TAPAS

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Trusted and QoS-Aware Provision of Application Services

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Third Year Evaluation and Assessment Report
(updated 23 March 2005)

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Third year Evaluation and Assessment Report (D14) (updated 23 Mar. 05)

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1 Introduction

1.1 Overview (Updated 23 March 2005)

This document shall give an overview over the results and their applicability by matching them to the requirements identified at the start of the project. Hence section 2 lists the identified requirements and describes if and how they have been achieved. In some cases it is necessary to point to other documents for a detailed discussion. Aside from formal requirements it is vital to the project to evaluate the results in a real world test bed, based on the scenario that has accompanied us throughout the project, which is provided in section 3.

Section 4 summarizes the project results from the point of view of adesso as the industrial partner.

In section 5 we list publications that originated from the project, while section 6 contains additional material, that could not be formatted in the text sufficiently.

We have to apologize that we could not use the MS Word change identification for the updated version, because it led to error-prone editing. Hence we included update hints into the section titles.

1.2 References to other deliverable documents

In this document we refer to a number of other deliverable documents as given in Table 1.

Short	Title
D1	Application Hosting and Networking Requirements
D2	Specification Language for SLAs
D3	Method for Service Composition and Analysis
D4	Service Composition & Analysis Tool
D5	Architectural Design Document
D6	Revised Architectural Design Document
D7	QoS Container Interface Specification
D8	QOS Enabled Group Communication
D9	Component middleware for Trusted Coordination
D10	QoS Monitoring of Service Level Agreements
D11	Revised Container Interface Specification
D15	QoS-Aware and Trusted ASP for Auctions

Table 1

We have to assume that the reader is familiar with the documents as we cannot give extended detailed discussions.

2 Requirements from deliverable D1

In this section we aim to highlight the initially stated requirements. During a long-running project it is quite obvious that some requirements will turn out to be outdated or no longer suitable, while others become more important.
The numbering in the subsection titles refers to the requirement numbering in D1.

2.1 R1.1: Usage of widely spread component-based middleware technology

The project has focussed on implementing the core functionality in Java-related technologies. The Java framework for enterprise support is the Java 2 Enterprise Edition, which is typically used in form of application servers. In our case a dedicated evaluation has been used to select an appropriate application server from the available open source servers. JBoss has been selected for several reasons, among which the distribution and the community support have spoken for JBoss.

However, some implementation strategies are hard to evaluate in a laboratory environment with J2EE as one would have to build rather complex testing scenarios. Hence, a solution in the area of group communication has been implemented in CORBA, which allowed to test the implementation in a online gaming scenario, which brings in communication requirements that occur in business scenarios only in large scale solutions. It must be noted, that CORBA technology has had major influence to the design of Suns J2EE technology, so that the technological gap seems to be of less importance.

It should be noted, that Java and J2EE are quite new technologies, so that in some cases especially runtime requirements have lead to a temporary C implementation. This is the case for the communication processes that run on each JBoss instance. The pure Java implementation turned out to consume to much time when processing requests as compared to a C implementation. However, due to the very fast progress in Java technology development the feasibility of Java merely seems to be a question of time rather than a basic issue.

2.2 R1.2: Representation of structured data in XML and utilization of derived standards

XML has been used by the project team as a structure for SLA specifications. Contract contents has been mapped to final state machines (FSM), which provide well-known semantics. In fact, ebXML has not been used, because it would not have allowed to define action monitoring sufficiently.

2.3 R1.3: Utilization of standard modelling languages such as UML for SLA modelling

UML modelling for SLA contents has not been implemented, because it does not seem to bring in any benefit to express SLA contents in terms of objects, states or other UML elements together with SLA contents. It seems far more important and beneficial that modelling the elements of the SLA language, i.e. a domain model, has been done in UML. When defining other types or more elaborated types of SLAs, one can add entities to this UML model together with constraints in the object constraint language (OCL). The real benefit comes from using this model as a starting point for generating a SLA checker infrastructure in Java, which allows system engineers to construct SLA monitoring components very easily.

It should be noted, that generation of code is only required when extending the SLAng language, not for every SLA.

2.4 R1.4: Evaluation of applicability of the OSS/J API for TAPAS components

The OSS/J API provides specific service definitions in the area of telecommunication industry, allowing to integrate hardware and software components without substantial changes to provisioning software. Based on the adesso experience from its participation in IP value GmbH (www.ip-value.de), it can be said that the areas of ASP and telecommunication provisioning systems seem now more different than at the time of identifying the requirements.
Hence the API requirements have been left aside.

2.5 R1.5: Exploitation of Web Services where applicable

The Web Services technology provides standards for accessing services without knowledge of its implementation. Being beneficial in many ways in today's industrial architectures, Web Services still do not cover some important real world issues such as transaction management or authentication management.

However, the available TAPAS technologies can be seamlessly interwoven into Web Services usage. TAPAS middleware extensions are based on intercepting service requests in order to measure and to balance the load. This has been realized for HTTP requests, hence it supports Web Services of course. RMI requests are the secondly important request type that has been targeted for interception by TAPAS technology. Furthermore, all other requests can be intercepted in JBoss easily.

On the other hand it must be noted that the requirement to push measurement data to an external monitoring instance is not implemented by a Web Service. Though it could be possible to build a Web Service to accept the measurement data on the monitoring instance, it is much safer to put messages on a queue. Besides the push semantics of this communication it is even more beneficial as JMS implementation comes for free with JBoss.

2.6 R1.6: Exploitation of current IETF network standards

IETF network standards have been discussed in D8, building a basis for implementation of non-repudiation protocols, group communication implementations such as a reliable multicast protocol.

2.7 R2.1: Formal SLAs must allow to specify different aspects

2.7.1 R2.1.1: performance

Performance is a typical key requirement when talking to APS clients. However, clients are often quite unaware, what type of performance they want. The term itself does not indicate, if the processing speed or, more likely, the response time are meant. Typically a general performance requirement will be refined into a response time requirement. It must be noted, that response time can be measured in two ways. Firstly, the first response of a server could be measured. When doing so during the auction evaluation it turned out to be a meaningless measurement as it is close to 0 milliseconds. Secondly, the total response time could be measured. This includes the total processing of a request, i.e. the time from sending the request completely till all data belonging to the response have been transmitted. Included in the total response time are as well network layer delays, which can typically be ignored in a test bed.

Response time constraints and hence performance constraints can be expressed in SLAng.

2.7.2 R2.1.2: availability

SLAng allows to express availability conditions, see D2 and D3.

2.7.3 R2.1.3: reliability

A reliability requirement goes back to availability and can hence be expressed in SLAng. Further reliability considerations lead to discussing the semantics of a service in depth. This is because some errors are intended, e.g. to respond to incorrect input.

2.7.4 R2.1.4: maintainability

This item cannot be expressed sufficiently in a formal SLA language as it merely refers to the quality of source code and architecture.

It should be noted, however, that the maintenance of SLA specifications is achieved in TAPAS by separating SLA descriptions from the application, allowing that the application is completely unaware of the QoS-aware TAPAS middleware.

2.7.5 R2.1.5: security

Security cannot be expressed in SLAng. However, there does not seem to be a need to specify security constraints such as encryption of data. Standard technology exists to implement HTTPS connections for instance, so that this item is neglected.

2.7.6 R2.1.6: monitoring

During the development of the TAPAS solutions the team has decided to separate the specification and the monitoring functionality into different components, so that the monitoring will compare specifications against the measurements.

Some of the measurement means will access the service from outside to check availability and response time. Measuring data inside the service at the same time will lead to data, that contains the additional testing requests as well.

Hence it could in theory be desirable to express monitoring overhead in the SLA specification. On the contrary, SLAng already allows to extend the specification meta model or to adopt such constraints into OCL expressions. On the other hand specifying these overheads seems quite unnecessary in real world scenarios, because clients will obviously only negotiate about very detailed and sophisticated SLAs if the application itself will be used with high loads. In such situations, monitoring overhead specification seems pointless.

Monitoring facilities itself are of course highly integrated into the TAPAS platform.

2.7.7 R2.1.7: penalty

The specification of penalties as contained in today’s prose contracts has been shifted to the specification for contracts. This goes back to the need that ASPs may not be that much interested in monetary penalties and that trusted third parties will be in a better position to monitor financial regulations. However, even though penalties can be expressed in the contract specifications it must be noted, that financial clearing is beyond the projects scope.

2.8 R2.2: Modelling of SLAs should be supported by an appropriate modelling language

TAPAS has produced the SLAng language, which is not only expressive enough to cover the core ASP items, but can be extended for items that are not yet covered, see D2 and D3.

2.9 R2.3: The SLA modelling process should be supported by modelling tools

TAPAS did of course not produce a tool that can be used by any untrained, non-technical client staff member. However, SLAs can be edited by a dedicated tool implemented in Java SWING technology, that allows to postulate OCL expressions as well.

On the other hand should be noted, that XML editing would be a valid approach on its own as there are many available XML editors. Reasoning about SLAs can be done as shown in the Model Driven Performance Analysis approach as presented in conference papers by UCL. The construction of a dedicated, user-ready reasoning tool, however, is beyond the project scope.

2.10 R2.4: If modelling and reasoning tools should not only be integrated into one tool, they should interact seamlessly

This requirement can be neglected, as the current available tools make use of standard technology. It can be observed, that components from the SLAng meta model can be used to generate monitoring and editing components. This is achieved by usage of XMI technology, hence exploiting a standard in favour of constructing own tools. Furthermore, SLAng utilized OCL specifications, thus adopting another well-known standard.

2.11 R2.5: It would be desirable to have visual editors for the specification of SLAs

SLAng specifications can be edited by using a variety of existing XML editors or by using the partly generated SLAng modelling tool, which is based on SLAng meta model. However, end-user tools are not in the scope of the project itself.

2.12 R2.6: SLA modelling language should be expressive enough to allow reasoning about the aspects

See section 2.7

2.12.1 R2.7: Specification of both horizontal and vertical SLAs must be supported by TAPAS techniques

The initial concept of horizontal and vertical SLAs has been refined into several other, more appropriate types of SLAs:

- electronic service SLAs reflect the relationship between ASP client and application owner, thus expressing the relationship type formerly described vertical. Horizontal relationship types, e.g. between an application owner and an external service provider, can equally be expressed by electronic service SLAs.
- Hosting SLAs build the next layer by allowing to express relationship properties between application owner and ASP. Hence they could be classified as vertical SLAs.
- Other types such as storage SLAs and network SLAs are not implemented yet but can easily be constructed by the TAPAS means: firstly one will have to extend the meta model and to re-generate the SLA editor and the SLA checker. Secondly dedicated sensors need to be implemented for each type. It should be noted, that the TAPAS strategy enables administrators to add QoS monitoring for these objectives without actually touching the application code.

2.13 R2.8: SLA modelling process should regard the correlation of SLAs items

Obviously, there is not a single answer to this requirement. Firstly, it must be noted that the SLAng editor used to define and change SLAs consequently makes use of cross-references inside the SLA by re-using type definitions and named items such as service names.

Secondly the objectives as reflected in section 2.7 are not atomic neither independent from each other. Hence the discussions about the semantics of these items have been coined into the SLAng meta model, that defines the entities and their relations.

Thirdly, SLAng allows to utilize OCL expressions to enrich the syntax with semantic constraints, formulas and so on. By integrating OCL SLAng allows the correlation of items in a simple but powerful way.

2.14 R2.9: SLA modelling process should take into consideration the interaction of depending SLAs

This requirement was based on the concept of having vertical and horizontal SLAs. However, as discussed in section 2.9, this has been resolved into dedicated SLA types. It can be observed that an electronic service SLA will need to be part of a corresponding hosting SLA because the second one refines the first one. Hence, the need for modelling dependent SLAs is reflected by this simple, but tight coupling.

2.15 R2.10: It shall be possible to define SLAs between users, owners and providers

As discussed in section 2.9 several types are supported. During the project discussions showed that the users of a hosted application will typically not have individual SLAs with the ASP client. Their relationship is usually governed by terms and conditions, which can be expressed in TAPAS as contracts and can hence be monitored by the inter-organisational relationship monitoring.

2.16 R2.11: Tool-based translation of a SLA into a deployment descriptor

SLAng makes use of XML to store the contents of an SLA. This XML file will be used for monitoring and configuration purposes. While monitoring components directly access the XML file, the resource configuration components will need a processing step. The service level specified in an SLA must be interpreted and mapped to the existing infrastructure. If a maximum response time is given, the interpreter needs to configure an initial set-up that will fulfil the descriptive requirement. The deduction of such configuration issues depends on the available resource types.

2.17 R2.12: TAPAS QoS-aware component technology must be able to work together with clustering mechanisms

The TAPAS middleware extensions enhance the existing clustering mechanisms of JBoss.

2.18 R2.13: SLA modelling techniques should regard clustering techniques

It must be noted that this requirement is based on negotiation experiences, resulting in discussions regarding the technical implementation of a hosting scenario. However, technical details of achieving service level fulfilment should in general not really matter to ASP clients as long as the SLA will be fulfilled.

The ASP staff members may on the other hand be interested in predicting the applications behaviour, which can be achieved by the approach of model driven performance analysis, see D3.

2.19 R2.14: It must be possible to monitor and measure compliance to SLAs for all stakeholders

Different mechanisms are provided by TAPAS to suite the different types of stakeholders.

An ASP can of course read the data that has been produced by the TAPAS middleware. The same data can be used by an external party, be it the client himself or a trusted third party to check it against SLA regulations.

When considering the stakeholders it should be mentioned that the TAPAS middleware allows to monitor the QoS of External Services that are used by a hosted application. They can easily be monitored regarding their SLA fulfilment by using the TAPAS technology by wrapping the otherwise TAPAS-unaware external service into a dedicated component, be it a single Session Bean, a JCA adaptor or even an own J2EE application.

For existing applications this of course would lead to the necessity of restructuring the conventional service invocation to use such a session bean, for instance, if the application architecture does not provide own wrapping elements.

Due to the fact that external service monitoring can be reduced to monitoring of internal components, a more detailed discussion is not given here.

2.20 R2.15: The auction application can be implemented using the TAPAS technology

The auction application scenario has been chosen, because it provides a variety of interacting parties, each of which is interested in different aspects of QoS. However, during the project runtime discussion led to the basic question, if an application shall or shall not be aware of QoS-monitoring and related services. If is obviously beneficial to be able to deploy a QoS-unaware application to a QoS-platform, thus gaining QoS-monitoring and even SLA-aware reconfiguration of resources.
Hence the auction application could be realized indeed without explicitly using TAPAS technology. On the other hand it should be noted, that real-world applications tend to follow J2EE concepts only to a certain point, because in same cases there currently still are better solutions outside J2EE, e.g. when accessing large sets of data.

2.21 R3.1: Add additional value propositions for existing businesses

In the ASP scenario there are quite a few business stakeholders for which QoS-related technology is beneficial.

First of all there are ASP clients, who are currently not or only quite rarely in the position to monitor the fulfilment of SLAs. It is quite obvious that the availability to monitor such services is beneficial to them instantly for existing ASP situations. For a future ASP client it is even more beneficial because the client is not only in the position to ask for an SLA but as well for monitoring access. For the duration of an ASP contract, clients will be even be able to identify differences and subsequently claim financial penalties. In order to achieve this goal, the ASP must use a TAPAS platform, providing data to externals, be it the client or a third party.

The ASP is now able to find out the resource requirements before he has to enter a costly general SLA, i.e. the prediction preciseness is much better than today. Typically, ASPs will need to run load testing to configure the parameters appropriately, resulting not only in more precise SLAs but as well in a better resource usage in terms of used machines in a cluster node.
The benefit of the resource usage especially lies in the likeliness of the predicted load. If the average expected load results in usage of two machines (or, nodes) in a cluster while the more unlikely higher loads will require four machines in the cluster, the resource usage can be optimised.
However, the main benefit can be achieved by providing a unique infrastructure that will host multiple applications of perhaps many clients.

