2010 International Conference on Complex, Intelligent and Software Intensive Systems

Defining minimum requirements of inter-collaborated nodes by measuring the weight of node interactions

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Abstract – **In this paper we are focusing on the minimum requirements to be addressed in order to demonstrate a inter-node communication within a Virtual Organisation (VO) using the method of Self-led Critical Friends (SCF). The method is able to decide paths that a node can choose in order to locate neighbouring nodes by aiming at realizing the overhead of each communication. The weight of each path will be measured by the analysis of prerequisites in order to achieve the interaction between nodes. We define requirements as the least fundamentals that a node needs to achieve in order to determine its accessibility factor. The information gathered from an interaction is then stored in a snapshot, a profile that is made available during the discovery stage.**

Keywords-component: Grid Technology, Self-led Critical Friends, Metadata Snapshot Profile, Graph Theory.

I. INTRODUCTION

In this paper we propose a new approach to extend current VO node inter-cooperation practices as described in [2]. In order to achieve this endeavor, we employ graph theory as the method to represent the interconnection of nodes and aiming at defining weighted paths that nodes can choose for job assignments. In a typical grid VO it is common that the number of the nodes and their communication is previously acknowledged and are connected in random topologies composing cliques. Also, we assume that each node may have many interconnections with foreign nodes belonging to several VOs. We call these nodes self-led critical friends (SCF) and they play the role of mediators. Finally, the SCF are the means to achieve the interconnection between several VOs with different characteristics and roles.

Thus, we aim to utilize the fact that each VO is a specific neighborhood of nodes composing a clique of vertices. By defining each path weight we aim to identify several paths between pairs of nodes. Eventually, the measured weight of path edges will be supportive to the resource discovery method. By assigning a value to each path we may then calculate the best job assignment selection based on the minimum requirements that a node should achieve. These are extracted from a node's necessities in order to achieve a job delegation. These include: a) Policy management control, b) Knowledge coupling, c) Physical resource announcements and d) Execution time constraints. In a rational way, node communication is achieved firstly by attaining policies, followed by pairing knowledge background, and finally by physical resource and time information coupling. Data gathered from minimum requirements analysis are stored in a public profile of each node called a metadata snapshot profile. Finally, nodes will be able to decide the weight of each edge and make use of the weight at a later stage of discovery. We will conclude this paper by describing two relevant scenarios; the one expresses the interaction of internal VO nodes and the second the interaction between two VOs by utilizing a SCF interconnection.

II. MOTIVATION

Centralized grid environments have received considerable attention in academia in recent years. Efforts within the Grid community that address centralized or hierarchical models such MDS in Globus and MatchMaker in Condor have high efficiency and reduce the response time [11]. However, when the system extends to a large scale the performance will be affected by a single point of failure [12]. Recently a new scheme has received the attention of the academic community; the *fully decentralized model* which turn clusters of collaborating enterprises into an efficient community of cluster member. In this model every VO participant needs to embrace any partner in order to provide a more autonomous solution. Therefore, [10] suggests that large networks without apparent design principles have been described as random graphs that are the simplest and straightforward realization of complex networks. Using graph theory the demonstration of dynamically joining a community of nodes; without a central control manager; has proven to be the simplest and most straightforward method to use for complex networks.

In order to develop such an open grid environment it is crucial to identify a grid VOs minimum requirements [1, 3] primarily including policy management control, resource discovery and representation mechanisms. [4] suggests that nodes may be members of any number of VOs, may have

978-0-7695-3967-6/10 $26.00 © 2010 IEEE
DOI 10.1109/CISIS.2010.84

any number of roles within a given VO, and their VO membership must remain confidential as well as being able to select and deselect VOs and roles. It should be also possible to list resources and actions to which a VO member or role has access to carry out specific actions. This can be achieved by storing resources in a public profile of each node that is accessible to everyone either member of the VO or external co-operators [2].

It is vital to determine if a VO member and role has access to a certain resource and authorisation to carry out specific actions. On the other hand a VO must be able to specify a membership policy and user authorisation method. Finally, a resource owner must be able to allow or forbid authorisation by VO and VO role membership. Our vision herein is based on the ideal grid, i.e. sharing resources among several VOs [1]. Specific research questions are focused on the importance of assigning a value to a path, the method of considering the weight and the novelty of the study scheme. This work aims to deliver an inter-collaboration plan, by utilizing SCF as a novel notion of a resource discovery method [2]. The proposed architecture allows us to treat a grid community as an inter-collaborating group of users in which everyone can access and delegate jobs with respect to minimum requirements articulated by VO cliques.

