TAPAS

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Trusted and QoS-Aware Provision of Application Services

TAPAS
Periodic Progress Report – PPR2

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Partners: Adesso, Dortmund – Germany; University College London – UK; University of Bologna – Italy; University of Cambridge – UK

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1. Executive Summary

In the TAPAS project, we are particularly interested in developing solutions to the problem faced Application Service Providers (ASPs) when called upon to host distributed applications that make use of a wide variety of Internet services provided by different organisations. This naturally leads to the ASP acting as an intermediary for interactions for information sharing that cross organisational boundaries. However, despite the requirement to share information and services, autonomy and privacy requirements of organisations must not be compromised. Organisation will therefore require their interactions with other organisations to be strictly controlled and policed. Furthermore, an ASP should be capable of meeting specific quality of service (QoS) requirements of hosted applications.

This creates major challenges. Contractual relationships between multiple organisations for information access, sharing and QoS will need to be governed by *service level agreements* (SLAs), which will need to be defined and agreed between the organisations and then enforced and monitored by the ASP. Unfortunately, ASPs currently lack tools and techniques for offering hosting facilities for such distributed applications: the reason why TAPAS project has been created. First year work has been concerned with developing an overall framework for the development of software tools and techniques for hosting advanced distributed applications: deliverable reports: D1 (requirements), D2 (SLA specification), D5 (TAPAS architecture, describing trust management and regulation of inter-organisation interactions), D5 supplement (overview of TAPAS architecture), and D7 (TAPAS middleware platform: QoS enabled application servers).

Second year work has been concerned with design and implementation of various subsystems in accordance with the above deliverables. SLA specification and analysis tools have been developed (deliverable D3), QoS enabled multicast communication, trusted coordination, and QoS monitoring services have been developed (deliverables D8, D9 and D10 respectively); deliverable report D13 describes how these services will be used in the TAPAS platform for hosting a distributed auction application.

2. Project Rationale and Exploitation Plan

2.1. Rationale

Organisations, particularly small and medium scale enterprises (SMEs), are increasingly finding it difficult to develop, maintain and manage their IT applications largely due to difficulties in retaining and attracting trained IT staff. *Application Service Providers* (ASPs) hold the promise of providing an attractive solution by making available application hosting facilities on remotely managed servers. However, to work effectively, ASPs must guarantee security, provide resilience and *service level agreements* (SLAs) over commonly available infrastructures. Furthermore, ASPs need to ensure that hosted applications are capable of accessing a wide variety of services irrespective of the platform or the organisation through which they are provided. An ASP typically uses middleware and component technologies for deploying, hosting and managing applications of an organization from a centrally managed facility. However, as organisations become global and distributed, such centrally managed hosting solutions will need to be replaced by multi-site, distributed hosting solutions.

The goal of TAPAS is to develop multi-site, distributed hosting solutions. We argue that many research problems in enterprise distributed computing will need to be solved to achieve the goal of TAPAS. An ASP will increasingly be called upon to host distributed applications that make use of a wide variety of Internet services provided by different organisations. This naturally leads to the ASP acting as an intermediary for interactions for information sharing that cross organisational boundaries. However, despite the requirement to share information and services, autonomy and privacy requirements of organisations must not be compromised. Organisation will therefore require their interactions with other organisations to be strictly controlled and policed. This creates two major challenges. Firstly, contractual relationships between multiple organisations for information access, sharing and quality of service (QoS) will need to be governed by SLAs, which will need to be defined and agreed between the organisations and then enforced and monitored by the ASP. Secondly, the ASP will have to establish appropriate *trust relationships* with the organisations and implement corresponding security policies before organisations will permit the ASP to act as an intermediary for inter-organisational service invocations. Unfortunately, middleware services for inter-organisational interactions as outlined above do not yet exist; indeed, development of such services is very much a research problem. Thus ASPs currently lack tools and techniques for offering hosting facilities for advanced Internet based applications.

2.2. Exploitation Plan

Updated exploitation plans of each partner are provided here.

Newcastle University: The Distributed Systems Group has a strong record of working with industries. In conjunction with Nortel (Harlow research lab), we contributed to the development of the workflow standard by making a submission to the OMG based on our workflow technology (Nortel and University of Newcastle upon Tyne, "Workflow Management Facility Specification", Revised submission, OMG document bom/98-03-01). We collaborated with IBM, IONA Technologies and others in making an OMG submission "Additional structuring

mechanisms for the OTS"; this submission has now been adopted as the OMG standard for extended transactions, and will be part of future release of J2EE middleware. Results from TAPAS will be used in existing and future research projects on middleware related distributed computing.

HP Arjuna Labs was founded as Arjuna Solutions Ltd., in October 1998 by members of the Distributed Systems Group at the University of Newcastle-upon-Tyne. Arjuna's founders participated in the creation of an early example of a distributed object transaction system (in 1989), and the first C++ and Java implementations of the Object Transaction Service (in 1997). Arjuna Solutions Ltd. was acquired by Bluestone Software Technologies in July 2000 and six months later, Hewlett-Packard acquired Bluestone resulting in Arjuna being renamed HP Arjuna Labs. The Labs 100% Java implementation of the Java Transaction Service (JTS) from Sun Microsystems, is being sold as part of the resilient pack of the HP-Application Server along with other Java based distributed technology including messaging technology and web services. The recent merger of Compaq with HP led to a major restructuring within HP, with HP pulling out of the middleware business. HP Arjuna lab is now operating as Arjuna Technologies Ltd (ATL) and is based in the University. Close collaboration with the Distributed Systems Group is being maintained ATL has a seat on the Industry Advisory Board.

Newcastle and ATL are taking part in EU Project IST-2001-37126: "ADAPT (Middleware Technologies for Adaptive and Composable Distributed Components" where there is specific collaboration of trust and security. Newcastle is also taking part in two UK funded projects on virtual organisations that complement the work being done in TAPAS. In particular, in the GOLD project, Web services and component middleware will be used as the enabling technology to develop a set of methods and tools for dealing with trust, security, lifecycle and information management in highly dynamic Virtual Organisations (VOs) the chemical industry.

