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ADVANTAGE OF INSTALLING MOODLE LEARNING MANAGEMENT SYSTEM UNDER IIS/MARIADB OVER APACHE/MYSQL†††

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Irina Poghosyan, *Master of Science in Computer and Information Science, French University in Armenia. Republic of Armenia*

Email: *irina.poghosyan@pers.ufar.am*

Abstract

This article examines the advantages and disadvantages of installing Moodle's popular learning management system using MySQL, MariaDB, Apache, and Internet Information Services. It considers the impact of these choices on performance, database server speed, and cyber security, which is critical for dealing with many users and students whose numbers have increased dramatically since the onset of the global pandemic caused by the SARS-CoV-2 virus. It has been determined that IIS/MariaDB represents the optimal configuration for Windows-based systems, while Apache/MySQL is optimal for Linux distributions. The selection of specific solutions should be based on the particular needs of the educational institution in question, the available infrastructure, and the financial capabilities of the institution in question. MariaDB's functionality is enhanced by including the Galera Cluster, which offers a higher throughput than MySQL's. Both IIS and Apache have some advantages and disadvantages. The decision to use one or the other is made based on the choice of operating system.

Keywords: *Moodle, Learning Management System (LMS), MySQL, MariaDB, Apache, Internet Information Services (IIS), Cybersecurity, Galera Cluster, Database Performance, Educational Technology Infrastructure.*

INTRODUCTION

In the wake of the global pandemic, the proportion of distance education worldwide has risen markedly, prompting a crucial examination of the efficacy of computer-based Learning Management Systems (LMS) employed for this purpose. One of the most widely used LMSs is the Modular Object-Oriented Dynamic Learning Environment (Moodle). It is imperative for all educational organizations that require optimization of their information infrastructure and online learning processes to prioritize optimization of the Moodle database alongside the assurance of a robust cybersecurity and data protection strategy. Therefore, selecting the appropriate software system and database server is crucial. The most prevalent approach is deploying Apache with the

database management system (DBMS) MySQL. This installation option is popular with Moodle since it was initially developed to share this software. However, studies have demonstrated that there are better solutions than this, with installation under Internet Information Services (IIS) and MariaDB exhibiting superior performance of Moodle.

Utilizing this software bundle in conjunction with multiple servers, as opposed to a single server, has enhanced performance and server processing times for requests and responses. The following section will compare the software tools used above to identify the most relevant option for an educational institution and consider its specific requirements.

LITERATURE REVIEW

Moodle is a widely adopted open-source Learning Management System (LMS) that provides educators with tools to create personalized learning environments (Raetsky, Ulyanin, & Ermakova, 2016). The performance and scalability of Moodle are heavily influenced by the underlying web server and database management system used in its deployment. Traditionally, Moodle has been deployed using the Apache HTTP Server and MySQL database. However, there is a growing interest in alternative configurations, explicitly using Internet Information Services (IIS) and MariaDB, due to potential performance and scalability benefits.

Apache HTTP Server and MySQL in Moodle Deployments

The Apache HTTP Server has been a staple in Moodle deployments owing to its open-source nature, robustness, and extensive community support (Wikipedia contributors, 2024). MySQL, similarly, has been favoured for its reliability and integration capabilities with Moodle (MySQL: MySQL 8.4 Reference Manual). Despite their widespread use, some studies have pointed out limitations in handling high concurrent connections and scalability challenges in large-scale Moodle environments (Yusuf & Kusniyati, 2020).

Emergence of IIS and MariaDB as Viable Alternatives

IIS is a flexible, secure, and manageable web server that hosts web applications on the Windows platform (Internet Information Services - MoodleDocs). It offers seamless integration with other Microsoft products and technologies, which can be advantageous in specific institutional IT environments (Leanserver, 2023). Discussions within the Moodle community have highlighted

that IIS can provide better performance on Windows servers than Apache, along with more straightforward configuration and management (Moodle in English: IIS vs Apache for Moodle, 2015).

MariaDB, a fork of MySQL, has gained attention for its enhanced performance features and additional storage engines (Storage engines - MariaDB KnowledgeBase). It is fully compatible with MySQL, making it a drop-in replacement offering better performance and scalability (MariaDB - MoodleDocs). Benchmarks have demonstrated that MariaDB outperforms MySQL in various scenarios, particularly in cloud environments (Friedenbach, 2022).

Performance Optimization and High Availability

Optimizing the performance of Moodle is critical for providing a smooth user experience, especially in institutions with a large number of users. Studies have explored various methods to enhance Moodle's performance, including database optimization, load balancing, and clustering techniques. Ksiazek (2022) discussed building a highly available database for Moodle using MariaDB replication and clustering, emphasizing improved reliability and performance.