III. RELATED WORK

In order to achieve a highly scalable cooperative community, the authors of [9] propose a small world networking strategy based on randomly rewiring of all path edges via exchanging their end nodes' neighborhood in an initially regular graph. This small world community strategy realises two expected features: highly clustered groups of nodes and shorter diameter between nodes. However, the strategy is applicable on small grid networks using graph theory as a means of network illustration. On the other hand [11] consider a dynamical network system that proves a balanced load distribution and efficient resource discovery. In order to design such a dynamical system, they analyse the degree distribution of nodes in a stochastic network system with a fixed number of nodes and fixed average number of path edges using a graph theoretic model. Finally the work presented in [10] proposes structuring a grid using a small-world overlay graph, and developing an accurate simulation platform for evaluating performance of resource discovery algorithm under realistic network conditions.

By considering minimum requirements, [2] introduces a novel model, namely the "self led critical friends", as the next step to achieve cooperation between multi institutional VOs. Moreover, it is suggested that a SCF topology should be the means to realize interoperability and clarifies that a grid community can communicate within their VOs, thus they can form and manage their own perceptions about neighbouring nodes based on previous interactions, such as communication and delegation records. In other words, by using SCF, the discovery of nodes is based on a nodes internal knowledge independent of its VO domain. Information gathered by requirements is stored in a node metadata snapshot profile as a means of storing potentials. These capabilities can be roles within a node [2] and actions that a member can carry out. The profile is then made available through advertising information directly to the interconnected SCF nodes without having to be controlled by a central administrator or a fixed infrastructure.

IV. THE STRATEGY

It is fundamental for grid computing that resources of newly added nodes can be utilized by nodes already existing within the same VO. We call internal nodes of a specific VO a clique which typically have the same policy preference and knowledge background. Moreover, once gaps between multi-institutional VOs are bridged by SCF nodes belonging to multi-VOs, collaboration of job sharing can be achieved between nodes from either the same VO or different VOs. In this context, the formality of communication issues is playing a vital role in the perspective of high-quality cooperation. By defining clique paths, we aim to exploit the impact on VO topology led by newly added SCF nodes. The result will be a new VO composed of several cliques that respect requirements expressed by VOs. The newly regenerated VO will be a new topology of an ad-hoc nature, which will result in a new open pool of resources available to several VOs.

V. COMMUNICATION WITHIN COMMUNITY

Within a cooperative community and from the service perspective of nodes there are mainly two kinds of communication; point to multipoint broadcasting and searching within the community [9]. The point to multipoint broadcasting can be achieved by a node through an advertised information profile that it is willing to share to the community members. In this way capabilities of a node can be published internally to a VO domain and each member could be aware of possible roles and actions of any VO participant. On the other hand, any community member can discover directly the information or services by searching within a neighbourhood.

In both solutions VO members could establish some ad hoc, short-term relationships with one another so they can be provider, requestor, or both [9]. Its aim is to indirect communication, independently to each own status either idle or equipped. Primary challenging goal in building an ad hoc grid is supplying each grid member with specific directions for continuously maintain information related to each community participant, therefore act as an intermediate. Such information will be stored on each VO member public profile and be able for advertising at the resource discovery progress. In this paper the advertising method is selected for node cooperation and each member could be able to broadcast its public profile data to the entire community by searching within the community. Howbeit, the ad hoc configuration can be achieved by presenting a self configuring model for providing computing resources on demand utilizing each member public profile. In this way community members could be able to define their own locally administrative rules for communication and delegation within an inter-cooperative grid.

VI. Translation Of Requirements

To achieve inter-cooperation we define the minimum requirements as a sequence of steps in the following order:

A. Policy Management Control (PMC), as the internal authorization and membership procedure of a VO.
B. Knowledge Base Pairing (KBP), as the background of roles and actions that a node can carry out.
C. Physical Resource Announcement (PRA) as the advertised information of hardware capabilities.
D. Time Constraints Management (TCM) as the mean of realizing execution and communication durations.

The PMC is defined as the permissions that need to be addressed and obtained from nodes. Typically, clique nodes may have already decided and accepted a common PMC. Secondly, the KBP is critical for decisions to a node's task capabilities. The results are realized from the PRA, whose task is to classify hardware resources before the job delegation. A node with the best characteristics will be the candidate for the work assignment. Finally, the TCM will be the used to determine the expected time of job completion and communication duration based on previous interactions.

These requirements consist of a set of generated reports stored in a public profile of each node, which we define as a metadata snapshot profile. Data stored in the profile will be announced to each node after a request and kept up-to-date after a completed interaction. By combing data from the snapshot profile the weight of the node edges will be measured and a value will be assigned to each path.