Adesso AG:Adesso AG is a full service provider for the design, development and operation of e-business applications. The development paradigm applied is that of component-based software development. This paradigm and the application domain of e-business applications perfectly match because most e-business applications encompass various COTS components. This does not only pose some extra challenges with respect to system integration, release management and test of e-business applications, but it is also hindering the business model ASP for e-business applications. Due to the heterogeneity of e-business application standard ASP service level agreements usually cannot be applied. Instead it is necessary to relate service level agreements to components of an e-business application individually. This may, for example, mean to define service levels agreements as the following:

- The portal site will be accessible for 98% of the time.
- Access to the e-controlling component is ensured for 90% of the time.
- The minimal recovery time for the access to individual customer data is 20 minutes; the recovery time for profile data is 60 minutes.

This example shows, that different types of functionality ask for detailed agreements. Thus, fine-grained service level agreements help to provide the services needed at affordable costs. Of

course, it is possible to offer only more coarse-grained service levels, but this usually leads to cost explosions which are not acceptable for customers. With the possibility to define and implement fine-grained service level agreements developed by TAPAS, Adesso can foster its core business in several ways:

1. It is possible to argue for component-based development of e-business applications, because this is a prerequisite for fine-grained service level agreements.

2. The range of software systems which can be integrated into e-business applications, which are ASP-operated is extended. For the time being, systems whose low robustness endangers the availability of the overall e-business application cannot be integrated. If it was possible to agree for lower services or such a component, it would be possible to integrate despite its robustness.

3. The ASP services of Adesso will be much more attractive, if fine-grained agreements are possible. In contrast to standard offerings, the ASP levels can be precisely adapted to customer requirements.

While the first and second way to foster the Adesso business cannot be calculated in concrete numbers, the third way is supposed to allow an extra 20% growth in ASP business (after being able to define and implement fine-grained service level agreements).

In addition to these perspectives the results of the second TAPAS year have produced new aspects that adesso will exploit.

Firstly, the trust management scenario is now broken down into supervision and controlling inter-organisational relationships to ensure the fairness of business processes as seen by TAPAS. This is based on the ability to monitor the SLA-fulfilment from outside the ASP, typically by a trusted third party using dedicated TAPAS components to gather and evaluate data and process information. This setup seems to be very promising for certain types of business situations. For example, it is a common problem for insurance companies to assure that their brokers have a ensured quality when accessing the insurance's backend systems. It should be noted that brokers are quite often not employees of an insurance, which leads to obvious trust- and QoS-problems, because brokers have to pay directly or indirectly for using the infrastructure of insurance companies. The same type of problem arises in other sectors of industries where many external business users access a company's service. adesso has a strong knowledge in the insurance sector and plans to offer such QoS-related services to it's insurance clients.

Furthermore it can be observed, that the TAPAS tools and techniques will allow to predict the utilization figures for the existing infrastructure. This will of course help to optimise the resource planning, i.e. it will be safe to run two completely separated applications in the same environment. Due to increased resource utilization costs can be reduced, which shall lead to more competitive offers.

The TAPAS middleware implementation seamlessly integrates with the standardized J2EE environment, which will allow an ASP or application developer to even integrate foreign, non-TAPAS components and services with controlled SLA-fulfilment. This can be achieved by developing a simple interface component in J2EE technology, which is run inside the ASP on a TAPAS-enhanced application server. The requested SLA will then be supervised for this

dedicated component. This approach might not allow to reconfigure a weak server to fulfil the requirements but will at least enable ASPs to supervise services they pay for. Hence integration of services such as payment, rating etc. will be easier to integrate and therefore building new services will be less costly.

A promising approach of the TAPAS middleware implementation lies in the decision that applications are unaware of the TAPAS middleware services. The TAPAS extensions for the application server make use of the interceptor concept and are therefore completely transparent to the application. This offers the possibility to re-use existing J2EE-applications with a TAPAS-enhanced application server with very little or even none overhead. Hence it is simple to demonstrate clients the costs and advantages of the TAPAS-enhanced application server, which will result in extended offers for existing ASP clients.

Besides the comparability of two environments and the beneficial effect of proving the QoS-characteristics of an existing application, there is another benefit from adesso's point of view. It is good industrial practise to run load and stress tests for an application to ensure it's quality. By using a TAPAS-enhanced application server software developers will be able to retrieve detailed and accurate profiling information about the critical spots of their J2EE applications. Hence it will be much easier and therefore cheaper to identify and fix performance bottlenecks and inefficient coding.

This aspect leads to the business opportunity of taking over existing applications into an ASP solution, usually as part of an outsourcing project. Before signing a contract the ASP will be able to run tests and to find out non-obvious characteristics.

Adesso plans to exploit these aspects by dedicated offerings to existing clients. Furthermore adesso plans to extend it's portfolio to related services.

University of Bologna: The research group at the Department of Computer Science of the University of Bologna maintains close cooperation with national and international industries, including Microsoft (Cambridge Research Laboratory) and Sun Microsystems, and national research institutes, the "Fondazione Marconi" and the ENEA (the Italian bureau for new technologies applied to the energy and environment), in the form of joint investigations under contracts and grant programmes.

In addition, this research group is involved in the following two projects, recently approved by their relative funding bodies:

(i) "Information Society - Architectures and Protocols for Replicated Web Services", funded by the Italian Ministry of the Education, University, and Research (MIUR), and

(ii) "Design, development, and evaluation of an infrastructure for supporting mobile, multimodal access to Web services", funded by the Emilia-Romagna County Council.

Both these projects, which are carried out in collaboration with a number of Italian Universities and companies, address issues of design of QoS-aware middleware services and platforms. Specifically, the former project deals with issues of service replication in geographically clustered Web Services, and assumes that the geographical cluster of servers that support those Services can cross organizational boundaries. The latter, instead, addresses issues of Web

access ubiquity, and investigates the design of middleware solutions that enable the Web Service designer to meet the so-called Always Best Connected (ABC) requirement in a multimodal and mobile environment.

Owing to their very nature and relative scope, both these projects are planning to use of solutions and technologies which are being developed as part of the TAPAS project; thus, both these projects can notably contribute to the dissemination and use of those solutions and technologies.

