ConGUSTo: (HT)Condor Graphical Unified Supervising Tool

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Abstract

HTCondor is a distributed job scheduler developed by the University of Wisconsin-Madison, which allows users to run their applications in other users’ machines when they are not being used, thus providing a considerably increase in the overall computational power and a more efficient use of the computing resources. Our institution has been successfully using HTCondor for more than ten years, and HTCondor is nowadays the most used Supercomputing resource we have. Although HTCondor provides a wide range of tools and options for its management and administration, there are currently no tools that can show detailed usage information and statistics in a clear, easy to interpret, interactive set of graphics displays. For this reason, we have developed ConGUSTo, a web-based tool that allows to collect HTCondor usage and statistics data in an easy way, and present them using a variety of tabular and graphics charts.

Keywords

ConGUSTo — HTCondor — statistics

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1. Introduction

The Instituto de Astrofísica de Canarias (IAC) is the largest Spanish astrophysical research centre. The IAC manages two observatories located over 2000 meters ASL with more than 25 telescopes on the whole, including the current largest optical/infrared telescope in the world (GTC), all equipped with state-of-the-art instrumentation. These telescopes generate large amounts of raw data which must be processed and reduced before they can be analyzed. The data processing is usually done with both general-purpose and specialized software packages that need a lot of computational power. Most of this data reduction work is carried out by applying the same tasks over a large number of independent inputs, so it is much more suitable for distributing computing than for parallel supercomputing. In fact, there are several research projects at the IAC which are viable only thanks to the use of these kind of resources, since they need several thousands of CPU hours to be completed.\textsuperscript{1} So HTCondor, a software tool which will be briefly described in the following sections, plays a fundamental role at the IAC, with over 200 Linux desktops and 700 computing slots available to researchers when they are not being used by their owners. In the first semester of 2014, our staff executed jobs in HTCondor for a total of about 1,300,000 computing hours, that is the equivalent of one and a half century of sequential computing time in just six months.

As HTCondor system administrators, our interest in monitoring and supervising how HTCondor works is twofold. First, we must assure that HTCondor does not interfere with the regular use of the desktop PC by the user who is logged in. Both an imperfect knowledge of what HTCondor does (and what doesn’t), and some past failures in detecting user’s activity and evicting HTCondor jobs (a problem caused by an

\textsuperscript{1}As an example, one of the IAC research group is using holography techniques to create seismic maps of the solar interior, from observed velocity fields obtained by GONG (Global Oscillation Network Group). Maps are produced for about 500 depths, for observations spanning several months in order to study temporal variations. Each map requires about 10 minutes of computing time: HTCondor is the ideal resource for such kind of work, as it involves applying the same process to thousands of independent inputs.
Operating System upgrade and fixed shortly after it showed up) have made the users suspicious of HTCondor, which they have started to blame whenever their computer becomes slow, unresponsive or freezes at times (HTCondor has thus become the favorite scapegoat). Second, we must respond to the energy saving measures that are being studied and implemented by the IAC in order to reduce electricity bills. One of the proposals was to turn off all Linux desktops at night and on weekends, and we need to show that most of such desktops are indeed used by HTCondor outside regular work hours, and we cannot afford turning them off without seriously compromising those research activities that heavily rely on HTCondor.

The standard HTCondor installation comes with several tools and options for monitoring how each job was executed and to produce a log that can be interpreted by some HTCondor commands and external applications. It also generates some general statistics about the pool and the allocated resources. However, we have found out that there is no easy way to track the detailed usage of each machine by HTCondor, which is a key factor for our purposes.

In particular, we are interested mainly in the following points:

- To obtain detailed information about what jobs have been executed in each of our machines, at any time, with all the associated information such as owners, states, etc., as well as a comprehensive summary encompassing all machines. Such information must be easily accessed, preferably shown online in a graphic way easy to interpret and understand, thereby allowing users to check the status of their machines and contact us when experiencing issues that could be related to HTCondor.