Prakasa et al. (2024) investigated using HAProxy and MariaDB Galera Cluster to enhance Moodle performance. Their findings indicated significant improvements in load-balancing efficiency and database availability. Similarly, Triangga, Faisal, and Lubis (2019) analyzed different load-balancing algorithms on HAProxy, concluding that the choice of algorithm can significantly impact resource utilization efficiency.

Cloud Migration and Scalability

With the increasing demand for scalable and flexible LMS solutions, migrating Moodle instances to the cloud has become pertinent. Zdravev, Velinov, and Spasov (2021) presented a case study on migrating Moodle to the cloud, highlighting the challenges and benefits of such an endeavour. The study underscored the importance of selecting appropriate server and database configurations to ensure optimal performance in a cloud environment.

Cardoso et al. (2022) proposed a technological cluster to support eLearning platforms like Moodle. Their approach focused on enhancing scalability and reliability through clustered infrastructures, which can be effectively implemented using IIS and MariaDB.

Optimization of Moodle Configurations

Optimizing Moodle configurations is essential for leveraging the LMS's full potential. Slavko and Serhiienko (2021) explored various optimization techniques for Moodle configurations in the context of electrical engineering education. Their research demonstrated that careful server and database settings tuning could lead to substantial performance gains.

Advantages of IIS/MariaDB over Apache/MySQL

The literature suggests several advantages of using IIS with MariaDB over the traditional Apache and MySQL setup. IIS offers better integration with Windows servers, potentially improving performance and more accessible management in Windows-centric IT environments (Leanserver, 2023). MariaDB provides enhanced performance features, additional storage engines, and better scalability options than MySQL (Storage engines - MariaDB KnowledgeBase).

Moreover, combining IIS and MariaDB could offer synergistic benefits, such as improved handling of concurrent connections and better resource utilization, which are critical for large-scale Moodle deployments (Ksiazek, 2022; Prakasa et al., 2024).

While Apache and MySQL have been the default choices for Moodle deployments, the emerging literature indicates that deploying Moodle under IIS and MariaDB can offer significant performance, scalability, and integration advantages, especially in Windows-based environments. However, more comprehensive studies that directly compare these configurations are needed to provide concrete evidence of the benefits. This literature review highlights the potential of IIS and MariaDB as superior alternatives. It sets the stage for further research into the advantages of installing Moodle under IIS/MariaDB over Apache/MySQL.

METHODS AND METHODOLOGY

To compare the advantages and disadvantages of installing Moodle with IIS/MariaDB and Apache/MySQL, the available scientific articles were analyzed using different strategies to optimize the system, database, and server speed. These included using cloud technologies and a cluster of several servers rather than a single server for the database. Given the dearth of empirical studies in the scientific literature, an analysis was conducted to examine the characteristics of technologies for Apache and IIS web servers and MySQL and MariaDB databases. To achieve this, the official websites of the software developers in question and the relevant documentation and community testing data were consulted.

The principal indicators that illustrate the benefits of a specific Moodle installation method are the processing speed of database queries, the response time of the web server, and the corresponding latency times. Without numerical data and experiments on Moodle's cyber security under the two scenarios under study, it is only possible to assess the level of protection based on the cyber security of the web server and database technologies.

Modular Object-Oriented Dynamic Learning Environment

Moodle is one of the most popular LMSs due to some advantages that set it apart from the rest of the market. Moodle provides a comprehensive toolkit for educational institutions and corporate training providers. The potential for active engagement between students and learners is enhanced by the possibilities of interactive interaction between them and the academic course content. The Moodle platform offers many tools, including wiki pages, surveys, adaptive forms, glossaries, tests, practice text assignments, and lectures, which are widely used by educators and learners alike. When creating a course, the user can independently manage its structure. This may entail making the course non-linear, for instance, by opening the subsequent sections only after the user has demonstrated their comprehension of the material presented thus far. Additionally, the user may return to previously studied material or delve more deeply into it.

One of Moodle's most notable characteristics is its open-source software. The open-source platform permits users to utilize the software without incurring financial expenditure and, additionally, to modify and adapt it to align with their particular requirements. Many plugins are available, enhancing the system’s functionality and rendering Moodle a highly flexible tool for various educational institutions and organizations. To illustrate, the Siberian State Industrial University has developed a plugin designated “SibGIU Portfolio,” which enables the creation of an electronic portfolio for students, reflecting their achievements in multiple domains. Furthermore, Moodle boasts a substantial user and developer community, offering knowledge, discussion forums, and resources for troubleshooting, installing, supporting, and utilizing the system. Additionally, it provides insights into innovative and proven pedagogical practices.