University College London: UCL relies to a considerable extent on direct industrial funding and consulting. The knowledge required to be able to provide high-quality consulting services is often produced in projects such as TAPAS. UCL therefore hopes to exploit the results of the TAPAS in the following ways:

- Technology transfer initiatives towards the industry.
- Provision of consulting services to external companies (including education and training).
- Dissemination (consisting essentially of publications and courses).

The Software Systems Engineering Group of UCL is well positioned for this exploitation. It has ongoing research collaborations with a number of industrial partners, including British Telecom, Hewlett Packard Labs, IBM Hursley Park, Kodak, Microsoft Research, UK National Air Traffic Services, Philips, Searchspace, Telelogic, Toshiba Corporation, UBS Warburg, Unipower Solutions and the Zuehlke Technology Group. The TAPAS project partners hope to use these good collaborations as a route for exploiting the knowledge produced in TAPAS. Zuehlke Technology Group has a seat on the Industry Advisory Board.

University of Cambridge: Cambridge University has a plethora of industrial collaborators, and will seek to exploit any and all of its research when appropriate. In this project, links with Microsoft Research may prove extremely valuable, as they have a research laboratory in Cambridge working in collaboration with the University. As well as this, the Hewlett Packard research lab may also be potential paths to exploitation, given long term relationships with them. Finally, we will be able to use the output of TAPAS within the academic community itself directly to support more performant application services for teaching and research.

The Principal Investigator at Cambridge University is active in the IETF, in the RMT working group (5 RFCs last year), as well as more generally in Transport Area working group. As well as this, we co-chair the Grid High Performance Network research group of the GGF. In these two organisations, we have a direct path to taking group communications protocols to the Internet Standards world as well as to the scientific user community, and we can help with dissemination of results on technologies and techniques for implementing Service Level Agreement.

Cambridge also has another EU project and several PhD students working on a variety of techniques to support Trust in Distributed Systems. As well as working with the partners in the other project, we have been and will continue to publish in academic outlets.

As well as Microsoft Research, who fund several PhDs working in distributed computing in the lab, we also now have a strong working relationship with Intel Research Cambridge (started in the same building as the Computer Lab, after the TAPAS Project was initiated). Their interests in performance monitoring overlap with ours.

3. Project Objectives

3.1. Overall Objectives

The overall objective of the TAPAS project is to develop novel methods, tools, algorithms and protocols that support the construction and provisioning of Internet application services. The project will achieve the overall objective by developing QoS enabled middleware services capable of meeting Service Level Agreements (SLAs) between application services and will enhance component based middleware technologies such that components can be deployed and interact across organisational boundaries. The project will develop notations for expressing SLAs to enable specification of QoS, such as the availability as well as trust relationships. SLA trust specifications will be used for deriving service invocation primitives enriched with authentication, non-repudiation mechanisms, with or without the involvement of trusted third parties.

3.2. Specific objectives for the reporting period

First year work has been concerned with developing an overall framework for the development of software tools and techniques for hosting advanced distributed applications: deliverable reports: D1 (requirements), D2 (SLA specification), D5 (TAPAS architecture, describing trust management and regulation of inter-organisation interactions), D5 supplement (overview of TAPAS architecture), and D7 (TAPAS middleware platform: QoS enabled application servers).

Second year work has been concerned with design and implementation of various subsystems in accordance with the above deliverables. SLA specification and analysis tools have been developed (deliverable D3), QoS enabled multicast communication, trusted coordination, and QoS monitoring services have been developed (deliverables D8, D9 and D10 respectively); deliverable report D13 describes how these services will be used in the TAPAS platform for hosting a distributed auction application.

4. Achievements and project status

4.1. Summary

In the TAPAS project, we are particularly interested in developing solutions to the problem faced by Application Service Providers (ASPs) when called upon to host distributed applications that make use of a wide variety of Internet services provided by different organisations. This naturally leads to the ASP acting as an intermediary for interactions for information sharing that cross organisational boundaries. Essentially this means that an ASP should be capable of hosting Virtual Enterprises[1] (VEs): meaning, it should be capable of providing facilities for forming and managing VEs. The main problem in VE management is how enterprises can regulate access to their resources by other enterprises in a way to ensure that their individual policies for information sharing are honoured. Regulating access to resources by other enterprises is made difficult, since each potentially accessible enterprise might not unguardedly trust the others. Enterprises within a VE will therefore require their interactions with one another other to be strictly controlled and policed. And in this context, there will be a clear need among all parties to embark upon their business relationships underpinned by guarded trust management procedures. How can this be achieved?

Further, we note that in the near future ASP will require a distributed execution environment with a number of core services capable of meeting specific non-functional requirements of fault tolerance, availability, security, and timeliness; we will refer to these as *QoS enabled services*. State-of-the-art application services are developed using component-based technologies, such as those provided by the Java 2 Enterprise Edition (J2EE), Microsoft's .NET or the Object Management Group's CORBA Component Model. These technologies support the specification of functional component interfaces. They, however, do not adequately support the definition of the non-functional characteristics of component execution.

The first year work has been concerned with the design of the overall TAPAS architecture. The figure shows the main features of the TAPAS architecture. If we ignore the three shaded/patterned entities (these are TAPAS specific components), then we have a fairly 'standard' application hosting environment: an application server constructed using component middleware (e.g., J2EE). It is the inclusion of the shaded/patterned entities that makes all the difference.