A. *Policy Management Control*

It is important for each VO to contain a PMC, which is shared by all nodes of a clique. The assumption is that clique nodes have a unique account which is shared at the first time of VO construction. The procedure is administrated by a manager component which is currently treated as a black box component. We define a *Host node* as a node which requests a job submission and *Operators* the nodes which are available for job assignment. Each time a job delegation appears the clique nodes are identified by their account. Newly added nodes to the clique are assigned by contracting agreements after the first initialisation. If the new node belongs to the clique, then it is assigned by an internal agreement. In any other case it is a SCF and a new agreement is created.

Specific policy measures include logon procedure, clique contract, SCF contract, and reference contract, which are stored within a node's public profile. The logon procedure allows clique nodes to be identified by utilizing accounts assigned to the administrator. The clique contracts are agreements signed from the internal VO nodes and their functionality is to arrange interactions for newly added nodes to the clique.

The SCF contracts are agreements signed by the SCFs and clique nodes. These agreements are an indication for inter-collaboration of both parties at the time of initialization. Finally, the reference contracts are suggestions to a SCF contract which is settled by the clique VO in case a SCF needs to communicate with a node which is not aware of its existence.

Figure 1 demonstrates the sequence of actions starting from the logon process and terminating when permission is granted. During the procedure the Operator is capable of performing specific tasks such as contract validation and account creation for clique nodes. Moreover, the procedure validates contract agreements of SCF and the reference contracts as the mean to realize the interoperation of nodes.

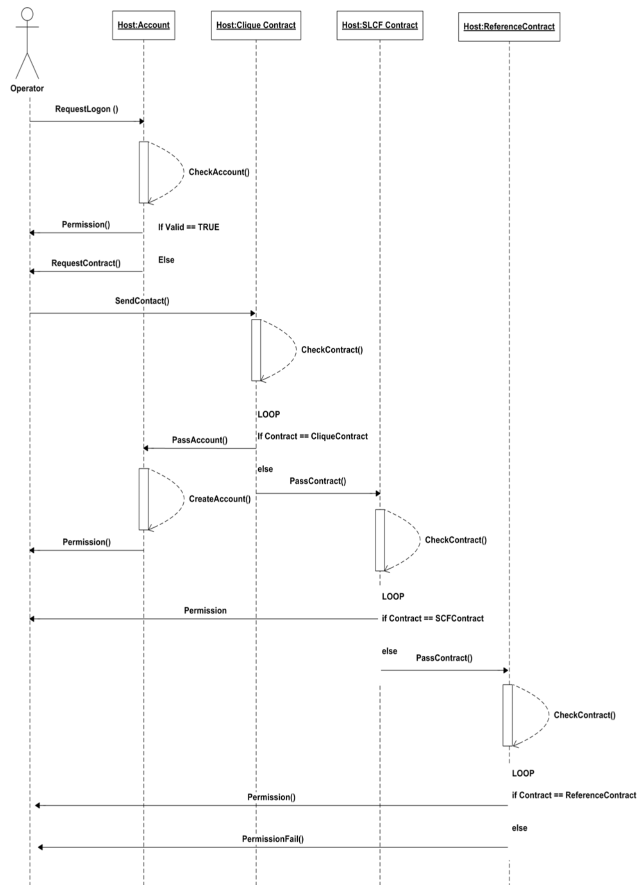

Figure 1 - Use case of a node PMC interaction

The contracts functionality is to guarantee that nodes are either clique or SCF nodes. The plan is that a Host delegates a job to an Operator. Firstly, the Operator checks the Host account and decide if it is registered in the profile considering accepting the connection. If the permission is granted then the Host is successfully logged on and moves to the next step. If the logon is unsuccessful the Host responds by sending the Operator a clique contract or an SCF contract. If the agreement does not exist in both contracts then the Host may be a critical friend of a clique node and it is suggested to respond with a reference contract. Finally, both parties are now able to sign an agreement protocol while the permission is successfully granted.

B. KNOWLEDGE BASED PAIRING

The public snapshot profile of a node should be able to provide information concerning its knowledge and capabilities. The pairing procedure is important as the node should be able to decide which node matches the needed job delegation. KBP includes current knowledge data, statistics information and suggestions for future familiar knowledge native interfaces which may be available. The plan is that the Operator request specific actions that could be carried out from the Host node. If the knowledge does not exist then the Operator returns an error message to the Host and the job fails; otherwise, the Operator retrieves a ranking for the specific knowledge awarded by previous jobs interactions. The native knowledge interface aims to decide which job could be assigned from existing native libraries concerning particular job delegation. In this stage we define knowledge as the capability of performing specific jobs. Ranking and native knowledge interface will be studied in future work. Figure 2 demonstrates the above sequence as the Host request knowledge background and the Operator retrieves rankings and native knowledge information.

