TOWARDS SERVMARK
AN ARCHITECTURE FOR TESTING GRIDS

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Introduction
Why Grid Service Benchmarking?

- Production Grids range from a few hundred to several tens of thousands of resources and services, and from few to thousands of users
- There is a need to understand and quantify the behavior and performance of such environments
- Evaluating the performance of services provided for a large number of wide-area distributed users is a non-trivial endeavor

Talk Outline

- Introduction
- Requirements for Grid Testing
- ServMark - A Grid Performance Testing Framework and the Starting Points
- DiPerF, GrenchMark, and ServMark Design Presentations
- Performance Metrics
- ServMark Validation, Setup, and Results
- Conclusions, Future Work, and Acknowledgments

Requirements for Grid Testing

① *Representative workload generation:* testing tools must create the conditions that the Grids were designed for

② *Accurate testing:* collected performance metrics are heavily dependent on the accuracy of various mechanisms employed by the testing framework

③ *Scalable testing:* the testing framework must be at least as scalable as tested system

④ *Reliable testing:* the testing framework must detect and account for its own failures, especially when operating in wide-area environments

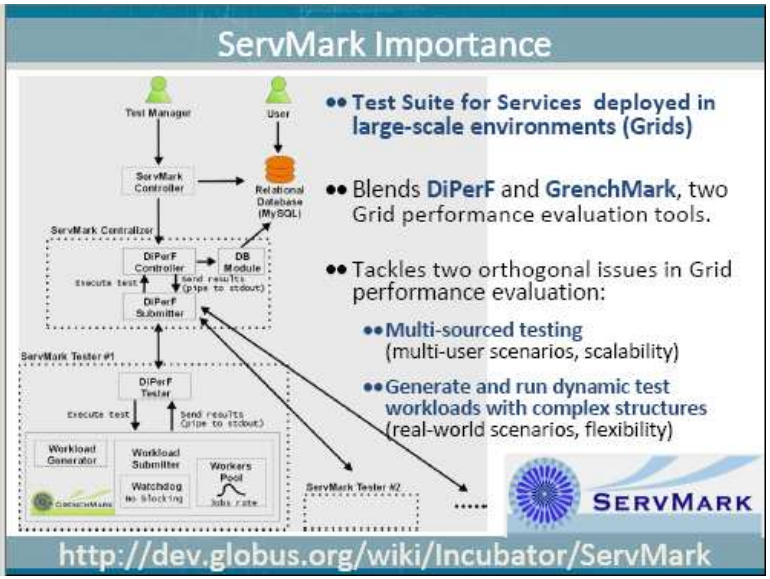
⑤ *Extensibility, Automation, and Ease-of-Use:*

- usability of a testing system is at least as important as its features
- without extensibility support, already obtained results would become obsolete, as they would not be comparable with those for the new systems
- automation and the ease-of-use can be summarized as *single-click testing procedure*

SERVMARK
A GRID PERFORMANCE TESTING FRAMEWORK

- Is aimed at simplifying and automating the testing process in real Grid environments
- Is capable of:
  - coordinating a pool of machines that test a target service
  - generating complex testing workloads
  - collecting and aggregating performance metrics
  - generating performance statistics
- Aggregates data and provides information on:
  - service throughput
  - service *fairness* when serving multiple clients concurrently
  - the impact of network latency on service performance, effectively enabling functionality and scalability testing

