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Thematic Priority: **Communication network development**

# D:JRA1.9: The first yearly report on the Job Submission and Job Monitoring task

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## Document Control Sheet

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## Executive Summary

This document describes the activity carried out in the Job Submission and Job Monitoring task during the first 12 months of the project; in particular, this report describes the work done from the start of the project (May 2006) to the end of month 12 (April 2007). The aim of the Job Submission and Monitoring task is to analyze and implement two OGF specifications of standard interfaces for Job Submission and Monitoring services. Specifically, the OGSA - Basic Execution Service (BES) and Job Submission Description Language (JSDL) are emerging as standard interfaces for describing and managing computational jobs in Grid systems. The JRA1 - Job Submission task within the OMII-Europe project will analyze these specifications, identify and propose possible extensions which can be useful for OMII-Europe infrastructures, and implement them in the different Grid middleware platforms, namely gLite, UNICORE, and Globus.

In particular, we considered the current JSDL and OGSA - BES specifications, checking whether the specifications are mature enough, and whether they provide enough functionality in order to be adopted in the middlewares of OMII-Europe. For JSDL, the final adopted specification v1.0 is available; while some features which are available in the job description notations used in the OMII-Europe grids are missing, JSDL provides a common core of basic functionalities which are surely enough for basic job submission and management; additional features can be implemented using a set of simple extensions which we identified and defined. The OGSA - BES specification, on the other hand, is still a working draft, so it is not possible to draw definitive conclusions. However, we believe that the OGSA - BES specification is mature enough to be taken into consideration: it provides a reasonable set of features, and some working prototype implementations have already been produced within OMII-Europe.

The activity performed so far in the JRA1 - Job Submission and Monitoring task resulted in two analysis documents being prepared; moreover, we also started the implementation of the OGSA - BES and JSDL specifications in gLite, UNICORE and Globus. These implementations are expected as Milestones MJRA1.9 and MJRA1.10, which are due at months 18 and 20 of the project, respectively. Nevertheless, we decided to start the implementations well in advance because (1) experience gained by actually implementing these specifications helped us to clearly identify their strengths and weaknesses, and (2) in order to have more time to cope with limitations and bugs on the tools which are used to handle Web services-related automated code generation. All in all, the activity within the JRA1 - Job Submission and Monitoring task is on track with respect to the planning contained in the project Technical Annex. No reason for deviation from the planning is foreseen at the moment.

## Table of Contents

## *Introduction*

A job submission and monitoring service is one of the basic functionalities of the most Grid systems available today. This service allows users to submit computational jobs to the Grid, manage them and monitor their progress. Job management involves suspending, resuming, or removing a Grid job. Monitoring involves checking the current status of the job. Moreover, job submission services also provide operations to handle the service itself, e.g. disabling further job submissions, check the service capabilities and so forth. The different Grid middleware platforms offer different interfaces for job submission and monitoring services today. This makes interoperability between different Grids extremely difficult: jobs originating on a Grid system cannot directly submitted to a foreign Grid, both because the job description notation is different and because the interfaces to the job submission services are incompatible.

In order to address these issues the Open Grid Forum (OGF) started the development of two specifications: the Job Submission Description Language (JSDL) and OGSA - Basic Execution Service (BES) specification. JSDL is an XML-based notation for describing computational jobs, while OGSA - BES is a Web Services-based standard interface for a Job Submission and Monitoring service. The JRA1/Job Submission and Monitoring task has two main goals: the first one is to analyse the OGSA - BES and JSDL specifications, in order to identify any missing functionality, and decide whether these specifications are suitable to be implemented in the Grid middlewares of OMII-Europe partners. The second goal is to actually implement these specifications, plus the identified extensions. Analysis of OGSA - BES and JSDL must be carried out during the first year of the project, while implementations must be done in the second year.

This task has strong relations with the JRA3 – Task 2 Infrastructure Integration and JRA3 – Task 1 Security tasks. The implementation of the OGSA - BES interface in gLite, UNICORE and Globus is an important step to achieve interoperability between these different systems. By using the OGSA-BES interface it is possible for a job originated, e.g. by UNICORE to be submitted on a gLite- (or Globus)-based system. Moreover, OGSA - BES-enabled job submission components can be used as standard components which can be easily integrated (plugged-in) into existing infrastructures. The JRA3 – Task 1 Security will give guidelines for authentication and authorization mechanisms which will enable secure job submissions to OGSA - BES services. In fact, the OGSA - BES specification does not mandate any security mechanism: it is then essential to couple OGSA - BES with suitable security mechanisms in order to propagate (and enforce) authentication and authorization information along with job submission and management requests.