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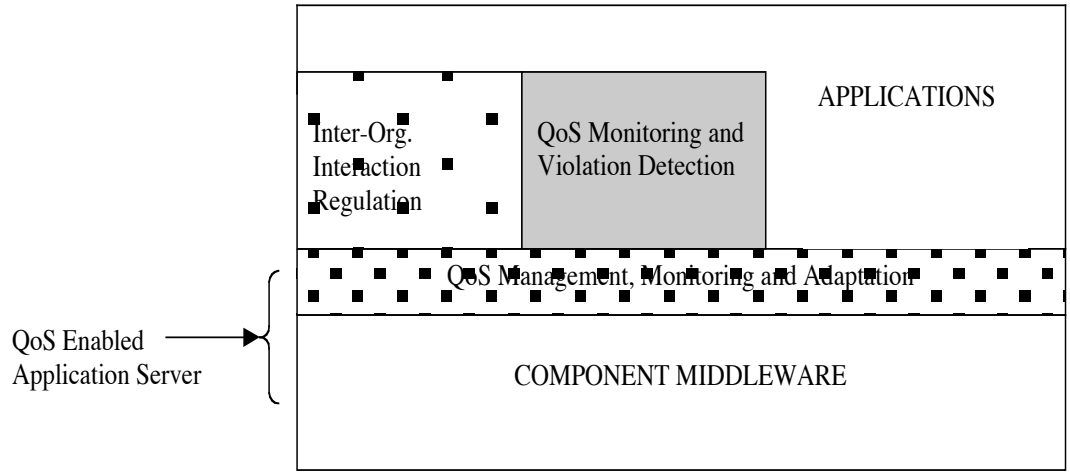
[1] A Virtual Enterprise comprises *n* independently existing and possibly mutually suspicious enterprises each of which wishes to establish a close business relationship for an agreed period of time without loosing its independence (autonomy).



TAPAS Architecture

Three main subsystems have been identified:

(i) The QoS management, monitoring and adaptation layer is intended to make the underlying application server QoS enabled. It is responsible for reserving the underlying resources necessary to meet the QoS requirements of applications hosted by that application server, and monitoring the reserved resources, and possibly adapting resource usage (e.g., reserving some more) in case the QoS delivered by these resources deviates from that required by the applications.

(ii) All cross-organisational interactions performed by applications are policed by the Inter-Organisation Interaction regulation subsystem. We have developed techniques that enable relevant aspects of contracts to be converted into electronic contracts (x-contracts) and represented using state machines and role based access control (RBAC) mechanisms for run time monitoring and policing. This contract management system needs trusted coordination services providing non-repudiable service invocation (NR-Invocation) and non-repudiable information sharing (NR-Sharing) facilities.

(iii) It is necessary to ensure that a hosted application actually meets the QoS requirements (e.g., availability, performance) stated in the hosting contract SLAs. For this reason, we need an application level QoS monitoring service, which must also measure various application level QoS parameters, calculate QoS levels and report any violations. That is the function of the third subsystem shown in the figure.

We can see that QoS monitoring is occurring at two distinct levels: within an application server for controlling use of application server resources and at higher level for controlling application level QoS requirements.

Second year work has been concerned with the development software for the above subsystems.

4.2. Overview of progress made in each workpackages

The work within the TAPAS project has been structured into four technical workpackages:

- WP1 (Application Service Requirements and Specification) will meet the objectives related to SLA specification, Service Composition and Analysis Techniques;
- WP2 (Design of QoS-aware Infrastructure for Application Hosting) and WP3 (Implementation of QoS-aware Core Services) together will meet the objectives related to Trusted and QoS-aware Services for Application Hosting; and
- WP4 (Case Studies and Evaluation) will meet the objectives related to assessment.

All the second year deliverables have been produced, and their contents is summarised here. Note that there are no WP2 related activities in the second year, as the main focus of the work is on WP3, concerned with implementation.

D3: Method for Services Composition and Analysis (WP1)

QoS requirements of hosted applications as stated in SLAs are specified using SLAng. Deliverable D3 presents our method for service composition and analysis. The method relies on integrating analysis methods, representations of QoS aware systems, and service level agreements in UML design tools. This locates all of the information required to reason about service composition and analysis in a single repository. The reasoning itself is supported by model transformations between design and analysis models, still within the same repository, enabling a powerful and flexible approach to analysis.

Our method relies on extending UML with a variety of domain specific languages each appropriate to a modelling task, for example performance analysis or the representation of SLAs. Each language is defined separately, but the common basis in UML permits the integration of all of these models into a coherent view of the system.

Each language has semantic information associated with it. SLAng, the profile for electronic service systems, and the real-time profile used as the starting point for analysis all have rich semantic models. Other languages such as the profile for queuing networks have a definition based in mathematical formalisms. We also define relationships between our language extensions. The mappings introduced relate analysis models to design domains. The correspondence stereotype introduced allows the association of QoS information of different types.

D8: QoS Enabled Group Communication (WP3)

Practical networked systems are under increasing obligations to provide certain levels of Quality of Service (QoS) to end users. We here introduce a generic system model called the *probabilistic asynchronous* model which we claim characterises the context in which many Internet-based applications are built. Specifically, our model regards that basic services and system components (e.g., network services) do meet their performance requirements most of the time, and occasionally they may not; only when they don't, they adhere to the classical asynchronous model. Our design approach will draw from, and combine probabilistic design

techniques and asynchronous ones. Its objective is to render systems that adaptively meet QoS obligations to the end users when system components meet their QoS guarantees or violate them only marginally; eventual correctness is never compromised when components fail in their QoS obligations.

Design and implantation of a QoS enabled reliable broadcast service using the principles of the probabilistic asynchronous model is described. It is possible that the QoS guarantees agreed by underlying network system are violated for a prolonged period. These violations can lead to the broadcast service being unable to meet its QoS obligations. An important aspect of a QoS enabled service is that it needs to be adaptive: it monitors the QoS offered by the underlying layer and then adapts the protocol behaviour in an effort to meet the agreed QoS to users. The QoS monitoring subsystem is thus an important part of the service. The QoS monitoring subsystem of our reliable broadcast service has been designed using the principles described in the deliverable report D10, on QoS Monitoring.

Note that in the TAPAS description of work document, deliverable D8 is referred to as 'Container for Group Communication', however, the name has been changed here to 'QoS enabled Group Communication' as it better reflects the scope of the work.

D9: Component Middleware for Trusted Coordination (WP3)

All cross-organisational interactions performed by applications are policed by the Inter-Organisation Interaction regulation subsystem. Each enterprise expects access to other's services. An operation on a service is allowed only if it is permitted by the rules of the contract and then only if it is invoked by a legitimate role player of a participating enterprise. Thus, a contract is a mechanism that is conceptually located in the middle of the interacting enterprises to intercept all the contractual operations that the parties try to perform. Intercepted operations are accepted or rejected in accordance with the contract clauses and role players' authentication. Our approach is to represent service interactions as finite state machines and make use of role based access control mechanisms for authenticated access. In the deliverable report D5, we describe how contract clauses can be converted into finite state machines (FSMs).

