
Supporting Collaborative Engineering Using an Intelligent Web Service Middleware

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Abstract. Collaborative Engineering tasks are difficult to manage and involve a high amount of risk – as such, CE tasks generally involve only well-known pre-established relationships. Such collaborations are generally quite static and do not allow for dynamic reactions to changes in the environment. Furthermore, not all optimal resource providers can be utilised for the respective tasks as they are potentially unknown.

The TrustCoM project elaborated the means to create and manage Virtual Organisations in a trusted and secure manner integrating different providers on demand. However, TrustCoM focused more on the VO than on the participant. The BREIN project enhances the *intelligence* of such VO systems to support even providers with little business expertise and provide them with capabilities to optimise their performance.

This paper analyses the capabilities of current VO frameworks on the example of TrustCoM and identifies the gaps from the participant's perspective. It then shows how BREIN addresses these gaps.

Keywords. Virtual Organisations, TrustCoM Project, BREIN Project, Service Oriented Architecture, Artificial Intelligence, Grid

1. Introduction

Modern day engineering tasks typically demand a complexity not supported by individual companies – accordingly, enterprises join in collaborations to outsource and distribute tasks according to the tasks that need to be fulfilled. Such collaborations are normally difficult to manage considering their size and complexity.

In recent years, the concept of Virtual Organisations has been developed to describe such collaborations *on basis of resources exposed to the internet*. Following the grid concept, such organisations allow for managed and dynamic collaboration between different resource *types*, or in other words to enable transactions between different companies in a coordinated manner.

The TrustCoM project has delivered a framework, as well as a reference implementation that enables organised and contract managed collaborations in a secure and trusted manner. Even though TrustCoM principally allows for dynamic on-demand creation of Virtual Organisations, as well as their autonomous management according to predefined collaboration description, the project does not support all issues to ensure full uptake by the eBusiness community.

This paper examines TrustCoM in view of one its particular application scenarios, namely the “CE scenario”, in which different companies participate in a Virtual Organisation to adapt an airplane according to a specific customer’s personal requirements. Basing on this scenario, we will examine in how far TrustCoM actually supports the individual participants in their task of supporting the VO requirements and thereupon elaborate the gaps that the recently started IP project BREIN is addressing.

2. An Assured Environment for Collaborative Engineering: The TrustCoM Approach

The main goal of the TrustCoM project consisted in providing a framework that would allow integration of any type of resource provider to form collaborations that meet specific business needs and goals. The framework makes extensive use of web service standards so as to allow common uptake from both larger and smaller companies, respectively individuals.

The framework ensures that all transactions within the Virtual Organisation are secured and that confidentiality issues are fully respected so that partners may remain anonymous, if so desired. Furthermore, as shall be detailed below, it allows participants to maintain their own infrastructure and their own means to realise the “products” they provide to a collaborative engineering task.

As one of the first projects, TrustCoM also extensively researched the influence and relationship of *legal* and *trust* issues on framework specific structures and its implementation. As such, TrustCoM allows for contractual support as well as selection of partners on basis of their performance in other collaborative tasks.

Contractual performance is enforced through means of Service Level Agreements that monitor behaviour and evaluate it with respect to the contractual agreements. Accordingly lacking performance can be identified in time and dealt with accordingly – depending on the overall requirements, this can consist in applying fines or even complete replacement of the partner, if lacking performance is considered critical for the full execution of the collaborative tasks.

For more details on the framework structure as realised by the TrustCoM project, please refer to [1].

2.1 “Abstract Entities”

TrustCoM’s main achievement in bringing Virtual Organisations closer to modern day business needs consisted in particular in introducing the concepts of “abstract entities” to the Grid and Web Services community. As opposed to the classical approach, where each actual resource as maintained by the individual enterprises is exposed as a service of its own, be it humans, printers, computers or actual applications and utilities, the “abstract entities” approach foresees that each participant in a Virtual Organisation is actual a *conglomeration* of individual resources that are executed and linked in a coordinated manner.

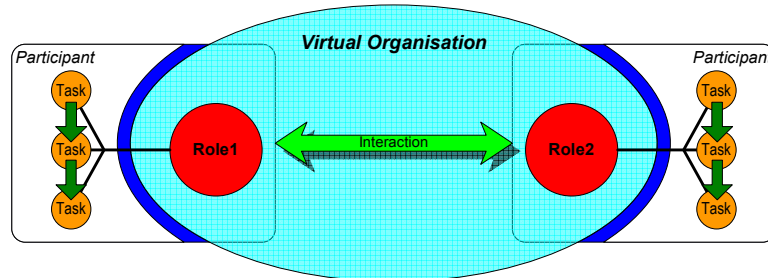


Figure 1. Abstract Entities in TrustCoM's Virtual Organisations

This way, participants are considered *real* business entities, with their own existing typical workflows to generate the “products” they sell and with an infrastructure they do not want to expose to, let alone be controlled by external bodies. From the TrustCoM perspective, enterprises participate in a Virtual Organisation according to the *roles* they bring in rather than according to their *resources*. This respects the first main issues in (electronic) business: the confidentiality of providers' infrastructure and leaving complete control over this in their hands.