Recently, within JRA3 it turns out that the new SAML-based Virtual Organization Membership Service (VOMS) ( of JRA1 – VOM) represent a crucial part of this process.

## *Partners and effort*

According to the approved description of work, this task will involve 4.7 staff years, INFN 2.3 (1.9 funded, 0.4 unfunded), FZJ 0.1 (0.1 funded), FLE 0.3 (0.3 funded), UEDIN 2.0 (2.0 unfunded). INFN will bring in EGEE expertise, FZJ and FLE will bring in UNICORE expertise and UEDIN will bring in GLOBUS expertise to this work. INFN leads this work.
The following table summarizes the person/months spent by each partner during the first year of the project, according to the monthly reports which have already been submitted. After a very brief manpower shortage during the first month, due to ramp-up effects, all the foreseen manpower was allocated to this task. At Month 7, INFN increased its manpower contribution to compensate the need for technical development and task coordination.

| Month | SOTON | FLE | FZJ | INFN | UEDIN | UCHIC | UWM |
|---|---|---|---|---|---|---|---|
| May 2006 | 0 | 0 | 0.05 | 1.0 | 0 | 0 | 0 |
| Jun 2006 | 0.5 | 0.15 | 0.05 | 0.66 | 1.0 | 0.5 | 0.25 |
| Jul 2006 | 0.5 | 0.15 | 0.05 | 1.0 | 1.0 | 0.5 | 0.25 |
| Aug 2006 | 0.5 | 0.15 | 0.05 | 1.0 | 1.0 | 0.5 | 0.25 |
| Sep 2006 | 0.5 | 0.15 | 0.05 | 1.0 | 1.0 | 0.5 | 0.25 |
| Oct 2006 | 0.5 | 0.15 | 0.05 | 1.0 | 1.0 | 0.5 | 0.25 |
| Nov 2006 | 0.5 | 0.15 | 0.05 | 1.3 | 1.0 | 0.5 | 0.25 |
| Dec 2006 | 0.5 | 0.15 | 0.05 | 1.3 | 1.0 | 0.5 | 0.25 |
| Jan 2007 | 0.5 | 0.15 | 0.05 | 1.3 | 1.0 | 0.5 | 0.25 |
| Feb 2007 | 0.5 | 0.15 | 0.05 | 1.3 | 1.0 | 0.5 | 0.25 |
| Mar 2007 | 0.5 | 0.15 | 0.05 | 1.3 | 1.0 | 0.5 | 0.25 |
| Apr 2007 | 0.5 | 0.11 | 0.05 | 1.3 | 1.0 | 0.5 | 0.25 |
| **Total** | **5.5** | **1.61** | **0.6** | **13.46** | **11.0** | **5.5** | **2.75** |

## *Progress*

As already introduced, the main goal the JRA1 - Job Submission and Monitoring task during the first year is to analyse the OGSA - BES and JSDL specifications, to assess whether they are suitable for implementation in the Grid platforms of OMII-Europe. If these specifications lack some features, these should be devised and — if necessary — fed back into the standardization process

within OGF. Moreover, the JRA1 - Job Submission and Monitoring task supports GRIDSAM within the UNICORE system. GRIDSAM (http://gridsam.sourceforge.net/) is a JSDL-compliant job submission and monitoring service which was developed by the OMII-UK project and recently supports an OGSA-BES interface. These goals of the JRA1 - Job Submission and Monitoring task have been documented in these documents which have been released as milestones of the project:

| Milestone | Due on | Delivered on |
|---|---|---|
| **MJRA1.7**: *"Definition of the required extensions needed to JSDL to satisfy OMII-Europe requirements"* | M6 | M6 |
| **MJRA1.17**: *"BES will be evaluated with respect to its adoption in the middleware of the OMII-Europe partners"* | M9 | M9 |
| **MJRA1.8**: *"GridSAM integration into UNICORE: architecture and implementation available"* | M12 | M12 |

An overview of the results of the milestones is provided in the following sections. We will also highlight the effort made by each paper towards each specific milestone, and towards the task goal in general.