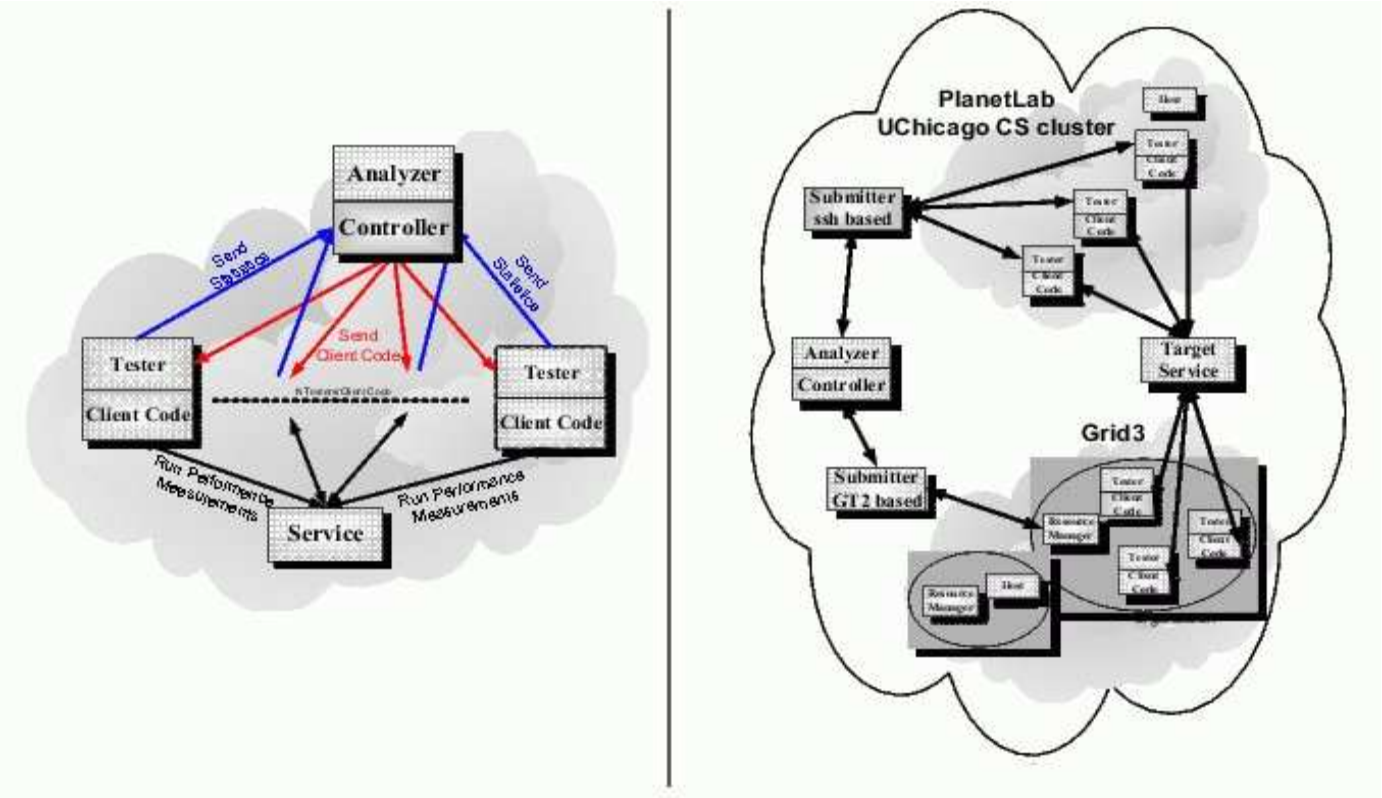
A GLOBUS INCUBATOR PROTOPROJECT



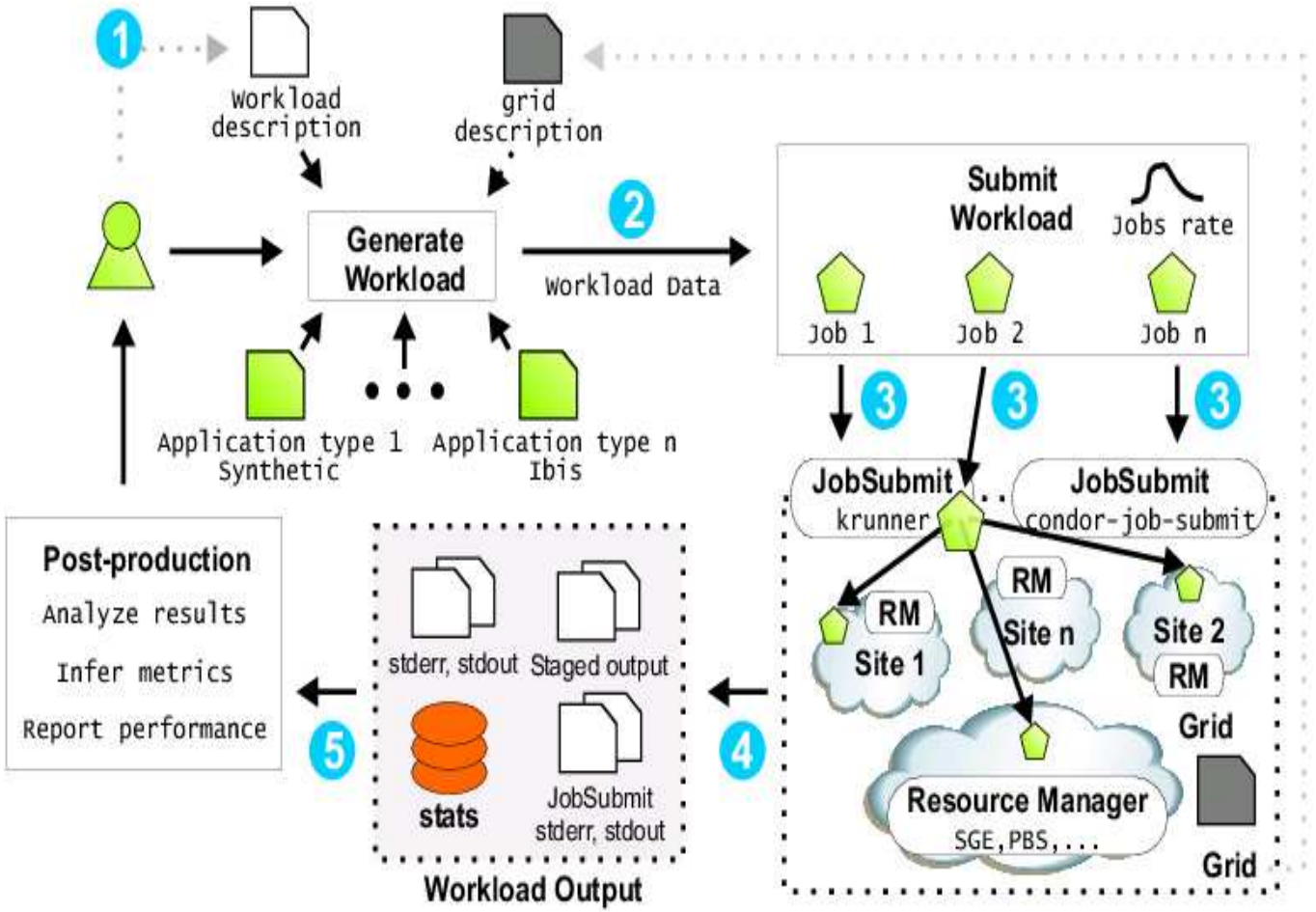
- ➜ Accepted: June 11, 2006
- ➜ Re-evaluated every quarter until either escalates into a full project or becomes obsolete
- ➜ Currently there are six comitters, but contributions and new members are welcome
- ➜ Presented at GGF'06 and SC'06 as part of the Globus Incubator (Proto)Projects

STARTING POINTS
DIPERF AND GRENCHMARK

➜ **DiPerF** coordinates a pool of machines, collects and aggregates metrics, and generates statistics



➜ **GrenchMark** generates and submits complex workloads



DiPerF Design
Four Components

- **The analyzer** receives the performance metrics from the distribution system and perform different operation on them in order to compute, for example, throughput
- **The controller** coordinates the performance evaluation experiment; it distributes the client code to testers via submitters and coordinates testers' activity
- **Submitters** provide the interface for distributing the testers and the testing client to the underlying testing environment (e.g., a Grid, a cluster resource manager, a P2P system, etc.)
- **Each tester** runs the client code on its local machine and times their (RPC like) access to the target service

GrenchMark Design

- Framework for synthetic Grid workload generation and submission developed in the Distributed Systems Group at Technical University of Delft, the Netherlands
- Allows new types of Grid applications to be included in the workload generation, or user's parameterization of the generation and submission processes
- Based on the concepts of unit generators, of job description files (JDF) printers, and of printers:
  - job description files describe at a high-level user's desired workloads
  - unit generators produce detailed descriptions on running a set of applications (workload unit) based on the description files
  - printers take the generated workload units and create end-system files suitable for grid submission
- Multiple unit generators can be coupled to produce a workload that can be submitted to a resource manager

Refined Requirements for ServMark

① Uniquely identify each test (*REQ1*)

② Automatically generate a multi-node test according to the user specifications (*REQ2*)