Inter-Organisation Interaction regulation subsystem has two main layers. The contract monitoring and enforcement layer makes use of the services of the underlying layer that provides trusted coordination.

To regulate the interactions involved, a given action must be attributable to the party who performed the action and commitments made must be attributable to the committing party. For example, it should not be possible for a client to subsequently disavow the request and/or consumption of a service. Similarly, it should not be possible for the service provider to subsequently deny having delivered the service. If information is shared then the parties sharing the information should be able to validate a proposed update, the update should be attributable to its proposer and the validation decisions with respect to the update attributable to the other parties. That is, to regulate an interaction we require attribution, validation and audit of the actions of the parties involved. Non-repudiable attribution binds an action to the party performing the action. Validation determines the legality of an action with respect to interaction agreements. Audit ensures that evidence is available in case of dispute and to inform subsequent interactions

This deliverable addresses these requirements by providing two building blocks for regulated interaction between organisations: non-repudiable service invocation (NR-Invocation) and non-repudiable information sharing (NR-Sharing). It builds upon our earlier work on B2BObjects described in D5. These building blocks have been implemented using the JBoss application server.

Note that in the TAPAS description of work document, D9 was titled as 'Container for Trusted Coordination'. The title of the deliverable has been changed slightly to 'Component Middleware for Trusted Coordination' as it better describes the scope of the work done.

D10: QoS Monitoring of SLAs (WP3)

Monitoring of contractual Service Level Agreements (SLAs) between service providers and consumers is concerned with the collection of statistical metrics about the performance of a service to evaluate whether the service provider complies with the level of Quality of the Service (QoS) that the consumer expects. Such monitoring is frequently required to be carried out with the help of third parties to ensure that the results are trusted both by the provider and consumer. Deliverable D10 discusses the fundamental issues that monitoring of contractual SLAs involves: SLA specification, separation of the computation and communication infrastructure of the service provider, service points of presence, metric collection approaches, measurement service and evaluation and violation detection service. This Deliverable develops an architecture, and gives reasons why currently it is only practicable to offer guaranteed QoS to consumers sharing Internet service providers with the service provider. The QoS monitoring subsystem of our reliable broadcast service (D8) has been designed using the principles described here. The Auction demonstrator application planned for September 2004 (deliverable D15) will demonstrate how contractual SLAs for auctions (specified in SLAng) can be monitored and any violations detected.

Note that in the TAPAS description of work document, D10 was referred to as 'Container for QoS Monitoring'. The title has been changed to 'QoS Monitoring of SLAs' as it better describes the scope of the work done.

D13: Second Year Evaluation and Assessment Report (WP4)

In this report we discuss the progress of the TAPAS project during the second project year from April 2003 to March 2004. The second year was characterised by highly interdependent and hence interactive research and development activities. In order to reflect these relationships we choose to present the main decisions and results of the second TAPAS year by discussing a typical TAPAS application scenario and it's technical implications. The scenario provides a realistic background for discussions as well as for the evaluations to come. Hence it is quite important to choose an appropriate scenario from industrial-relevant experiences. The chosen business scenario, electronic auctions, is discussed in section 2 of the document. The discussions about the technical solutions of TAPAS for providing trust and QoS in such a scenario are reflected in section 3, followed by a short outlook in section 4. It should be noted that we explicitly do not refer to the different deliverable documents as references as we aim to summarize the discussions as well as the resulting design decisions and coherent solution design. The Auction demonstrator application planned for September 2004 (deliverable D15) is intended to demonstrate main results of TAPAS.

5. Adherence to Workplan

5.1. Statement of resource usage

Effort in Person months for reporting period 1/4/03 – 31/3/04

5.2. Deliverable schedule update

No significant changes to the second year schedule were made. Work on D10 was performed by Newcastle and Cambridge (in place of Bologna), to enable Bologna to concentrate effort on QoS enabled application server (which will form the key element of demonstrator deliverable D15 due in September). The titles of three deliverable reports were changed to better reflect their technical contents. D8 is entitled 'QoS Enabled Group Communication' rather than 'Container for Group Communication', D9 is entitled 'Component Middleware for Trusted Coordination' rather than 'Container fro Trusted Coordination' and D10 is now called 'QoS Monitoring of SLAs' rather than 'Container for QoS Monitoring'.

The work for the third year will be concerned with integrating the various subsystems developed in the second year. The following deliverables will be produced:

- D4: Service Composition and Analysis Tool
- D6: Revised Architectural Design Document
- D11: Revised Container Interface Specification
- D14: Third Year Evaluation and Assessment Report
- D15: QoS-Aware and trusted ASP for Auctions
- D18: Technological Implementation Plan

5.3. Modifications to Workplan

Major effort of Bologna was devoted to the development of QoS enabled application server. An important aspect of this work is to do with cluster management. There is no specific second year deliverable on QoS enabled application server, so we have attached an interim progress report as an appendix that indicates the work currently led by Bologna.

6. Co-operation in project

WP1: Application Service Requirements and Specification

As was anticipated in the technical annex relatively little work was done over the reporting period (1/10/03-31/03/04) in WP1. In response to evaluation feedback provided by adesso, UCL produced a new release of the service level agreement language SLAng and published it at http://www.cs.ucl.ac.uk/staff/j.skene/slang. Moreover, work has commenced in Task 1.4 on generating a compiler for SLAng, that generates QoS monitors that can then be used in the framework developed within Task 3.4

The aim of Workpackage 1 is to identify the requirements of trusted and qos aware application service provision. This aim has been achieved within the first year of the project to a large extent.

The project has met in a number of plenary meetings in Bologna in April 2002, Cambridge in September 2002 and Dortmund in February 2003 to discuss requirements and an approach to

defining quality of service at different levels of abstraction. In addition to these plenary meetings, workshops between partners involved in WP2 were held at UCL (twice) and Bologna.

