DOMjudge at Amrita

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DOMjudge team

Amrita university conducted a programming contest with over 4000 teams participating and chose DOMjudge as the platform. This document describes how it was done, which problems were encountered and what is being done to address those.

Introduction

Amrita university was in the process of organising a contest with over 4000 teams and contacted the DOMjudge team to see if our programming contest software could scale up to this size. The DOMjudge developers gladly took up this challenge and helped the Amrita team design and configure a system that could handle this load.

System architecture

The DOMjudge programming contest system provides web interfaces for teams, jury and public, while data is stored in a database and the back end judging system consists of daemons running on separate linux hosts. The web interfaces are served from Apache with a MySQL back end. It can be scaled out according to existing industry standard best practices for these platforms, so there is no need to reinvent the wheel for DOMjudge specifically. Indeed, the approach by the Amrita team is based on standard web application scaling.

As front end to the system a load balancer is used, which distributes the requests over various web servers. The public interface is served by a Varnish cache and reads from a read-only MySQL slave, making sure that hits on the public scoreboard do not impact the rest of the contest. Three separate read/write webservers for the many teams and a last one for the contest judges interact with the MySQL master read/write database. Each webserver has two Quad core Xeon processors with 16 GB RAM. Memcache is used both as a query cache for MySQL and as a session handler for the team front ends. The Memory storage engine was used for the scoreboard caching tables.

DOMjudge's judging back end, the judgehosts, scale out trivially and without arbitrary limit; a fundamental design decision in DOMjudge. Each node has an Intel i5 CPU and 8GB of RAM, and there were around 25 in total. All systems were installed with Ubuntu 12.04.

A schematic overview of the setup is given on the last page of this document.

The contest

The contest was held on 7 October 2013. In total 4643 teams actually participated, who made a total of 18497 submissions for the four problems. Of those, 2453 were judged as correct. 434 teams solved at least one problem while 100 solved all of them.

Experiences during the contest

In preparation to the contest, it was discovered that some parts of the web interface (like the individual scoreboard row display for each team) could not gracefully handle the large number of teams. Drop down select lists with thousands of elements, present in the clarification part of the jury interface, also slowed down the browsing experience. Some quick patches were made to disable certain non-essential functionality in the interface.

The scoreboard was too large with over 4000 teams, so a separate version was generated containing just the top 1000 teams. A cronjob periodically exported this to static HTML, served to the teams and public.

The judgehosts saw random crashes during the contests. The reason was narrowed down to locking issues in the MySQL server, where each scoreboard cell recalculation does a full table lock on the scoreboard cache tables. DOMjudge does not have an active alerting system for judgehost problems, which required quite some manual work.

Regardless of these issues, overall the contest ran smoothly.

Lessons learned and actions taken

Overall the Amrita contest proved that DOMjudge can indeed be scaled out using standard techniques for web application scaling, but that a few specific bottlenecks remain when dealing with numbers of teams this large. For one part, this is inherent in the very special nature of this contest, and the open source aspect of DOMjudge made it possible for Amrita to apply the local changes they required for their needs. However, we analysed these changes to see whether it would be possible to address them in the standard DOMjudge distribution.