2.2 Managing the Virtual Organisation

Classical Grid VO approaches described the whole collaboration as a series of task executed by the individual resources as exposed by the participants. With actual enterprises participating in the Virtual Organisation, i.e. with them representing abstract entities that do not allow manipulation of their individual resources, such an approach is obviously not feasible anymore. Instead, TrustCoM describes the collaboration as interactions between roles in a choreography across organization boundaries as defined e.g. by WS-CDL.

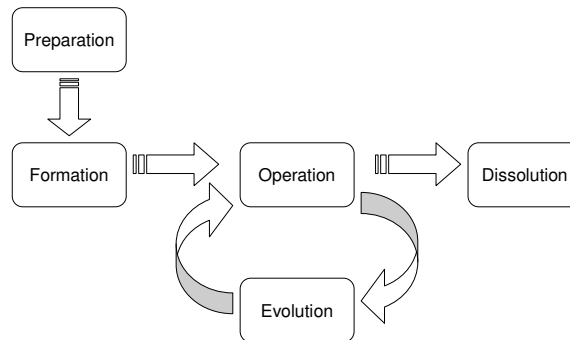


Figure 2. Typical Phases in the VO Lifecycle

Since Virtual Organisations may lose individual participants during execution, be it due to actual loss of connection, due to violation of the contractual terms etc., such a choreography and the according list of role providers needs to be carefully maintained by the Virtual Organisation. To this end, TrustCoM provides the VO

Management structures that manages participants in the collaboration and enacts the relevant tasks to maintain the VO structure, which includes the typical VO lifecycle phases as described by [2] (cf. figure 2).

3. Applying Virtual Organisations: The Collaborative Engineering Scenario

One particular application scenario of the TrustCoM project consisted in an engineering consortium (here “CE VO”) collaborating with a team of airplane analysts (“Analysis VO”) to support the tasks of an airline manufacturer that e.g. wants to extend the capabilities of an airplane to host internet capabilities on-flight to fulfil customer demands (cf. figure 3). It has to be noted here, that the so-called VOs in this scenario are actually the “abstract entities” as described in the preceding section, i.e. (smaller) collaborations that exist prior to the actual VO as supported by the TrustCoM framework and that only adapted minimally to the according customer needs. For more details on the legal impacts of such an approach, please refer to [4].

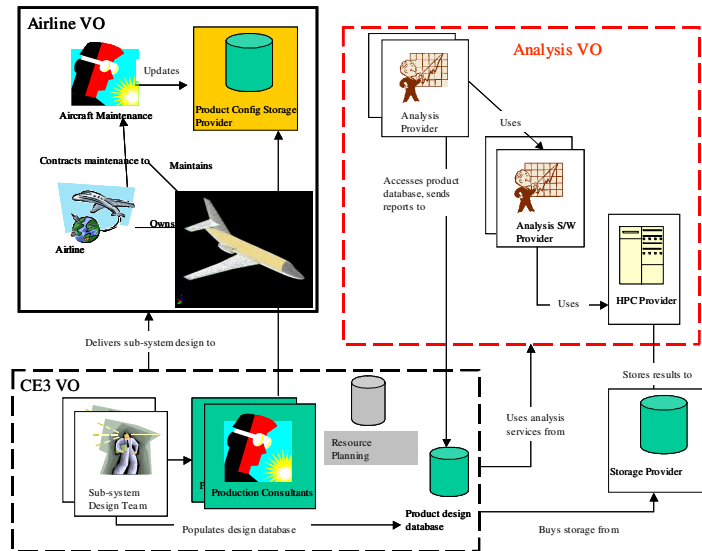


Figure 3. Actors in TrustCoM's CE Scenario

Beside the support to manage the lifecycle of a VO the main issue here is that the TrustCoM framework allows for such collaboration by providing a secure and contract managed middleware that enables the individual participants to expose “virtual” resources that reflect the capabilities of the respective “local” and private business processes. The framework provides participants with a means to host such an interface that secures message exchange, controls access according to the overall collaboration description and ensures that the according transaction requirements are met and automatically updated. From the individual participant's

perspective, interactions take place as with a single entity, non-regarding the changes in the VO structure. What is more, none of the participants needs to take over responsibility for any other entity, but itself.

This reduces the management overhead typically associated with such scenarios greatly. This scenario has also been thoroughly discussed in [3].