If an application *a* requires *n* nodes for average load and *m* nodes for a medium higher load level, the number of spare nodes is $s = \Sigma (m_a\text{-}n_a)$. If we now construct an estimation on the likeliness of reaching the higher load area, we can simply derive average resource requirements from this, allowing us to obviously use less nodes than in a static clustering approach. This is in fact only beneficial, if the nodes are available to all applications. An example is presented in section 6.1.
ASPs are then able to bundle those applications that have a high likeliness to reach higher load levels at different periods of a day, thus being able to reduce the total number of nodes while fulfilling each agreed SLA.
Aside from the cost benefit it must be noted that the availability of such QoS-aware services is a differentiation factor in the market.

Furthermore, SLA modelling by using a dedicated language and the appropriate tools enables consulting companies to offer dedicated services to improve the negotiation position of their clients.

Regarding the dissemination planned by adesso itself it is worth noting that a business case has been compiled and is under evaluation by the board of directors[2].

However, one drawback is that computing power costs are decreasing continuously while ASP clients tend to claim a dedicated hosting for their applications though technological matters should be transparent to them. Hence the cost benefit must be made known by means of marketing and sales.

Regarding the non-repudiation facilities we see that it is achieved by basically wrapping communication between a sender and a receiver, enhanced with dedicated logging mechanisms. It can easily be adopted to other types of communication. The wrapping is implemented by intercepting the request and response between the partners, so that intercepting HTTP requests would lead to securing the business processes on the web front en, thus enabling trust-worthy payment services, for instance.

A drawback of this solution lies in the requirement to modify the sender. In an Internet-based scenario senders will typically be web browsers, which are hard to modify. The more interesting field of applicability is the integration of external services, because the partners are well-known and the number of partners is limited. Especially for connections to bank and booking applications the functionality offers simple but powerful means to monitor request behaviour.

[2] “Vorstand” in German, which is slightly different from the role of board.

2.22 R3.2: Reduce the costs of defining, monitoring and entering service level agreements

With a given SLA language SLAng, dedicated tools and the availability of the TAPAS middleware as open source ASPs as well as software vendors can easily exploit the benefits of the projects results. Furthermore, they do not necessarily need to deploy the complete set of tools, but can choose appropriate levels of TAPAS solutions: while one client might only be interested in SLA modelling, another will deploy the dynamic cluster reconfiguration solutions.

2.23 R3.3: Support for the specialization of businesses

In today's ASP market ASP companies typically will try to cover as much of the value chain as they can, thus extending their business to a maximum profit. On the other hand it is currently still difficult for small and medium companies to act as an application owner, because they cannot really prove that they deliver the promised service quality, while companies like IBM can easily act as full service providers.

TAPAS has produced the notions of electronic service SLAs and hosting SLAs. With the circulation of TAPAS technology and concepts it will be easier for entrepreneurs to start companies dedicated to services such as an application owner, who does not actually host the application but relies on an ASP. In fact, during the preparation for the auction application it turned out that DaimlerChrysler has given the mandate to run a procurement auction platform to a mid-size company (see D13, D15). This company in turn relies on an ASP/ISP company to actually run the systems.

Besides the QoS guarantee and monitoring provided by TAPAS it can be observed, that monitoring QoS is still an issue, because in today's ASP business the ASP will monitor the SLA fulfilment. Only in rare cases ASP clients will monitor the fulfilment themselves. However, even with TAPAS technology somebody will have to evaluate the monitoring results. Considering other industries it seems a fair assumption that it makes sense for ASP clients to outsource monitoring issues to a third party such as TÜV or DEKRA in Germany[3].

2.24 R3.4: Enable new types of businesses

Though TAPAS results are already available it is quite difficult to reason about future business types. Asides from SLA-related services in consultancy, software development and hosting, the availability of formal SLAs can foster a completely different type of business. When building web portals most companies are eager to integrate foreign services, depending on the portals target group. While Internet portals will typically integrate information and shopping services such as weather data, stock exchange rates or dedicated offerings for members, portals for employees tend to integrate internal and external services such as time sheets, travel booking etc. Focussing on external services it will be easier for start up companies to offer data services, because they can prove their SLA fulfilment and thus gain reliability.

[3] Both companies are providing quality inspection services for a variety of technologies

However, as markets and economies are changing rapidly reliable predictions will be rather difficult to construct.

2.25 R3.5: Facilitate the lengthening of the value chain

Though TAPAS does not address all aspects of the ASP scenario, it is obvious that open and clear interfaces together with proven QoS will enable outsourcing of currently integrated services. During the last years it could be observed in the market that for instance Storage Area Networks (SAN) became quite popular, which resulted in companies offering even storage via Internet TCP/IP connections. In contrast to this outsourcing trend costs for disk space and memory have fallen to a level, where it does not pay to outsource the storage any more. It seems that human work is the more expensive factor, so that currently manual process steps such as software development and support are outsourced to foreign countries.
However, based on the clear separation of concerns in TAPAS it is fair to say that business partners can find suitable division of work, thus allowing to outsource parts into new business types.

3 Scenario-driven evaluation of requirements

3.1 Auction application characteristics

This section gives an overview of the auction application, that is used by adesso to evaluate the TAPAS solutions.

3.1.1 Goals and use cases

Auctions have been chosen because there are many participating stakeholders with a high demand for QoS-related requirements. On the other hand it can be noted, that online auctions are a still quite new, upcoming way to negotiate about prices. This is well-known for private auctions. However, inspection of existing business auctions led to the insight, that especially large companies such as DaimlerChrysler, Volkswagen and General Electric are using procurement auction applications (see D13, D15).

In Figure 1 we show the basic use cases for an auction owner. He has the possibility to create auctions, invite bidders to an auction and to get an updated rating for a bidder. Moreover, auctioneers select the winner for each auction.

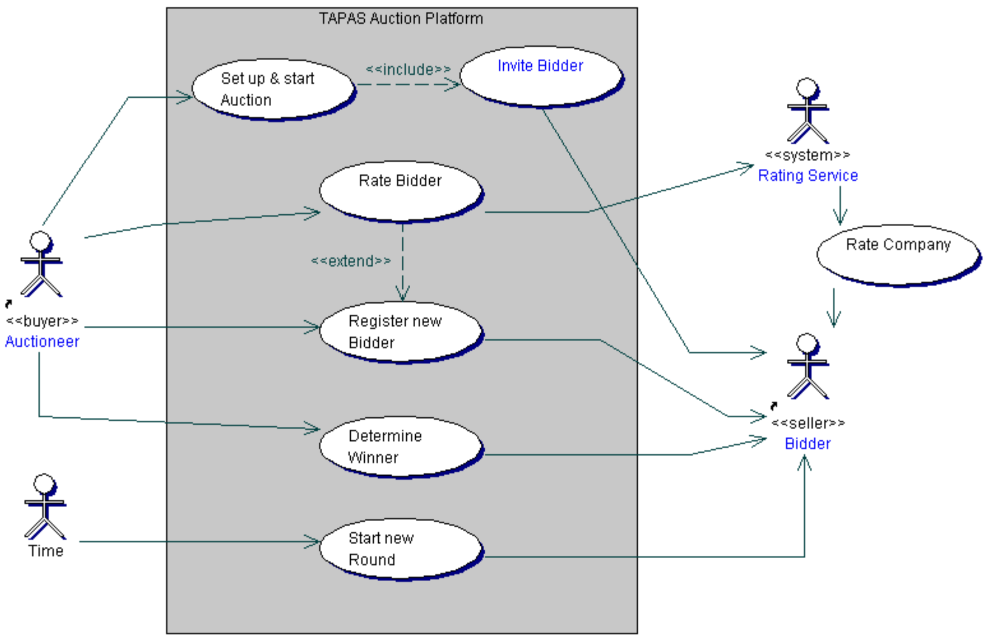


Figure 1

In Figure 2 we show the use cases for bidders: they can only reply to invitations and place bids.

The application has been designed with real application scenario in mind. Hence bidders are invited by email and they can be rated by an external rating service on request by the auctioneer. The bidding rounds are started by an external timer.

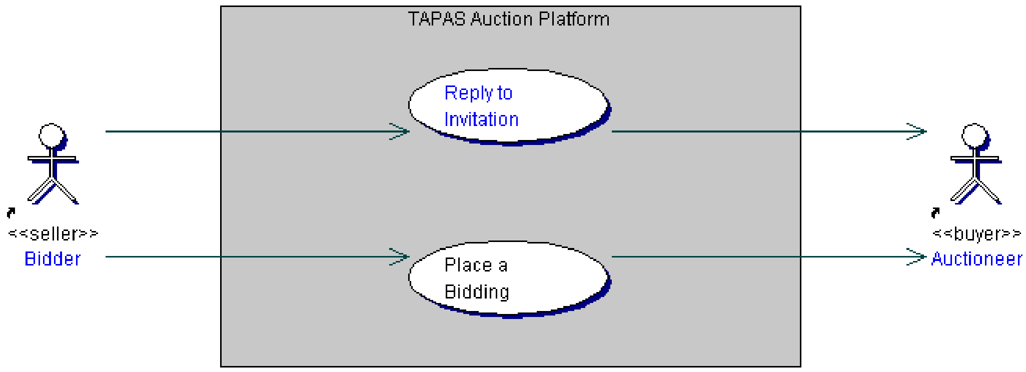


Figure 2

3.1.2 Components

The application has been developed as a multi-tier application in J2EE technology:

- Java Server Pages (JSP) and the Struts library have been used for the presentation layer.
- Enterprise JavaBeans have been used for the business logic and persistency implementation, hence using Session Beans for the business logic and Entity Beans with Container Managed Persistence for storing data.
- The external service and some of the internal methods are accessed via Web Service interfaces.
- Time-based triggering is implemented by using an open source component, Quartz, with a JMS connection, that is used by a message-driven bean.
- All used basic components are open source components:
  - Application Server: JBoss 3.2.5 with Tomcat
  - Database: MAXDB / SAPDB 7

In Figure 3 we show the principal component architecture.

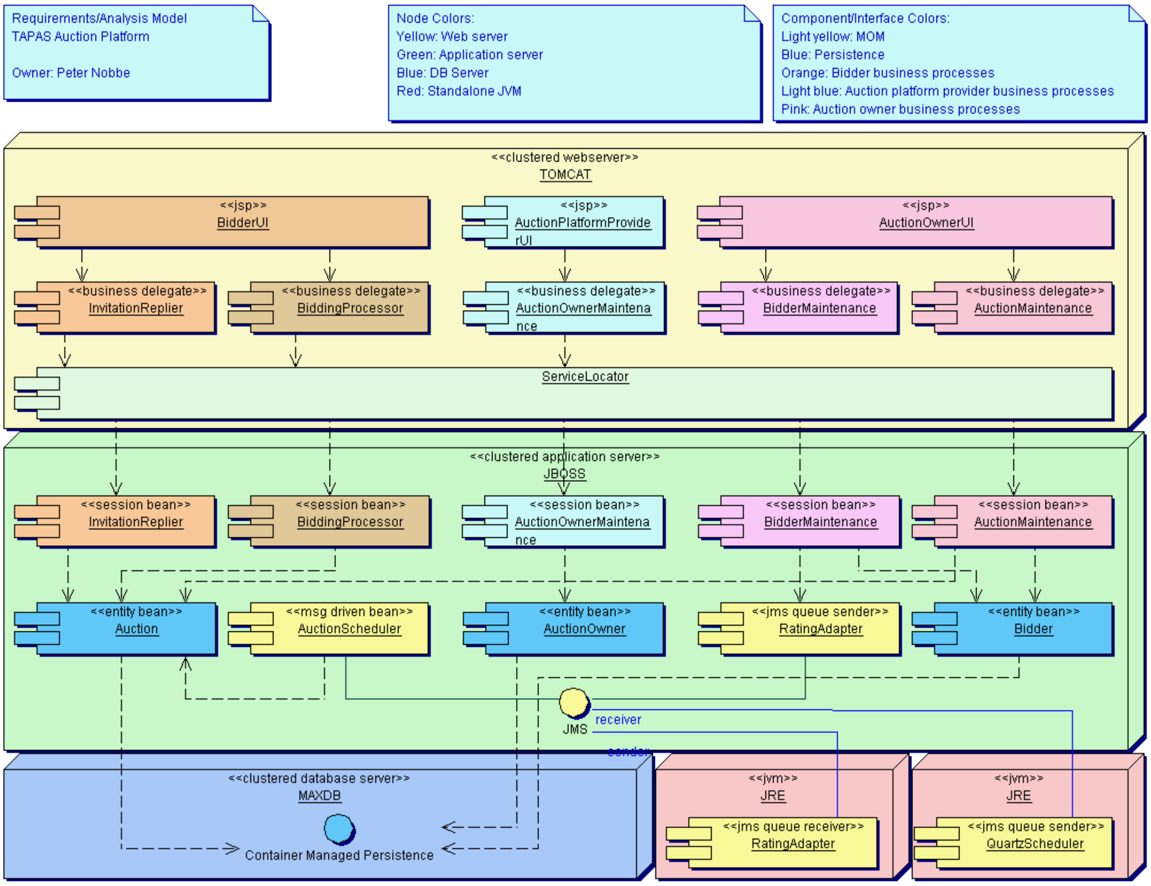


Figure 3

Though a discussion of architecture details is out of the scope of this report, it should be noted, that the time server is a potential single point of failure because it is running as a standalone process. However, in a production environment one would need to have a mitigation strategy for this risk.

3.2 Deployment and test bed

In this section we intend to give an overview over the deployment scenario used at adesso.

In Table 2 we list the machines belonging to the test environment as shown in Figure 4. It should be noted, that this constellation reflects in fact real world constraints: typically, ASPs will have a wide range of machine types and various degrees of CPU speed and memory.

Machine name	CPU	RAM	OS	Installed software
Bordo	Intel Pentium III 650	512 MB	SuSE Linux 9.1, Kernel 2.6.5	JBoss 3.2.5, Apache WebServer
Piacenza	Intel Pentium III 500	512 MB	SuSE Linux 9.1, Kernel 2.6.5	JBoss 3.2.5
Asiago	Intel Pentium III 550	512 MB	- SuSE Linux 9.1, Kernel 2.6.5	JBoss 3.2.5

Marsaglia	Intel Xeon 3GHz	1 GB	Suse Linux 9.0, Kernel 2.4.21	MECO, Non-repudiation dispatcher
Pontevico	Intel Xeon 2.80GHz	2 GB	SuSE Linux 9.0 , Kernel 2.4.21	External rating service (dummy): Tomcat, MAX DB

Table 2

Three of these five machines are used to build the cluster: Bordo, Asiago, Piacenza.

Pontevico is used as database server, thus reflecting typical ASP scenarios, in which a single database machine or a hardware cluster acting like a single machine, will be used. Though this reflects typical ASP deployment scenarios it must be noted that the database server in our approach is a single point of potential failure. To avoid this there are many state-of-the-art solutions available, that are not in the scope of the project:

- Usage of a storage area network
- One could replace the single machine with hardware cluster or a database cluster, e.g. implemented by a commercial Oracle database.
- Extension of the machine's hardware by
    - Multiple CPUs
    - Multiple power supplies
    - RAID storage

Bordo is used as the entry point for the requests, i.e. all clients connect to Bordo, which will then distribute the request to the other machines.

