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TRANSFORM WITH MIGRATION OF THE UNIVERSITY LEARNING MANAGEMENT SYSTEM TO CLOUD SERVICES

Abstract: *We show how moving a university LMS consisting of many servers to cloud services will help solve several problems. Yandex Cloud (similar to AWS system) will be used as the main infrastructure. We describe the benefits of using cloud infrastructure.*

Key words: *LMS Moodle, SaaS, Yandex Cloud, Yandex Object Storage.*

Language: *English*

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Introduction

Currently, LMS of SPbPU consists of of more than 15 servers and uses Moodle [1] installed on the traditional LAMP/LEMP infrastructure (Linux, Apache/Nginx, MySQL, PHP/Perl/Python) [2]. There is a server for general disciplines (these are disciplines that are taught to several specialties of education - for example, physics, mathematics), institute servers for special disciplines (taught to one or two specialties), a server for olympiads, etc. The vast majority of these servers are virtual. As a rule, for each discipline for each teacher for each type of lesson (lecture, practical exercises, laboratory) a course is created in the corresponding LMS every semester. Each of the more than 30,000 students and 2,000 teachers of SPbPU is registered and actively uses several of these courses, usually located on different servers. The total amount of data on these servers is several tens of terabytes - these are video recordings of lectures, presentations and teaching materials for classes, tests, service information, etc. The administration of such a zoo of servers leads to certain difficulties, and the reliability inside the university server rooms can be an order of magnitude less than in the data centers of providers - power supply problems, network reconfiguration, changes in the address space, purchase of server capacity upgrades, etc., so it is planned to transfer LMS to cloud Services. In this article, we will describe how such a transition to the use of SaaS [3] allows us to solve existing problems.

Existing problems and their solution

Problem 1 - students often complain that the video is either not available or downloads very slowly. This is because the Moodle system has problems keeping large files up to date. In addition, when storing a large number of video files in the LMS, there are problems with archiving and creating copies of courses. There are also problems with a large number (and file size) of assignments in courses: 3D models, recording audio responses from listeners, working in PDF format, etc. It is clear that such systems need regular backups (Full backup, Differential backup, Incremental backup) and it is clear that RAID is necessary to improve fault tolerance and performance. Having dozens of terabytes of static data files, it is

necessary to purchase new data storages, which leads to problems in monitoring their status, difficulties in administration.

The solution to this problem would be to place the video files in the Yandex Object Storage S3 storage [4], and the links to these video files would be stored in the LMS. What would be the advantages of this solution:

- distributed storage would be used (Content Delivery Network [5]);
- this would allow rapid deployment of new data stores;
- this would give a departure from the concept of a data source and a transition to services;
- this would provide a convenient mechanism for loading data;
- this would provide a flexible storage management mechanism;
- of course, this would provide more reliability for data storage.

Thus, this would lead to a solution to problem 1 - students (and teachers) will not complain about playing and downloading video files. Fig. 1 shows an example of working with Yandex Object Storage S3 storage for video files.

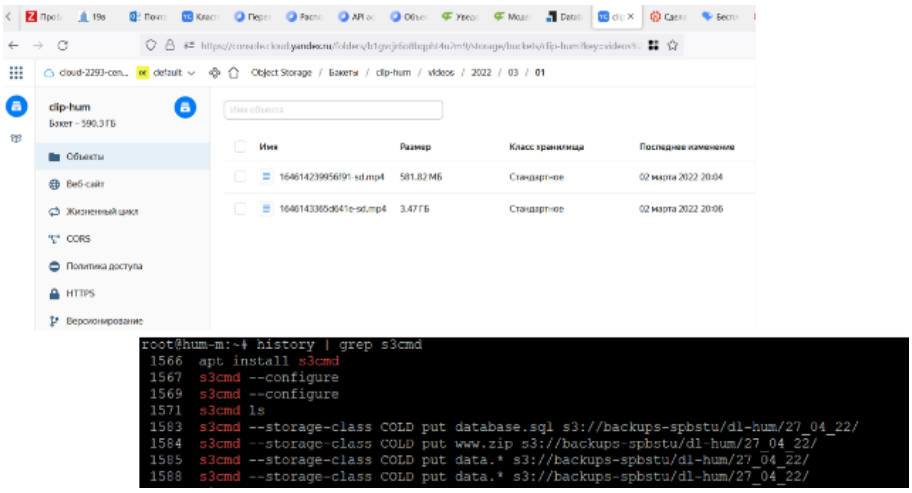

Fig 1. a)

Примеры кода

Список имен бакетов:

```php
// Предполагается, что AWS SDK установлен через Composer
require '/path/to/vendor/autoload.php';
use Aws\S3\S3Client;

$s3 = new S3Client([
    'version' => 'latest',
    'endpoint' => 'https://storage.yandexcloud.net',
    'region' => 'ru-central1',
]);
$buckets = $s3->listBuckets();
foreach ($buckets['Buckets'] as $bucket) {
    echo $bucket['Name'] . "\n";
}
```

Fig 1. b)

Fig. 1. An example of working with Yandex Object Storage S3 storage for video files.