WP3: Implementation of QoS-aware Core Services

TAPAS partners held several meetings to carry out the work for the deliverables D8, 9 and 10. Cambridge and Newcastle jointly produced D10. Newcastle and Bologna worked on the design of the QoS enabled application server. Adesso activities were focused on giving support and feedback to the other partners. The feedback was based on two aspects, which are in the domain of Adesso's knowledge. Firstly Adesso could bring in its industrial knowledge about ASP scenarios into the discussions about inter-organizational regulation and QoSmonitoring. This leads to economically reasonable decisions about the design and implementation directions. Secondly adesso could utilize its proven knowledge in the field of J2EE software development by giving feedback for middleware design and new impulses to the implementation activities. These activities have not only taken part during the team workshops and the technical meetings but as well during the distributed design and development activities by using email and other means of communication.

Based on the experiences from many J2EE projects, in which Adesso successfully planned and implemented clustered application server environments, the Adesso experts were able to provide meaningful hints and knowledge transfer to the implementation teams. Aside from the J2EE implementation activities Adesso fed its ASP knowledge into the discussion about the SLAng items. This led to valuable feedback for the UCL team as well as for the Bologna team. However, the technical feedback and integration have been very valuable for the progress of the TAPAS activities. It should be mentioned that the social integration of the TAPAS team has been stimulated by these discussions, which helped to increase the efficiency and to avoid misunderstandings.

WP4: Evaluation and Assessment

One major goal of the TAPAS project is to provide industrial relevant solutions. This is achieved on the one hand by the participation of Adesso as industrial partner and on the other hand by discussions with the industrial advisory boards, let alone the proven industrial knowledge of the scientific team members. Hence Adesso is responsible for the evaluation of the results, achieved by evaluation reports on the one hand and by developing a dedicated application on the other hand. The second year evaluation report is contained in deliverable D13, which reflects the application scenario discussions and the resulting technical design decisions. The choice of the scenario and hence the type of application for evaluation has been driven by the need to reproduce QoS and trust problems by application use cases in order to evaluate the TAPAS solutions for QoS and trust. Auctions have been quickly identified to be a promising field for such issues, because auction users have a high demand for QoS and trust. In order to define a sound scenario Adesso has been exploring the field of B2B auctions. This leads to certain specifications for the application to be developed and has been incorporated in the vision document, which is part of D15. It must be noted that currently typically large enterprises such as car manufacturers use auctions in the procurement processes to lower prices, while small and medium enterprises mostly do not dare yet to invest into this type of service. Based on the observations and discussions with TAPAS partners we were able to produce artefacts for the

subsequent software development activities such as a vision document, use cases, requirements, domain model, component and deployment diagrams. Due to the iterative nature of the Unified Process, which we follow, these documents need refinement in subsequent steps. Currently Adesso developers work on implementing a prototype, which is intended to highlight certain risks that have been identified. For instance the usage of a component to provide time-based activation of e.g. auction rounds will leave the concept of J2EE application servers, which leads to many problems with clustering and reliability. In addition Adesso has started to derive test cases and a demonstration scenario from the use cases and the vision in preparation of the evaluation activities.

WP5: Dissemination and Implementation

Werner Beckmann has been interviewed by "Computerwoche" regarding outsourcing and service management. This resulted in an article covering the recent outsourcing trends. Furthermore we are currently preparing sales prospects and presentations to address existing and new clients regarding QoS-assurance and supervision. A number of research publications have been produced and presented at international conferences (see section 8).

WP6: Project Management

In this workpackage the management activities included attendance to EB and IAB meetings as well as the preparation of technical meetings.

Also during this period there was a change of personnel at the University of Cambridge. Dr Panos Gevros left to join a bank working on using similar ideas to TAPAS, but instead of network provisioning and performance guarantees, investment portfolio prediction!

Dr Michael Dales joined the University of Cambridge fairly soon after, and took up immediately work on monitoring collaborating with Newcastle, and attended the last project meeting in Bologna.

7. Co-ordination with other projects/programmes

Cooperation has been established with the following both EU funded and nationally funded projects.

UCL: SEGRAVIS RTN (Collaboration between TU Berlin, Milan Bicocca and UCL) started first results presented at 4th ACM Workshop on Software Performance. European Grid for Solar Observations (EGSO), joint work on web services orchestration.

Cambridge: Jon Crowcroft met with Ulrich Lang from the EU COACH project, and talked about trusted SLAs - a further meeting is foreseen.

Bologna: RTD Projects funded by the Information Society Technologies Programme of the European Commission: ADAPT (Middleware Technologies for Adaptive and Composable Distributed Components), IST-2001-37126; nationally funded projects:

- "Information Society - Architectures and Protocols for Replicated Web Services", funded by the Italian Ministry of the Education, University, and Research (MIUR);
- "Design, development, and evaluation of an infrastructure for supporting mobile, multimodal access to Web services", funded by the Emilia-Romagna County Council;
- FIRB "WebMinds" project funded by the Italian Ministry of Education, University and Research.

Newcastle: Newcastle, Bologna and Arjuna Technologies are taking part in EU Project IST-2001-37126: “ADAPT (Middleware Technologies for Adaptive and Composable Distributed Components” where there is specific collaboration of trust and security. Newcastle is also taking part in two UK funded projects on virtual organisations that complement the work being done in TAPAS. In particular, in the GOLD project, Web services and component middleware will be used as the enabling technology to develop a set of methods and tools for dealing with trust, security, lifecycle and information management in highly dynamic Virtual Organisations (VOs) the chemical industry.

8. Promotion / Information Dissemination

8.1. Conferences and Workshops

TAPAS project members attended the following conferences during the second year of the project:

14th Database and Expert Systems Applications (DEXA'03) attended by Nicola Mezzetti.

Test and Analysis of Component Based Systems, 13th April, overall European Joint Conferences on Theory and Practice of Software (ETAPS) in Warsaw 5 – 13 April '03 attended by J Skene.

Future Trends of Distributed Computing Systems (FTDCS) May 28 30, 2003, Puerto Rico attended by D. Lamanna

IEEE International Conference on Electronic Commerce, Newport Beach, CA, June 2003, attended by Carlos Molina

4th IEEE International Workshop on Policies for Distributed Systems and Networks, Lake of Como, 4-6 June 2003 attended by A di Ferdinando

Middleware 2003 16-20 June 2003, Brazil attended by D Lamanna

7th International Conference on Internet, Multimedia Systems and Applications (IMSA 2003), Honolulu, (HI), August 2003.