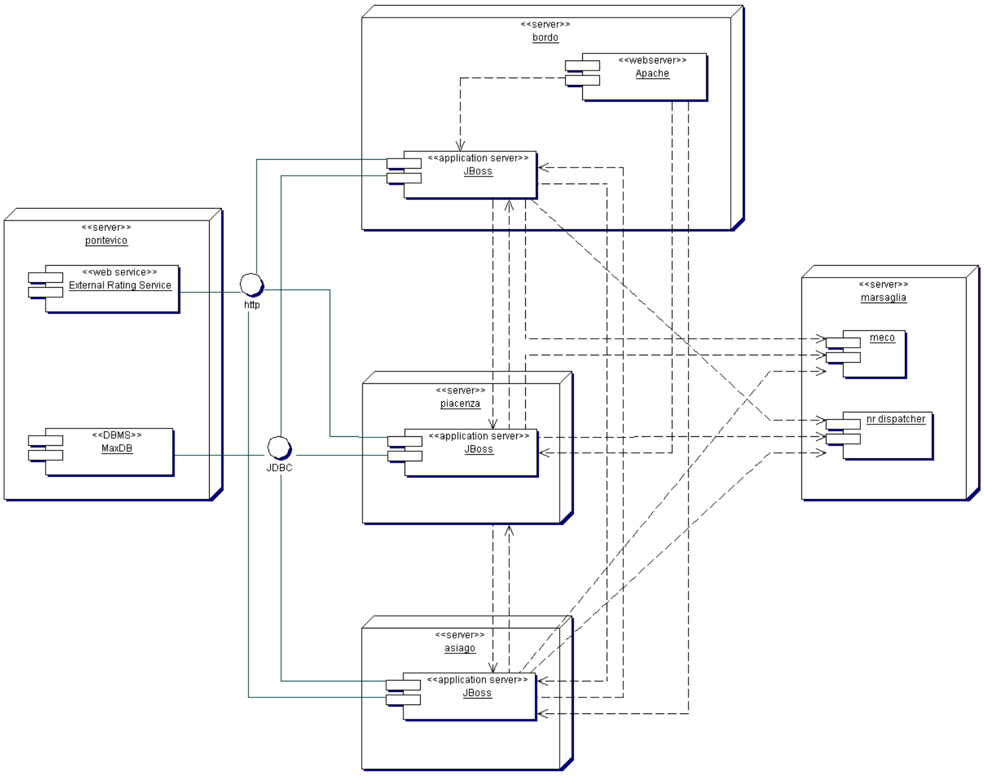


Figure 4

The JBoss installations on these machines contains a dedicated TAPAS server configuration which provides the TAPAS extensions. The JBoss installation itself is untouched, so that the deployment can be easily switched to a standard JBoss cluster by starting with a different configuration.

One of the experiences from the installation session in Dortmund is that we could not use all machines due to difficulties with RMI connections. Despite having the same Linux version with the identical patch levels on similar hardware, some machines did not accept RMI connections. For further use this problem should be inspected, but it can be postponed for the moment.

The MECO application needs to gather data which is recorded by the JBoss TAPAS extensions. This is achieved by using the JMS implementation of JBoss, i.e. by queues. However the JBoss 3.2.5 version we are using does not allow to access queue end points via message driven beans from each node in a cluster. This restriction leads to the isolation of the MECO on Marsaglia. However, this does not seem to be a general drawback, because existing newer JBoss versions fix this problem.

When starting the test development we used desktop machines to run the tests but learned soon that some tools tend to cause heavy load on the test machines. We then switched to run our tests on Marsaglia, which allowed us to increase the number of parallel accesses in a meaningful way.

All machines are placed in the DMZ, thus being accessible from outside. However, it is quite fair to assume that no other traffic will cause network latency.

3.3 Running tests

3.3.1 Test tools

When testing web applications several tools can be used for several purposes. Among the open source tools we chose two that we used during our testing work. Firstly we started with JMeter as it is quite well-known and offers a development user interface which hides all programming details. During the progress of the work we found that JMeter comes with a couple of rather displeasing consequences:

- When interpreting web sites the stable version ran into problems with using cookies. A beta version solved some issues but is beta in other areas.
- During the tests JMeter collects data and shows corresponding graphs. Due to the load generation, i.e. the processes running on that machine, the machine was completely blocked. However, using the server version of JMeter did not work properly.
- The JMeter concept of wizard elements and descriptive programming is quite useful as long as the information required shall not be processed in a more complex way. The extension mechanisms, i.e. Java programming, allow a variety of interactions, but are quite inflexible in a web environment.

For these reasons we had to abandon the JMeter tests and chose a different tool. TestMaker (http://www.pushtotest.com) is a free Jython / Python based framework that provides some basic functionality for writing HTTP-based test scripts. The scripting language is easy to handle and easy to learn, so that a need for a more time-consuming Java-based tool could not be seen. Furthermore, it can run without any difficult installation on a Linux box that has Java installed. Hence we used Marsaglia as the machine running the tests.

3.3.2 Test scripts and parameters (Updated 23 March 2005)

In Figure 5 we show the steps of the constructed test script. In principal, bidders login to an auction and place their bids. Table 3 lists the dimensions used for typical testing.

Entity	Quantity
Number of auctioneers	1
Number of bidders	150
Number of auctions	15
BidderPause	1 sec
BidderStartPause	1 sec
BidderPackagePause	120 sec
Test duration	60 sec x10 rounds

Table 3

Based on the chosen scenario of business procurement auctions we assume that an auctioneer starts several auctions by inviting the bidders to an auction. The auctions run at the same time, bidders are assigned to auctions exclusively. Between two steps of a bidder we assume to have a certain pause. Another pause is assumed when all bidders of an auction (named “package” in the graphic) are logged in and have placed their bids. This reflects the think time of bidders after each round.

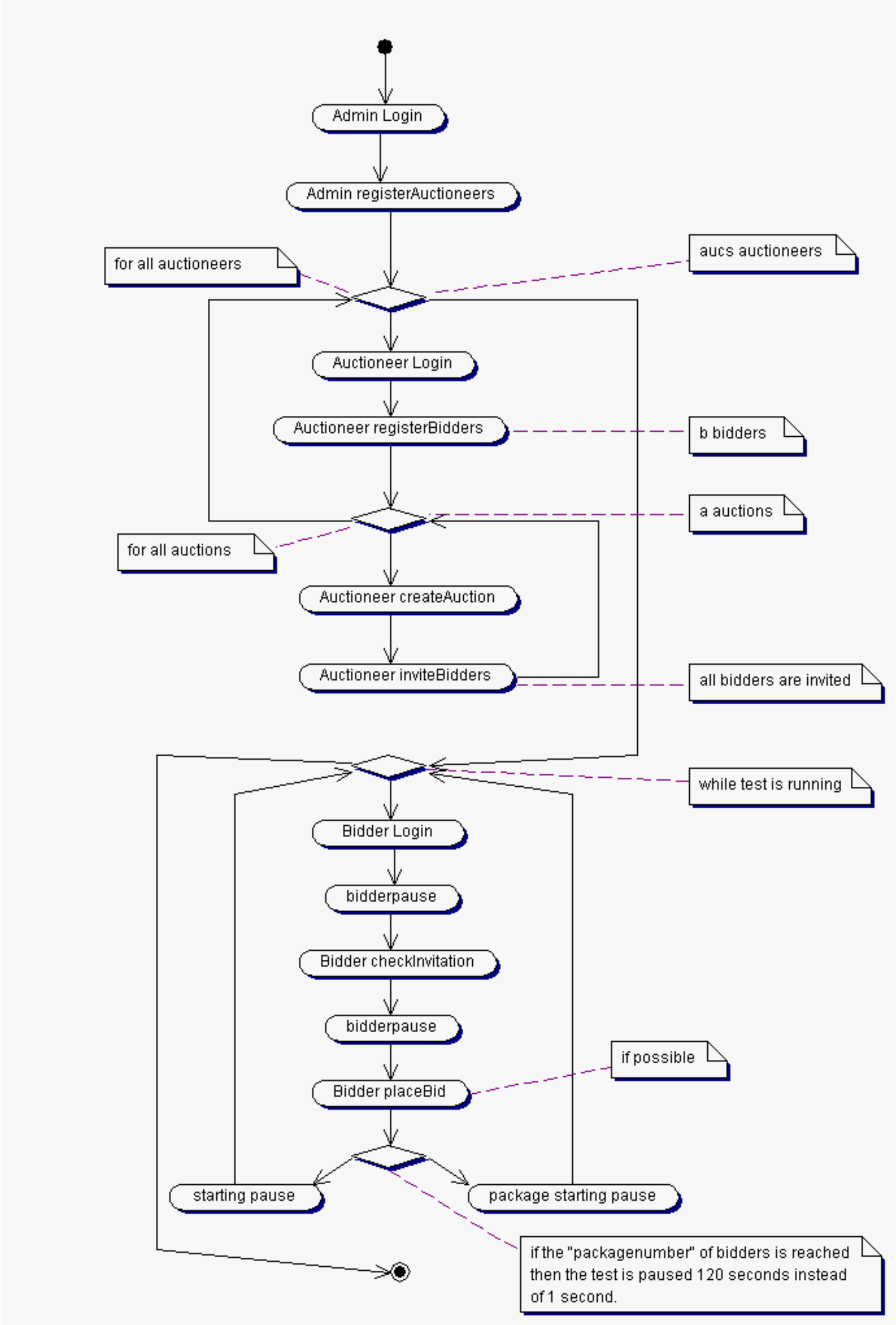


Figure 5

After initial tests with some difficulties we had to shorten the test scenario in order to make the whole test run work. This simply goes back to the complexity of the overall installation, including the database and e-mail server. However, in a 2nd approach we used different numbers of auctioneers, for each configuration 10 or 30, while we were testing configurations with two or three nodes. This has been done for TAPAS and Non-TAPAS (i.e. standard JBoss with a fronting Apache) clusters using the test control flow shown in Figure 6.

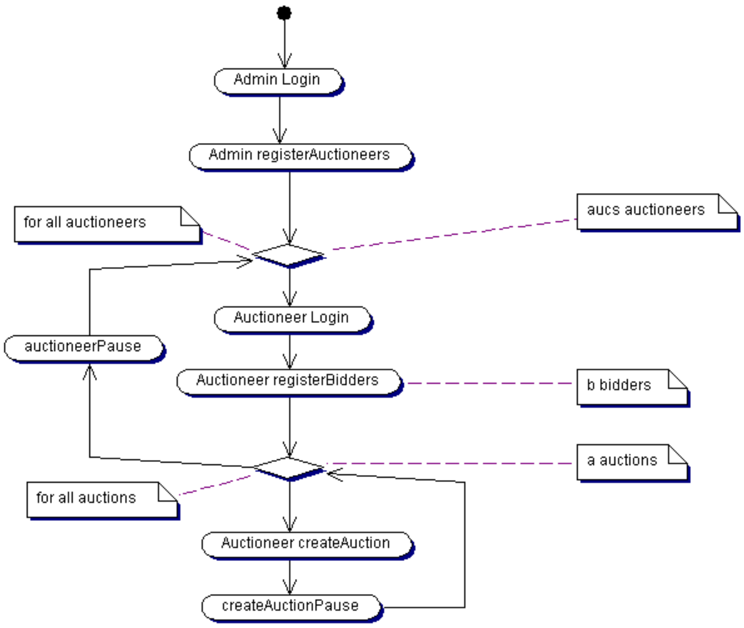

Admin Login
Admin registerAuctioneers
for all auctioneers
aucs auctioneers
Auctioneer Login
auctioneerPause
Auctioneer registerBidders
b bidders
a auctions
for all auctions
Auctioneer createAuction
createAuctionPause

Figure 6

3.3.3 Other test environments

With respect to the complexity of the auction application and the connected complexity of test scripts team members decided to use a different scenario, which is much easier to configure and to control. Hence partners in Bologna used a simple book shop application as described in deliverable D11.

3.4 Testing results

3.4.1 Result data (Updated 23 March 2005)

In order to judge the performance and potential overheads of the additional components we ran different tests with different configurations.
While first results showed substantial differences and quite unexpected behaviour[4] as shown in section 6.2 and section 6.3, we can now present the more elaborated results in section 6.4. Explanations and figures from the first version have been moved from here to the end of section 6.2.

Server nodes	Auctioneers	TAPAS	JBoss
2	10	745	838
2	30	1260	829
3	10	599	660
3	30	686	875

Table 4

In Table 4 we list the average total response time values for different configurations, the corresponding diagram is shown in section 6.4.9. For each set of either two or three nodes and a load generated by 10 or 30 auctioneers the values are given for TAPAS-enhanced JBoss and the default JBoss cluster. The used service level agreement is attached in section 6.5.

As a summary we find that in our test runs the TAPAS configuration has a better response time for three nodes in the cluster in general and even for higher loads.

3.4.2 Interpretations and insights (Updated 23 March 2005)

We will now restrict ourselves to the test runs reflected in section 6.4, because it turned out that some issues could be solved after thorough investigations. During the first test run we found that external systems built the real bottlenecks. While the mail system could be migrated to the Pontevico server, the database installation could not yet be enhanced due to technical limitations. Hence this test run produced server errors because database connections could not be opened. It turned out that the two processor machine running the database was not successfully using the second processor at first. Furthermore, log file sizes and Unix user right restrictions could be solved successfully. From running the test scripts we learned as well that JBoss 3.2.5

[4] contained in the first version of this report

seems to run into problems with undeleted temporary data now and then, which prevents correct processing for unknown reasons.
As a consequence it seems rather difficult to collect meaningful data in a complex real world application and much effort needs to be put into a working configuration to avoid bottlenecks.

It should be noted, that the server response time sometimes is seen as the time till the very first bit of the response. We have decided to focus on the total response time, using the term response time as a synonym for the total response time.

In section 6.4[5] we can see that response time values as well as the requests taken over by idle nodes seem to be more balanced in the TAPAS case. This might explain the better average response time, based on the round-robin-strategy used by the standard JBoss cluster. In fact, we excluded tests with different static clustering strategies from our tests, thus using JBoss recommendations.
It must be noted, that the response time diagrams still show peaks for both cases. Hence some requests still cannot be answered within the specified time. Speaking from an industrial perspective, it is advantageous in today's e-Business application scenarios to be able to answer the majority of requests within a given timeframe instead of guaranteeing complete fulfilment with more resources.
At the start of some the tests there seem to be effects of a "cold start", resulting in compilation time for JSPs and the like. Hence, response time curves show peaks here.

There seems to be a special situation in case of having two nodes and serving 30 auctioneers, because the TAPAS configuration shows a much higher response time than the JBoss configuration. Based on some investigations and the insights from the very first test runs we see that in this case database connectivity is again an issue, resulting in a insufficient number of connections. It could not yet be fully clarified, if the connection bottleneck could have even been caused by a better load distribution, resulting in serving all requests instead of aborting with errors as in the case of the similar JBoss configuration.

In section 6.4.9 we show the diagram containing the response time values. However, TAPAS technology seems to be adequate, when used with more than two nodes in our hardware scenario and for higher loads. In this set-up we have could only use three machines for the cluster itself, while two more powerful machines were used for the database and for running the tests. Due to technical limitations we could not include more nodes into the cluster. The reason lies in limitations adesso currently has to face for the number of machines in the DMZ. On the other hand, the machines had to be in the DMZ to be available for project partners and switching from DMZ to internal net requires significant configuration work.

3.4.3 Next steps (Updated 23 March 2005)

We still can say that configuration of application server technology is not simple. However, we did not need to migrate the database to a commercial database as planned after the first test runs.

Aside from other types of dissemination activities adesso is currently working to migrate an internal system, the adesso project database (aproda), to run on the

[5] the layout of the diagrams will be explained in the section itself

TAPAS cluster to gain further experiences with demanding users[6]. However, this requires migration steps towards the used JBoss/Tomcat configuration. Furthermore we are investigating the possibilities to deploy a JBoss-based solution developed for a insurance customer to the TAPAS platform as a preparation for a hosting offer. Regrettably it must be said, that prior offers have been declined due to long-running contracts with the current ASP.

