Atlas Data-Challenge 1 on NorduGrid

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The first LHC application ever to be executed in a computational Grid environment is the so-called ATLAS Data-Challenge 1, more specifically, the part assigned to the Scandinavian members of the ATLAS Collaboration. Taking advantage of the NorduGrid testbed and tools, physicists from Denmark, Norway and Sweden were able to participate in the overall exercise starting in July 2002 and continuing through the rest of 2002 and the first part of 2003 using solely the NorduGrid environment. This allowed to distribute input data over a wide area, and rely on the NorduGrid resource discovery mechanism to find an optimal cluster for job submission. During the whole Data-Challenge 1, more than 2 TB of input data was processed and more than 2.5 TB of output data was produced by more than 4750 Grid jobs.

1. Introduction

In order to prepare for data-taking at the LHC starting 2007, ATLAS has planned a series of computing challenges of increasing size and complexity [1]. The goals include a test of its computing model and the complete software suite and to integrate grid-middleware as quickly as possible. The first of these Data-Challenges, the Atlas Data-Challenge 1, has run in several stages in the second half of 2002 and in the first half of 2003. For the first time, a massive worldwide production of many different physics samples was run in a total of more than 50 institutes around the world. NorduGrid was the Scandinavian contribution to this Data-Challenge.

In the following, we will describe the NorduGrid involvement in this Atlas Data-Challenge 1. We start out by giving a description of the NorduGrid testbed and then move on to describe its tools seen from a user’s perspective with some emphasis on how Atlas jobs are run on NorduGrid. Then we describe the different stages in the Atlas Data-Challenge 1 and the achievements of NorduGrid. A detailed description of the NorduGrid architecture will be given in a separate article [2].

2. The NorduGrid testbed

The aim of the NorduGrid project has from the start been to build and operate a production Grid in Scandinavia and Finland. The project was started in May 2001 and has since May 2002 been running a testbed based on the architecture discussed in [3]. Since July 2002, it has been used for production by different groups as for example described in this article. The NorduGrid software is a light-weight and portable grid-middleware that requires minimal changes to already existing non-grid resources from the corresponding system administrators. This has allowed NorduGrid to get adopted by many existing supercomputer centres in the Nordic countries. The NorduGrid software runs on clusters with such different Linux distributions as Redhat 6.2, Redhat 7.2, Mandrake 8.0, Debian 3.0 (Woody) and others.

By now, the NorduGrid resources range from the original small test-clusters at the different physics-institutions to some of the biggest supercomputer clusters in Scandinavia. It is one of the largest operational Grids in the world with approximately 1000 CPU’s available 24 hours a day, 7 days a week. The list of clusters currently available on NorduGrid can at anytime be seen on the NorduGrid GridMonitor (http://www.nordugrid.org/monitor/loadmon.php). See also figure [1].

3. The NorduGrid User Interface

The NorduGrid User Interface consists of a set of command-line tools used for submitting jobs, for querying the status of jobs, for fetching the output of jobs (if any), for killing and deleting jobs, for moving and copying files between Storage Elements and
Replica Catalogs and so on. The complete list of commands can be seen in table I and detailed information about these can be found in the NorduGrid User Interface manual [4].

To submit a job, the user has to specify his job-requirements in the so-called eXtended Resource Specification Language, xRSL [5]. xRSL is an extension of the Globus job-description language RSL [6] and is used to describe in a set of attributes all the information needed to run the job — name of executable, arguments, input-files and so on. In addition, the user can specify a set of requirements that a given cluster must satisfy to be able to run the job. These requirements include e.g. that a certain amount of disk space is available for the job on the cluster.

One of the most important requirements is that specified by the runTimeEnvironment-attribute. A simple example of a runtime environment configuration script for the Atlas-rpms provided by NorduGrid is shown later in figure 2.

The user submits his grid-job to NorduGrid using the command ngsub. During job-submission, the User Interface queries the NorduGrid Information System for available resources and clusters and then queries each cluster to perform the check of the requirements specified by the user. If the xRSL specifies that certain input-files should be downloaded from a Storage Element or Replica Catalog, the User Interface contacts these to obtain information about the input-files. Finally the User Interface performs the brokering according the information gathered and submits the job to the chosen cluster.

From here on, the NorduGrid Grid Manager automatically takes care of the job — handling the preprocessing (e.g. downloading input-files and so on), job-submission to the local PBS-system and post-processing (e.g. automatically uploading output-files to Storage Elements). The user can at anytime check the status of his submitted job using the command ngstat. A job can be in several different states during job-processing. A list of possible states with a short explanation is shown in table II.