4. Ready for eBusiness 2010?

TrustCoM provides all the relevant features to relieve business providers from the burden of complex and in particular costly adaptations of the infrastructure to meet individual customer's demands and to maintain security and access right restrictions. It also ensures that dynamicity is maintained without impact on the individual participants and that the risk of participation is reduced through means of contractual binding, sensible responsibility distribution and SLA support.

However, TrustCoM can not relieve the participants from the burden to *understand* the system and to prepare their infrastructures so as to meet the TrustCoM requirements. As such, business ("role") providers need to understand the Service Level Agreement language, as well as describe the link between those and their resource capabilities. They need to be capable of reading and understanding the policy descriptions they subscribe to as part of their contracts. They need to describe and set up their infrastructure so that it can interface a business process engine which in turn is exposed to the VO. Furthermore customers wanting to exploit the TrustCoM framework need to have great knowledge about collaborations so as to form the initial collaboration description and specify the requirements with respect to the individual participants.

Since furthermore the TrustCoM system does currently not support any intelligent matching, it takes a unique way of describing service capabilities to ensure that the exposed functionalities match the ones described in the collaboration description.

As such TrustCoM must be regarded as a great step towards providing business providers with a framework that supports their business needs from a *technical* perspective, yet as such it could not cater for specific needs that would allow "business agnostic" providers easy integration into the system. With smaller to medium enterprises in particular focus of the Virtual Organisation goals, the TrustCoM middleware runs the risk of being yet too complicated for fast uptake, non-regarding the simplifications achieved by this project.

TrustCoM can hence only be an intermediary step towards reaching the actual end-user, be it SME "role provider" or customer.

5. Filling in the Gaps: The BREIN Approach

The BREIN project is loosely coupled to TrustCoM and extends the achievements of the latter with a particular focus on the *human* behind the system. It pursues three main goals:

- supporting the business providers in all tasks related to exposing and integrating his/her capabilities into a Virtual Organisation.
- supporting the customer in getting the capabilities and services he/she needs.
- optimising the behaviour of both the whole VO *and* the individual participant in a way that respects everybody's demands without disrespecting according corporate policies.

As such, BREIN is one of the first IP projects to address the *whole* requirements of enterprises to participate in Virtual Organisations (cf. figure 4), i.e. by enhancing the pure technical level according to *human* needs. As opposed to TrustCoM, the project does *not* look into the legal aspects involved in VO enactment and does not intend to extend the issues related to measuring individual participant's trustworthiness. With this respect it builds upon existing results (such as by TrustCoM).

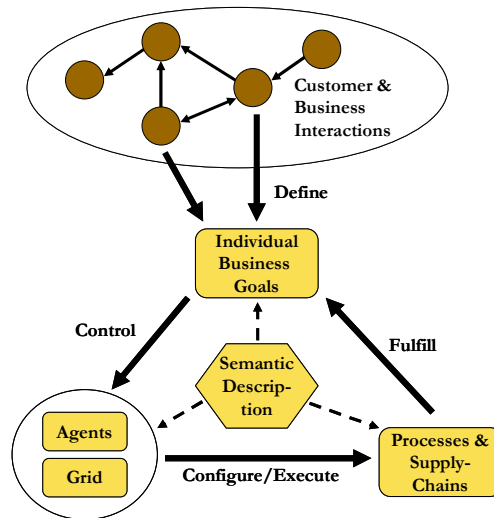


Figure 4. An overview over the technologies in the BREIN project

5.1 The BREIN Framework

The BREIN framework builds strongly upon Web Service technologies and incorporates existing VO middleware solutions, as well as communication standards and specifications that promise or already found wide acceptance by the research and eBusiness community. Thus, it will realise a Service Oriented Architecture that integrates the most relevant aspects related to supporting and realising Virtual Organisations.

With a significant relationship between Grid and Agent technologies [5] the BREIN project focuses on extending common grid technologies with the autonomy and negotiation capabilities of Multi-Agent approaches and thus implicitly extending Multi-Agent technologies with the stability and reliability of the Grid. With respect to modern day eBusiness requirements, the BREIN consortium identified in particular the following technical areas as most important for future VO middleware needs (cf. figure 5):