Besides using the installation for demonstrations adesso is currently preparing press releases for the German business and computer magazines, because during the 2nd project year there were a lot of journalists interested in results. We expect to place at least articles in Computerwoche, Computer Zeitung and Versicherungswirtschaft. adesso is cooperating here with an external agency[7].

As a last point a high interested among adesso staff members can be observed. W. Beckmann will give internal talks about the project results, which are available in the adesso intranet for all employees.

4 Summary (Updated 23 March 2005)

adesso as the industrial partner is highly interested in results that can be turned into business. From our point of view the TAPAS components have already proven to be suitable for ASP market problems:

- SLA modelling allows to formalize SLAs and to re-use gained experience
- Middleware monitoring allows to gather data that is otherwise hard to determine in test runs
- Dynamic clustering provides a novel, promising way to run clusters, with the perspective to efficiently utilize resources as discussed in section 2.21.
- External SLA monitoring, based on the TAPAS middleware, allows to outsource a supervision solution, that is currently not even planned for most hosting solutions.
- Contract monitoring can even more enforce the fairness of distributed parties in complex scenarios.
- The Non-repudiation protocol implementation allows to gain trust by implementing an enveloping of requests and response.
- Group communication protocols enhance the JBoss cluster communication, thus building an integral part of the middleware services.

It must be said that we have been mainly focussing on middleware technology in this report. Today's market tendencies head into direction of outsourcing and off-shoring, but still clients do not ask for quality monitoring. This is mainly caused by the need for cost cuttings, so that low costs are regarded as by far more important than quality.

Besides the TAPAS software deliverables D4 (service composition and analysis), D8 (QoS aware group communication), D9 (trusted coordination), D10 (QoS monitoring) and D11 (QoS aware application server) has been made available in open source form at sourceforge.net (http://tapas.sourceforge.net). Given the use of JBoss application server within the project, it seems natural to seek closer collaboration with the JBoss organisation that develops the open source application server. Accordingly, the project team has enlisted itself as academic partners with them (there is a link to TAPAS on the main JBoss site).

[6] aproda is used by all adesso employees to keep track of project efforts
[7] efforts charged by the agency are not billed to the project.

With respect to the long list of academic publications and with a view to the benefits of the TAPAS solutions, the project has been very successful from adessos point of view. The industrial dissemination activities planned by adesso will not only aim to win new ASP clients, but will exploit various of the results.

Apart from the potential benefits of the technology we can resume that the participation in the project has served us to gather knowledge, train staff members and to serve as reference in the sales process sufficiently.

adesso is looking forward to final results and to further exploitation.

5 Dissemination and publications

This section is dedicated to give an overview over the dissemination in terms of conference attendances, published papers and press articles. Due to the very intense scientific activities of the TAPAS team it must be noted, that a minor number of items might be missing.

However, with respect to the long list of publications it is fair to say that the scientific dissemination has been achieved to a very satisfying degree.

In particular, the Workshop on Quality of Service for Application Servers 2004 (QoSAS'04) should be noted. It was organised by TAPAS members to provide a forum for researchers, application designers and users to review, discuss and learn about new approaches and concepts in application server QoS development. The topics of the workshop reflected the work carried out in the TAPAS project. As such, the workshop provided an ideal opportunity to disseminate the ongoing results from the TAPAS project to an audience of academics and industrial professionals. In addition, work from others (non TAPAS members) were also presented at the workshop, providing an excellent opportunity for members of the TAPAS project to learn from other academics/industrialists carrying out work in similar areas.
All the papers submitted to the workshop were reviewed by at least three members of the Program Committee (constituted from industrial/academic experts in distributed systems research). Seven papers were selected as regular papers. These paper presentations were complemented by an invited talk and a panel session.

The workshop was organised as five sessions. The first session was an invited talk given by Dr. Graeme Dixon from IBM on recent developments of IBM's application server (WebSphere). The focus of the second session (adaptability) was on how application servers may be configured during run-time to make best use of processing resources while still satisfying QoS guarantees. The third session (scheduling) presented work aimed at satisfying the QoS requirements of real-time systems. The fourth session (web services) presented research associate to satisfying QoS requirements of service based architectures. Finally, the fifth session was a panel discussion entitled "research challenges for application server developers". The workshop was a success, attracting paper submissions from over ten different countries and delegates from both academia and industry.

5.1 Conferences and Workshops

5.1.1 Year 2002

Partner	team member	title
CAM	J. Crowcroft	Global Grid Forum meeting, where he co-chairs the working group on High Performance Network requirements
UCL	W. Emmerich	3rd, International Workshop on Software Engineering and Middleware, Orlando, Florida
UCL	W. Emmerich	23rd International Conference on Software Engineering, Orlando, Florida, May 2002

NCL	S.K. Shrivastava and P.D. Ezhilchelvan	IEEE/IFIP International Conference on Dependable Systems and Networks (DSN-2002), June 2002, Washington DC
NCL	S.K. Shrivastava	Workshop on Future Directions in Distributed Computing (FuDiCo), Bertinoro, Italy, June 02
UCL	D.D Lamanna and J. Skene	3rd. International Workshop on Software Performance (WOSP), Rome, July, 2002
CAM	J. Crowcroft	ACM SIGCOMM 2002, Pittsburgh, USA, 23-25 August
UCL	W. Emmerich	17th IEEE Int. Conference on Automated Software Engineering, Edinburgh, Sept 2002
UNIBO	E. Turrini	2nd IEEE International Conference on Peer-to-Peer Computing, Linköping, Sweden, 5-7 Sept. 2002
NCL, CAM, UNIBO	S.K Shrivastava, F. Panzieri, J. Crowcroft	IST Broadband Networking Conference, Bucharest, October 02
NCL	G. Ferrari	7th Cabernet Radical Workshop, Bertinoro (FC), Italy, 13-16 Oct. 2002

5.1.2 Year 2003

Partner	team member	title
UNIBO	N. Mezzetti	14th Database and Expert Systems Applications (DEXA'03)
UCL	J. Skene	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
UCL	D.D. Lamanna	Future Trends of Distributed Computing Systems (FTDCS) May 28 30, 2003, Puerto Rico
NCL	C. Molina-Jiminez	IEEE International Conference on Electronic Commerce, Newport Beach, CA, June 2003
UNIBO	A. Di Ferdinando	4th IEEE International Workshop on Policies for Distributed Systems and Networks, Lake of Como, 4-6 June 2003
UCL	D.D. Lamanna	Middleware 2003 16-20 June 2003, Brazil
CAM	J. Crowcroft and P. Gevros	Workshop on Revisiting IP QoS: Why do we care, what have we learned? (RIPQOS) Karlsruhe, Germany, August 27, 2003
NCL	S.K. Shrivastava	Seventeenth Annual IFIP WG 11.3 Working Conference on Data and Applications Security, Estes Park, Colorado, August 2003

CAM	J. Crowcroft	IEEE International Conference on Information Technology: Research and Education (ITRE 2003), Newark (NJ), August 2003
UCL	W. Emmerich	Bertinoro Summer School on Formal Methods for Software, Bertinoro, Italy, 22-24 September, 2003
UCL	J. Skene	Workshop on Service Based Software Engineering in Pisa (FM2003-SBSE), 8th September with FME, Pisa, 8 – 14 Sept. 03
NCL	Carlos Molina-Jimenez	Business Contracts Represented as Finite State Machines DIM Workshop/Summer School, 3-5th Dec 2003, Auchrannie, Brodick, Isle of Arram, Scotland.

5.1.3 Year 2004

Partner	team member	title
CAM	S.K. Shrivastava	(presented a course on middleware): Bertinoro International Spring School for Graduate Studies in Computer Science, 8-19 March 2004

5.2 Publications

5.2.1 Year 2002

G. Morgan, A. I. Kistijantoro, S. K. Shrivastava and M. C. Little:
Component Replication in Distributed Systems: a Case study using Enterprise Java Beans

W. Emmerich:
Distributed Component Technologies and their Software Engineering Implications
Proc. of the 24th Int. Conference on Software Engineering, Orlando, Florida. pp. 537-546. ACM Press. 2002

G. Piccinilli, W. Emmerich, C. Zirpins and K. Schuett:
Web Services Interfaces for Inter-organizational Business Processes: An Infrastructure for Automated Reconciliation
In Proc. of the 6th IEEE Int. Conference on Enterprise Distributed Object Computing, Lausanne, IEEE Computer Society Press. pp. 285-292. 2002

W. Emmerich and N. Kaveh:
Component Technologies: Java Beans, COM, CORBA, RMI, EJB and the CORBA Component Model
Proc. of the 24th Int. Conference on Software Engineering, Orlando, Florida. pp. 691-692. ACM Press. 2002

N. Cook, S.K. Shrivastava and S.M. Wheater:
Distributed Object Middleware to Support Dependable Information Sharing between Organisations
IEEE/IFIP International Conference on Dependable Systems and Networks (DSN-2002), June 2002, Washington DC

S.K. Shrivastava:
Middleware for supporting inter-organisational interactions
Proceedings of Workshop on Future Directions in Distributed Computing (FuDiCo), Bertinoro, Italy, June 02

E. Turrini and F. Panzieri:
Using P2P Techniques for Content Distribution Internetworking: A Research Proposal
in proceedings of the 2nd IEEE International Conference on Peer-to-Peer Computing, Linköping, Sweden, 5-7 Sept. 2002

G. Lodi:
End-to-end QoS-aware Middleware Services
7th Cabernet Radical Workshop, Bertinoro (FC), Italy, 13-16 Oct. 2002

E. Turrini
A Platform for Request Routing in Content Distribution Internetworks
7th Cabernet Radical Workshop, Bertinoro (FC), Italy, 13-16 Oct. 2002

N. Mezzetti and F. Panzieri:
The Data Grid: Security and Privacy Issues
Proc. 4th European Dependable Computing Conference, Toulouse (F), 22-25 Oct. 2002

A. Aldini, M. Bernardo, R. Gorrieri and M. Roccetti:
QoS Evaluation of IP Telephony Services: A Specification Language Based Simulation Software Tool
Systems Analysis Modelling Simulation, Taylor and Francis Group Pub., accepted for publication, December 2002

5.2.2 Year 2003

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

G.N. Rodrigues, G. Roberts, W. Emmerich and J. Skene:
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

D.D. Lamanna, J. Skene and W. Emmerich:
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

D.D. Lamanna, J. Skene and W. Emmerich:
SLAng: A Language for Defining Service Level Agreements
Accepted for Poster presentation, Middleware 2003, Rio de Janeiro, Brazil

N. Kaveh and W. Emmerich:
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)
J. Skene and W. Emmerich:
Model Driven Performance Analysis of Enterprise Information Systems
In Proc. of International Workshop on Test and Analysis of Component Based Systems, Warsaw, April 13th, 2003 in conjunction with European Joint Conferences on Theory and Practice of Software (ETAPS) 2003.
And in Electronic Notes in Theoretical Computer Science, April 2003, vol. 82, number 6 (SE03: Performance)

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

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

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

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

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

J. Crowcroft, S. Hand, R. Mortier, T. Roscoe and A. Warfield:
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

P. Gevros:
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

P.D. Ezhilchelvan and S.K. Shrivastava:

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

S. Ferretti and M. Roccetti:
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

M. Roccetti and P. Salomoni:
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

N. Mezzetti:
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)

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

A.I. Kistijantoro, G. Morgan, S.K. Shrivastava and M.C. Little:
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

J.Skene and W. Emmerich:
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

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

N. Cook, S.K. Shrivastava and S. Wheater:
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

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

E. Turrini:

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

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

5.2.3 Year 2004

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

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

E. Turrini and V. Ghini:
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

N. Cook, P. Robinson and S.K. Shrivastava:
Component Middleware to Support Non-repudiable Service Interactions
DSN 04, Florence, June 2004

C. Molina-Jimenez, S.K. Shrivastava, J. Crowcroft and P. Gevros:
On the Monitoring of Contractual Service Level Agreements
The First IEEE International Workshop on Electronic Contracting (WEC), July 2004, San Diego

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

L. Capra. "Engineering Human Trust in Mobile System Collaborations". In Proc. of the 12th International Symposium on the Foundations of Software Engineering (SIGSOFT 2004/FSE-12). November 2004. To appear

L. Capra. "Towards a Human Trust Model for Mobile Ad-hoc Networks". In Proc. of 2nd UK-UbiNet Workshop. May 2004, London, United Kingdom

N. Mezzetti, ``Enabling Trust-Awareness in Naming Services'', *Proceedings of the 1st International Conference on Trust and Privacy in Digital Business*, Lecture Notes in Computer Science, Springer-Verlag, Vol. 3184, pag. 20-29, 2004.

N. Mezzetti:
A Socially Inspired Reputation Model, Lecture Notes in Computer Science, Springer-Verlag GmbH, Volume 3093 / 2004: Public Key Infrastructure: First European PKI

Workshop: Research and Applications, EuroPKI 2004, Samos Island, Greece, June 25-26, 2004, Editors: Sokratis K. Katsikas, Stefanos Gritzalis, Javier Lopez

Giorgia Lodi, Fabio Panzieri:
"QoS-aware Clustering of Application Servers", Proc. 1st IEEE International Workshop on Quality of Service in Application Servers (QoSAS 2004), in conjunction with 23rd Symposium on Reliable Distributed Systems (SRDS 2004), Jurerê Beach Village, Santa Catarina Island, Brazil, 17 October 2004.

Davide Rossi, Elisa Turrini:
"Testing J2EE clustering performance and what we found there", Proc. 1st IEEE International Workshop on Quality of Service in Application Servers (QoSAS 2004), in conjunction with 23rd Symposium on Reliable Distributed Systems (SRDS 2004), Jurerê Beach Village, Santa Catarina Island, Brazil, 17 October 2004.

Di Ferdinando A., Ezhilchelvan P.D., Mitrani I.:
"Design and Evaluation of a QoS-Adaptive System for Reliable Multicasting" . In Proceedings of the 23rd Simposium on Reliable Distributed Systems (SRDS04), Florianópolis, Brazil, October 2004. (basically is the TAPAS group comm protocol)

G. Ferrari, S. Shrivastava, P. Ezhilchelvan:
„An Approach to Adaptive Performance Tuning of Application Servers“. In Proc. 1st IEEE International Workshop on Quality of Service in Application Servers QoSAS 2004), in conjunction with 23rd Symposium on Reliable Distributed Systems (SRDS 2004),Santa Catarina Island, Brazil, 17 October 2004.

5.2.4 Year 2005

Davide Rossi, Elisa Turrini:
Analyzing Performance Data Exchange in Content Delivery Networks, Proc. International Conference on
Networking (ICN '05), Reunion Island, April 17-21, 2005 .

N. Mezzetti:
Design and Evaluation of a Trust-Aware Naming Service, To appear in Computer Systems Science and Engineering Journal, 2005.

To appear:
Wolfgang Emmerich, James Skene:
Engineering Runtime Requirements-Monitoring Systems using MDA Technologies, Symposium on Trustworthy Global Computing (part of ETAPS in Edinburgh, April 2005), to be published in LNCS by Springer Verlag

Carlos Molina-Jimenez, Jim Pruyne and Aad van Moorsel:
Software Architectures for Service Level Agreements and Contracts, To appear in "Architecting Dependable Systems III", to be published in the LNCS series by Springer in 2005, Editors: Rogerio de Lemos, Cristina Gacek and Sascha Romanovsky

5.3 Articles

EU-Forschungsprojekt fördert ASP-Markt (EU research project encourages ASP market)
Industriemanagement (Industrial management), pp 77, GITO mbH Verlag,1/2003, Berlin, Germany

Marktbelebung durch mehr Sicherheit und Qualität (Market upturn by more security and quality)
Versicherungswirtschaft (Insurance economy) pp 67, Verlag Versicherungswirtschaft GmbH, 1/2003, Karlsruhe, Germany

Die zweite ASP-Welle ist auf dem Weg (The second wave of ASP is on it's way)
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

6 Additional material

6.1 Calculation of average resource usage

The table columns are

- application: simple ID
- av. Nodes: the nodes used for the main load level area
- max. nodes: the nodes used to fulfil the SLA for the maximum usage (random numbers here in this example).
- P for different periods of a day: the likeliness (0 to 1) that higher load level area is reached in the given period
- Nodes for different periods: the resulting number of nodes required.
- The lines below list the total number of nodes in case of static clustering (55), while the last line contains the difference to the averagely used nodes as computed above.