Problem 2 - heavy workload of network nodes. However, many of these busy nodes use the same external address, and traffic can exceed 1 Gb/s. We would also like to split the service traffic and Moodle traffic into two different nodes. In this case, of course, it is necessary that when one gateway node fails, the second would take its address. To solve this problem, it is proposed to use the keepalived service [6] (on the frontend) to distribute the load of the gateway, which allows organizing service fault tolerance and load balancing. To automatically switch IP addresses between keepalived servers, the VRRP (Virtual Router Redundancy Protocol) [7] protocol is used. Fig. 2 shows an example of using keepalived. What are the benefits we get from this:

- in the event of a virtual machine crash, nodes with web services will be available;
- there is no reserve of the virtual machine and IP addresses - the implementation of the master-master (in this case, the master-slave is also possible);
- scheme recommendation for loaded nodes from Nginx, Inc.;
- implementation of intellectual logic is possible.

```
Tue Jan 22 22:52:53 2019:    NIC netlink status update
Tue Jan 22 22:52:53 2019:    Reset promote_secondaries counter 0
Tue Jan 22 22:52:53 2019:    Tracking VRRP instances = 0
Tue Jan 22 22:52:53 2019:  Name = docker0
Tue Jan 22 22:52:53 2019:    index = 5
Tue Jan 22 22:52:53 2019:    IPv4 address = 172.17.0.1
Tue Jan 22 22:52:53 2019:    IPv6 address = (none)
Tue Jan 22 22:52:53 2019:    MAC = 02:42:81:da:d0:8c
Tue Jan 22 22:52:53 2019:    MAC broadcast = ff:ff:ff:ff:ff:ff
Tue Jan 22 22:52:53 2019:    State = UP, not RUNNING
Tue Jan 22 22:52:53 2019:    MTU = 1500
Tue Jan 22 22:52:53 2019:    HW Type = ETHERNET
Tue Jan 22 22:52:53 2019:    NIC netlink status update
Tue Jan 22 22:52:53 2019:    Reset promote_secondaries counter 0
Tue Jan 22 22:52:53 2019:    Tracking VRRP instances = 0
Tue Jan 22 22:52:53 2019: (VI_1) Entering BACKUP STATE (init)
Tue Jan 22 22:52:53 2019: VRRP sockpool: [ifindex(2), family(IPv4), proto(112), unicast(0), fd(9,10)]
Tue Jan 22 22:52:56 2019: Track script Checkhaproxy is already running, expect idle - skipping run
Tue Jan 22 22:52:56 2019: VRRP_Script(Checkhaproxy) timed_out
Tue Jan 22 22:52:56 2019: (VI_1) Changing effective priority from 100 to 75
Tue Jan 22 22:52:56 2019: pid 12 exited due to signal 15
Tue Jan 22 22:52:56 2019: pid 14 exited due to signal 15
Tue Jan 22 22:52:56 2019: pid 15 exited due to signal 15
Tue Jan 22 22:52:57 2019: (VI_1) Receive advertisement timeout
Tue Jan 22 22:52:57 2019: (VI_1) Entering MASTER STATE
Tue Jan 22 22:52:57 2019: (VI_1) setting VIPs.
Tue Jan 22 22:52:57 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:52:57 2019: (VI_1) Sending/queueing gratuitous ARPs on enp2s0 for 10.8.8.18
Tue Jan 22 22:52:57 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:52:57 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:52:57 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:52:57 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: (VI_1) Sending/queueing gratuitous ARPs on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: Sending gratuitous ARP on enp2s0 for 10.8.8.18
Tue Jan 22 22:53:02 2019: Track script Checkhaproxy is already running, expect idle - skipping run
Tue Jan 22 22:53:02 2019: pid 17 exited due to signal 15
Tue Jan 22 22:53:02 2019: pid 19 exited due to signal 15
Tue Jan 22 22:53:02 2019: pid 18 exited due to signal 15
Tue Jan 22 22:53:06 2019: VRRP_Script(Checkhaproxy) succeeded
Tue Jan 22 22:53:06 2019: (VI_1) Changing effective priority from 75 to 100
```

Fig. 2. An example of using keepalived.