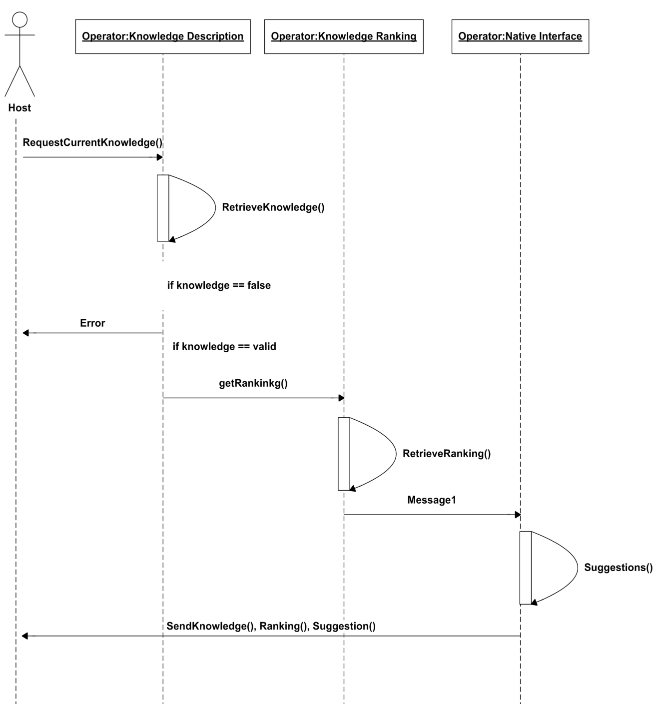

Figure 2 - Use case of a node KBP interaction

C. PHYSICAL RESOURCE ANNOUNCEMENT

The physical resources of an Operator include information about hardware and software capabilities. These records are essential and are required to be announced to the public profile of each node. In general much information can be captured by a public profile such as CPU, Memory Space, Disk Space, Operating System, Processor Architecture, Operating System Architecture, Processor Product, Resource Cache, Number of Processors etc and heuristic information concerning network devices and capabilities. Due to the huge number of physical resources the PRA advertise resources stored at each node public profile by including the following:

- CPU Power as the maximum available CPU for job delegation.
- Memory Space as the maximum allocated memory.
- Disk Space as the maximum allocated hard disk space.

A public operation is utilized by the PRA which generates a list with meets the requirements discussed above. The list is then passed to the Host which determines job assignments. The necessary prerequisites of this process are that the PCM and KBP already exist. When the Host requests an interaction, the Operator will be able to send a list of available physical resources. The data will be obtained from each node's internal procedure. If a job already exists, then it is obvious that node resources will be limited. Finally, the Host informs the Operator if it is capable of executing the job. The following mathematical formula calculates the physical resource ranking:

$$\text{Ranking} = 1/\ (\text{CPU}*\text{CPUCoefficient} + \text{Memory}*\text{MemoryCoefficient} + \text{HD} * \text{HDCoefficient})$$

The coefficient value is assigned by the Operator as a measure of required values for each physical resource. For instance, if a node requests high CPU power the CPU Coefficient will be 1, in other case will be from 0,1 to 0,9. Finally, the minimization of the value for later use in a graph theoretic model is achieved by the division of 1 with the formula.

D. TIME CONSTRAINTS MANAGEMENT

Time management is an important issue to be settled before the job delegation. The due time of a job is comprised of the execution time of the Operator and the communication time through the selected path. If a node requests a job submission via an Operator then time is affecting its decision of selecting paths. The expected execution time and the link duration will also affect the communication weight as it is the most important feature after the PRA pairing.

In order to define the expected execution time we need to identify the Optimistic Completion Time (OCT) for a job. The OCT value is defined as the best completion time achieved for a specific job and is stored in the public profile of the snapshot. The pessimistic completion time (PCT) is the worst time which the same job completes the post. The most likely completion (MLCT) time is the averaged value of jobs. When a Host requests the expected execution time, the Operator calculates the value according to the information stored in the public profile based on previous interactions. The expected execution time (EET) between events is calculated according to the following equation [8]:

$$\text{ET} = (\text{MPT} + 4\text{MLCT} + \text{OCT}) / 6$$

Finally, the duration link is defined as the time required achieving the communication, and is calculated by summing up the linked duration needed from one node to another. A method for determining the duration is by calculating the ping time of each interaction. We assume that each node's total distance in a certain path is an average of 1000 pings multiplied by two.