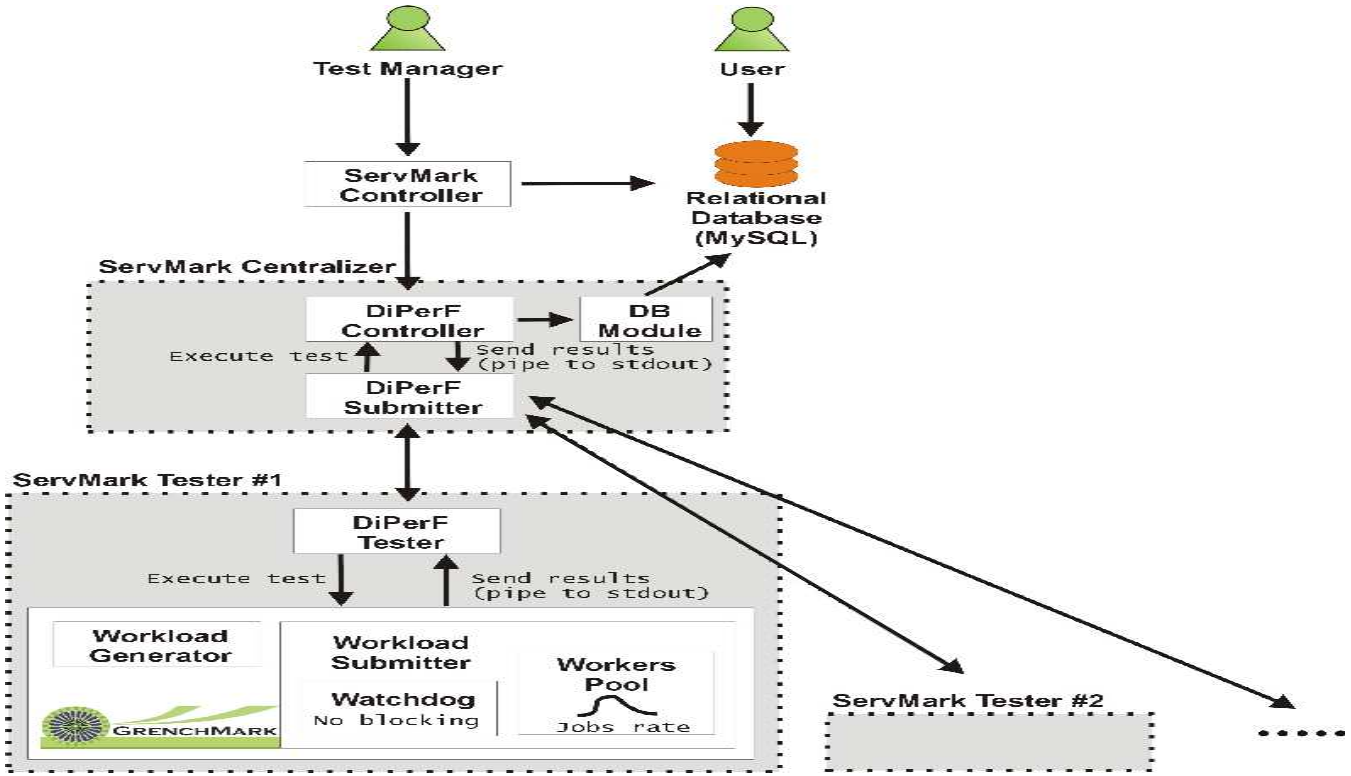
③ Store the test and make it available for replay (*REQ3*)

④ Run the test and store its results permanently (*REQ4*)

⑤ Analyze the results and compute complex statistics (*REQ5*)

⑥ Performance evaluation must be online: results should be able to be visualized as the testing process advances (*REQ6*)

Performance Measurement
A Closer Look at ServMark



ServMark blends DiPerF and GrenchMark, and:

- ➜ adds the necessary coordination and automation layer
- ➜ testers' management becomes *user-transparent*
- ➜ complex workloads are described by a few characteristics

ServMark's Default Performance Metrics

- **Service processing time**: time from request issuance to reply receiving
- **Service throughput**: number of requests completed averaged over a short time interval
- **Offered load**: number of concurrent service requests
- **Service fairness**: standard deviation for utilization when all clients are active
- **Job success rate (per client)**: the ratio of jobs that were successfully completed for a particular client
- **Job fail rate (per client)**: the ratio of jobs that failed for a particular client
- **Time to job completion (TTJC)**: difference between the moment of successful completion and the previous moment of a successful completion
- **Time to job failure (TTJF)**: for every failed job, the difference between the moment of failure and the previous moment of a failure

More Performance Metrics
Internal and User-Defined

- **Ping time:** the time required for a UDP packet round-trip
- **Clock skew among tester nodes:** the time difference among the controller and tester node, and used for clock fixing
- **User-defined:** any metric reported by a client under the following format:

  name: time (10^{11}.000000) value (0.00000) host.00000

TOWARDS REAL GRID TESTING, SERVMARK ...