Problem 3 - the database is heavily loaded. With such heavy use of Moodle courses, the database is often an Input/Output bottleneck. Therefore, the correct strategy is not just to move the database to a separate node, but to take it out to several nodes at once. But this leads to some difficulties in database administration. The solution to this problem is the transition to a cloud database - access to the database as a service.

Using Yandex Managed Service for MySQL [8] allows you to get the following benefits:

- no need to administer the database cluster;
- easier to switch between database versions;
- database snapshot system “right out of the box”;
- very simply (literally with one click) you can change the parameters of the number of nodes, their connectivity;
- monitoring tools;
- integration with Yandex Cloud services.

Fig. 3 shows an example using MySQL Cloud.

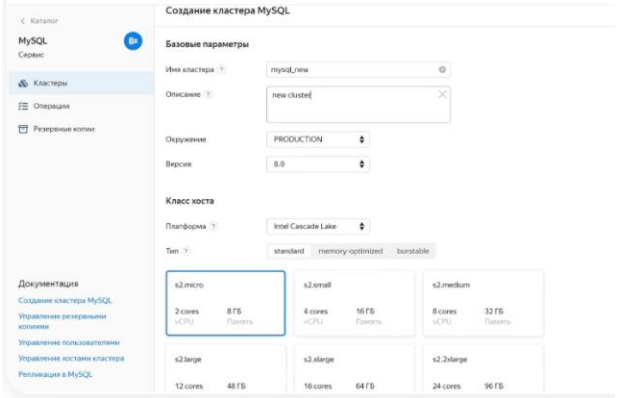

Fig. 3. An example using MySQL Cloud.

Problem 4 is described in our paper [9]. This is a desire to make life easier for students (especially foreign ones) and teachers by transcribing video lectures into text. The developed system [9] allows foreign students to better understand what is said in the lecture (both with the help of subtitles in Russian and foreign languages, and with the help of the text of the lecture), and Russian-speaking students and teachers - to create electronic notes, search for the phrase from the time-tagged video.

Problem 5 - with such intensive use of Moodle, the size of static data in the /moodledata directory grows greatly. As with problem 1, this requires new storage resources to be allocated. You need to mount, migrate or increase the size of the /moodledata partition. In this case, you need to store more than 1Tb of static data files - and as described in Problem 1, there is a problem with backup and data transfer. We would also like to increase the transfer rate of this static data. The solution to this problem is similar to the solution of Problem 1 - for static data (/moodledata) use the Yandex Object Storage S3 storage.

The problem of the speed of deploying new nodes (provisioning) and the allocation of new capacities is also solved.

Problem 6 - we would like to use a complex search in the document database, for example, search taking into account the morphology of the language, use various analytics. The solution to this problem is the use of Elastic Stack (ELK - Elasticsearch + Logstash + Kibana) [10] and Yandex Managed Service for Elasticsearch in the Yandex Cloud infrastructure [11]. It becomes possible to receive tags according to the course data, which can be used for tagging courses as well as to improve navigation and search for courses by content.

Conclusion

Thus, the transfer of university LMS Moodle to cloud services can solve the problems of bottlenecks and application architecture (availability, fault tolerance, ease of scaling, administration). Of course, at the same time, the transition to the cloud will require redoing the integration of the application with data sources to work with services. But after the transition to the cloud of the LMS system, it is possible to use digital services and it is easier to carry out further integration with other services within the framework of the new ideology.

What benefits, in addition to solving the problems described above, do we get? For the University, as for many companies, the administration of such a large information system is accompanied by some complexity, so it is often easier to make services and transfer them to the cloud to someone. At the same time, you will have to pay only for the operation of the service (and further for the possible development of new services), and not to maintain your own large staff of system, network and database administrators. Reliability increases - in the IT structure of a university, as a rule, all the main equipment is located in one place, and possible problems with power supply in this place or failure of storage or network equipment can lead to big problems, so backups are often required. While the use of cloud services implies geographical distribution over several data centers, and the reliability of the IT infrastructure increases. This, of course, does not cancel the regular backup, but it allows more flexible allocation of data storage resources, which saves resources, according to some estimates, by almost an order of magnitude. The transition to cloud services leads to a decrease in the time for deploying IT systems, allows better scaling of systems, increases flexibility - it is possible to use a lot of computing resources for some time, while the load during normal times can be small. As already noted, it becomes possible to use various cloud services - speech recognition, pictures, automatic translation into other languages, automatic generation of subtitles, etc., it becomes possible to develop digital systems based on the use of various cloud digital services.

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