ILDG Middleware Working Group Status Report

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We report on the status of the ILDG Middleware Working Group.

1. INTRODUCTION

The Middleware Working Group was formed with the aim of designing standard middleware to allow the interoperation of the data grids of ILDG member collaborations. Details of the working group are given in section [section]. In this contribution we outline the role of middleware in the ILDG, present our proposed middleware architecture and discuss our current status and future work within the working group.

1.1. What is Middleware

Consider a lattice gauge theory practitioner in the US wishing to retrieve data from the data grid in the UK. He\(^1\) is used to the way things work in the US. However, for historical reasons, the UK has developed its own drive on the left grid software before the advent of the ILDG. The US and UK systems are different. They use different databases for the catalogues. They use different storage systems. How is the researcher to avoid the headache of re-learning everything he has painstakingly learned about the US data grid?

The researcher interacts with applications (such as web browsers) which we will also refer to as clients. The actual databases holding the catalogues and the storage systems are called the back end. The middleware comprises of the layers of abstractions, interfaces, services and protocols between the applications and the back end. One piece of middleware for example would be a front end to a catalogue that an application could send queries to in a single standardised way, irrespective of the actual back end database. Another piece of middleware may be an abstraction such as the concept of a logical name given to a piece of data. The logical name differs from a filename in the sense that it does not encode the location of the data. Hence applications dealing with logical names instead of file names can immediately work between different grids sharing the namespace of files. However, in order to retrieve the data, logical names still need to be resolved to actual file names. This can be done by sending the logical name to a service that can return the location details. The file can then be downloaded using a particular file transfer protocol, such as FTP, HTTP, or GSIFTP.

1.2. Web Services

Middleware can thus allow the interoperation of data grids given that the abstractions, protocols, interfaces and services comprising it are standardised. How can the interfaces and services to be standardised?

In the past, gateways to services were server programs which interacted with client programs through some messaging protocol. Custom and sometimes unportable messages were often used. Web services are modern versions of these server programs, with the difference that the definitions of the interfaces and the messaging protocol have been standardised. Messages and interfaces are specified in Extensible Markup Language (XML) \(^2\), using the Simple Object Access Protocol (SOAP) \(^3\) for messages and Web Services Description Language (WSDL) \(^4\) for the interfaces. XML, SOAP and WSDL are industry

\(^{1}\)for the sake of grammar only, we assume that the researcher is male
standards defined and maintained by the W3C consortium [4].

2. WEB SERVICE ARCHITECTURE

2.1. Overview

The ILDG middleware architecture is to be based on a collection of stateless web services. These are to provide a standardised interface to back end services such as a local storage system or the grid service layer of a non ILDG data grid.

We illustrate the middleware architecture in figure 1. The large rectangles represent the grids belonging to hypothetical participating collaborations X and Y. These are split into the Middleware and Locally Implemented Back End respectively. The ILDG Middleware web services appear in the Middleware half. We have drawn in the three main web services:

- ILDG Metadata Catalogue (MDC),
- ILDG Storage Resource Manager (SRM)
- ILDG Replica Catalogue (RC) service.

These web services interact with back end implementations. The back end implementations are specific to the participating grid. For example the back end storage system may be directly controlled by the ILDG SRM service for collaborations who use SRM to manage their data. Alternatively, the back end storage system may be some collaboration specific non–SRM implementation, in which case the ILDG SRM web service acts as an “interoperability layer” allowing ILDG compliant applications to treat the back end storage as if it was an SRM. What is important from the point of view of interoperability is that the applications see a standard web service interface.

Figure 1 also shows possible data transfers between the application, the web services and the back end. The SOAP messages exchanged between the application and the web services are shown as dashed-dotted lines. The solid line between the application and the back end storage system illustrates the idea of third party transfers, where the storage system can initiate data upload/download between itself and the application directly. We also show the hypothetical case of the ILDG MDC returning the result of a metadata query, and how this can be rendered from its XML form into a human readable web page by passing it through an HTML rendering servlet.

Finally we illustrate in figure 1 a possible way for applications to learn of the existence and whereabouts of the ILDG Web Services of participating collaborations. This may be done through the use of directory services. An application can consult, say, the MDC Directory service to discover how to contact one or more ILDG MDC services. It is not yet clear who will operate the directories. Each collaboration may operate one, or perhaps the ILDG could maintain one or more ILDG MDC services. It is not yet clear who will operate the directories. Each collaboration may operate one, or perhaps the ILDG could maintain one or more global instances of these services, details of which may be made public on the ILDG web pages.

At this point we should highlight that the middleware working group regards its primary role as that of standardising the web services in the architecture just presented. The working group does not feel responsible for providing the applications or the back end services described.

2.2. Naming the Data

It is envisaged that each item of data in the ILDG will be identified by a global logical file name (GFN). The space of GFNs will be partitioned between participating collaborations to
avoid name clashes. The individual collaborations will then be responsible for managing their own allocated name spaces.

Since the data item may be replicated a GFN may correspond to several copies of the data. The mapping between GFNs and individual files is maintained by the RC. We will refer to these individual filenames as site universal resource locators (SURLs). SURLs may be presented to the SRM service in order to retrieve the actual files.