Workshop on Revisiting IP QoS: Why do we care, what have we learned? (RIPQOS) Karlsruhe, Germany, August 27, 2003 attended by Jon Crowcroft and Panos Gevros

Seventeenth Annual IFIP WG 11.3 Working Conference on Data and Applications Security, Estes Park, Colorado, August 2003, attended by Santosh Shrivastava

IEEE International Conference on Information Technology: Research and Education (ITRE 2003), Newark (NJ), August 2003

Bertinoro Summer School on Formal Methods for Software, Bertinoro, Italy, 22-24 September, 2003 attended by W. Emmerich

Bertinoro International Spring School for Graduate Studies in Computer Science, 8-19 March 2004, attended by Santosh Shrivastava (presented a course on middleware)

14th DEXA Workshops 2003, Prague, Czech Republic, 1-5 Sept. 2003.

Workshop on Service Based Software Engineering in Pisa (FM2003-SBSE), 8th September with FME, Pisa, 8 – 14 Sept. 03 attended by J Skene

8th CaberNet Radicals Workshop, Ajaccio, Corsica, 5-8 October 2003.

5th CaberNet Plenary Workshop, 5-7 November 2003, Porto Santo, Portugal

3rd International Conference on Networking (ICN'04), February 29 - March 4, 2004: Creole Beach Hotel, Gosier, Guadeloupe, French Caribbean.

8.2. Publications

Amoroso, A. and Panzieri, F., "*A scalable architecture for responsive auction services over the Internet*", TR UBLCS-2003-09, Dept. of Computer Science, University of Bologna, June 2003.

Cook, N., Shrivastava, S. and Wheater, S. "*Middleware Support for Non-repudiable Transactional Information Sharing between Enterprises*", 4th IFIP International Conf. on Distributed Applications and Interoperable Systems, DAIS 03, November 2003, Paris

Nick Cook, Paul Robinson and Santosh Shrivastava, "Component Middleware to Support Non-repudiable Service Interactions", DSN 04, Florence, June 2004.

Crowcroft, J., Hand, S. Mortier, R., Roscoe, T., Warfield, A "*QoS`s Downfall: At the bottom, or not at all!*" In Proceedings of the ACM Workshop on Revisitng IP Quality of Service (RIPQoS), pp. 109-114, August 2003, Karlsruhe, Germany.

Denaro, G., Polini, A. and Emmerich, W."Early Performance Testing of Distributed Software Applications", in Proceedings of the 4th Int. Workshop on Software and Performance, San Francisco, January 2004 (ACM Press)

Di Ferdinando, A., McKee, P. and Amoroso, A.: *A Policy Based Approach for Automated Topology Management of Peer To Peer Networks and a Prototype Implementation*

Ezhilchelvan, P.D. and Shrivastava, S.K. "*Systematic Development of a Family of Fair Exchange Protocols*", Seventeenth Annual IFIP WG 11.3 Working Conference on Data and Applications Security, Estes Park, Colorado, August 2003.

Ferretti, S., Roccetti, M.``On Designing an Event Delivery Service for Multiplayer Networked Games: An Approach based on Obsolescence", Proc. 7th International Conference on Internet, Multimedia Systems and Applications (IMSA 2003), Honolulu, (HI), August 2003.

Gevros, P. "*Internet Service Differentiation using Transport Options: the case for policy-aware congestion control*" In Proceedings of the ACM Workshop on Revisitng IP Quality of Service (RIPQoS), pp. 151-157, August 2003, Karlsruhe, Germany.

Kaveh, N and Emmerich, W. *Validating Distributed Object and Component Designs* in Formal Methods for Software Architecture, Springer Verlag, Lecture Notes in Computer Science, vol. 2804, 2003, pages 63-91, Edited by M. Bernardo and P. Inverardi KE03: Validating)

Kistijantoro, A.I., Morgan, G, Shrivastava, S.K. and Little, M.C. "*Component Replication in Distributed Systems: a Case study using Enterprise Java Beans*", 22nd IEEE/IFIP Symposium on Reliable Distrinbuted Systems (SRDS2003), Florence, October 2003, pp. 89-98, ISBN: 0-7695-1955-5.

Lamanna, D.D., Skene, J and Emmerich, W *SLAng: A Language for Service Level Agreements* In Proceedings of the 9th IEEE Workshop on Future Trends in Distributed Computing Systems (LSE03: SLAng), 2003, (pages 100-106) IEEE Computer Society Press

Lodi, G. and Panzieri, F. "*JBoss vs. JOnAS*", TAPAS Project Internal Report, June 2003.

Mezzetti, N.: "*Towards a Model for Trust Relationships in Virtual Enterprises*" In Proceedings of 14th Database and Expert Systems Applications (DEXA'03) Workshop, 1 - 5 September 2003, Prague (Czech Republic).

Molina-Jimenez, C., Shrivastava, S.K., Solaiman, E. and Warne, J. "*Contract Representation for Run-time Monitoring and Enforcement*", IEEE Conference on Electronic Commerce (CEC'03), Newport Beach, CA, June 2003, pp. 103-110.

C. Molina-Jimenez, S.K. Shrivastava, E. Solaiman and J. Warne, "Run-time Monitoring and Enforcement of Electronic Contracts", Electronic Commerce Research and Applications (ECRA), Elsevier, Vol. 3, No. 2, 2004.

Carlos Molina-Jimenez, Santosh Shrivastava, Jon Crowcroft and Panos Gevros, "On the Monitoring of Contractual Service Level Agreements", The First IEEE International Workshop on Electronic Contracting (WEC), July 2004, San Diego.

Roccetti, M.,Salomoni, P. ``The Design and Performance of a Wireless Internet Application for Supporting Multimedia City Guides'', Proc. IEEE International Conference on Information Technology: Research and Education (ITRE 2003), Newark (NJ), August 2003.

Rodrigues G N, Roberts, G, Emmerich, W and Skene, J *Reliability Support for the Model Driven Architecture* In Proceedings of the ICSE Workshop on Software Architecture for Dependable Systems 2003 (RRES03: Reliability Support), ICSE 2003.