- makes use of the properties of both its constituent systems in order to generate truly significant testing scenarios. First, by using a distributed approach
- is able to generate a wide range of testing conditions for many Grid environments and services
- synchronizes the time between client nodes with a synchronization error smaller than 100ms
- detects client failures during the test, and reports the failure impact on the obtained results' accuracy
- can be automated to the degree of a single-click testing procedure, especially for periodic functionality or performance testing repository

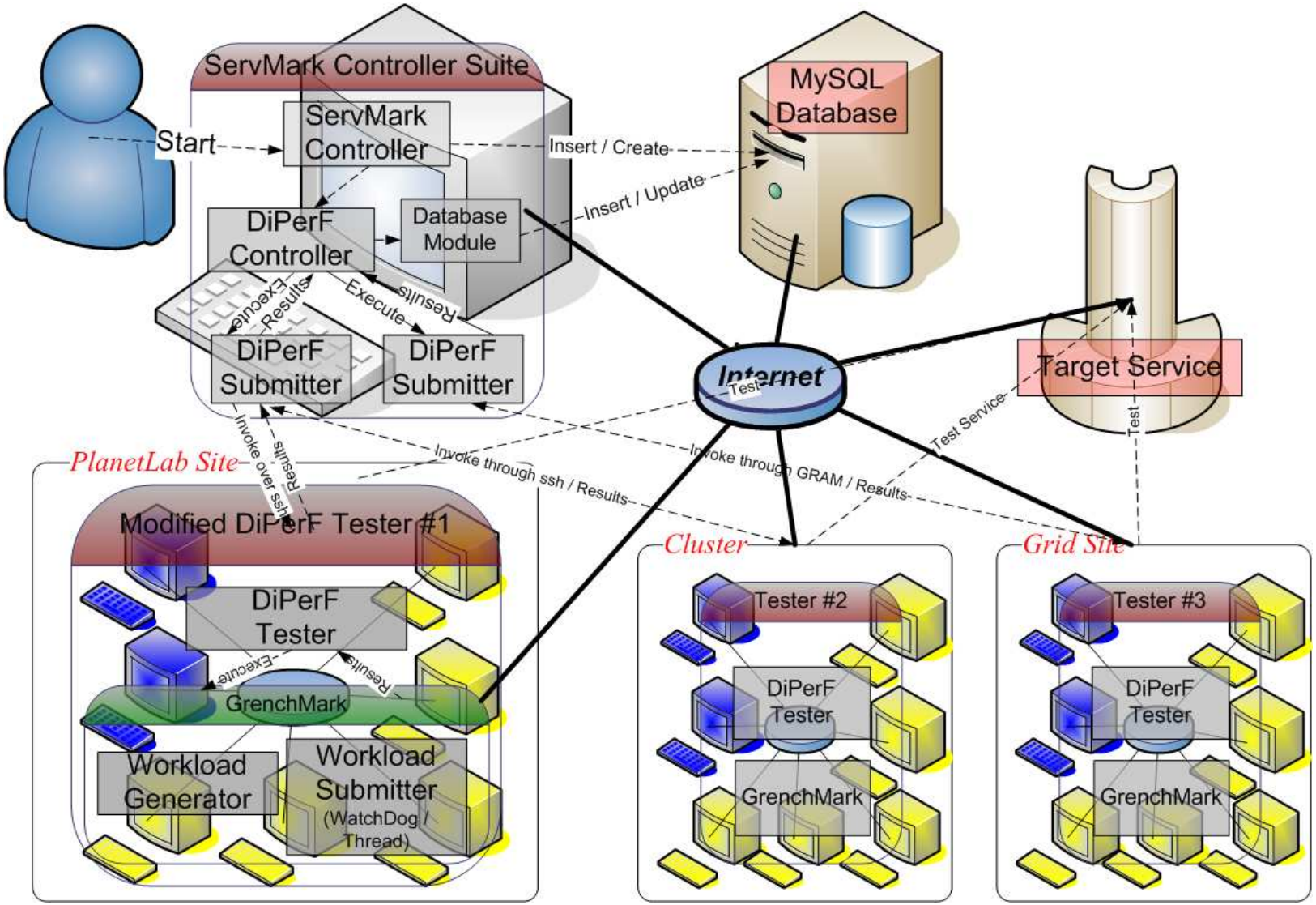
SERVMARK VALIDATION BY MEANS OF ...