VII. Metadata Snapshot Profile

The snapshot profile is formed according to the minimum requirements gathered after the first initialization of a VO. We assume that each VO clique is managed by a VO administrator component which is able to assign clique contracts and knowledge background to each node. Then, physical resources are extracted internally and announced to the snapshot profile. Execution time data are collected from completed jobs within a node. Figure 3 demonstrates the snapshot profile attributes and operations, as well as the pairing procedure. The Host node sends its public profile data to the Operator and the procedure starts. Finally, the Operator returns a new record to the Host. If the pairing is successful, then the job delegation process starts, in any other case the pairing fails. Updated profiles of Host and Operator are stored in the metadata snapshot profile of each node.

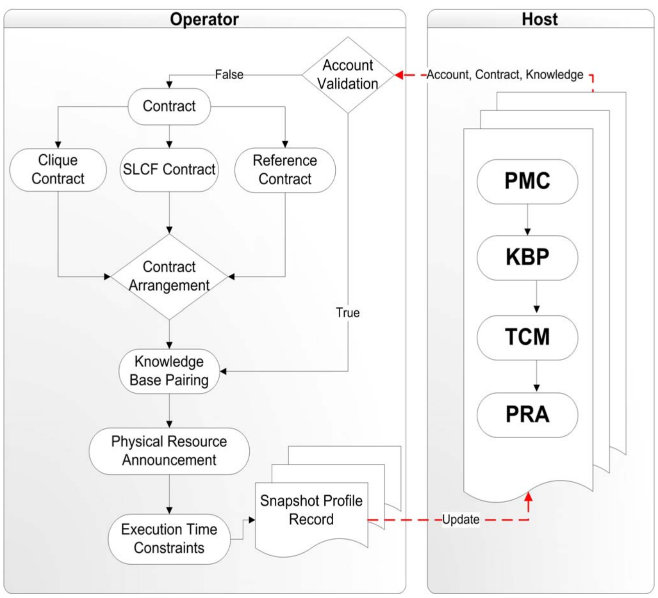

Figure 3 - Snapshot profile interaction

The weight of a specific job is measured by combining data collected from the profile. These data are determined by contract agreements, pairing of knowledge, physical and time constraints respectively for Host and Operators. The following initializes the above algorithm:

1st Phase: The algorithm initializes the PMC routine which determines the policy of connection and validates contract.

Algorithm Policy Control Management

Precondition: Account acc, Contract con, Permission PCM
Precondition: con ∈ {CliqueContract, SCFContract, ReferenceContract}

```
if acountc exists in Snapshot Profile then
    utilize PCM = True
else if contract = CliqueContract then
        utilize PCM = True
        create Account acc for new node
        else if contract = SCFContract then
            PCM = True
            else if contract = ReferenceContract then
             PCM = True
                update SCFContract with Reference Contract
end if, end if, end if, end if
```

2nd Phase: Once the contract validation is successfully completed, the KBP procedure defines whether the Operator is able to accept the job from the scope of actions capable of carrying out.

Algorithm Knowledge Base Pairing

Precondition: Knowledge Description kd, Knowledge Ranking kr, Knowledge Pairing KBP, PCM = True

```
if kd = Current Knowledge then
    utilize KBP = True
    kr = Extract Current Knowledge Ranking
else KBP = False
    create Account acc for new node
end if
```

3rd Phase: Once the PMC and KBP are paired successfully the algorithm defines the physical resource ranking as well as data about duration. The algorithm updates the profile when a job delegation successfully completes.

Algorithm Physical Resource Announcement and Execution Time Management

Precondition: Physical Resource Description Ranking, expected time et, most pessimistic time MPT, most optimistic time OCT, most likely completion time MLCT, Duration pingTimes, Time T,
Precondition: Constant a, b, c
Precondition: PCM = True, KBP = True

```
Ranking = = a * CPU + b* Memory + c* HD
Ranking = = 1/ Ranking
ET = (MPT + 4MLCT + OCT) / 6
dur = sum of durations
T = ET + 2 * ping
Update ET when job completes
if ET < OCT then
   OCT = ET and store in the profile flag1= true
end if
```

```
if ET > MPT then
  PCT = ET and store in the profile flag2 = true
end if
if (flag1 = false and flag2=false) then
  MLCT = (MLCT+ET)/2
end if
```

4[th] Phase: The following formula calculates the weight of a path by multiplying time and ranking.