2.3. Metadata Catalogue

The ILDG MDC service has the task of allowing the standardised interrogation of the MDCs of participating collaborations. Applications can present metadata queries to the ILDG MDC. The replies can be either GFNs or they can be full or partial metadata instance documents that are selected by the query. This gives the ILDG MDC read only semantics. It is envisaged that the ILDG MDC will interrogate a locally implemented MDC which allows for maintenance of the local catalogue. In other words: insertion/deletion of metadata is expected to be handled outside of the ILDG framework by the participating collaborations.

2.4. Replica Catalogue

The ILDG RC service has to track various existing copies of a given file. Essentially, it performs a mapping from a GFN to one or more SURLs. In order to allow files to migrate it may be necessary for the back end services or applications to create and remove entries from the catalogue. Further, we expect that as files migrate, some of the SURLs returned from the replica catalogue may become invalid. The burden of dealing with this complexity is pushed onto the applications. Prototype RCs exist at the Jefferson Laboratory \(^2\) (JLab) and at Fermilab \(^3\).

2.5. The SRM

The Storage Resource Manager (SRM) has the task of managing the storage system within a collaborating data grid. SRM is actually a sophisticated storage resource management system developed between a variety of institutions. The design of the SRM is lead by the Storage Resource Management Working Group which is soon expected to become a Global Grid Forum Grid Storage Management Working Group \(^5\).

At the time of writing, version 2.1 of SRM has been defined and the WSDL definition has been made available online \(^5\). The JLab has an implementation of the SRM 2.1 specification, which was completed in the middle of summer 2004.

The chief envisioned functionality of the SRM in the ILDG, which may be much more limited than its complete functionality, is to allow the downloading of files. On the presentation of an SURL, the SRM identifies the individual file server which holds the file and returns a transfer URL (TURL) to the file. This is a URL which can be used to download the actual file, for example by using the `wget` utility with the TURL if the download is to proceed via the HTTP transfer protocol, or the `globus-url-copy` utility if the transfer is to proceed through GSIFTP.

3. FUTURE WORK

We have presented a high level overview of the middleware architecture as it is currently envisaged. Many details still require discussion, in particular the detailed WSDL definition of the interfaces of all the components remains to be completed. This is particularly true for the case of the MDC and the RC. Work on the MDC is underway at the CCS at Tsukuba, and at Fermilab. A prototype RC implementation is nearly ready at the JLab.

The UKQCD collaboration will attempt to implement an SRM compatibility layer in order to allow the transfer of data between its UK QCD-Grid and a standard SRM such as the one at the JLab.

The interaction of MDCs between grids still needs to be clarified. One suggestion has been to produce a specification which is recursive. In this case one can interact with a root MDC, which transparently queries lower level MDCs it knows about. Another suggestion which has already been alluded to is the use of directory services.

An interesting unresolved issue is how to per-
form metadata queries. The metadata working group has proposed a definition of QCDML which assumes a hierarchical XML data model. However hierarchical and XML databases are not as mature and well known as relational ones, and it may be desirable to hold the metadata in a relational database at least at the lowest level. The question is whether to present an XML (XQuery) or a relational (SQL) view of the databases for the applications to query, or perhaps to provide both. If the SQL view is to be provided, it may be useful to define a relational table based view of the QCDML schema in order to allow straightforward use of SQL back end databases.

4. FILE FORMATS AND PACKAGING

So far we have neglected issues pertaining to the format and packaging of data. The middleware working group is currently in discussion with the metadata working group on these issues.

The key question is whether the ILDG should or should not mandate a standard gauge configuration file format. Should a file format be mandated, the question arises as to how to provide tools so that collaborations can transform the data between the standard format and their own formats in a straightforward manner. It is also possible to not mandate a standard format, but to provide a standard way to describe the format of the stored configurations from which tools can be generated to effect the transformation between formats.

One option for the former case is to maintain program code as part of the metadata whereas in the latter case the binary data layout may be completely specified by BinX markup [6]. The BinX project also provides a software library that can be used to perform transformations on the data such as a rearrangement of indices, reversal of bit and byte order and the selection of various slices, making it straightforward to write programs to transform the data in any desired way.

Nonetheless, progress is being made albeit slowly. The working group plans to hold a working meeting to be attended by the conveners and some implementers to finish the definitions of the web services described here.

6. ABOUT THE WORKING GROUP

The working group has three joint conveners:

- William Watson from the Thomas Jefferson National Accelerator Facility (JLab), Newport News, VA, USA,
- Mitsuhisa Sato from the Centre for Computational Sciences, Tsukuba, Japan,
- Bándit Joó from the School of Physics, University of Edinburgh, Edinburgh, UK.

We would also like to highlight the participation of Eric H. Neilsen from Fermilab, Batavia, IL, USA, who, while not a convener, has been an extremely active member of the working group contributing a lot of material including analysis, use cases and samples of WSDL that have greatly aided the progress of the working group.

Communication in the working group has hitherto proceeded by email and through the public mailing list [7] which is archived at [8]. Further information about the working group is also available through the ILDG Web Site [9].

REFERENCES

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