## MJRA1.7: Analysis of the JSDL specification

One of the most important functionalities offered by any Grid middleware is the possibility of submitting jobs, which will then be executed on suitable computational resources. While the exact notion of "job" usually varies from Grid to Grid, there are many common features that represent a common minimal set. For example, a "job" usually consists of executing some executable program on a given processor; the program may operate on one or more input data files, and produce one or more output data files. Moreover, job requirements (minimum available memory, disk space, CPU speed) may be part of the job specification. The existence of those job features across different Grid platforms was the motivation of the development of common standards for job descriptions and job management. In this way users have a single notation for describing jobs, regardless of the system where they will be executed.

The Job Submission Description Language (JSDL) is an XML—based notation for describing the requirements of computational jobs for submission to Grid environments. The JSDL notation is defined by means of a normative XML Schema that facilitates the expression of those requirements as a set of XML elements.
The JSDL specification is motivated by the need to achieve interoperability by different Grid job management systems; in fact, it is not uncommon that the same user community uses different Grid systems at the same time, each with its own notation for describing jobs. In this scenario, a common, standardized notation such as JSDL is clearly desirable. Therefore, the aim of JSDL is to provide a notation for describing the structure and requirements of individual jobs.

Other, equally important, aspects of job submission and management are outside the scope of JSDL. For example, many Grid systems provide the notion of "structured job collections"; as an example, in the gLite and UNICORE systems, a DAG (Directed Acyclic Graph) can be used to represent workflows where multiple, independent jobs can be scheduled according to a set of user-defined inter-job dependencies. Most Grid systems have similar features; however, these are outside the scope of the JSDL specification that basically focuses on simple "atomic jobs". While the JSDL specification is general enough to encompass the basic features of most Grids, there are many other specific features which are not present. The JSDL specification has an extension mechanism by means it is possible to define extensions to JSDL, and add specific additional information. In the report for the MJRA1.7 milestone we identified the extensions to be used in gLite, UNICORE and Globus. In general, the standard JSDL specification allows the user to specify enough details on a job to be processed by these three systems. So, plain JSDL jobs can actually be sent and processed by the abovementioned Grid systems. In order to take advantage of specific features of the underlying middlewares, JSDL extensions have been described in the milestone document.

More recently, the OGF HPC-Profile evolved as a profile that combines the usage of OGSA-BES and JSDL into one profile suitable for HPC environments that are often accessed via UNICORE. This includes particular sets of JSDL elements specialized for HPC environments and thus, in addition to the overall task goal, UNICORE is HPC-Profile compliant that includes JSDL and OGSA-BES and the necessary additions to JSDL for HPC environments.

For this milestone to be completed, all the partners contributed expertise related to the requirements for their own Grid middleware: INFN identified extensions to be used in the gLite infrastructure; FZJ and FLE identified extensions to be used in UNICORE, while UEDIN, SOTON, UCHIC and UWM provided feedback for Globus. The current job description notations used in the three infrastructures were analyzed and compared with the features provided by JSDL. Important pieces of information which cannot be recovered from those provided in the JSDL will be passed using extensions which have been described in the milestone document. During the early phase, INFN also developed a converter from JSDL to the native job description notation used in gLite (Job Description Language, JDL). Native support for JSDL will be included in UNICORE and in the CREAM Computing Element of gLite during the second year of the OMII-Europe project, as required by MJRA1.9 milestone. JSDL is also being supported by Globus: GRAM in GT4.2 will include native support for JSDL and RSL, by translating JSDL (and RSL) into GRAM's internal Job Document Description.

## MJRA1.17: Analysis of the BES specification

The OGSA—Basic Execution Service (BES) specification describes a Web service interface for creation, monitoring and control of computational jobs. The meaning of "computational job" is quite broad: it could be a Host Operating System process, or even Web services of parallel programs. In the BES terminology, such a computational job is called *activity*. Activities are

described using the JSDL notation. In particular, a BES-compliant service exposes three different set of functionalities:

- BES-Factory: functionalities to create, monitor and control a set of activities, and monitor BES attributes
- BES-Activity: functionalities to create, monitor and control individual activities
- BES-Management: functionalities to control the BES server itself

The following illustration shows the general application framework of OGSA - BES and JSDL. As can be seen, different client applications are able to send computational jobs described in the standard JSDL notation to different OGSA - BES-compliant Grid systems. By implementing a common set of specifications, client applications are able to harness the power of multiple Grid systems without any additional effort.