- To collect further information about when each machine is executing jobs, with the aim of implementing some power saving measures like automatically suspending or hibernating idle machines, and letting HTCondor wake them upon jobs allocation.

- To have a real-time graphical "panoramic view" of the status of all our machines. We do not wish to merely create a graphical representation of the condor_status command output, but we want also to include additional information that is not generated by that command and could be very useful to detect problems: the last time that a specific machine executed a job, if it has some specific time restriction (for instance HTCondor jobs are allowed to run at night and on weekends only), if there is enough space in the scratch disk, and many other parameters that allow us to do an in-depth assessment of individual machines.

- To avoid having to install additional software on each machine that belong to HTCondor pool.

With these goals in mind, we have developed ConGUSTo, a graphical online supervising and statistics system for HTCondor that we believe could be interesting for other HTCondor users and administrators. This paper presents ConGUSTo, and is organized as follows: Section 2 gives a brief description of HTCondor and the current log options that it offers, while in Section 3 we list the main ConGUSTo features. In Section 4 we present how ConGUSTo has been implemented, and in Section 5 several illustrative examples are shown. Finally, Section 6 gathers our conclusions and proposes future lines of development.

2. HTCondor and its current log options

This section does not try to be a rigorous or exhaustive description of HTCondor and all its log possibilities; any user interested in that can consult the extensive documentation available at [http://research.cs.wisc.edu/htcondor/]. Our intent here is to offer a very short account of how HTCondor works, and explain briefly those common commands and options available that can be used to obtain information about jobs and machines’ status.

2.1 What is HTCondor?

HTCondor is an open source software that gives support to High Throughput Computing (HTC) [http://research.cs.wisc.edu/htcondor/htc.html]. It was developed by the Center for High Throughput Computing at University of Wisconsin-Madison[http://chtc.cs.wisc.edu/]. In a nutshell, according to its developers, it is "a specialized workload management system for compute-intensive jobs". Basically, HTCondor manages a pool of machines and a queue of jobs: whenever a machine is idle (not being used by their owners and with a low load) HTCondor will match a suitable job to run on it.

HTCondor will carry out all the operations needed to correctly match idle machines with queued jobs according to specifications coming from both, execute those jobs and place the outputs where the user has specified, successfully dealing with a wide and complex set of circumstances.

Thus, using the HTCondor software, a group of off-the-shelf PCs connected by a local network can be transformed into a powerful Supercomputer where users can simultaneously run several instances of their programs over a variety of data, reducing considerably the time needed to obtain the results (up to a factor of several hundreds, depending on the application, the data and the number of available machines). Besides, HTCondor not only provides a substantial boost to computational capacity, but also enables a better and much more efficient use of the available computing facilities, minimizing the waste of energy and resources. HTCondor is used in many companies and institutions, among them the NASA Advanced Supercomputing Division, the European Organization for Nuclear Research (CERN) [http://linuxsoft.cern.ch/cern/mrg/slc5X/x86_64/RPMS/repoview/condor.html], etc. A more detailed, technical introduction of HTCondor can be found at [http://research.cs.wisc.edu/htcondor/description.html].
2.2 HTCondor logging and statistics options

HTCondor has several options in its configuration files to manage logfiles, which are generated and updated by the different daemons that HTCondor runs. By default, each computing machine keeps its own logs, with HTCondor providing a command that allows administrators to consult log files located on those machines. As usual, administrators can set the log level to decide what information will be stored in the logfiles, specify the place where they will be created, impose a size limit, etc.

Users running their jobs with HTCondor can include a command in their submit files in order to generate specific log files for each execution. Once the jobs are done and the logs generated, they can be used to get detailed information about the execution. HTCondor provides a set of commands for that purpose, such as `condor_userlog`, `condor_history`, etc. If users are interested in getting a graphical visualization of such data, they can use the java application logview or some third-party applications like the HTCondor Log Analyzer [http://condorlog.cse.nd.edu/].