MariaDB vs MySQL

To ascertain the most appropriate software for use as a database management system in Moodle, it is first necessary to consider the similarities and differences between the most popular

DBMS solutions and those recommended by the official Moodle documentation. These include MySQL, MariaDB PostgreSQL, OCI, and MS SQL Server, each exhibiting differences in the operators used to create XMLDB format tables. The paper aims to compare MySQL and MariaDB, the most commonly used DBMSs for Moodle.

MySQL represents the global benchmark in open-source relational DBMS. It is compatible with all contemporary operating systems. It boasts an optimized architectural design, which endows it with high performance and the capacity to process a substantial volume of data simultaneously. SQL query language is relatively straightforward and has a relatively simple syntax. The GNU General Public License (GPL) distribution license enabled the community and developers to transform it from a low-speed system into a functional and robust solution for database management. MySQL offers comprehensive support for nine distinct transactional and non-transactional storage mechanisms. These are InnoDB, MyISAM, CSV, Memory, Merge, Example, Archive, Blackhole, and Federated.

MariaDB is an open-source relational DBMS, an offshoot of MySQL. It was created after Oracle acquired MySQL. It offers compatibility with MySQL, facilitates more efficient scaling, and enables faster query processing. Additionally, it incorporates all MySQL data storage engines, along with new ones such as XtraDB, MariaDB Columnstore, Aria, Cassandra Storage Engine, Connect, Memory Storage Engine, Mroonga, MyRocks, QQGraph, Sequence Storage Engine, FederatedX, SphinxSE, Spider, TokuDB, and others. It offers the capability to encrypt binary logs and temporary tables and provides the capacity to manage over 200,000 concurrently connected users. Compared to its predecessor, MariaDB, this software may encounter difficulties in the event of scarce resources and materials, community support, and instances where integrations with Oracle services are required.

Given its extensive user base and open-source nature, MariaDB has the potential to supplant MySQL as the default database management system on the majority of Linux distributions. Notably, the MariaDB Foundation has conducted comparative tests on Amazon RDS performance cloud hardware with the MySQL Server 8.0.21 Community Edition. The results indicate that the MariaDB Community Server 10.5.5 has a higher throughput and lower latency under a plausible workload (90% read, 10% write). This is illustrated in Diagram 1.

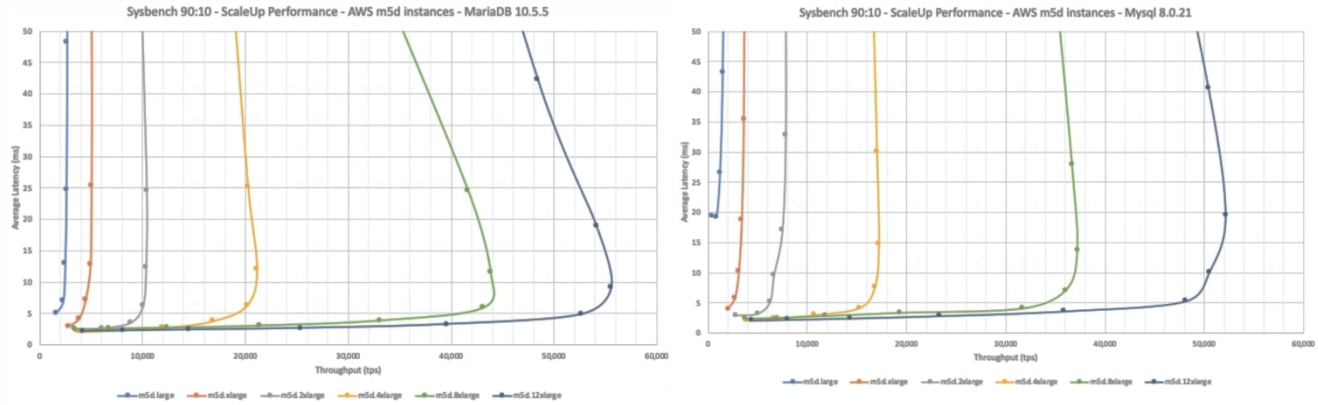

Diagram 1 – Comparison of throughput versus latency curves for MariaDB and MySQL at different numbers of parallel threads. The Diagram is taken from the source.

To ensure future compatibility with MySQL, it is essential to specify the MariaDB driver (DB type = 'MariaDB') in Moodle's config.php file when installing MariaDB following the official recommendations. Otherwise, the installation of these DBMSs and the commencement of work with them are analogous. Although the software is already optimized and conDiagramd to the highest standards, some official recommendations can be applied depending on the user's requirements.