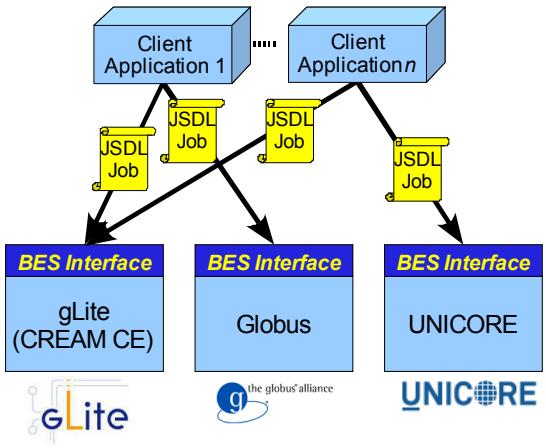



*Illustration 1: Job Submission through BES*

The OGSA - BES specification has many useful features. It supports "Idempotent execution", which refers to the ability of identify (and ignore) duplicate requests. This can be important for operations such as creation or termination of jobs, which are not idempotent by definition: if the service receives two copies of the same request to create a job, two different jobs will be created instead of one. Furthermore, OGSA - BES services may allow clients to subscribe for status change notifications. This means that client applications may instruct the BES service to send notifications each time the status of a job changes. Notification handling, strictly speaking, is not part of the BES specification itself, but it is done according to the WS-Notification specification (which can be implemented on the same service alongside with BES).

The OGSA - BES specification is still under development, although it is currently in the *public comment* phase. Implementing an evolving specification is always risky, as changes in the specification may arise unexpectedly during the standardization process. For an OGSA-BES Supercomputing 2006 interoperation demo, for instance, it was decided to temporarily "freeze" the

draft version 26 of the specification so that implementers could have the time to implement that version of OGSA - BES. However, we expect that the specification will be finalized shortly, and within the timeframe of the OMII-Europe project. Therefore we will be able to provide a stable implementation by month 20 (as requested by MJRA1.10 milestone: “OMII-Europe supports BES plus required extensions”). Currently the middleware platforms all adopt the most recent version that is draft 33. The interoperability of these implementations is tested within the JRA3 Task 2 activity during the deployment of the implementations in the multi-platform Grid infrastructure.

The OGSA-BES itself is concerned with job submission and management, so security considerations have been kept out of the specification. However, it is obvious that actual deployment of OGSA – BES - enabled services will need a strong authorization and authentication mechanism. To provide an example, within the Supercomputing 2006 interoperation demo, the services were required to implement the WS Security - Username Token specification over HTTP/SSL encrypted connections. This simple approach was only an interim solution for the demo itself, and is not suitable for large-scale deployment. The OMII-Europe project has a task, in particular JRA3 Task 1 - Common Security Infrastructure, whose goal is to define a core set of security features that will enable users to make use of multiple middlewares with a single underlying security infrastructure. The primary focus will be on interoperability between Globus, gLite, and UNICORE, and eventually will result in the definition of a common security technology "profile". This document should describe a set of technologies and standards, or sub parts of these, that will and can be supported by all the "compliant" Grid middlewares and baseline technologies.

The OGSA - BES specification states in its introduction that implementations may support other resource models and related access mechanisms, in particular by composing appropriate port-types from the WS-RF/WS-Notification, WS-Transfer/WS-Eventing or WS-ResouceTransfer families of specifications. However, details on how OGSA-BES-compliant services are expected to do that in a commonly agreed way are not given. The rendering of OGSA-BES activity properties within the WS-RF Basic Profile is sketched in Appendix I of the specification, but that is not intended to be normative. It is advisable that more normative details are given with respect to the optional WS-RF binding of the specification. This, for instance, can be realized by the OGSA-BES group by providing one core specification of OGSA-BES in abstract IDL. In addition, separate rendering documents that define the concrete mappings of the abstract OGSA-BES functionality to the correspondent models WS-RF, WS-Transfer, and others could be defined. However, since the process of the specification is already quite far in the OGF editorial process it is not assumed that they will change their style of the document.