When a job has finished, the user can retrieve those output-files that have not already been uploaded au-
tomatically to a Storage Element using the command ngget. Furthermore the user can at anytime get the standard output of the job displayed using ngcat. This can be useful for checking whether a job is running as intended. If it’s not, the user can kill it using ngkill and try again.

4. Atlas-software

The different releases of the Atlas software are installed at CERN in a public afs-directory under the ATLAS tree. Sites with afs-connection can use these Atlas releases directly but this solution is far from ideal especially since the releases has for a long period been very Redhat 6.1 specific.

For Data-Challenge 1, official Atlas-rpms for the different releases were distributed. These rpms were used by many sites with satisfaction. But primarily because of the diversity of different Linux-distributions on NorduGrid and the requirements of the different site-administrators, NorduGrid decided to produce its own set of Atlas-rpms that one was able to build from scratch starting from a generic vanilla Linux-distribution. Indeed the NorduGrid Atlas-rpms

- are buildable from scratch on many different Linux distributions from the provided SRPMS.
- are trivially relocatable.
- have an install-area that allows a very simple Atlas-runtime Environment to be setup.
- come with an automatic install-script.

With the efforts of the different site-administrators on NorduGrid, these Atlas-rpms have been built and installed on many of the NorduGrid sites. Lately these Atlas-rpms have also been used in Chicago in phase 3 of Data-Challenge 1 in connection with the Chimera project (see http://grid.uchicago.edu/atlaschimera/). In figure 2 a typical runtime-environment script for Atlas release 6.0.3 is shown. The simplicity of this script is due to the install-area that these Atlas-rpms are equipped with.

Additionally for each Atlas-release, validation procedures for the clusters were constructed. These consisted of a set of standard validation grid-jobs to test the Atlas-software-installation at each cluster. The validation jobs were run on each cluster, before the site-administrators were allowed to advertise the corresponding Atlas-runtime Environment in the Information System. This assured that the production would only be performed on validated clusters.

5. Data-Challenge 1

The simulations performed in Data-Challenge 1 was based on requests from the High-Level-Trigger community and different physics communities. These requests were divided into several datasets and each dataset was assigned either fully or in parts to different institutes participating in the Data-Challenge. The first phase, the simulation phase, running from July to August 2002 consisted of large-scale ATLAS detector simulations using the ATLAS physics simulation program, atlsim, from Atlas release 3.2.1. In the second phase, running from December 2002 to January 2003, the already simulated events had to be piled up with minimum-bias events. This was also done in atlsim, with Atlas release 4.0.1, using a new highly efficient event mixing procedure. The participating institutes were assigned the same partitions as they had already simulated in phase 1. The third phase consisted of large-scale reconstruction of the produced data from the first two phases — using Atlas releases 6.0.2 and 6.0.3.

In the first and second phase, NorduGrid was assigned 300 partitions of the dataset 2000 — corresponding to 10 percent of the full dataset — and the total dataset 2003 consisting of 1000 partitions. Before and during phase 3 additional partitions from dataset 2000 and dataset 2001 were assigned and moved to NorduGrid for reconstruction. In the following, we will describe in some detail the different phases.

5.1. Phase 1 — Simulation

As mentioned NorduGrid was assigned 300 partitions of the dataset 2000. The corresponding input-files containing the generated events to be simulated in the Atlas physics simulation program were 15 files.
Table I The NorduGrid User Interface commands.

| command | action |
|---------|--------|
| ngsub   | Job submission |
| ngstat  | Show status of jobs |
| ngcat   | Display standard output of running jobs |
| ngkill  | Kill running jobs |
| ngclean | Delete jobs from a cluster |
| ngsync  | Update the User Interface’s local information about running jobs |
| ngcopy  | Copy files to, from and between Storage Elements and replica catalogues |
| ngremove | Delete files from Storage Elements and Replica Catalogs |

Table II Possible states of a NorduGrid grid-job.

| state            | meaning                                      |
|------------------|----------------------------------------------|
| ACCEPTED         | The job has been submitted to a cluster.     |
| — it is waiting  | to be processed by the Grid Manager.         |
| PREPARING        | The Grid Manager is preparing the job        |
| — e.g. downloading | input-files specified by the job-description.|
| INLRMS: Q        | The job has been submitted to the local PBS-system and is queued. |
| INLRMS: R        | The job has been submitted to the local PBS-system and is running. |
| FINISHING        | The job has finished running in the local PBS-system. |
| — the Grid Manager is doing the post-processing. |
| FINISHED         | The job has finished. The output of the job can be retrieved. |

Each job produces a set of output-files. These are specified under outputFiles and will at the end of the job be automatically uploaded by the Grid Manager to the location specified under outputFiles. In this case, the output-files specified will be uploaded to a physical location registered in the NorduGrid Replica Catalog defined by the replicaCollection attribute, so that on request from the Grid Manager, the Replica Catalog resolves e.g. rc://dc1.uio.no/log to gsiftp://dc1.uio.no/dc1/2000/log and uploads the file to that Storage Element. Similarly with the other files.