Algorithm Weight Calculation

Precondition: Edge Weight w, Physical Resource Description Ranking, completion time t
Precondition: PCM = True, KBP = True, Ranking<>0

```
w = T * Ranking
```

The above algorithms demonstrate the procedure with the appropriate sequence. First of all, the PMC and KBP algorithms utilize a procedure in which we aim to define a pairing of policies and knowledge background. Once this has been established, the TCM algorithm defines a way to measure execution and communication duration within a node. Finally, we assign a weight to a path according to the minimum requirements.

VIII. SCENARIOS

The following scenarios illustrate the minimum requirements pairing procedure in order to calculate the weight of each path. The first scenario illustrates a VO internal interaction; and the second one explains the interaction process between two VOs by utilizing SCFs as mediators of inter-collaborated nodes.

1. Scenario 1

The first scenario demonstrates grid node interaction amongst 3 clique nodes (O_1, O_2, and O_3), one new added node to the clique (O_4) and two SCF nodes (O_5, O_6). It is assumed that the aforementioned nodes have already initialized and specifications of values concerning PMC, KBP, PRA and TCM have been assigned by a manager component. Figure 4 demonstrates the interconnected nodes to the Host. The plan is that the Host node requests information for job assignment of nodes O_1 to O_6. The nodes respond with data contained in each public profile and the pairing procedure starts.

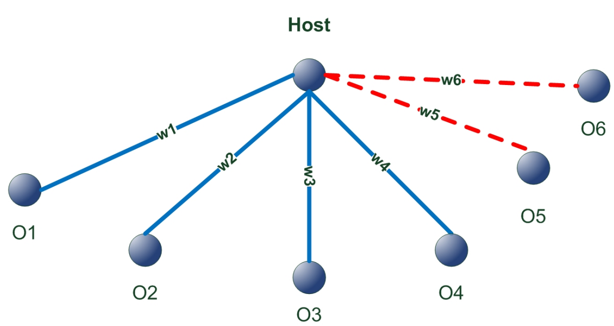

Figure 4 - Scenario 1: Clique nodes interaction

The following table contains Contracts and Knowledge of the snapshot profile of Host and Operators.

TABLE I. CONTRACTS AND KNOWLEDGE

Node	Contracts	Knowledge
Host	CliqueContract, SCFContract	A,B,C
O_1	Clique Contract	A,B
O_2	Clique Contract	A,B,C
O_3	Clique Contract	A
O_4	Clique Contract	A,C
O_5	SCF Contract	A,B
O_6	SCF Contract	A,B,C,D

The Host requires a job submission for knowledge A job with high processor, memory and low hard disk space requirements. The next table contains the data setup in conformity with Host requirements.

TABLE II. COEFFICIENT VALUES

Required Knowledge	Processor Coefficient	Memory Coefficient	Hard Disk Coefficient
A	1	1	0,01

According to the aforesaid algorithms the pairing procedure will occur in four phases respectively for each node.

1[st] Phase: PCM authentication happens directly for nodes O_1, O_2 and O_3 where the PCM validates their accounts. Node O_4 is checked for its contract and after the successful pairing a new account is attributed. Finally, Nodes O_5, O_6 are critical friends and are recognised by their SCF Contracts. So permissions are arranged for all nodes.

2[nd] Phase: It is assumed that nodes within a clique will be able to share the same knowledge background. In this scenario knowledge pairing for job A is decided by the assumption that each node is capable of performing the particular job.

3[rd] Phase: The PRA is defined by an internal calculation of each node. Each ranking is calculated by the following formula:

$$Ranking = 1/\,(CPU * CPU\ Coefficient + Memory * Memory\ Coefficient + HD * HD\ Coefficient)$$

Consequently, the following table contains the calculated ranking value of each node.

TABLE III. RANKINGS

Node Name	CPU	Memory	HD	Ranking
O_1	3	2	300	0,125
O_2	2.5	4	250	0,111
O_3	2	3	280	0,128

O_4	3	1	350	0,133
O_5	2.8	2	500	0,102
O_6	3.2	4	400	0,089

The execution time for job A is stored in each node TCM profile. It is calculated by the following formula:

$$ET = (MPT + 4MLCT + OCT) / 6$$

Finally, we need to calculate the ping time of each interaction in order to calculate the path distance. The assumption is that the value is the average of 1000 pings performing by the Host to each Operator.