Application	av. Nodes	max. nodes	p (06-08 hrs)	p (08-10 hrs)	p (10-12 hrs)	p (12-14 hrs)	p (14-18 hrs)	p (18-22 hrs)	nodes (06-08 hrs)	nodes (08-10 hrs)	nodes (10-12 hrs)	nodes (12-14 hrs)	nodes (14-18 hrs)	nodes (18-22 hrs)
1	1	1	0,1	0,4	0,3	0,8	0,3	0,1	1	1	1	1	1	1
2	2	2	0,1	0,4	0,3	0,8	0,3	0,1	2	2	2	2	2	2
3	2	3	0,1	0,4	0,3	0,8	0,3	0,1	2,1	2,4	2,3	2,8	2,3	2,1
4	2	4	0,1	0,4	0,3	0,8	0,3	0,1	2,2	2,8	2,6	3,6	2,6	2,2
5	2	5	0,1	0,4	0,3	0,8	0,3	0,1	2,3	3,2	2,9	4,4	2,9	2,3
6	2	6	0,1	0,4	0,3	0,8	0,3	0,1	2,4	3,6	3,2	5,2	3,2	2,4
7	2	7	0,1	0,4	0,3	0,8	0,3	0,1	2,5	4	3,5	6	3,5	2,5
8	2	8	0,1	0,4	0,3	0,8	0,3	0,1	2,6	4,4	3,8	6,8	3,8	2,6
9	2	9	0,1	0,4	0,3	0,8	0,3	0,1	2,7	4,8	4,1	7,6	4,1	2,7
10	2	10	0,1	0,4	0,3	0,8	0,3	0,1	2,8	5,2	4,4	8,4	4,4	2,8
Total nodes	55							22,6	33,4	29,8	47,8	29,8	22,6	
delta									32,4	21,6	25,2	7,2	25,2	32,4

6.2 Test result diagrams A

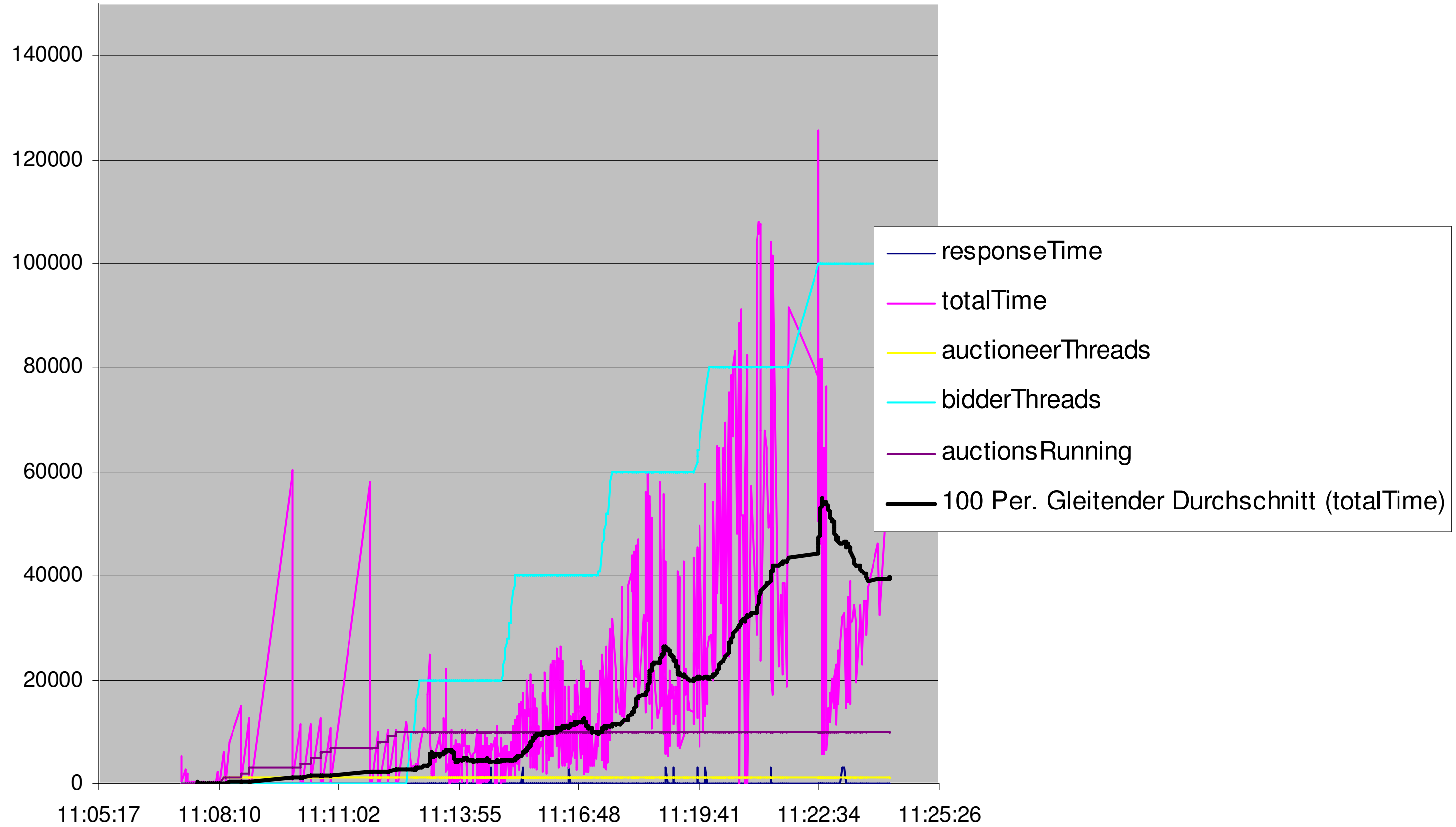


Figure 7: 3 nodes TAPAS

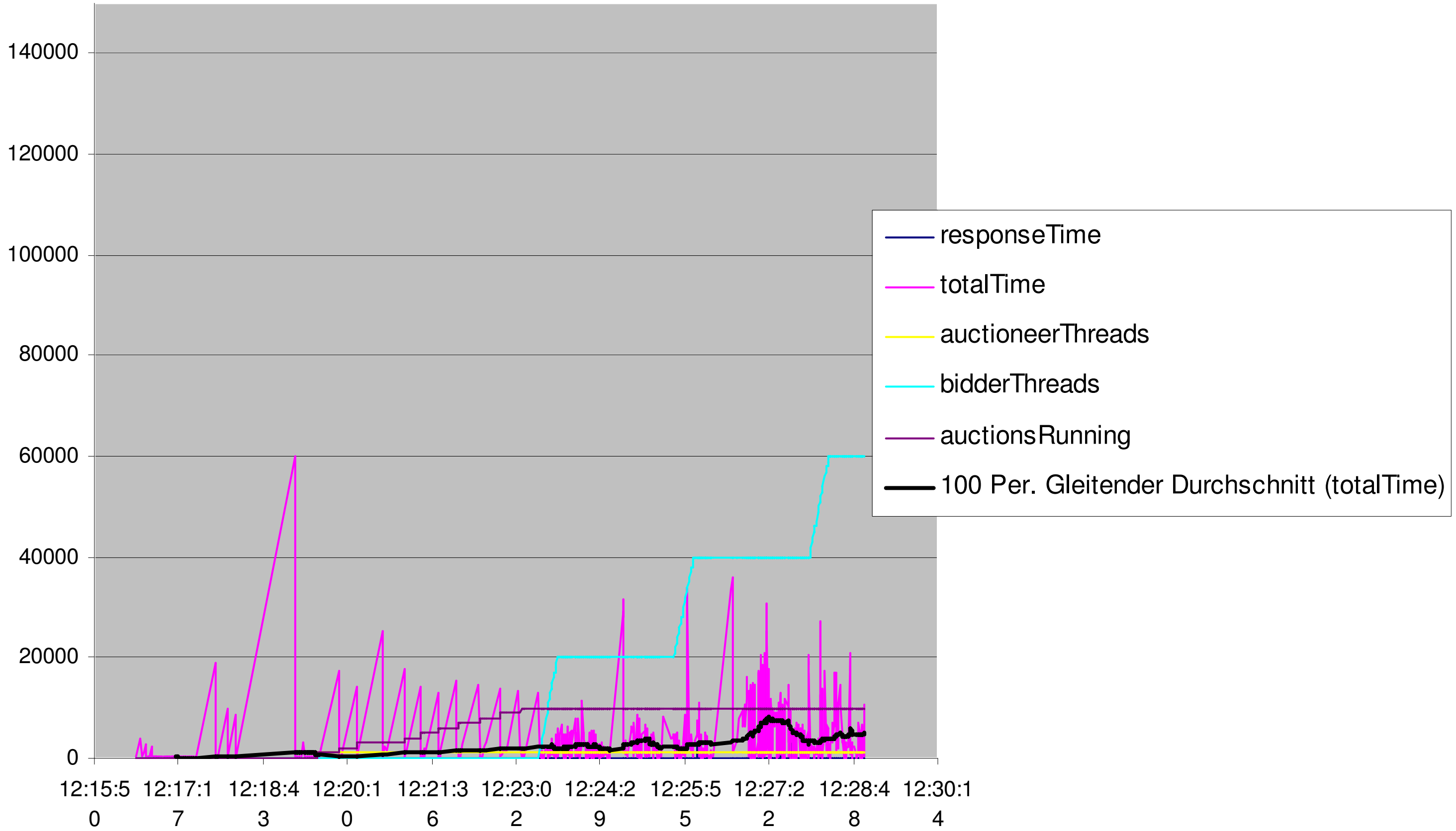


Figure 8: 3 nodes JBoss

Each of the diagrams shows the total response time for each operation in milliseconds on the Y-axis, while listing the time on the X-axis. To indicate the load the number of bidder threads has been woven into the diagrams. Each diagram contains a black curve, marking the average value for each 100 elements. Depending on the behaviour roughly 2500 to 3100 requests are issued per test.

The average total response time for a request is as follows:

Test run	cluster type	Average total response time
A	standard	5132,0 sec
A	TAPAS	19356,6 sec
B	standard	21372,9 sec
B	TAPAS	19007,6 sec

The SLA used for this configuration states that all actions need to be performed on average with a response time of 3 seconds:

```
<OperationPerformance clauseId="showAuctioneers.do" CPUUsage="3.0" memoryUsage="20.50" avgResponseTime="5.0s" >
    <Operations>
        <Operation name="showAuctioneers.do"/>
    </Operations>
</OperationPerformance>
```