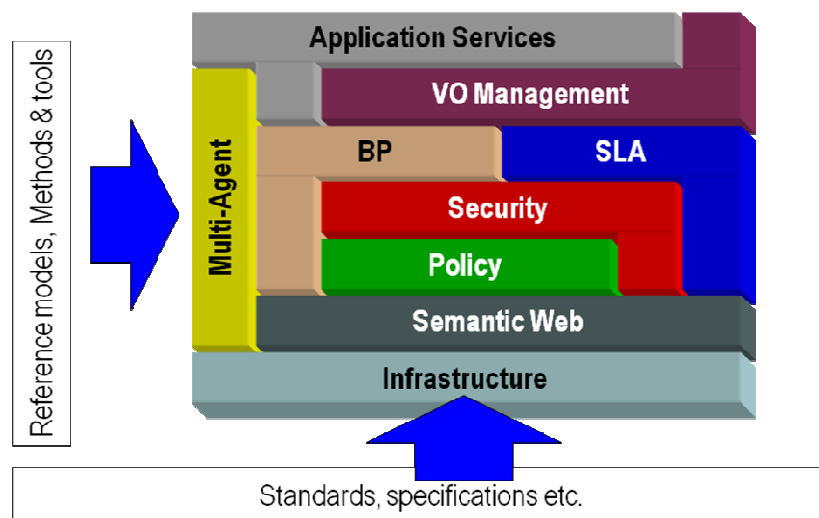


Figure 5. Framework structure of the BREIN project

Infrastructure capabilities represent the most classical Grid functionalities, namely to allow for standardised messaging in different formats, as well as the encapsulation and publication of service capabilities (cf. section 2.1 “Abstract Entities”). The full VO middleware is based upon such infrastructure capabilities to provide a common messaging platform.

Semantic Web technologies ensure that information *about* participants and their products are commonly understood, even though their details (such as capabilities) are defined by humans and as such subject to great variations between each other. This also allows more flexibility in defining and understanding terms. Semantic Web technologies are therefore part of the common middleware basis.

The term *Policies* is generally defined in different ways – in the context of VO capabilities, it covers general behavioural policies for the VO on the one hand, as well as the individual participants on the other. This involves issues such as business goals, but also event-condition-actions to allow for the respective dynamicity. In addition to this, a policy may state access right details, i.e. which entities to admit and which to reject.

Accordingly, *Security* builds partially upon the policy capabilities but also covers aspects related to authentication (to enable access right policies) as well as message encryption to ensure integrity and privacy. Obviously, security capabilities are crucial to most collaborations.

Business Processing covers aspects related to executing individual (“private”) workflows [6], as well as the coordination of the overall workflow execution, i.e. the main collaborative tasks.

Service Level Agreements (SLA) describe terms and conditions related to contractual clauses with a particular focus on monitoring and enforcing these. SLAs map between common contractual terms and verifiable status information.

VO Management represents basically the supervising capabilities of the Virtual Organisation, such as ensuring that all contact points are up-to-date, that the contractual basis is maintained etc.

Multi Agent technologies serve mostly as a conceptual input as the respective technologies have not (yet) found wide uptake in the eBusiness community. For the BREIN project they serve as means to making the individual components more capable of taking decisions (such as protocol usage) autonomously (cf. above).

5.2 CE Scenario Revisited

With the enhancements as pursued by the BREIN project, scenarios such as the Collaborative Engineering one described above will profit very much from both provider as well as customer perspective:

- customer and provider may describe their requirements, respectively their capabilities in a more abstract way
This way, no additional background knowledge about the underlying common language model needs to be acquired and participants can expose and make use of functionalities in their own way. This allows in particular integrating providers according to their capabilities, rather than having to respect interoperability issues.
- business processes and collaboration may be described in a more intuitive manner with only limited business expertise, collaboration details are derived automatically from capabilities and requirements
Since complex engineering processes are difficult to design and require expertise in particular to optimise the execution, such an approach allows providers to implement and realise new services more effectively. Given the business processes and the requirements / capability descriptions, the BREIN framework furthermore supports the design process in a way that allows customers to define complex collaborations more easily
- contract details are (more) human readable
- the collaboration is capable to adapt to changes in the environment in a more autonomous manner
With the intelligence to monitor and integrate environmental information, participants in the VO are enabled to react more quickly and effectively. This may involve both changes on the local infrastructure side (such as limited resources) as well as external effects (such as additional customer requirements).

Given the capabilities, the BREIN framework will allow participants to generate and integrate their services more efficiently with less effort. From the CE perspective, this allows in particular to realize more complex engineering tasks without the additional effort of having to “understand” the system first.

6. Summary & Conclusion

The paper has shown that the Collaborative Engineering scenarios can gain much from the current progress being made in Virtual Organisation research: not only does it allow to reduce risk and adaptation cost, it also allows more flexibility and easier integration into collaborations.

Great progress has been made over the recent year to achieve this goal by such projects like TrustCoM which furthermore laid the basis for integrating legal and trust aspects. Reference implementation and demonstrations have shown that the vision of dynamic Virtual Organisations on an internet / network basis *are* possible indeed and will form the future of eBusiness.

However, the approaches so far still show great inflexibility with respect to human specific needs, in particular where such complex issues such as business objectives are concerned. And even though deployment and administration of such middleware becomes more and more easy, the actual usage is still restricted to technically educated engineers with the according knowledge.

One step in overcoming these obstacles is taken by the BREIN project which integrates Agent, Semantics and Web Service technologies with VO middleware to provide the necessary flexibility that brings eBusiness closer to the modern market.

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