activity-->

<CCML: readChannel Channel="PIG_channelName" Service="PIG_serviceName" action="PIG_actionName" port="portName">

<!--implement one service activity-->

<!--process-aware logic of *PIG* reads the context requirement and implement from corresponding service register channel. -->

<!--read service register channel-->

<CCML: readReg reg="PIG_registerName" Service="PIG_ServcieName" action="PIG_actionName" port= "portName">

<CCML: execute action="PIG_actionName" Service="PIG_serviceName">

<!--write channel-->

<CCML: writeChannel Channel="PIG_channelName" Service="PIG_serviceName" action="PIG_actionName" port="portName">



Figure 2. Transformation and transition of trust.

<!--write service register channel-->

<CCML: writeReg reg="PIG_registerName" Service="PIG_ServcieName" action="PIG_actionName" port= "portName">

<CCML: execute action="PIG_actionName" Service="PIG_serviceName">

</CCML: sequence>

</CCML: composition>

6. Conclusions

Thinking about preferences of service selection and composition, this paper analyzes and argues the trust reasoning strategies and implementation measures of service flow platform. For goal preferences and topology effectiveness, this paper designs and achieves process-aware approach that *PIG* is the main adjustment mechanism, then gives the algorithm and adjustment platform logic for actual implementation case.

In processing of problems, timely goal preferences of goal and trust reasoning of flow are the key problem in service computing and cloud computing, *PIG* fully considers goal preferences and topology trust, and reduces SCP-strategy logic, and achieves the context process-aware logic and implementation process. Through actual case's R&D and optimal project of platform, it improves the autonomous optimization and evolution capacity of service flow.

Acknowledgements

This paper is supported by National Natural Science Foundation of China (61373027, 11101243), Natural Science Foundation of Shandong Province of China (ZR2012FQ011, ZR2012FM023, ZR2009GM009), the Key Science-Technology Development Project of Shandong Province of China (No. 2009GG10001014, 2012GGX10123) and Promotional Foundation (2005BS01016) for Middle-aged or Young Scientists of Shandong Province, SRI of SPED (J12LN06, J07WH05), DRF and UF (3XJ200903, XJ0609) of QFNU.

References

- [1] Zhang, J.-L. and Fan, Y.-S. (2010) Service-Oriented Enterprise and Business Ecosystem. *Computer Integrated Manufacturing Systems*, **16**, 1751-1759.
- [2] Xu, L.-D., Liu, H.-M., Wang, S., et al. (2009) Modeling and Analysis Techniques for Cross-Organizational Workflow Systems. Systems Research and Behavioral Science, 26, 367-389. <u>http://dx.doi.org/10.1002/sres.978</u>
- [3] Armbrust, M., Fox, A., Griffith, R., et al. (2010) A View of Cloud Computing. Communications of the ACM, 53, 50-58. <u>http://dx.doi.org/10.1145/1721654.1721672</u>
- [4] Zeng, L.Z., Benatallah, B., Hgu, A.H.H., et al. (2004) QoS-Aware Middleware for Web Services Composition. IEEE Trans on Software Engineering, 30, 311-327. <u>http://dx.doi.org/10.1109/TSE.2004.11</u>
- [5] Ardagna, D. and Pernici, B. (2005) Global and Local QoS Guarantee in Web Service Selection. Proceedings of Business Process Management Workshops, Springer, Berlin, 32-46.
- [6] Yu, T. and Lin, K. (2005) Service Selection Algorithms for Composing Complex Services with Multiple Qos Constraints. Proceedings of the 3rd International Conference on Service Oriented Computing, Springer, Berlin, 130-143.
- [7] Kormza, T. and Krunz, M. (2001) Multi-Constrained Optimal Path Selection. *Proceedings of the 20th Joint Conference of IEEE Computer and Communications*, Piscataway, 834-843.
- [8] Canfora, G., Penta, M.D., Esposito, R., et al. (2005) An Approach for QoS-Ware Service Composition Based on Genetic Algorithms. Proceedings of the 2005 Conference on Genetic and Evolutionary Computation, ACM, New York, 1069-1075.
- [9] Fan, X.Q., Jiang, C.J., Fang, X.W., *et al.* (2010) Dynamic Web Service Selection Based on Discrete Particle Swarm Optimization. *Journal of Computer Research and Development*, **47**, 147-156.
- [10] Beynon, M. (2001) Reduces within the Variable Precision Rough Sets Model: A Further Investigation. European Journal of Operational Research, 134, 592-605. <u>http://dx.doi.org/10.1016/S0377-2217(00)00280-0</u>
- [11] Pomykala, J. (1988) The Stone Algebra of Rough Sets. Bulletin of the Polish Academy of Sciences, 36, 495-507.