Finally, if enabled, HTCondor is able to generate some general statistics, which are stored in plain HTML format and can be displayed graphically by means of a java applet. There are two kinds of information: the first is a graph and tabular data for the Pool User (Job) Statistics (total allocation time, average and peaks of running and idle jobs), the second the Pool Resource (Machine) Statistics (average and peak number of machines according to their states). Information is given for the current day, week, month, or any month in the last year.

The latest stable versions of HTCondor that have been recently released (8.2.x) claim to have an enhanced monitoring system integrated with the third-party software Ganglia [http://ganglia.info/]. We have tested the live demo and found it much more powerful than any of the previous log and statistics systems available in HTCondor. However, it does not fulfill our requirements, described above, as it seems to be too focused on showing those physical parameters contained in the ClassAds, and it does not appear to be compatible with previous versions of HTCondor. There are other third-party software alternatives, like CycleServer [http://www.cyclecomputing.com/products-solutions/cycleserver] or Cumin [https://fedorahosted.org/grid/wiki/CuminForUsers], but although they can be powerful, they also need a more complex management and/or the installation of software on each machine of the HTCondor pool.

3. What ConGUSTo offers

As we have just explained, the present HTCondor logging system is useful for debugging or check details about executions; however, trying to know, for instance, if a machine executed some job a few days (or months) ago and what and whose job it was could be really difficult, as it may require to dive into huge log files all with a somewhat complicated format, or it may be even impossible if the log data are too old, since logfiles are periodically deleted to save space.

Motivated by these limitations, we have developed ConGUSTo, which offers many features not available in the current HTCondor implementations. The most important are:

- Graphical view of all jobs executed in a specific machine, with more detailed info about each of them accessible online (using any web browser). For each machine in the pool we can show both summarized and detailed info about all the jobs that HTCondor has executed on it.
- Friendly and intuitive way to display data. Besides tables with numerical data, most information is also presented by means of interactive graphs.
- Data can be presented in periods of one day, one week or one month, allowing users and administrators as well to choose the starting day of that period.
- Panoramic view of all machines and slots to see the current HTCondor status in a glance.
- Panoramic view is highly configurable with a wide range of options and filters.
- Easy installation: ConGUSTo only needs to be installed on one machine (typically the web server). No data base is required; the data, stored in plain text with a format similar to CSV, are generated by just one of the machines in the pool (in our case it is the HTCondor master node, which is on 24/7) using a simple bash script executed by crontab. Thus there is no need for HTCondor to be installed on the same machine where ConGUSTo is located.
- Fully compatible with previous versions of HTCondor.
- It shows data that at the present moment Ganglia cannot supply, such as information per slot, time restrictions, last time a machine executed a HTCondor job, and much more.
- Adding new pieces of information to show is easy.

4. Implementation of ConGUSTo

As already mentioned, our objective is to generate a more friendly log system based on the information that we can obtain from HTCondor. We want this system to be able to show, in an intuitive and interactive way, what each machine was doing at any time, if it was executing a job (and then which job and by whom), whether it was idle, or used by someone else. These data must be kept updated and available online in order for both HTCondor administrators and users to be able to visualize them.
4.1 How ConGUSTo retrieves the data

The jobs data we want to show in principle could be extracted from the log files generated by HTCondor. For instance, we could parse the logs generated by the daemon `STARTD` on each machine that executes jobs, in order to track what jobs have been executed in each slot. However, we decided to discard this option for a number of reasons: such files generally have a different location depending on each machine; they are usually quite big and it may take a long while to parse them; their specific format in plain text is quite complex and not suitable for this purpose; while they contain many useful data, some basic, interesting info is missing, for instance the status of the job. User’s logs obtained when executing are not useful either, since they depend on the users’ commands written in the submit files, and even if created, they will be located wherever the user has specified. Finally, the statistics generated by HTCondor are useful for knowing the global status of the jobs queue or the machines’ pool at a given time, but cannot track what each machine has been doing.