- ➜ tests on fine-grained services deployed in real large-scale environments, which is a difficult aspect of the generic problem of testing services in P2P and Grid environments
- ➜ machines from PlanetLab (*a World-scale System*) and DAS-2 (*the Dutch Grid System*) testbeds
- ➜ measurements on the performance of six most-used web servers: *Apache*, *Null HTTPD*, *Apache Tomcat*, *Nweb*, *Jetty* and *Awhttpd*
- ➜ results capturing:
  - services' maximum throughput
  - service "fairness" when multiple clients access the service concurrently
  - the impact of network latency on service performance from both client and service viewpoint

TESTING SETUP

- **ServMark controller** was installed on *s8.uchicago.edu* located at *the University of Chicago*
- **Web servers** were started on *alice01.rogrid.pub.ro* located at *the Polytechnic University of Bucharest*
- **ServMark testers** were spawned on machines part of *PlanetLab*
  - for each test, 20 testers were run on hosts from *North* and *South America*, *Asia*, and *Europe*
  - each ServMark tester launched 100 HTTP requests, with a Poisson inter-arrival time distribution of λ = 1s
  - a request which remained unanswered for more than 25 seconds was considered to be faulty and was terminated

DETAILED TESTING SETUP



Results for Comparing Six Web Servers in WAN

Table 1: Service processing time for the six web servers (s)

Web Server	Average (Std. Dev.)	Minimum	Maximum	Weighted Average
Apache	1.0779 (0.647)	0.0810	16.5440	1.0969
Null HTTPD	**0.9442 (0.482)**	0.1244	30.4872	**0.9495**
Apache Tomcat	1.3617 (0.732)	0.1724	24.2665	1.3930
Nweb	0.9731 (0.565)	0.1293	10.9908	1.0152
Jetty	10.0745 (1.210)	0.2651	35.4375	9.0297
Awhttpd	1.1739 (0.558)	0.1242	29.5580	1.0117

Table 2: Time to job completion (TTJC) for the six servers (s)

Web Server	Average (Std. Dev.)	Minimum	Maximum	Weighted Average
Apache	**3.8803 (1.975)**	0.0022	13.5419	**3.6702**
Null HTTPD	3.9409 (1.922)	0.0177	11.7235	3.7446
Apache Tomcat	4.0902 (2.061)	0.0034	13.8347	3.8399
Nweb	4.0870 (2.008)	0.0393	14.1707	3.8613
Jetty	6.4677 (1.582)	0.0010	15.0310	5.9648
Awhttpd	4.1798 (2.041)	0.0106	13.9180	3.9005

Table 3: Time to job failure (TTJF) for the six web servers (s)

Web Server	Average (Std. Dev.)	Minimum	Maximum	Weighted Average
Apache	No Failures	-	-	-
Null HTTPD	2.7893 (0.000)	0.0000	5.5786	2.7893
Apache Tomcat	No Failures	-	-	-
Nweb	No Failures	-	-	-
Jetty	1.4840 (0.000)	0.000	17.8760	1.4840
Awhttpd	No Failures	-	-	-

Our Comments

- Results show the existence of three classes of web servers, very fast, fast and slow:
  - *very fast class*: Nweb, Null HTTPD, and Apache
  - *fast class*: Apache Tomcat, and Awhttpd
  - *slow class*: Jetty web server
- Observations:
  - very large service processing times in the case of the Jetty web server
  - Jetty web server is the only one using the Java platform and the Java Virtual Machine used during our tests was non-commercial

CONCLUSIONS

- Initial results demonstrate the operation of ServMark when testing fine-grained services in large-scale environments
- ServMark was tested on DAS-2 for simple shell commands, and PlanetLab for comparing the performance of six Web servers
- ServMark fulfills the main requirements for testing in large environments: generates workloads, provides accurate testing, is scalable and reliable, and supports extension
- In practice, ServMark can be easily used for complete automated testing (one-click scalability testing)
- *We conclude that ServMark is useful for testing P2P and Grid services and environments*

Future Work

- Better interface between users and the ServMark controller for alternative testing scenarios
- Alternative ways to send information from testers to the controller, i.e., through configurable push/pull mechanisms
- Integration with other systems for distributed resource management (.e.g., Condor, gLite)
- Complete porting to a fault-tolerant Grid service
- Many more tests and scenarios for validation purposes (ranging from monitoring systems, such as MonAlisa, to P2P systems, such as Tribbler)

THANKS ...

- ServMark is available from the Globus Incubator Project Web Site: *http://dev.globus.org/wiki/Incubator/ServMark*
- This TechReport (#0062) is available at: *http://www.coregrid.net/mambo/content/view/209/203/*
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AND
... ANY QUESTIONS?