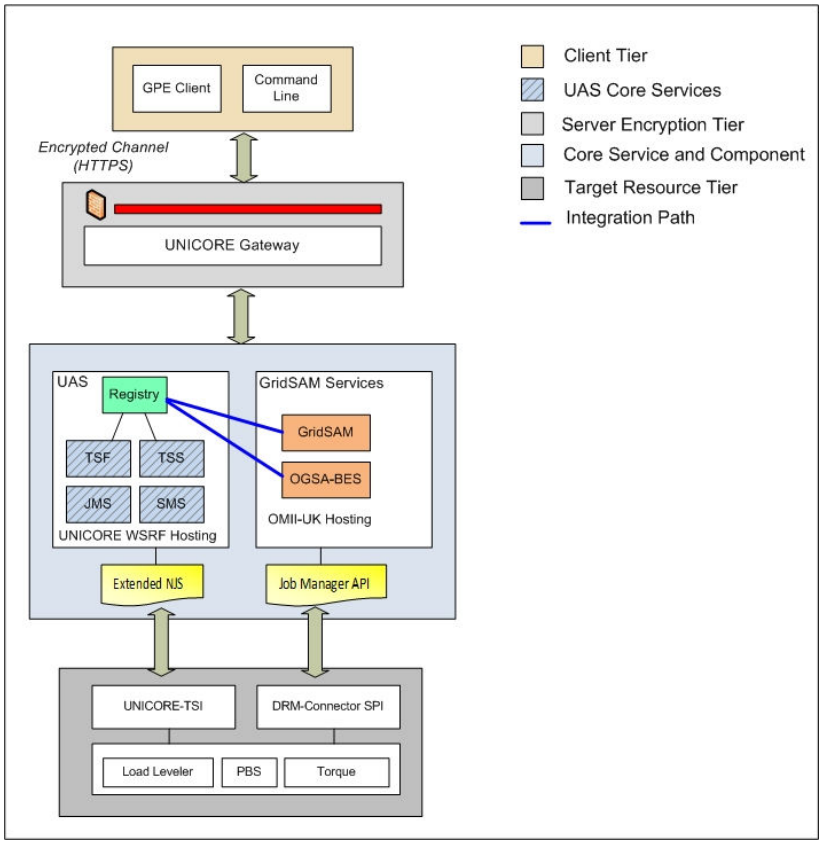
During the adoption of OGSA-BES (which implies JSDL) within the project it becomes clear that OGSA-BES has some issues. We provide an example in the context of the UNICORE Grid middleware and its adoption of OGSA-BES. In particular, within the European UNIGRIDS project, the UNICORE community has developed the UNICORE Atomic Services (UAS). Although the project ended in July 2006, its defined uniform interfaces to Grid Services, the UAS, lead to a major impact on the Grid community since it was the first time that UNICORE and Globus developers

worked together on a standard execution interface to their systems. In more detail, both communities jointly developed the Execution Services Interface (ESI) taking Globus GRAM execution management requirements and requirements of the UAS of UNICORE into account. The ESI specification in turn was given as a comprehensive input into the OGSA - BES working group of OGF. The idea was that the OGSA-BES specification should be revised by taking the ESI specification into account that contents requirements of the UNICORE and Globus community.

While OGSA-BES only focuses on simple job executions that are described by JSDL documents, the UAS on the other hand cover this functionality, but also provides an interface for storage and file transfer, named as Storage Management Service and File Transfer Service. Both are still needed in conjunction with OGSA-BES in order to provide the basic functionality that is needed for JSDL-based job executions that rely on staged data. Data staging is an important feature which is needed for job execution, since many jobs rely on input data. However, since this issue is outside the scope of OGSA-BES, a new OGF group has been created that will eventually cover the functionality of the File Transfer Service of the UAS, named as the OGSA - Data Movement Interface (DMI) working group. Nevertheless, a concrete interface to storages such as the Storage Management Service of the UAS is still missing, but there is already some work in the Grid Storage Management (GSM-WG) that might be useful as well as implementations in the context of storage resource managers (SRM) and storage resource brokers (SRB). This raises a demand for the adoption of the OGSA-DMI specification and storage managers by BES-compliant services in general, and by the middleware platforms of OMII–Europe in particular. Hence, it is strongly recommended by this JRA1/Job Submission activity that OMII-Europe 2 will try to augment the major Grid middleware platforms with the upcoming OGSA – DMI interface developed in OGF as well as support for storage resource managers/brokers. The adoption of these technologies in conjunction with OGSA-BES will lead to a powerful standardized interface collection to Grid platforms in the future.