Skene, J. and Emmerich, W. *Model Driven Performance Analysis of Enterprise Information Systems* in Electronic Notes in Theoretical Computer Science, April 2003, vol. 82, number 6 (SE03: Performance)

Skene, J and Emmerich, W *A Model Driven Architecture Approach to Analysis of Non-Functional Properties of Software Architectures* In Proceedings of the 18th IEEE Conference on Automated Software Engineering (SE03: AModel), October 2003, Montreal, Canada (pages 236-239), 2003. IEEE Computer Society Press

Skene, J., Piccinelli, G. and Stearns, M *Modelling Electronic Service Systems Using UML* in Workshop on Service Based Software Engineering, FM2003-SBSE, Pisa, Italy, 2003, September, "Technische Universitaet Muenchen", pages15—30, url: http://www.cs.ucl.ac.uk/staff/J.Skene/phd/sbse2.pdf (SPS03: Modelling)

J. Skene, D. Lamanna and W. Emmerich. Precise Service Level Agreements. In Proc. of the 26th Int. Conference on Software Engineering, Edinburgh, UK, Sept. 2004. ACM Press.

Solaiman, E., Molina-Jimenez, C. and Shrivastava, S.K. "*Model Checking Correctness Properties of Electronic Contracts*", International Conference on Service Oriented Computing, Trento, November, 2003

Turrini, E. "Dependability Issues in Content Distribution Internet-working", in Proc. of the International Conference on Dependable Systems and Networks, Student Forum, June 2003

Turrini, E, Ghini, V. "A Protocol for exchanging performance data in Content Distribution Internetworks", 3rd International Conference on Networking (ICN'04), February 29 - March 4, 2004 – Creole Beach Hotel, Gosier, Guadeloupe, French Caribbean

Turrini, E. "A Protocol for exchanging performance data in Content Distribution Internetworks", 8th CaberNet Radicals Workshop, Ajaccio, Corsica, 5 - 8 October 2003.

Turrini, E."An architecture for Content Delivery Networks federation", CaberNet Plenary Workshop, 5-7 November 2003, Porto Santo, Portugal.

Turrini, E. "Analyzing web response time" , CaberNet Plenary Workshop, 5-7 November 2003, Porto Santo, Portugal.

"Die zweite ASP-Welle ist auf dem Weg" (The second wave of ASP is on it's way) in "Computerwoche", pp 34-35, IDG Business Verlag GmbH, 26/2003, München, Germany

"TAPAS macht Appetit auf ASP" (TAPAS whets one's appetite for ASP), eCommerce Magazin 06-07 /2003, IWT Magazin Verlags-GmbH, Vaterstetten, Germany

"An Answer to the JBoss vs. JOnAS Comparison", W. Beckmann, M. Koßmann, adesso AG, 30 June 2003

8.3. Press Articles

Memos: "An Answer to the JBoss vs. JOnAS Comparison", W. Beckmann, M. Koßmann, Adesso AG, 30 June 2003

8.4. Activities related to standardisation

UCL: Monitoring developments on MDA at OMG. Contribution to MDA discussion.

Jon Crowcroft attended the IETF in Seoul, Korea, and contributed in working groups for group communication.

8.5. Industrial Advisory Board Meetings

The members of the IAB were invited to meet with the TAPAS Executive Board at the TAPAS EB/IAB Meeting, held in London on 2nd February, 2004. Three members of the IAB attended: Prof. Dr. Rudolf Keller (Zühlke Engeneering), Dr. Stuart Wheater (Arjuna Technologies), Paul McKee (BT exact Technologies).

This section summarises the remarks made by these IAB members with regard to the progress of TAPAS by February 2003, as evidenced by the presentations. The following presentations were made:

1. Overview, Santosh Shrivastava, Ncl
2. Service Level Agreement Language, James Skene, UCL
3. QoS Management, Monitoring and Adaptation, Fabio Panzieri, Bologna

4. QoS Monitoring and Violation Detection, Carlos Molina, Ncl

5. Evaluation approach for TAPAS, Werner Beckmann, Adesso

6. 'Under the bonnet', Jon Crowcroft, Cambridge

Much of the discussion centred on the talks made by Bologna (QoS Management, Monitoring and Adaptation) and Newcastle (QoS Monitoring and Violation Detection).

QoS Management, Monitoring and Adaptation:

Bologna is about to set up an experiment on clustering across all sites - we are keen to know from IAB members if they thought this was a good idea. In general there was acknowledgment that it would be and that the results would be interesting. Paul McKee thought that this is a good idea in terms of providing QoS over wide area clusters. Paul McKee enquired why we are using JBoss, when earlier analysis made positive comments on JoNas. Fabio Panzieri stated that use of interceptors in JBoss enables easy accommodation of monitoring and trust related enhancements; further, currently, JBoss has better load balancing and clustering facilities.

QoS Monitoring and Violation Detection:

This talk raised an interesting point concerning violation detection between parties involved (ISP and service consumer) that will require the project team to think through the 'monitoring' in more detail. Shrivastava asked what industry (BT) does now. Paul McKee replied if the customer pays enough then all eventualities are covered including monitoring of the 'service consumer'. On the whole need different strategies for different problems.

Rudolf Keller said that having missed the last meeting (April '03), he is impressed at how much progress has been made. He can see that the implementation stage will be most interesting and is curious to learn the results in due course. Paul McKee agreed that the project was at an interesting stage and looked forward to the results of the geographical clustering experiment from Bologna. This would be a nice QoS feature if successful.

9. General Comments

The first year activities already have utilized recent developments and research topics such as Model Driven Architecture (MDA), which has been incorporated into the Model Driven Performance Analysis (MDPA) research.

Adesso remarked that especially in Germany, there is an economic downturn, that leads to reinforced outsourcing activities. This is reflected in various articles on ASP in the German press.

Since TAPAS started, a Web Services have arrived on the scene and are rapidly being adopted in industry. In order to ensure validity of the TAPAS results, Web Services have been incorporated into the Service Level Agreement Formalism defined at UCL. The TAPAS architecture is well suited to the Web services world as J2EE component middleware and Web services are closely linked.

10. Conclusion

The project has produced all the deliverables on time and is running on schedule.