Thus, we have implemented our own system to obtain the required data. Instead of reading the data off the log files, we obtain the information using standard HTCondor shell commands and then we process their output. We only need to execute the command once to get the information from all machines, avoiding parsing hundreds of huge log files, one for each machine.

In this way we obtain all the information we need, restricting it to those jobs that are running or suspended, the ones we are interested in. The output from this command is then processed by a shell script using simple shell commands such as `grep`, `sed`, `awk`, `tr`, `cut`, etc. and finally stored in a CSV-like format. Everything is managed by a bash script periodically executed by `crontab`. This script has fewer than 20 lines of code, which reflects the efficiency of our approach.

ConGUSTo has been designed in such a way that data displaying is totally independent from data generation. This perspective has the advantage of not requiring the web server to run HTCondor itself (we think that web servers should be doing their work and not running unrelated software packages), and we can use any other machine where HTCondor is running to obtain all data (typically the HTCondor collector). We evaluated the option of storing the collected data in a database, but to make it simple and to avoid the need for a database system, we chose to store the data in plain text files keeping the format as it is generated (CSV-like). So to let it work, we only need to make sure that data are stored in a location accessible by the web server. For example, files can be created in a shared directory accessible from the web server via NFS, or transferred by FTP, etc. The file organization is also simple: there is a root directory and then subdirectories for years, months and days, in a tree structure where the nodes are files of a concrete date, one file per each machine. This organization pattern based on dates and machines makes it easy to find the data for a specific date or range, and also makes the installation of ConGUSTo in other systems much simpler.

On the other hand, there is also some information that does not need to be stored, for instance the current state of machines in the pool. This kind of data is obtained in real-time and since it is directly displayed, there is no need to save it. (Those data are obtained by the use of the `condor_status` command, forcing it to produce its output with a predetermined format.)

All the commands and applications that ConGUSTo uses to get and store the data are (or should be) available in any Linux machine. We also expect that implementing the same tools in Windows should be relatively straightforward.

4.2 How ConGUSTo displays the data

ConGUSTo has been developed from scratch. To generate the web pages that display the information we have chosen PHP [http://php.net/]. PHP is a web programming language widely popular, available on virtually all Operating Systems, and used by such big enterprises or web projects as Wikipedia, Yahoo, (some parts of) Facebook, Wordpress, etc. [http://en.wikipedia.org/wiki/PHP]. As it can be run in Linux and Windows Server (and Mac OS X as well), it helps make our implementation very portable.

All the calculations needed to process and display the data are done by PHP scripts, while graphs are generated using the API of Google Charts [https://developers.google.com/chart/], also widely used and customizable. This allows us to show rich, interactive graphs where users can consult specific items. ConGUSTo translates the information stored in data files into a representation that Google Charts can understand in order to draw the graphs. We have customized this translation process in such a way that adding new data and graphs is easy: most times it is sufficient to specify the new graph position and type to automatically generate it. This proved to be especially useful in the code that shows a panoramic view of the current status of all machines, where dozens of options have been implemented to show or hide different kinds of data for every machine and/or slot, filter them according a wide set of attributes, or select among a large number of predefined graphs. In particular, user can choose to show or hide three main groups of information (machines, queue, graphs about attributes), while each of these groups can be independently customized. For machines, a lot of different data are available, like name, number of slots, free disk space (total and per slot), memory (total and per slot), Operating System, average load (both total and HTCondor), etc. Besides this general information, our tool also stores some specific data, one of the strong points of our implementation, since it is not commonly offered by other tools: time restrictions on jobs execution, last time a job was executed on each machine, etc.

To finish, we want to mention other third-party tools and snippets we have used in our development, such as SCW (Simple Calendar Widget) to present the calendar [http://www.target.info/calendar/scw.htm], Tooltip [http://jqueryui.com/tooltip/] to display extra information according to the context, Chosen to allow searches on the lists [https://github.
We present in this section several screenshots of ConGUSTo to illustrate its functionalities and main features.