6.3 Test result diagrams B

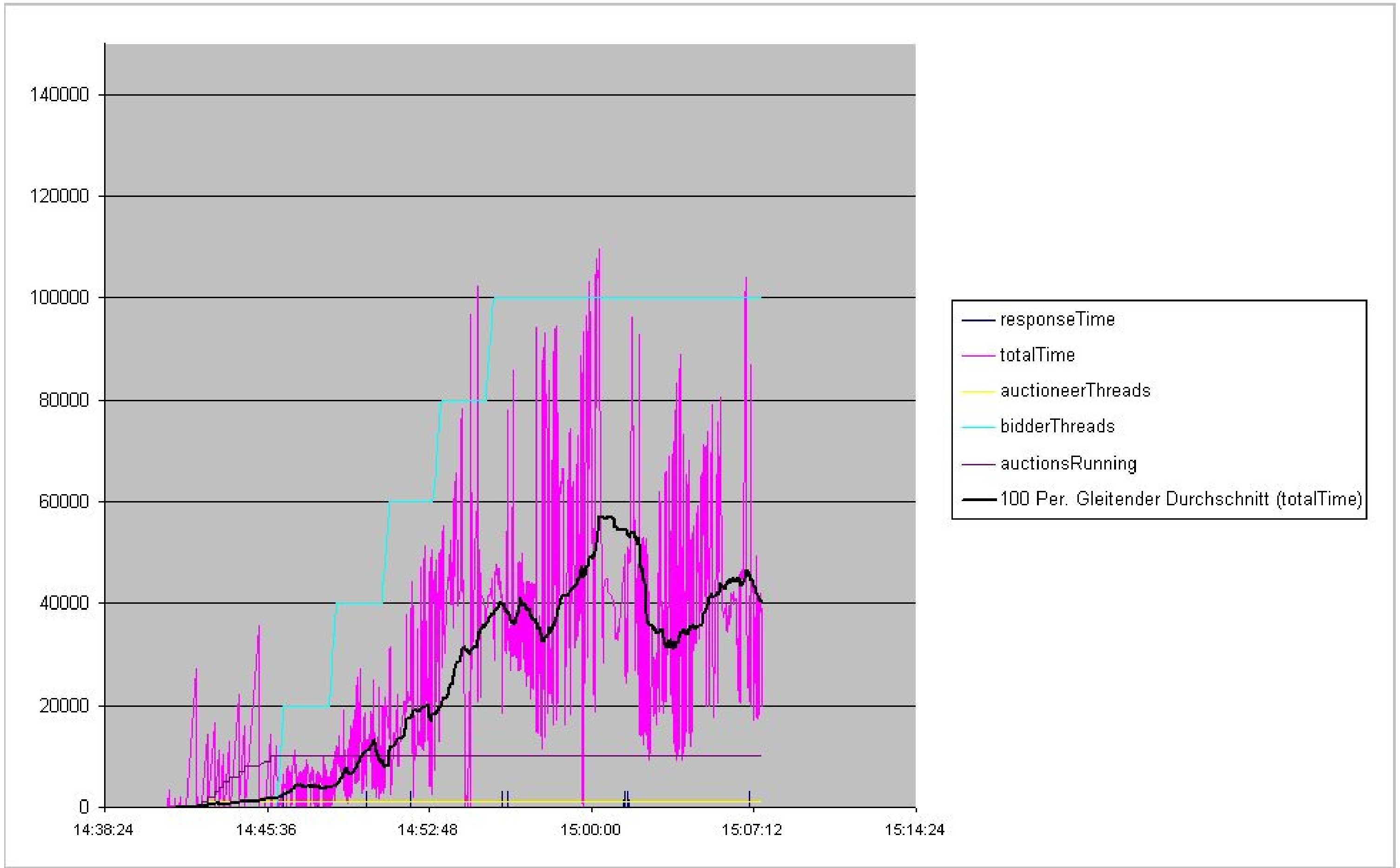


Figure 9: 3 nodes TAPAS

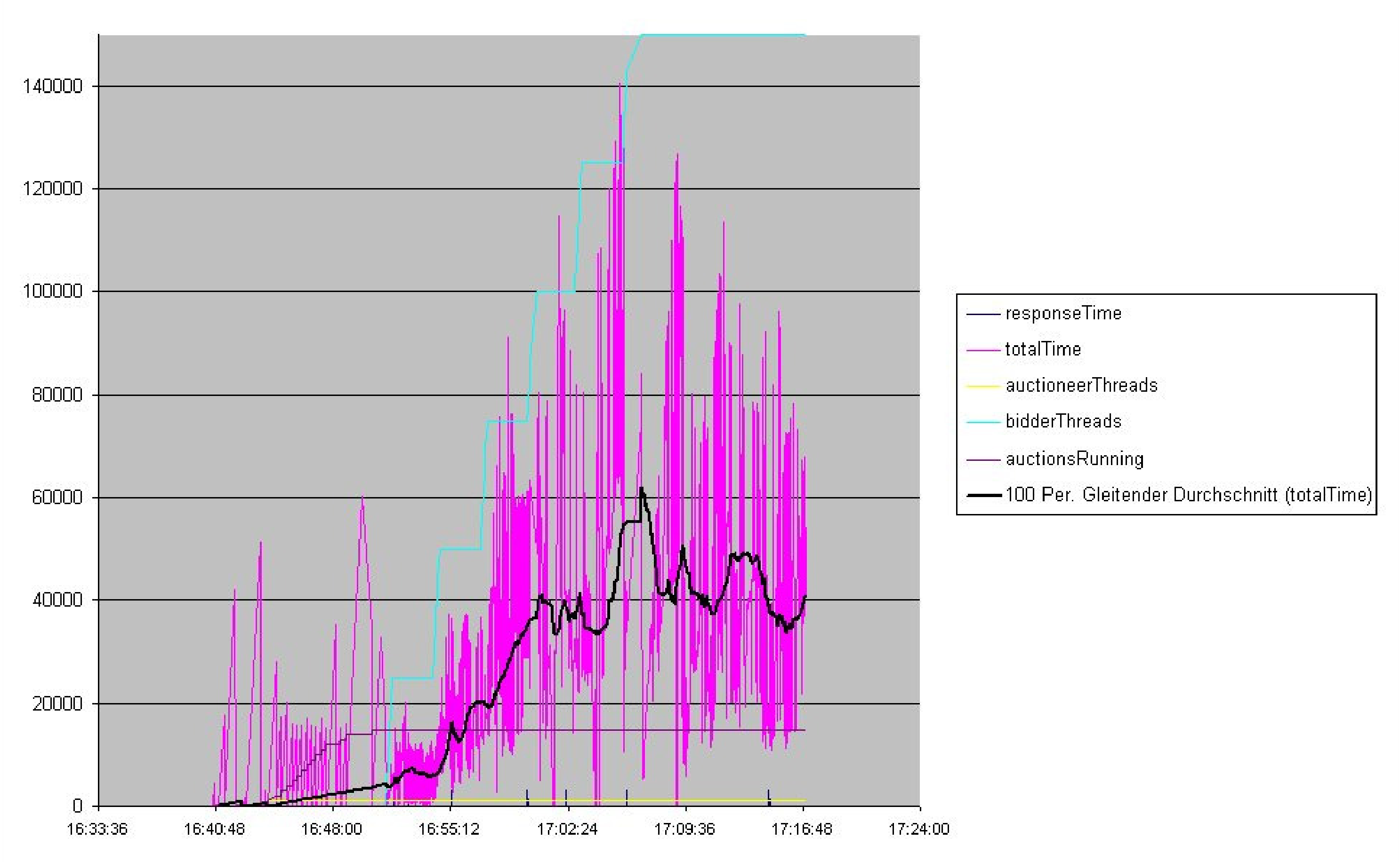
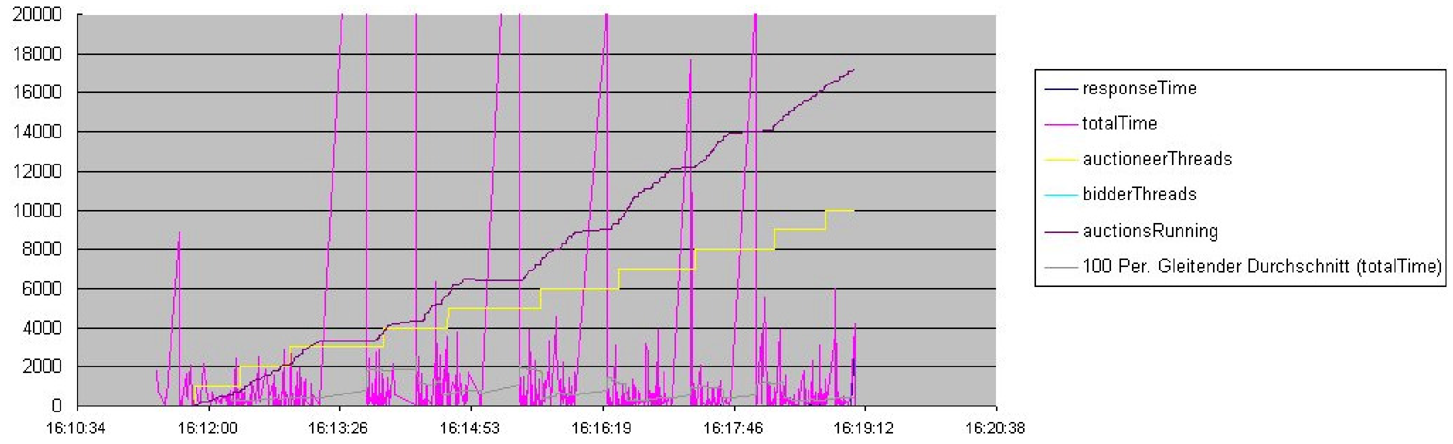


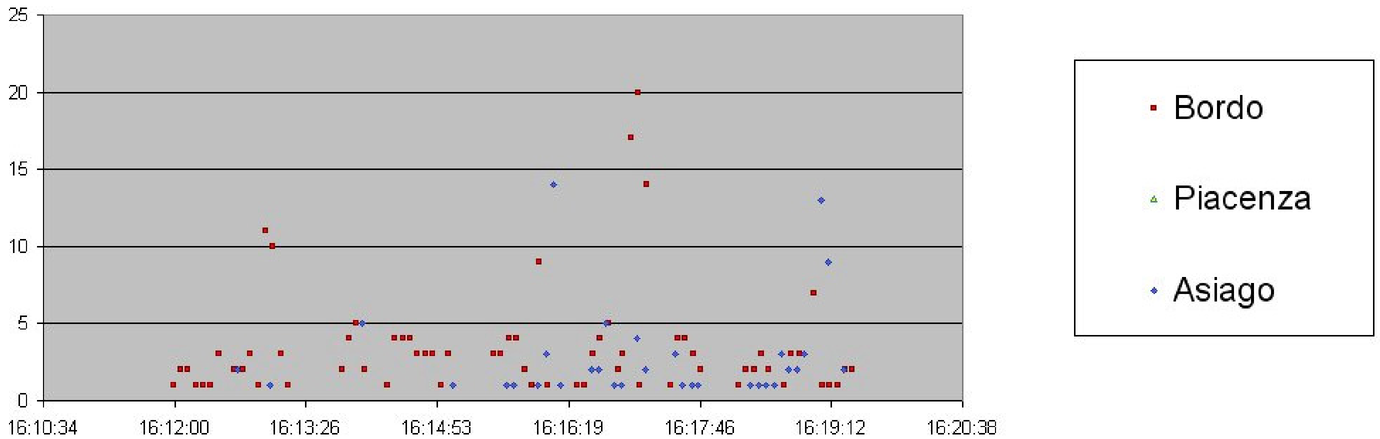
Figure 10: JBoss cluster

6.4 Further test results after installation changes (added 23 March 2005)

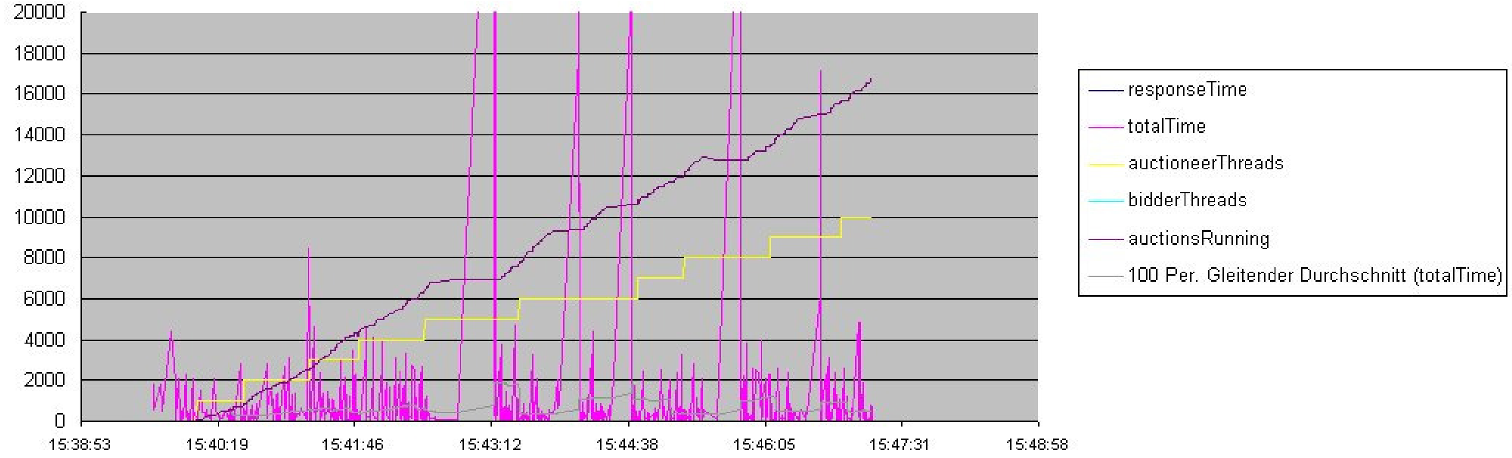
The diagrams in the following subsections will consist of a response time diagram and a connected diagram indicating the number of requests a node takes over at a time. This second diagram type goes back to the fact that a node maintains a list of waiting requests while processing one request. In a cluster, idle nodes will hence actively take over waiting requests. In our scenarios up to 20 requests may be taken over by a node.
The response time diagrams list the test duration in time of day on the x-axis while showing the response time in milliseconds (2000 ms for each horizontal line) on the y-axis. The yellow auctioneer thread lines indicate the generated load. Each second diagram uses symbols for each node of the cluster to show, how many requests have been taken over by that server at a specific point. This gives an impression of the load balancing strategy.

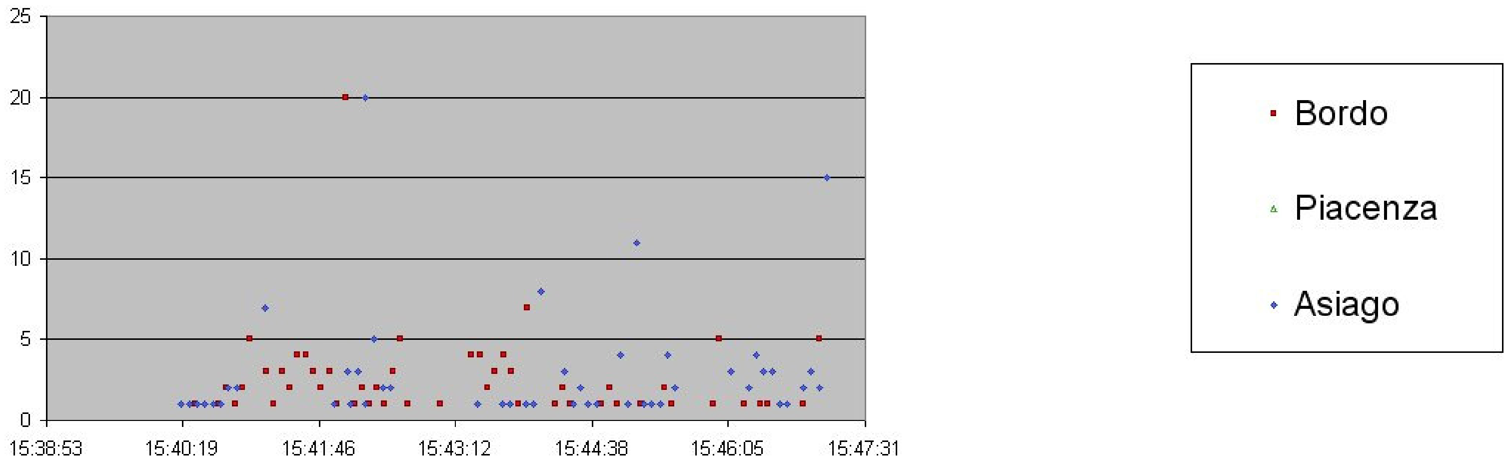
6.4.1 JBoss cluster 2 nodes 10 auctioneers



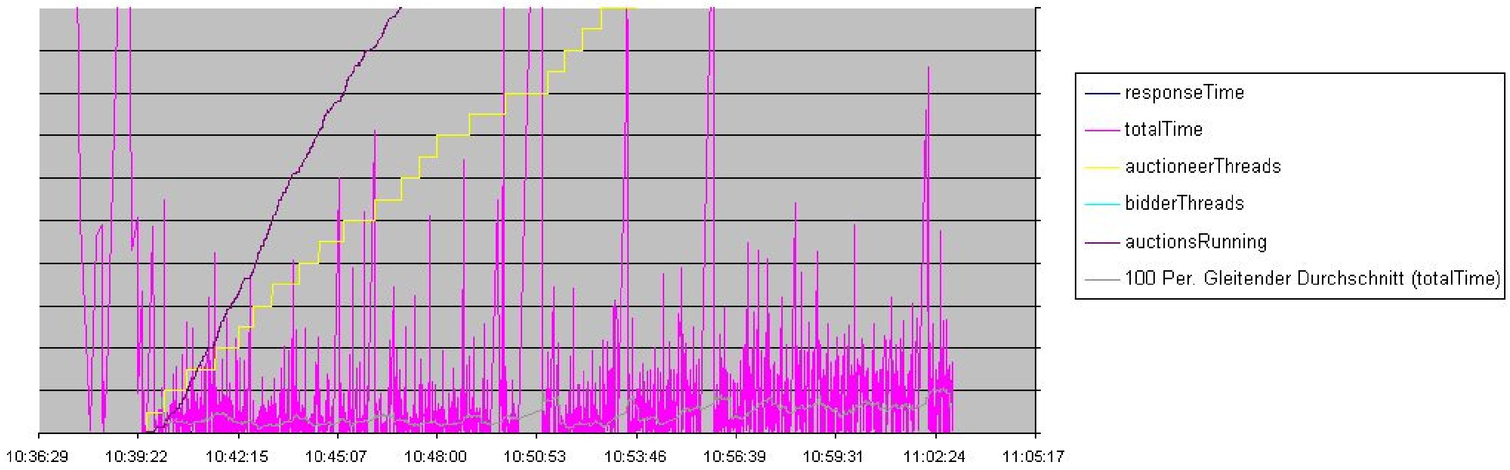


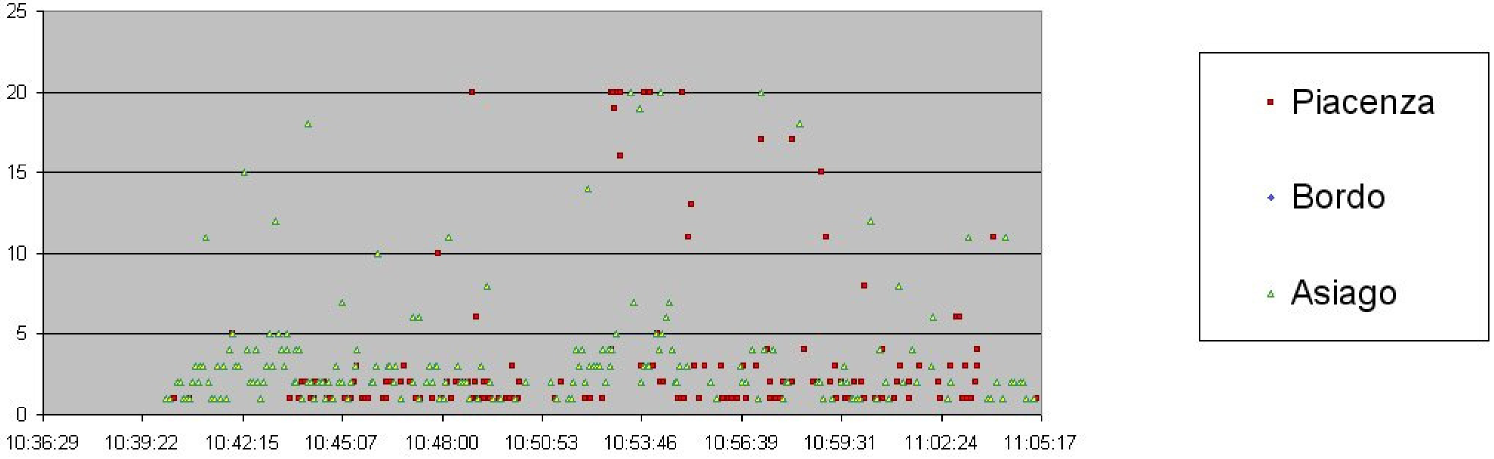
6.4.2 TAPAS cluster 2 nodes 10 auctioneers