4th Phase: The following formula calculates the final weight:

$$W = T*Ranking, \text{ So } W = (ET+ Ping * 2)*Ranking$$

TABLE IV. WEIGHT CALCULATIONS

NODE	O_1	O_2	O_3	O_4	O_5	O_6
ET	2,29	2,57	2,23	2,14	2,8	3,2
PING	2	3	3,3	2,4	2,8	3,1
W	0,78	0,95	1,13	0,92	0,85	0,83

Finally, the above values could be assigned to each path edge as the measured weight of each interaction.

2. Scenario 2

The plan is that the Host node requests information for job assignment for nodes O1 to O6, while O5, O6 propose connection with nodes O10, O11, O12 as they form internal clique nodes of clique 2. The following table contains Contracts and Knowledge of Host and Operators.

TABLE V. CONTRACTS AND KNOWLEDGE

Node	Contracts	Knowledge
Host	Clique Contract, SCF Contracts	A,B,C
O_1	Clique Contract	A,B
O_2	Clique Contract	A,B,C
O_3	Clique Contract	A
O_4	Clique Contract	A,C
O_5	SCF ContractO_5	A,B
O_6	SCF ContractO_6	A,B,C,D
O_7	Clique Contract	A,B,C,D
O_8	Clique Contract	A,B,C,D
O_9	Clique Contract	A,B,C,D
O_{10}	ReferenceContract to O_6	A,B,C,D
O_{11}	ReferenceContract to O_6	A,B,C,D
O_{12}	ReferenceContract to O_5	A,B,C,D

Figure 5 illustrates interaction between two cliques when a Host of Clique 1 request profile information from clique nodes and SCF of Clique 2. Inter-connected nodes are proposed for inter-collaboration with the Host according to reference contracts signed by SCF parties from both cliques.

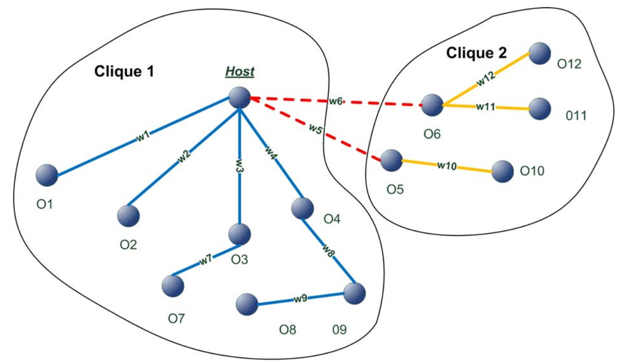

Figure 5 – Scenario 2: Two cliques' interaction

The Host requires a job submission as Scenario 1. The following phases should be carried out in order to calculate each path edge weight.

1st Phase: PCM authentication occurs automatically for nodes O_1 to O_9 where the PCM validate their accounts. Nodes O_5, O_6 are SCF and are recognised by their SCF Contracts and O_{10} to O_{12} are recognised by their reference contracts.

2nd Phase: It is assumed that knowledge pairing for job A is successfully paired from entire VOs nodes.

3rd Phase: The PRA is defined by an internal calculation of each node. The following table contains calculated physical resource ranking of each node. For this reason the following formula is utilized:

$$Ranking = 1/ (CPU*CPUCoefficient + Memory*MemoryCoefficient + HD * HDCoefficient)$$

TABLE VI. RANKINKGS

Node	CPU	Memory	HD	Ranking
O_1	3	2	300	0,125
O_2	2.5	4	250	0,111
O_3	2	3	280	0,128
O_4	3	1	350	0,133
O_5	2.8	2	500	0,102
O_6	3.2	4	400	0,089
O_7	3.36	3	467	0,092
O_8	3.58	3	492	0,088
O_9	3.8	3	517	0,084
O_{10}	4.02	3	542	0,080

O_{11}	4.24	3	567	0,077
O_{12}	4.46	3	592	0,074

The execution time for job A is stored in each node TCM profile. It is calculated by the formula:

$$T = ET + Ping * 2.$$

The following data are calculated according to the above formula and contained in the next table:

TABLE VII. TIMES CALCULATIONS

NODE	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}
ET	2,29	2,57	2,23	2,14	2,8	3,2	3,11	3,26	3,41	3,56	3,71	3,87
PING	2	3	3,3	2,4	2,8	3,1	3	3,2	3,25	3,4	3,5	3,45
T	6,29	8,57	8,83	6,94	8,4	9,4	9,11	9,66	9,91	10,36	10,71	10,77

4th Phase: So weight is calculated by the formula w = Ranking * T and the following table contain calculated values:

TABLE VIII. WEIGHT CALCULATIONS

w_1	w_2	w_3	w_4	w_5	w_6
0,786	0,951	1,132	0,923	0,856	0,836

w_7	w_8	w_9	w_{10}	w_{11}	w_{12}
0,864	0,850	0,832	0,828	0,824	0,782

IX. CONCLUSION

Our work herein addressed a notable opportunity to see grid VOs as a huge graph with nodes and vertices. The study introduces the notion of SCF as a way to achieve the inter-cooperation ideal. We assume that a typical VO, which is in fact a clique of nodes with similar characteristics, is already constructed by a manager. Several requirements can be extracted from [4, 6] however [1] concludes that minimum prerequisites are focusing to each internal domain knowledge and an inter-collaboration user need not meet all these requirements. Finally, the proposed method is illustrated by making use of two scenarios each one aimed at demonstrating a SCF interaction. We empirically assign a value by assuming that knowledge is standard.

The philosophy of the proposed mechanism corresponds with ad hoc grid characteristics. In this direction the planned authorization mechanism and knowledge pairing does not apply to specific grid architecture as also they are independent of any centralized control.

Future work also includes a workflow manager component which will be able to administer the entire procedure for evaluation purposes. Furthermore, metadata snapshot profile representation is an important issue and should be described using current semantic grid technologies. The physical resource announcement profile should also include more information concerning software and hardware information as a future step of realization.

Prospect efforts include utilization of Graph Theory concepts, which studies the properties of graphs, as a way to represent VOs node interactions within a grid. The latter field can really be promoted from the application of Graph Theory, since a VO is essentially a graph of paths in which weight is already measured by the analysis of minimum requirements. The study of graph properties can be valuable for representing a grid as a set of graphs in which properties of communication issues have already be defined.

X. REFERENCES

[1] I. Foster, C, Kesselman, S. Tuecke, "The Anatomy of the Grid: Enabling Scalable Virtual Organizations", International Journal of High Performance Computing Applications 15(3) (2001) 200.

[2] Y. Huang, N. Bessis, P. Kuonen, A. Brocco, M. Courant, B. Hirsbrunner. "Using Metadata Snapshots for Extending Ant-based Resource Discovery Functionality in Inter-cooperative Grid Communities". In: International Conference on Evolving Internet (INTERNET 2009), IEEE, Cannes/La Bocca, France, August 2009

[3] D. De Roure, N.R. Jennings, N.R. Shadbolt, "The Semantic Grid: Past, Present and Future", Proceedings of the IEEE, 93 (3), pp 669-681, 2005.

[4] L. J. Winton, "A simple virtual organisation model and practical implementation", Proceedings of the 2005 Australasian workshop on Grid computing and e-research, Vol. 44, pp 57-65, 2005.

[5] Y. Gil, E. Deelman, J. Blythe, C. Kesselman, , H. Tangmunarunkit, "Artificial Intelligence and Grids: Workflow Planning and Beyond", IEEE Intelligent Systems, Vol. 19, pp 26-33, 2004.

[6] EU DataGrid WP6 (2002), "VOMS vs EDG Security Requirements", EU DataGrid, Work Package 6, 2002.

[7] Y. Huang, N. Bessis, A. Brocco, S. Sotiriadis, M. Courant, P. Kuonen, B. Hirsbrunner, "Towards an integrated vision across inter-cooperative grid virtual organizations", in Lee, Y., Kim, T, Fang, W and Slezak, D. (eds), Future Generation Information Technology (Lecture Notes in Computer Science), ISBN 978-3-642-10508-1,pp 120-128

[8] J. Marasovic , T. Marasovic, "CPM/PERT Project Planning Methods as E-Learning Optional Support", 2006 International Conference on Software in Telecommunications and Computer Networks, Issue Date: September 2006, pp. 352-356

[9] S. Liu, J. Yu, Y. Liu, J. Wei, P. Gao, W. Li , J. Ma, Make Highly Clustered Grid a Small World with Shorter Diameter, The Sixth International Conference on Grid and Cooperative Computing(GCC 2007)

[10] Erdos, P., and Renyi, A., On random graphs I., Publicationes Mathematicae Debrecen 5 (1959), pp. e290-297.

[11] Y.Ma, B. Gong, L. Zou, Resource Discovery Algorithm Based on Small- World Cluster in Hierarchical Grid Computing Environment (2008)

[12] K. Globus Czajkowski, S. Fitzgerald, I. Foster, and C.Kesselman, "Grid information services for distributed resource sharing". Proc. of 10th IEEE symposium on High Performance Distributed Computing (2001).