MCS, a new approach to data treatment in astronomical projects

G. Calderone\textsuperscript{1} and L. Nicastro\textsuperscript{2}

\textsuperscript{1} Istituto Nazionale di Astrofisica, IASF, Via U. La Malfa 153, 90146 Palermo, Italy
\textsuperscript{2} Istituto Nazionale di Astrofisica, IASF, Via P. Gobetti 101, 40129 Bologna, Italy

Abstract. Today’s astronomical projects need computational systems capable to store and analyze large amounts of scientific data, to effectively share data with other research Institutes and to easily implement information services to present data for different purposes (scientific, maintenance, outreach, etc.). Due to the wide scenario of astronomical projects there isn’t yet a standardized approach to implement the software needed to support all the requirements of a project. The new approach we propose here is the use of a unified model where all data are stored into the same data base becoming available in different forms, to different users with different privileges.

1. Introduction

Information services can be separated in two classes: those in which the information produced are addressed to humans, and those in which they are meant for the use by other software applications. In the former case there is a quite standardized way to develop such an information service, essentially based upon a web server, a database server, a scripting language and HTML pages. In the latter case instead there is no such standardization, and here's why MCS (My Customizable Server) was implemented.

MCS is a set of software tools aimed at easily implement information services, that is an application that provides a service over the network. At the core of a MCS-based system there is a TCP server which listen for user’s request coming from the network, eventually will access a database and/or execute an external program, then it will send the answer to the user using the MCS protocol. The main features of application servers built with MCS are:

- easy to configure;
- authentication and grant support;
- secure connections (through SSL);
- database access (MySQL);

MCS has been developed on the GNU/Linux platform and is released under the GPL license. It can be freely downloaded from the site \texttt{ross.iasfbo.inaf.it/mcs/}. This site contains all news, updates, documentation and downloadable software packages. The documentation is present as a user manual (in pdf format) which focuses on the main aspects of an MCS-based application, describes the server environment, commands, and the interfaces for various languages, and as a technical reference documentation for all MCS’s classes (in html format, automatically generated using Doxygen). The site is still under development, so check for updates.

2. The MCS architecture

The MCS core is basically a set of high level C++ classes aimed at providing all the functionalities of an application server, that is an application that will listen for user’s request coming from the network, eventually will access a database and/or execute an external program, then it will send the answer to the user using the MCS protocol. The main features of application servers built with MCS are:
– base commands set, support to create new customized commands;
– accessibility (as clients) from other languages such as C, Fortran, IDL, PHP, etc.;
– logging facility, etc.

All these features are already available, without performing any customization. So to implement a simple service with the above features you’ll only need to install MCS and configure it through a simple configuration file. The only code needed is as follows:

```c++
#include <mcs.hh>
using namespace mcs;

int main(int argc, char *argv[]) {
  //Start the server...
  Env* env = mcsStart("simplest");
  //...and wait for its end
  mcsWait(env);
}
```

For more complex services you can customize the server behavior in several ways:

– adding external programs, either real external applications or batch lists of MCS commands;
– adding SQL programs, to be executed on the database server;
– adding customized commands, deriving the `UserThread` class;
– modifying the behavior of the server side thread, deriving the `LocalThread` class;

In a typical application you should implement a database with all the tables needed to store all the relevant data related to the project, and eventually prepare the required external programs. Figure 1 shows the typical architecture of an MCS-based system:

**Database server**: the database server is used to handle clients authentication, to store all application specific data and anything else necessary to the application itself. This server isn’t accessible directly from the clients, but it is visible only to the application server. At the moment the only supported database server is MySQL. In the future other servers may become accessible through MCS.

**Application server**: the application server is the core of the information system. It implements the client/server model: a client opens a TCP socket towards the host running MCS and sends a request, then the server “computes” an answer, eventually querying the database and/or executing some external programs, and sends it back to the client. The behavior of the MCS server can be customized deriving some classes.

**External programs**: external programs are software applications written in any language, which interact with the application server via command line and the standard output. Support to these programs was added to easily integrate already existing applications within MCS.