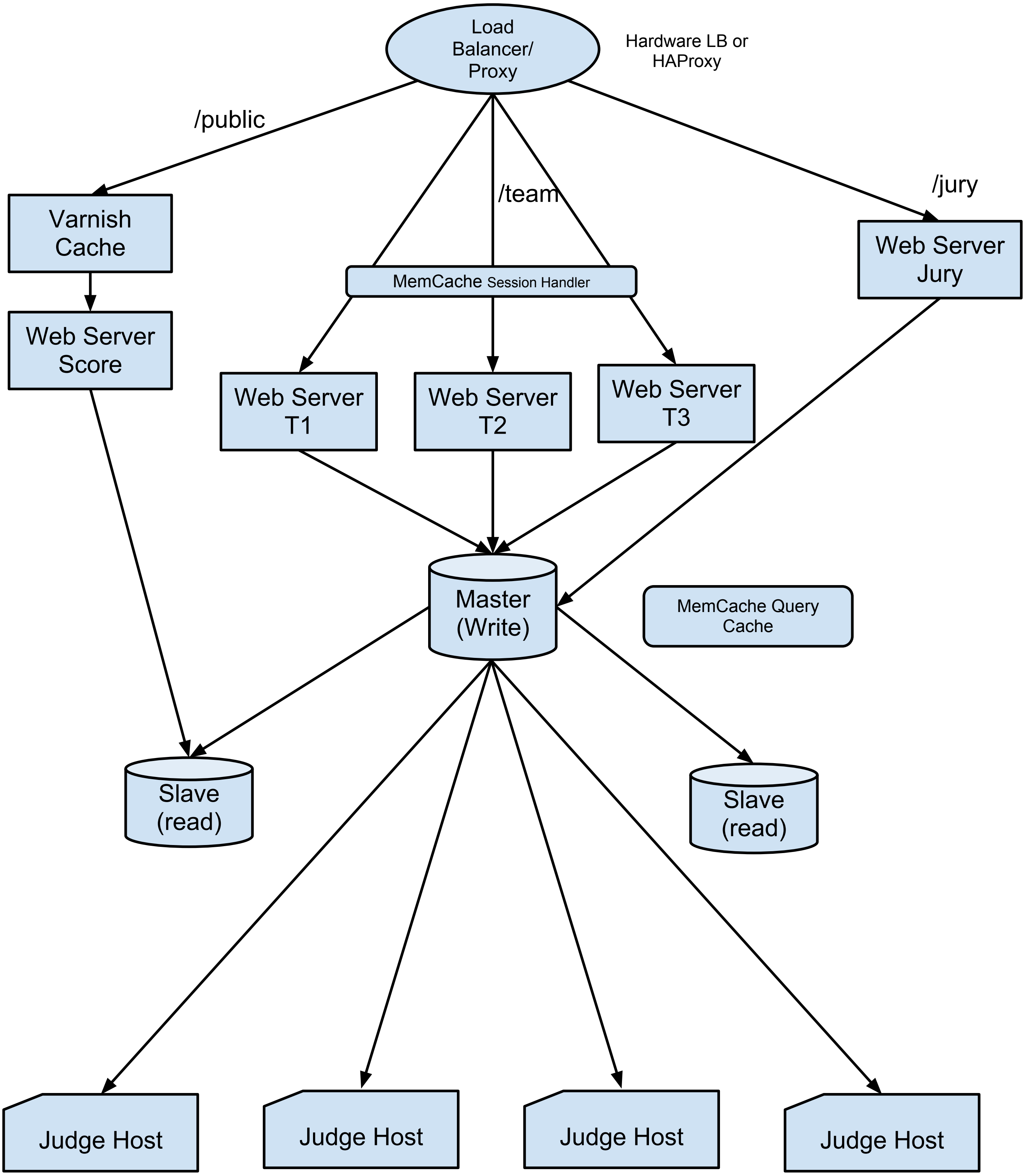
On the team interface page, displaying the information relevant to the single specific team turned out to be dependent on the total number of teams. The cause was that calculation of the team rank involved processing the scores of all teams in the contest. The database design has been changed so the rank of a specific team is now cached and calculated inside a query involving this cache table, instead of from data retrieved from the database. Although this does not reduce the linear[1] complexity in terms of the number of teams, it reduces web server load and the team page rendering time to be unnoticable.

For the complete scoreboard: the changes described above also impact the time needed to compute the complete scoreboard. Discussions are ongoing to further reduce memory usage in scoreboard calculation. Still, a generic solution for very large contests is not yet available at the time of writing. Aside from processing times, this is mostly a design question, as the current table based layout does probably not yield a useful scoreboard when it contains thousands of rows, regardless of how fast it is calculated.

The lock contention issues in the judgedaemons has proven difficult to reproduce and has not yet been resolved. DOMjudge does monitor whether each of the judgedaemons checks in periodically, but does not actively alert the administrator when a judgehost fails to do so. Because we think that other tools already exist that do this well, we recommend to set up external monitoring software, like Nagios, to ensure the health of each system component is appropriately monitored.

All of the changes mentioned here have been included in DOMjudge 4.0, which is planned to be released before the 2014 ACM ICPC world finals.

[1] Most internal operations within the query are actually $\mathcal{O}(\log(\#\text{teams}))$, but due to technical details the overall query is still $\mathcal{O}(\#\text{teams})$.


Load Balancer/ Proxy
Hardware LB or HAProxy
/public
/team
/jury
Varnish Cache
Web Server Score
MemCache Session Handler
Web Server Jury
Web Server T1
Web Server T2
Web Server T3
Master (Write)
MemCache Query Cache
Slave (read)
Slave (read)
Judge Host
Judge Host
Judge Host
Judge Host