The first contact you have with our tool is a screen where you can choose which date, machine and view you want to see, as shown in Fig 1. All the options are displayed in a friendly style: users can choose the date pressing on a navigable calendar, while machines can be selected from a list that includes a search box, so it is even easy in large systems with hundreds of machines. Several views are available and they will be explained next.

5.1 Daily jobs execution on a machine (summary)
This first view will present summarized information about the selected day, as is shown in Fig. 2. Two graphs are displayed with a timeline listing the number of jobs executed at any moment (upper graph displays the AM hours and lower one the PM). The number of jobs that are or were running are shown in blue, while those in red are the suspended ones. This graph gives us in a glance an overview of what HTCondor has been doing on that machine, when it has been executing jobs and when some activity has been detected and jobs were suspended.

After the graphs, users can find a table that gathers quantitative data about the total time spent. The first row shows the maximum theoretical time limit; the second row displays the total amount of time the machine has been used by its owner or was idle (total time is printed alongside the average per slot and percentages), while the third row collects the total time consumed by HTCondor, broken down into time used when jobs are running and when are suspended (fourth and fifth rows, respectively).

5.2 Daily jobs execution in a machine (details)
If users want further information about the execution on a specific day, they can choose the detailed view as shown in Fig. 3. This view is similar to the summary, but graphs show detailed information about each job that was executed on each slot of the selected machine. As in the summary, for a clearer view the timeline is split between AM and PM hours, and jobs are shown in blue when they are running and in red when suspended. Among the information displayed is the ID of the job, the current status, its user, initial and ending time, and the total duration. If the job is long enough and there is space, part of that information will be printed on the job. If not, all information will be shown in a small pop-up window when you place the pointer over the job. Thanks to this view one can get such data as what jobs and users were executing on a machine, and use this information to gather further data in case of any issue.

5.3 Weekly and monthly jobs execution in a machine
Besides the summarized and detailed information for specific days, our tool also offers an overview of HTCondor usage for one-week and one-month periods. Users can choose the starting date of those periods and then display the cumulative hours and percentage of time consumed by HTCondor. Fig. 4 illustrates the one-week-period in both graphical and tabular way.

The month view is similar to the week one, as it is shown in Fig. 5. It offers a wider view of the performance of that machine, so it is easy to identify the days of highest or lowest usage, and then inspect summarized and/or detailed information about them with other views.

5.4 HTCondor machine panoramic view
The previous views allowed us to know the past and current status of a specific machine. Now we present a powerful,
panoramic view that lets us know in a glance the global status, at the current time, of all machines in the HTCondor pool. This view can be seen as a complement of the \texttt{condor_status} command, where the data are graphically displayed instead of being printed in a large text list, and with many more featured added. Fig. 6 shows the default, basic view.

Machines are represented with boxes and each slot is displayed with a different color according to its state (blue when they are used by their owners, red when running HTCondor jobs, green when idle, etc.), preceded by a summary of the pool general status and the link to the configuration options. By default only the name of the machine and the state of slots are displayed, since our aim is to keep the visualization as clean as possible. Therefore, detailed information is not presented by default, but our tool is able to gather much more information that users can consult by just placing the pointer over one specific machine or slot. Then extra info is displayed in a contextual window: free disk space, RAM, number of slots, Operating System, total average load and HTCondor average load, time restrictions, last time of HTCondor execution, and many other indicators. However, if users want to have all these data in the main window, they can use the wide set of provided configuration options to exactly select the specific items to be displayed, as well as enable or disable the contextual windows. For instance, Fig. 7 shows a more detailed view of the pool status.

The above data are complemented with information about the number of machines and slots shown and the HTCondor queue status that is shown right after. Fig. 8 shows the summary of the queue, similar to the output of the \texttt{condor_status -submitters} command. It consists of a table listing the total number of jobs, further broken down by their state (running, queued or held) and by their users.