**Clients**: clients are programs which access the MCS service over the network. Such programs can be written in any language and run on any platform, provided that they implement the MCS protocol. Interfaces that implement the MCS protocol are provided by the MCS library for the following languages on the Linux platform: C++, C, Fortran, IDL, PHP. Support for other languages (such as Java, Python and Perl) and the Windows platform will be available soon.

Note that such a system would not be a closed model, in the sense that existing databases and/or software tools may be integrated into the MCS-based systems. That’s because MCS doesn’t make any assumption about type and quantity of data you need to deal with. It uses a relational database system to store many of its data. Databases have become today the most useful, scalable and flexible way to store and give access to any sort of data.

From a user’s point of view MCS is very similar to the usage of a classic Unix shell, that is a command line interface with a prompt on which users can execute commands in their own environment and wait for the output before a new command is issued. It is therefore possible to make a comparison between the “components” of a shell, and the ones from an MCS connection (see Tab. 2).

The output of a command won’t be ASCII text like in a shell. Data will be instead formatted using the MCS protocol and can be sent and received in binary form in both directions. Figure 3 shows the typical sequence of events during an MCS session.

| Unix shell | MCS server |
|------------|------------|
| stdin and stdout | bidirectional TCP socket |
| system account | MySQL account |
| internal commands | base commands |
| programs, shell scripts | external programs (EXEC command) |
| home directory | work directory |

---

1 www.mysql.com
MCS classes can also be used outside an application server, for example it is possible to write a program in C++ which uses the DBConn and Query classes to access a database, or one of the VOT_Parser_Tree or VOT_Parser_Stream classes to read VOTable file. The same program can also be written in one of the languages for which we have an interface (at the moment C, Fortran, IDL, PHP; other will be developed in the near future).

2.1. Deriving MCS classes

Deriving a C++ class means creating a new class that has all the behaviour characteristics of an existing one (the parent class), plus some more specific behaviour added. In the MCS case the server behaviour can be customized through the derivation of the UserThread class (more specifically only the “virtual” methods should be derived, as described in the documentation). This way it is possible to create custom commands available as if they were “base commands” (see Tab. I). Another class that can be derived for customization is LocalThread. It runs in a server side thread, independently from other client threads. This class can be used to implement some server side tasks like data quick look or reduction, database maintenance, etc.

3. A real life example

In a typical scientific experiment we have an instrument producing data, a main storage system, a set of software tools to perform analysis, and people with different needs who wish to access the data. In this section we’ll analyze the components of an informative system based on MCS, applied to such an experiment. A common use of MCS in such a real life project would be as follows: an MCS server is running on the computer attached to the scientific instrument and collects data on local disks. Over these data the MCS server will eventually perform some automatic analysis for data quick-look, then will store the results and the raw data in the database. The quick-look tool can be implemented in C++, or it can be a previously written software; in the latter case you only need to implement a simple interface between this tool and MCS. A technician can then connect via a simple telnet terminal to the MCS server and check if everything goes fine. This can be done using mnemonic command codes, very similar to the commands issued in an ordinary Unix shell. These command codes can of course be customized. A researcher can use the “Client” class to develop a client tool to connect to the MCS server and perform a remote control of the instrument or retrieve scientific data in a variety of formats (typically formats are raw, ASCII, FITS or VOTable). As already mentioned, if the researcher doesn’t want to use C++ to implement the client tool, he can use one of the available interfaces to MCS from other programming languages such as C, IDL, Fortran or PHP. One of the main feature of these interfaces is that the function names are the same in all languages. Finally there can be a web server that connects to MCS through a PHP interface and provides bookkeeping and outreach information as web pages to external users. Each afore-mentioned user can of course have different privileges, and so being able to view and retrieve different kinds of data.

4. MCS and the Virtual Observatory

MCS doesn’t pretend to be an all-comprehensive, multi-wavelength repository for astronomical data like the Virtual Observatory is, nor a general purpose data analysis software. In this sense MCS is (of course) not a Virtual Observatory competitor. Instead it was implemented to easily setup real time information services, while reusing much of the already existing software tools and database tables. However in the near future MCS will implement the PLASTIC interface to connect and use the Virtual Observatory facilities.