Again, in this Milestone each partner contributed experties on its own Grid infrastructure. INFN contributed expertise for gLite, FLE and FZJ contributed expertise for UNICORE and UEDIN, UCHIC and UWM contributed Globus expertise. Similarly to what was done for milestone MJRA1.7, we started by examining the current job submission interfaces used in gLite, UNICORE and Globus. We observed that BES provides a limited but useful set of common features which can fit in the different Grid middlewares without major modifications.

## MJRA1.8: GRIDSAM implementation in UNICORE




*Ilustration 2: GridSAM integration into UNICORE 6*

Illustration 2 shows the integration of GridSAM into UNICORE 6 Grids according to the description of work. In short, the GridSAM endpoint can be an alternative job execution system deployed on a UNICORE 6 behind the UNICORE 6 Gateway. This includes that the GridSAM Web service is registered at the UNICORE 6 Registry service (WS-ServiceGroup) and thus be accessible by clients that query the Registry for services as usual in UNICORE 6 Grids. After authentication at the UNICORE 6 gateway a job submission/monitoring request is just forwarded to GridSAM instead to the TargetSystem Service (TSS) or TargetSystemFactory (TSF). More information can be found in the technical milestone document M:JRA1.8 in the Intranet.

FZJ and FLE contributed UNICORE expertise for this milestone.

## Conclusion

During the first year of the OMII-Europe project, the JRA1 - Job Submission and monitoring task analysed and started implementations of the JSDL and OGSA-BES specifications. JSDL provides standard notations for describing computational jobs to be submitted and executed through a Grid system. OGSA-BES provides a standard specification for an interface to job submission and

management services. Therefore OGSA-.BES-compliant services accept JSDL documents and instantiate new jobs according to the received request. These services also provide operations for job management such as cancelling, suspension, resuming and status querying of jobs. The JSDL and OGSA-BES specifications are an extremely important step towards interoperability between Grid systems. Together with the outcomes of the JRA3 activity, the OMII-Europe project could provide the building blocks to create "federated system" of Grids sharing resources to users. We envision a scenario where jobs originating on a Grid system can be transferred (provided that the users which originated them have are authorized to do so) to another Grid in the federation as seamlessly as they were executed and managed on the originating system. Initial scenarios like that are tested within the multi-platform Grid infrastructure of JRA3. During the first year of the project we assessed the feasibility of implementing OGSA-BES and JSDL in order to achieve interoperability. The result of this assessment is positive: OGSA-BES and JSDL, in their current status, are complete enough such that they have been implemented in gLite, UNICORE and Globus middlewares as an alpha prototype. Furthermore, the OGSA-BES implementation of GridSAM was integrated into UNICORE 6. An important missing piece (security) is being investigated within the JRA3 - Security activity of the OMII-Europe project. Recently it turns out that VOMS will be one important cornerstone of the mentioned security profile and thus initial development in JRA3 – Task 2 focus on an interoperability of the OGSA-BES interfaces with VOMS. In the second year of the project, we will provide full support for OGSA-BES and JSDL, with additional support for security (authentication and authorization), by using the outcomes of the JRA3 activity. OGSA-BES and JSDL compliant job submission and management services developed within JRA1/Job Submission will be used by the JRA3 – Task 2 task for the important interoperability tests. The JRA1 - Job Submission task has the following milestones in the second year of the project:

MJRA1.9 (due at month 18): Implementation of JSDL into OMII-Europe middleware together with the previously identified extensions;
MJRA1.10 (due at month 20): OMII-Europe supports BES plus required extensions.

The overall progressing and status of this activity is very good and in fact slightly ahead of the required milestones of the technical annex, therefore we are confident that the next milestones will be achieved in time.

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