The real power of this tool lies in its configuration capabilities and in the many available filters. Fig. 9 shows the configuration window, which begins with general options to enable or disable the three main groups: info about machines, info about HTCondor queue, and graphs to represent the data. Users can configure which information and how they want to display for each machine and/or slot, such as hardware parameters (free disk, RAM, etc.), software (OS, average load, etc.), and HTCondor specific data (time restrictions, last time of execution, etc.). Further options let users to order the machines according to several criteria, display alerts if the free disk space is lower than a specified limit, or enable the automatic update of the information in preconfigured time periods.

Next, blocks are used to apply filters on the machines, allowing users to have a more refined control of the HTCondor pool. In this way users can decide which machines and/or slots they want to display according to their communication status (up or down), which Operating System and version is installed, the state of the slots, what user is running what job on them, etc. Right after, there is a battery of filters to show or hide machines or slots according to attributes like memory, free disk space, system average load, HTCondor average load.
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Figure 5. Condor usage data over a one-month period.

and number of slots (machines) or time spent in the current status (slots). All these filters accept a range of values.

Finally, users can configure what data they want to show in charts. There is a set of 15 predefined graphs to see the pool status according to a number of parameters: amount of free disk or RAM, load, job state and owners. Fig. 10 shows some examples.

We want to point out that all these options are not only useful for HTCondor users, but also for system administrators. With ConGUSTo, they are able to have a graphical view of the machines status and get such valuable information as what machines are up or down, average load of each machine, free disk and total memory, Operating System, number of slots, etc. They can use also the available filters to select subgroup of machines, while the automatic refresh feature can convert this application in a real-time monitoring tool.

6. Conclusions and future work

For many years HTCondor administrators have lacked a powerful tool that provide a quick and clear overview of where and when HTCondor was executing the jobs, and what was happening in each specific machine of the pool. The new version in the 8.2.x series, released recently, is a good step in this direction, as it includes new features that are able to generate data that can be then represented with Ganglia, a third-party software. This feature is expected to improve in subsequent releases, but right now it does not seem to be compatible with older versions of HTCondor.

We have thus developed and implemented ConGUSTo, an advanced logging and monitoring system for HTCondor that provides an online visualization of the status of all the machines that belongs to the HTCondor pool. Our implementation is compatible not only with the most recent HTCondor release, but also with older versions. Its main goal is to allow users and administrators to know at any moment, in real time, what the status of any machine is and what jobs they have executed or are executing. All this information is available online in a friendly and easy to interact with format, with no need to dig into huge log files anymore.

The current ConGUSTo implementation has room for a number of improvements. We plan to explore the following lines:

- Study other ways to store in a more compact format the gathered data.
- Test our implementation on other HTCondor systems with different versions.
- Identify what options and configurations are the most used by our users.
- Receive feedback and comments from our users, so as to find new features that could be implemented.
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**Figure 8.** Summary of the current status of HTCondor usage, broken down by status and users.

**Figure 9.** Configuration panel with the list of all applicable options and filters to customize the panoramic view.

- Assess in detail the capabilities provided in the latest HTCondor release and see how they can be incorporated into ConGUSTo to enhance and expand it.

**Software availability**

While at the moment ConGUSTo is not publicly available, interested users can contact us via email to get a copy. We will be more than happy if you wish to share your impressions and feedback with us.

ConGUSTo is distributed in a `.tar.gz` file. Detailed installation instructions will be provided to interested parties, however the basic steps are:

1. Decompress the tar file in a directory of your web server where you can run PHP script files.

2. Build the file containing the list of machines (this is used to list all machines belonging to the pool, even if they are not active at that moment), by using the script `build_machine_file.sh` in any machine in the HTCondor pool; and then move that file to the same directory where you decompressed the files in step 1.

3. Install crontab entry to get the periodic data. That can be done in any machine running HTCondor, but since you have to ensure it will be always working, we recommend you install it on the HTCondor master node. If this machine is different from the web server, make sure that the web server have read access to the generate files.

4. Set the system up by setting the configuration variables with the appropriate values.

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