MCS can also be seen as a starting point to implement or simply make practice with a distributed computing en-
vironment like in the “GRID” based projects. A network of computers, each running an MCS server, can connect to all the others as client to perform computation or database queries. Of course, also in this case MCS and “GRID” are not competitors because they are supposed to be used for different purposes: in fact implementing a service and setting up an MCS server is much more simple than setting up a node or putting a service on the “GRID”. On the other hand the “GRID” projects offer many more features than MCS does.

5. The MCS companion tools

We have developed a number of software tools that can be used with MCS to improve its functionalities (of course these software can also be used as standalone):

- MyRO (My Record Oriented privilege system): this software provides a natural extension to the MySQL privilege system, offering the possibility to specify privileges on a record level. It supports users and groups like those of a Unix system, giving the possibility to set a read and/or write permission to each record. Needs MySQL version 5.
- DBEngine for FITS and VOTable: a DBEngine is a software library linked into the database server (MySQL in this case) which let users read and write table in a format different from the MySQL proprietary. Our software let you read and write FITS and VOTable files as if they were database tables (this software is still under development).
- Database interface to HEALPix and HTM: this software provides some of the functions of the HEALPix and HTM library as MySQL functions, to be used directly in SQL queries. Functions allowing (fast) circular and rectangular selections of entries in HTM indexed database tables will also be available soon.

6. The future

MCS is in continuous development. It will soon implement interfaces for other languages such as Python, Perl, Java, Tcl/Tk. Another feature that will be implemented soon is the integration with MyRO to handle a more complex privilege system.

User contributed libraries for the various supported languages are being built. This will allow an even easier access to the MCS functionalities to non expert programmers. Moreover, commonly used, independently developed external packages will also be included and made accessible trough MCS. They include the afore mentioned HEALPix and HTM libraries for sky pixelization scheme, the Naval Observatory Vector Astrometry Subroutines (NOVAS – aa.usno.navy.mil/software/novas) used for astrometric calculations and transformations, the World Coordinate System (WCS – fits.gsfc.nasa.gov/fits_wcs.html) library and tools.

7. MCS is already used by...

MCS is already used for managing the data produced by the ROSS camera. The SPort experiment, whenever it will be resumed, will have the data fully managed by an MCS based system. The Astrometry group of the Turin Astronomical Observatory is making use of the MCS client library through the IDL interface to cross match HTM indexed catalogues. Other astronomical experiments from the gamma-rays to the radio band have shown interest to use MCS for their data management. One of them is the Italian gamma-rays satellite AGILE.

8. Conclusions

Several astronomical projects are still supported by software developed under an old conception: handling all data files with “ad-hoc” developed scripts, running stand alone applications which can read only proprietary ASCII or binary files, relying on users responsibility to follow the format and naming specifications for files, absence of any mechanism to automatically update a web site, etc. However today information technology offers a lot of new tools which can give several benefits to astronomers: database systems to efficiently store and retrieve huge quantities of data, libraries to easily distribute data across the network, widely used standard formats for information interchange using freely available libraries, new high level languages to quickly implement sophisticated data handling and processing, and so on. All of these tools are being effectively used by the Virtual Observatory and GRID projects. They will become the standard “de-facto” in the near future, so software developers involved in astronomical projects should start to get used to these new technologies. MCS aims at being the simplest and fastest tool to let developers build new software to support scientific projects using these new technologies.

Acknowledgements. The SPort experiment was supported by ASI. The REM Observatory is supported by INAF.

References

Cortiglioni S., Bernardi B., Carretti E., et al., 2004, New Astron. 9, 297
Covino S., Stefanon M., Sciuto G., et al., 2004, SPIE Symposium, Proc 5492, 1613, G. Hasinger & M. J. L. Turner eds.
Nicastro L., Calderone G., 2002, AIP Conf. Proc. 609, 279, S. Cecchini, S. Cortiglioni, R. Sault & C. Sbarra eds.
Tosti G., Bagaglia M., Campeggi C., et al., 2004, SPIE Symposium, Proc 5492, 689, G. Hasinger & M. J. L. Turner eds.