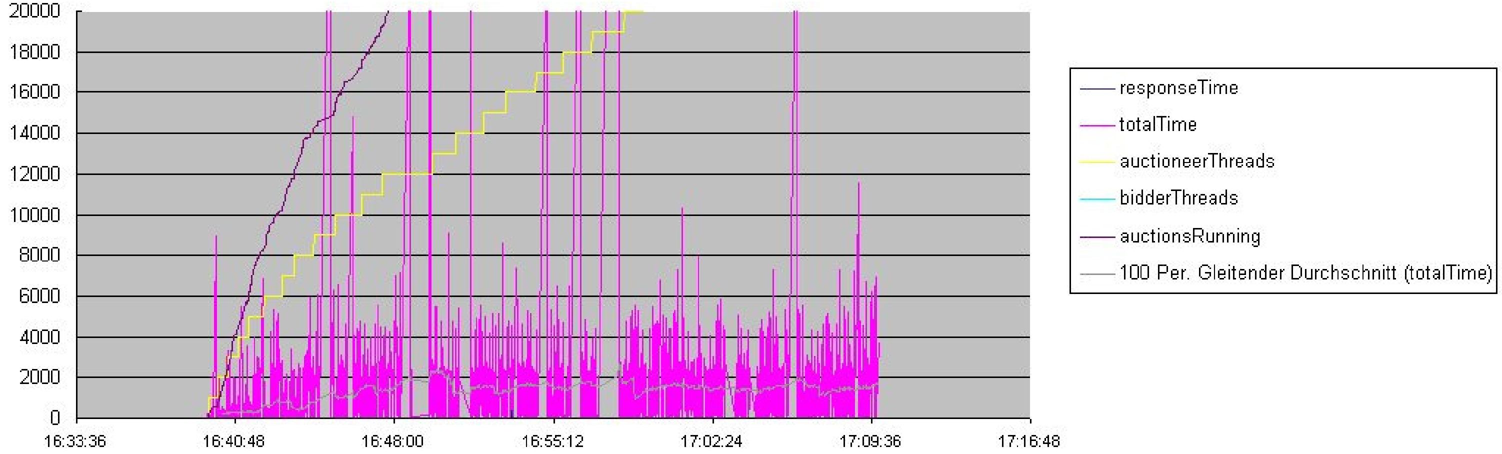


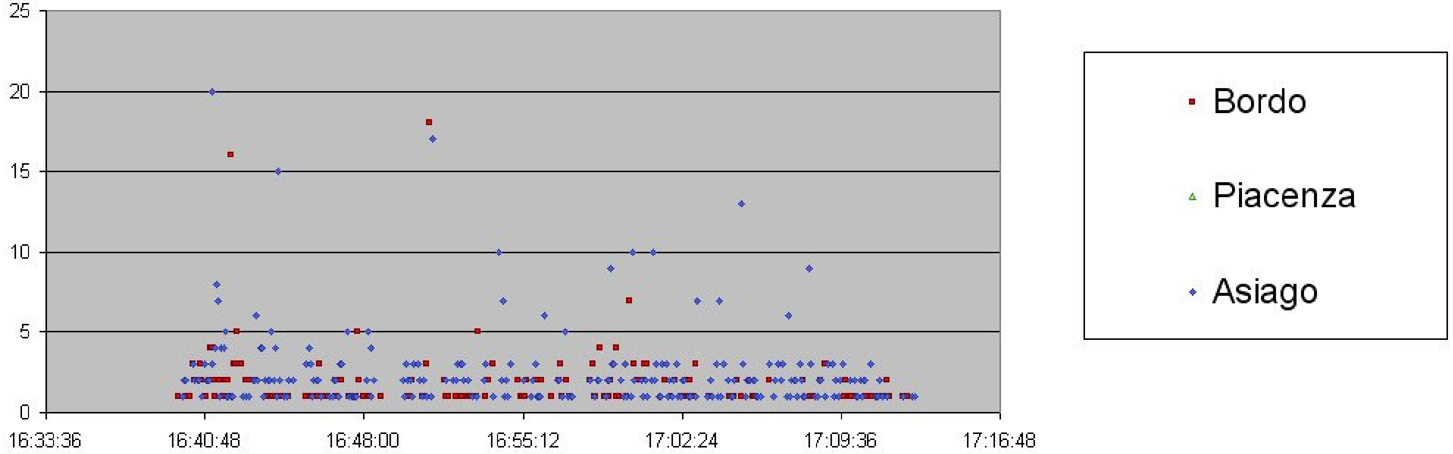
6.4.3 JBoss cluster 2 nodes 30 auctioneers



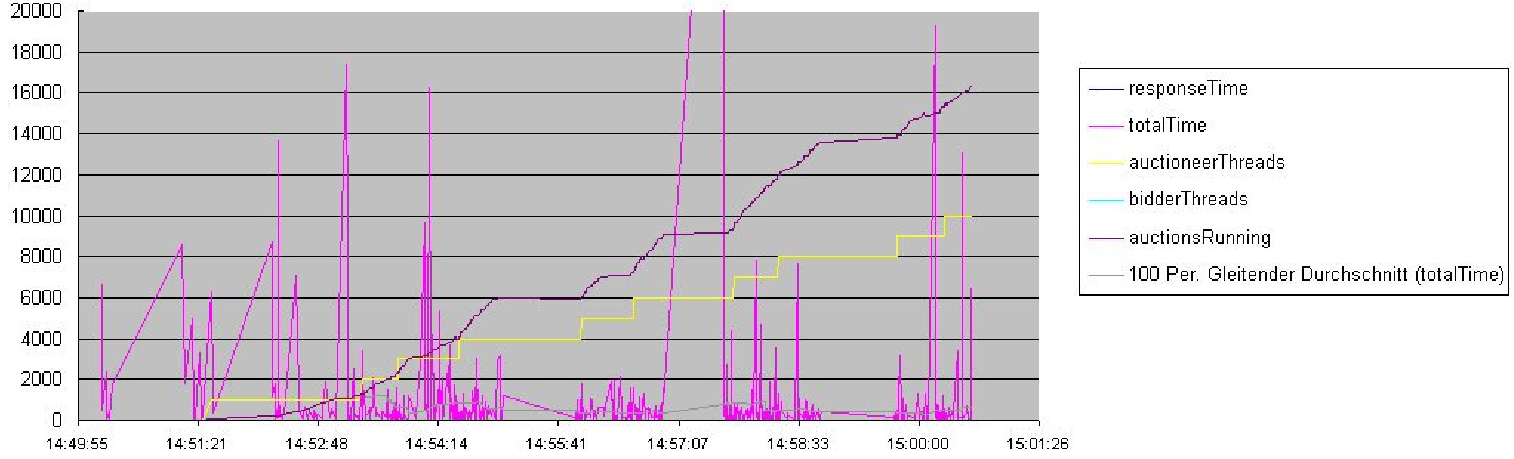


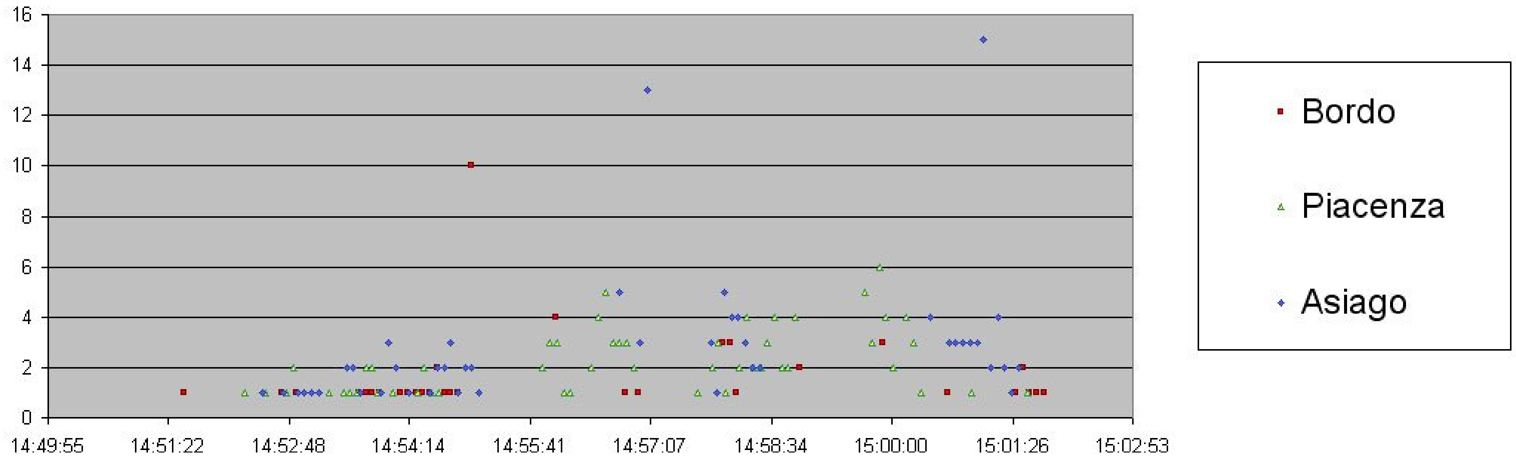
6.4.4 TAPAS cluster 2 nodes 30 auctioneers



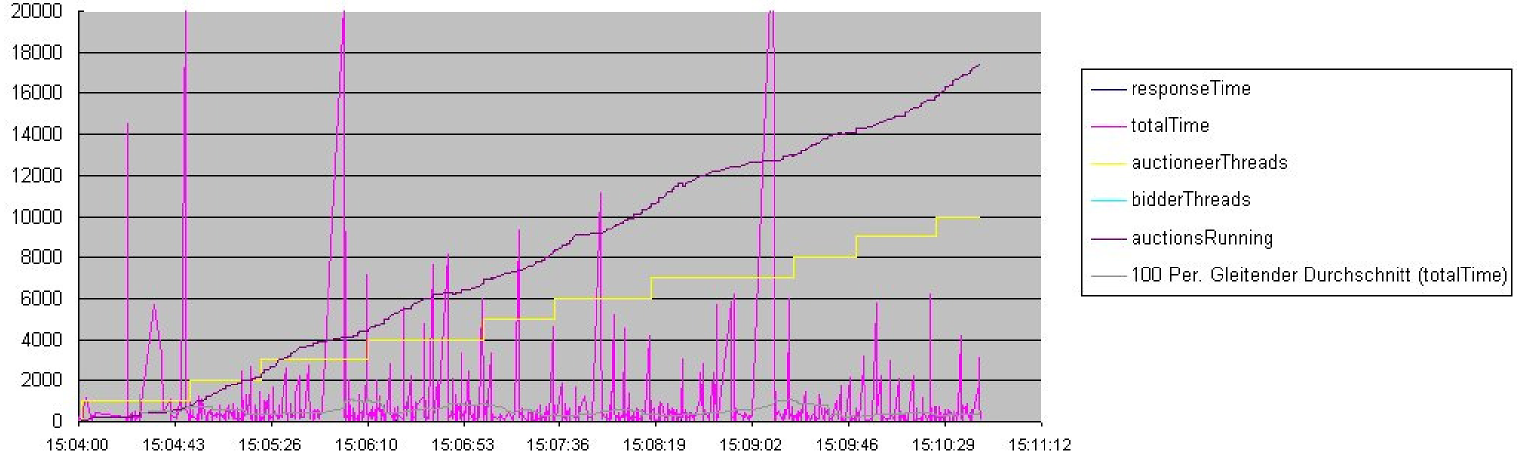


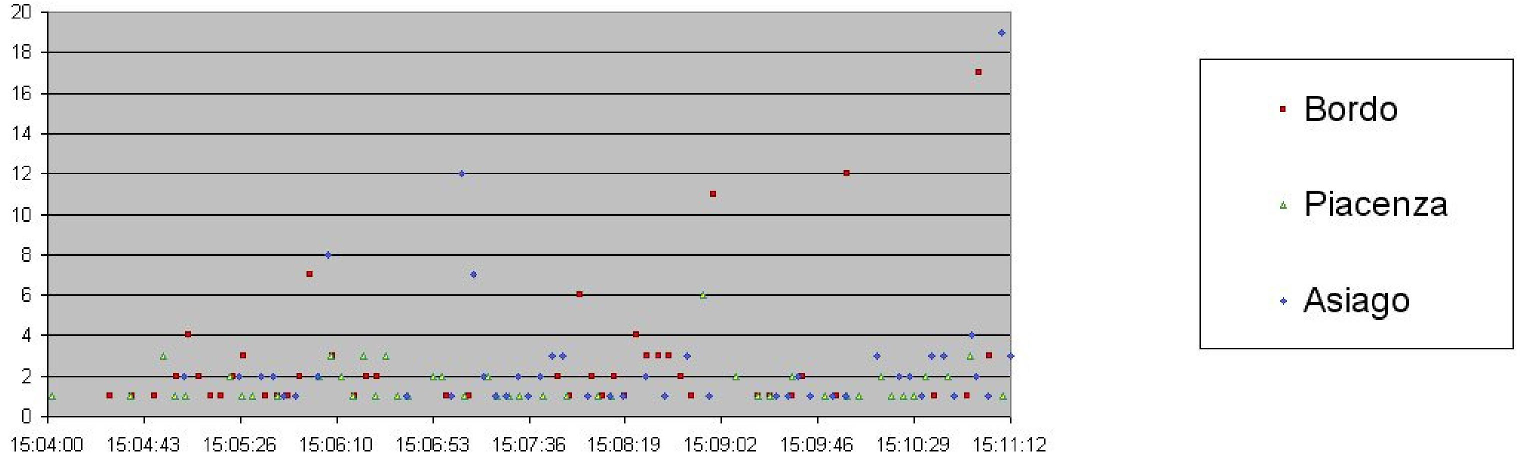
6.4.5 JBoss cluster 3 nodes 10 auctioneers