The 300 jobs for dataset 2000 in this first phase used around 220 CPU-days and produced 5 \times 300 output-files with a total size of about 320 GB. All output-files were uploaded to a NorduGrid Storage Element as discussed above. A web page querying the Replica Catalog for output-files was setup to allow for an easy browsing and check of log-files, output-sizes, error-codes and so on. This provided a very easy check of whether something had gone wrong during the job-processing. A screen-shot of this is shown in figure 4.
was therefore decided to distribute only subsets of these. All the distributed input sets were then registered into the Replica Catalog so that at the job-submission stage, the broker could query the Replica Catalog for clusters having the necessary input-file for that job. The job would then preferably be submitted to such clusters. However, if all clusters with the required input-file were full, the job would be submitted somewhere else, and the Grid Manager would use the information in the Replica Catalog and proceed to download the input-file into the local temporary cache on the cluster. A snapshot of the Replica Catalog with the dataset 2003 input-files registered is shown in figure 5.

Otherwise the simulation were in principle completely similar to dataset 2000. For this part, there were 1000 jobs using about 300 CPU-days and producing approximately 442 GB of output. All output-files were uploaded to the designated NorduGrid Storage Element and registered into the Replica Catalog. In total for phase 1, NorduGrid produced 780 GB of data in a total of 1300 jobs.

5.2. Phase 2 – Pileup

From a grid point of view, all 3 phases were very similar — in principle only the application changed. The biggest difference from phase 1 to phase 2 was that the input-files of phase 2 were the output-files of phase 1. This meant that the Grid Manager during job-preparation had to download each input-file from the designated NorduGrid Storage Element. It turned out that this did not pose any significant problems. The minimum-bias files were distributed as in phase 1 to the different sites before the simulations. Again – if a chosen site did not have all the required minimum-bias files, the Grid Manager would proceed to download these as well into the local cache.

In this phase 1300 jobs were processed having about 780 GB of input-files and producing about 1080 GB of output-files. All output-files were again automatically uploaded to a designated Storage Element and registered into the Replica Catalog.

5.3. Phase 3 – Reconstruction

During phase 3, NorduGrid was assigned additionally 400 partitions from dataset 2000 and 750 partitions from dataset 2001 to be reconstructed together with the 300 + 1000 partitions from dataset 2000 and 2003 already present on NorduGrid. The input-files for these were transferred directly from Russia and the US to a NorduGrid Storage Element using the ngcopy-program and used in the simulations from there.

In the reconstruction phase, an external mysql noise database situated either at CERN or at BNL was used for the first time to provide noise for the LArCalorimeter-system. This initially posed a number of problems since most clusters in NorduGrid do not allow for internet-connection from the worker nodes and a reconstruction job would thus die because it could not contact the external database. This was quickly solved though so that a job could download a standalone version of the database instead and use
Figure 4: A snapshot of the webpage querying the Replica Catalog for output-files of dataset 2000 during phase 1. For each partition, the production node, the number of fully simulated events, the CPU time spent per event, the submission time, the output sizes of the zebra- and histogram-files and the logfile are be shown. A red exclamation mark is shown for bad partitions.

Figure 5: A snapshot of the Replica Browser showing the dataset 2003 input-files as registered in the Replica Catalog.
that in the reconstruction.

With this, no further problems were encountered and the corresponding partitions have now all been reconstructed. In this phase the NorduGrid share has been between 15 and 20 percent.

6. Conclusion

NorduGrid, as the Scandinavian contribution, has contributed substantially to the Atlas Data-Challenge 1 in all 3 phases. Important lessons about the NorduGrid middleware have been learned during these stress tests which has been used to extend the stability, flexibility and functionality of the software and NorduGrid itself. The software is now being adopted by several computer centres throughout the Scandinavian countries which shows exciting prospects for NorduGrid in Scandinavia in the future.

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