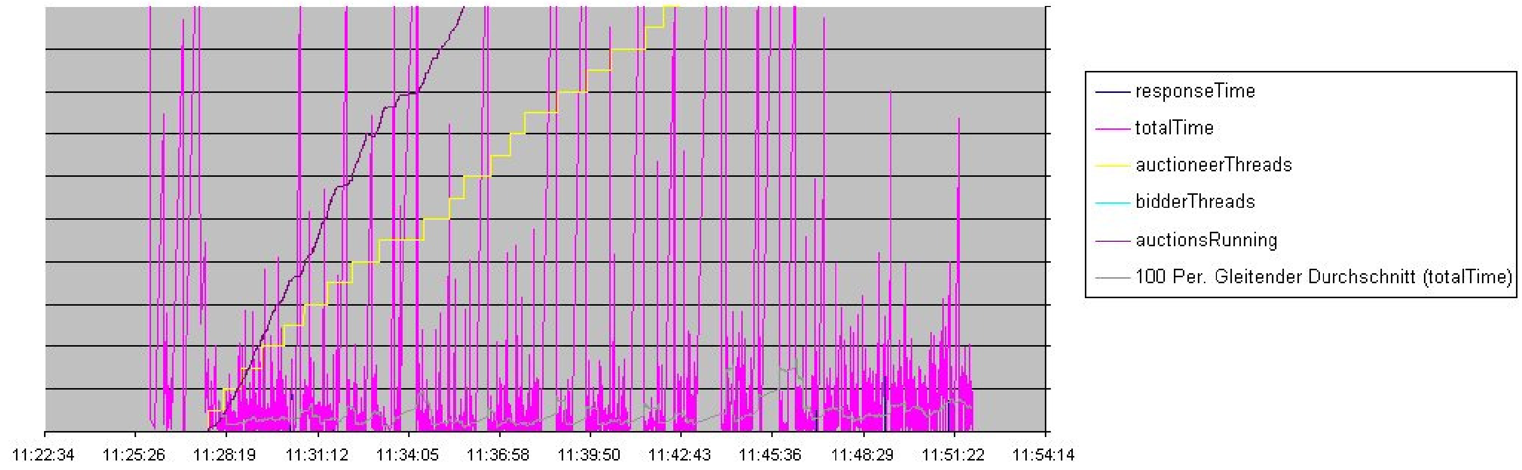


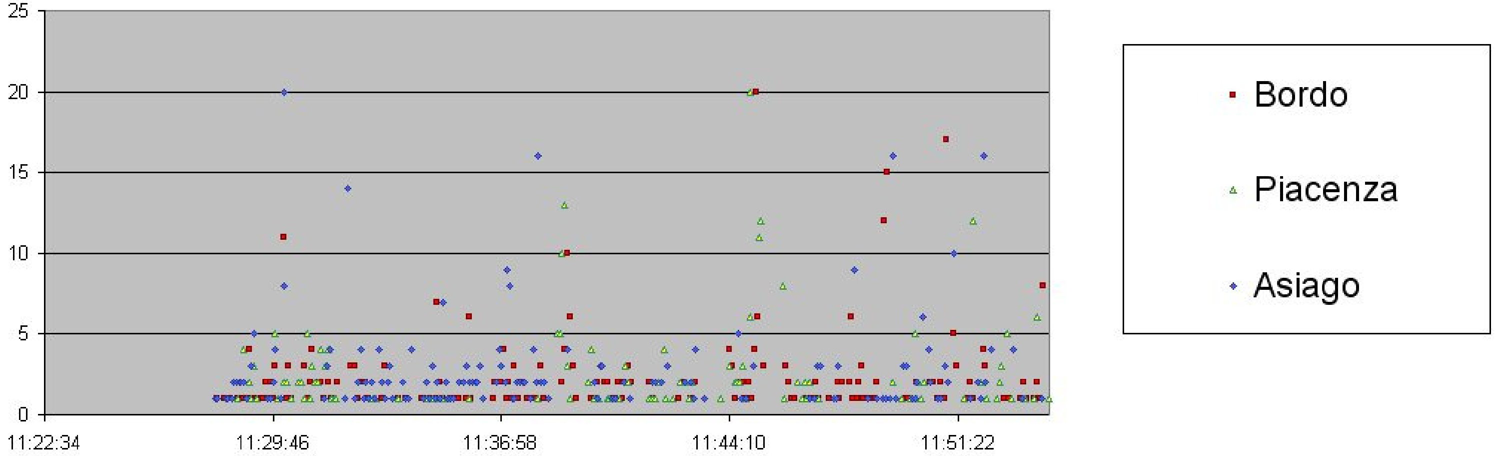
6.4.6 TAPAS cluster 3 nodes 10 auctioneers



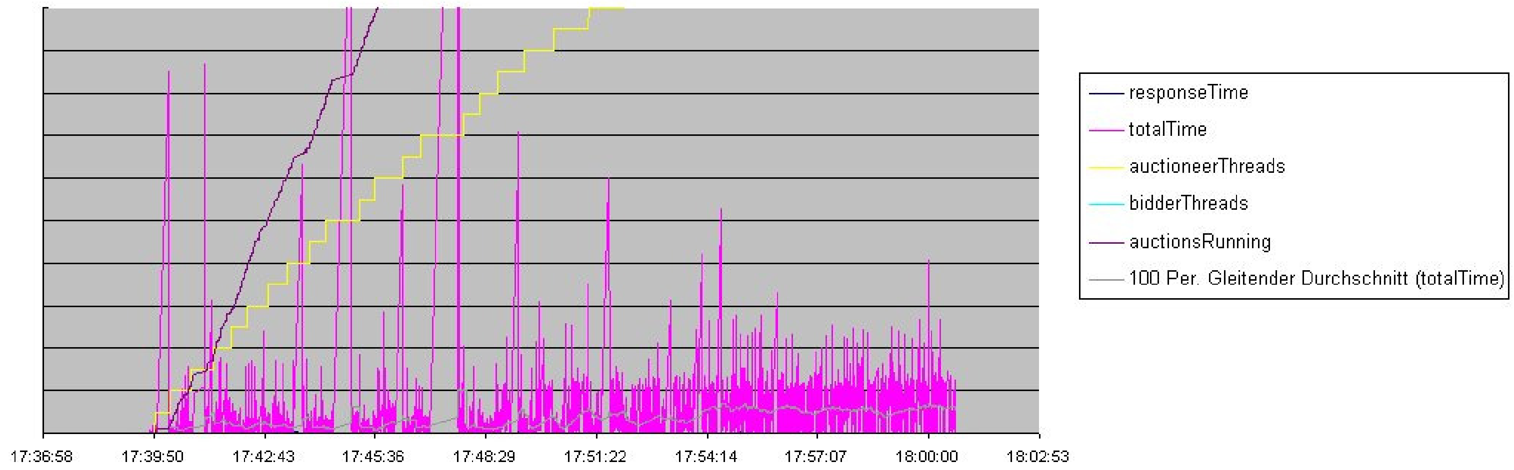


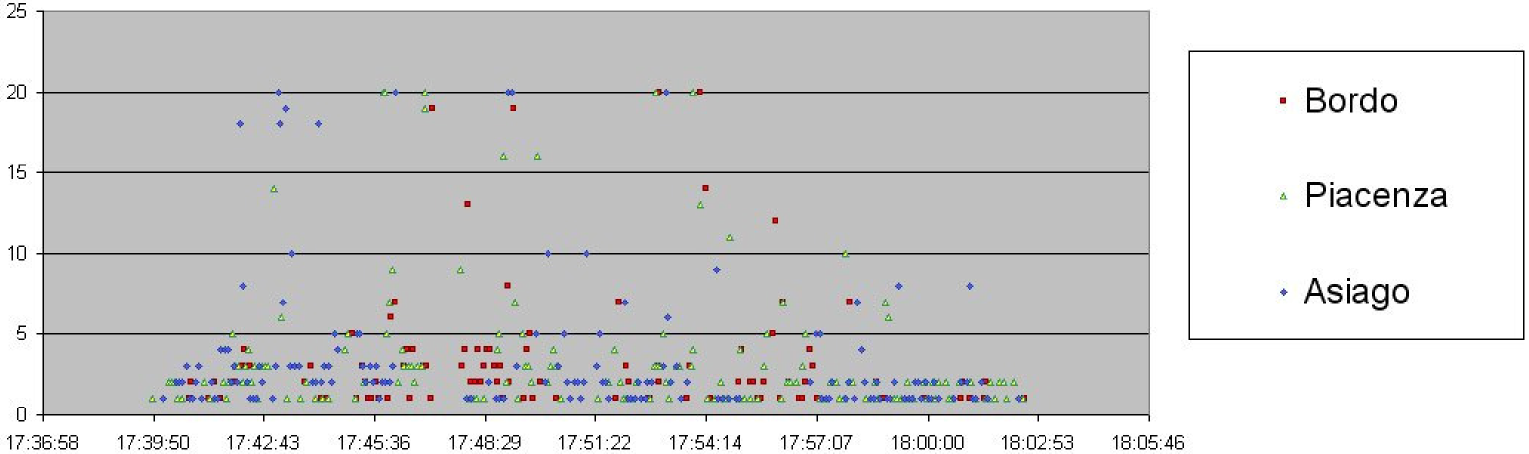
6.4.7 JBoss cluster 3 nodes 30 auctioneers



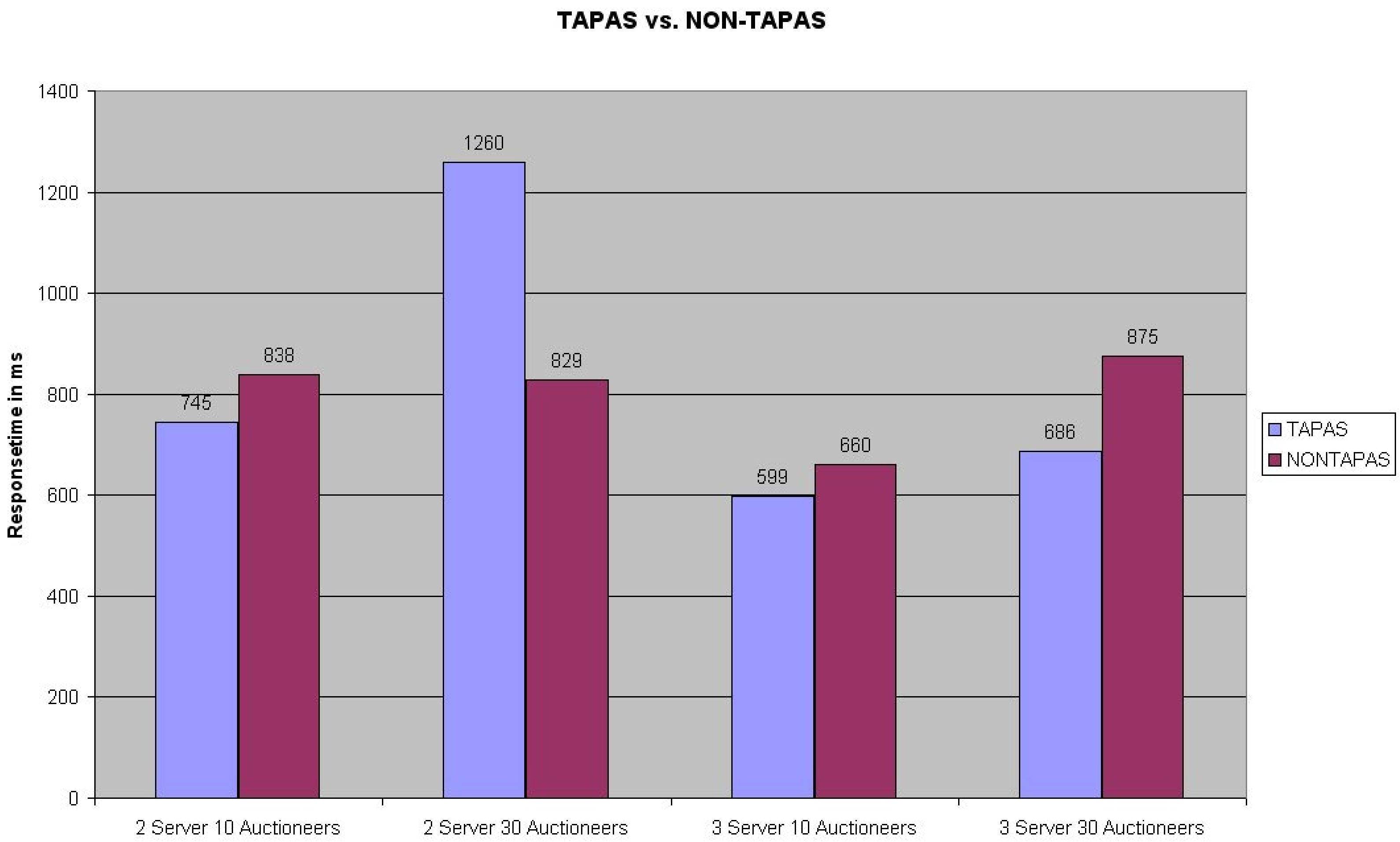


6.4.8 TAPAS cluster 3 nodes 30 auctioneers





6.4.9 Summary


TAPAS vs. NON-TAPAS
Responsetime in ms
1400
1200
1000
800
600
400
200
0
745
838
1260
829
599
660
686
875
2 Server 10 Auctioneers
2 Server 30 Auctioneers
3 Server 10 Auctioneers
3 Server 30 Auctioneers
TAPAS
NONTAPAS

This table lists the numbers of the diagram:

Server nodes	Auctioneers	TAPAS	JBoss
2	10	745	838
2	30	1260	829
3	10	599	660
3	30	686	875

Table 5

6.5 Used SLA (added 23 March 2005)


```
<?xml version="1.0" encoding="UTF-8"?>
<SLAng xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
        <Parties>
                <Client>
                        <Name>Facilitare Inc.</Name>
                        <Address>Frankfurt</Address>
                </Client>
                <Server>
                        <Name>Subito Inc.</Name>
                        <Address>Stockholm</Address>
                </Server>
        </Parties>
        <SLS>
                <Hosting>
                        <ClientResponsibilities>
                                <ContainerServiceUsage clauseId="Login" requestRate="100/sec">
                                        <Operations>
                                                <Operation name="login.jsp"/>
                                                <Operation name="login.do"/>
                                        </Operations>
                                        <Schedule>
                                                <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                                <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                                <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
```

```
                                <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                        </Schedule>
                </ContainerServiceUsage>
                <ContainerServiceUsage clauseId="CreateAuction" requestRate="100/sec">
                        <Operations>
                                <Operation name="visualizeAuction"/>
                                <Operation name="createAuction"/>
                        </Operations>
                        <Schedule>
                                <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                        </Schedule>
                </ContainerServiceUsage>
        </ClientResponsibilities>
        <ServerResponsibilities availability = "0.60">
                <OperationPerformance clauseId="login.do" CPUUsage="5.0" memoryUsage="20.50" avgResponseTime="5.0s"
avgThroughput="50/sec">
                        <Schedule>
                                <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                        </Schedule>
                        <Operations>
```

```
                <Operation name="login.do"/>
            </Operations>
        </OperationPerformance>
          <OperationPerformance clauseId="registerAuctioneer.do" CPUUsage="5.0" memoryUsage="20.50" avgResponseTime="5.0s"
avgThroughput="50/sec">
            <Schedule>
                <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
            </Schedule>
            <Operations>
                <Operation name="registerAuctioneer.do"/>
            </Operations>
          </OperationPerformance>
          <OperationPerformance clauseId="showAuctioneers.do" CPUUsage="5.0" memoryUsage="20.50" avgResponseTime="5.0s"
avgThroughput="50/sec">
            <Schedule>
                <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
            </Schedule>
            <Operations>
                <Operation name="showAuctioneers.do"/>
            </Operations>
            </OperationPerformance>

            <OperationPerformance clauseId="showBidderAuctions.do" CPUUsage="5.0" memoryUsage="20.50"
avgResponseTime="5.0s" avgThroughput="50/sec">
            <Schedule>
```

```
                                        <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                        <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                        <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                </Schedule>
                                <Operations>
                                        <Operation name="showBidderAuctions.do"/>
                                </Operations>
                                </OperationPerformance>

                                <OperationPerformance clauseId="showCheckInvitation.do" CPUUsage="5.0" memoryUsage="20.50"
avgResponseTime="5.0s" avgThroughput="50/sec">
                                <Schedule>
                                        <Cycle cycleId="mondays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                        <Cycle cycleId="tuesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="wednesdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="thursdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="fridays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                        <Cycle cycleId="saturdays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H"
period="P7D"/>
                                        <Cycle cycleId="sundays" startDate="2005-01-01" endDate="2005-12-31" duration="PT08H" period="P7D"/>
                                </Schedule>
                                <Operations>
                                        <Operation name="showCheckInvitation.do"/>
                                </Operations>
                                </OperationPerformance>
                        </ServerResponsibilities>
                </Hosting>
        </SLS>
</SLAng>
```