One notable attribute of MariaDB is its Cluster feature, which enables load distribution management across database server nodes. The utilization of this feature in conjunction with ProxySQL as a load balancer enhances fault tolerance, as a redistribution of traffic to an alternative node will occur automatically should the current node be unable to perform a write operation. A typical scheme reflecting a database cluster is illustrated in Diagram 2.

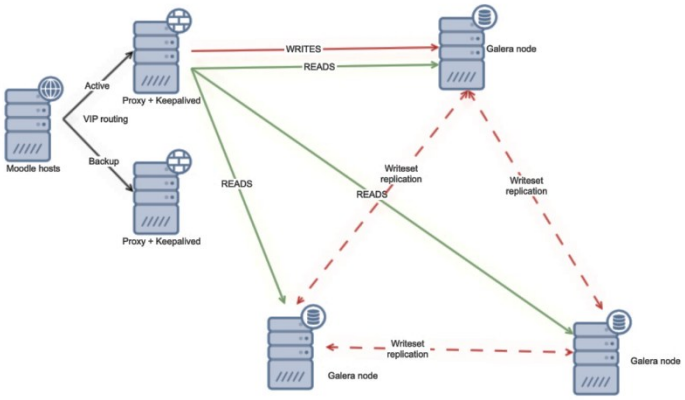

Diagram 2 – Schematic of a possible database cluster structure created with MariaDB Galera Cluster and ProxySQL. The Diagram is taken from the source.

Apache vs IIS

In addition to the DBMS, selecting software for the construction and operation of the web server represents a significant consideration. The most prevalent web servers utilized with Moodle are Apache and Internet Information Services (IIS).

The Apache HTTP Server, or simply Apache – is widely used open-source web server software given its cross-platform multiprocessing, flexibility, and reliability. Apache is compatible with several programming languages, including PHP, Python, Ruby, Perl, ASP, and Tcl. It is also interoperable with numerous content management systems like WordPress and Joomla. As a consequence, it is a prevalent choice. However, if the volume of traffic becomes considerable, performance is adversely affected due to the emergence of a queue of operations for which there are insufficient threads with a large number of visits to the site. Furthermore, it is highly susceptible to alterations in the configuration files of web server settings, which can potentially lead to critical errors and vulnerabilities.

IIS is a Microsoft web server software used in Windows. It differs from Apache in that it employs a threading model whereby each request is processed by a separate thread from the entire pool. In contrast, Apache can utilize both a multi-threaded and a multiprocessor architecture. To some extent, this results in a reduction in the performance of IIS compared to Apache. Furthermore, as it is a proprietary product provided by Microsoft and not under an open-source license, its capabilities are severely limited to the community that develops supporting tools. A further disadvantage is that IIS is only designed for Windows operating systems and cannot be used on Linux, UNIX, or Mac OS. However, integrating IIS with Microsoft products such as .NET and ASP.NET represents a significant advantage for developers working within the Microsoft ecosystem.

Additionally, Microsoft offers an official support service for IIS, which may be more convenient for enterprise users who require rapid and reliable assistance. Furthermore, Microsoft assumes responsibility for ensuring IIS users' security, privacy, and data protection. This is achieved through the company’s commitment to maintaining and updating the software, which provides a higher level of protection than the dynamic and dedicated Apache community offers. However, this also increases the risk of cyber-attacks.

The community reports that IIS processes HTTP and PHP requests faster, uses less RAM, and consumes less server CPU resources. Previous software versions had been observed to experience

issues with hangs during backups. It is also noteworthy that Apache exhibits reduced performance on Windows operating systems relative to Linux distributions.

RESULTS AND DISCUSSION

Some studies have employed diverse methodologies to enhance the functionality of Moodle. To illustrate, the paper describes implementing a load-balancing method on the web server, application server, and database server. The performance evaluation went through testing the system under standard and high values for the number of CPU cores (2-core vCPU, 1-core vCPU), RAM size (2 GB, 4 GB, 1 GB), and data storage size (20 GB, 40 GB, 40 GB) using the Apache Benchmark and Sysbench plugins. The results of the tests demonstrated that the data storage memory size parameters exerted the most significant influence on performance. Increasing the amount of database memory from 20GB to 40 GB, with other standard parameters, provided the University of XYZ with a tenfold increase in data processing speed. Diagram 3 shows a graph of the dependence of relative performance, normalized from the maximum indicator, on the query time (workload is 29 per 1 second). Moreover, the curves are presented for various system configurations, where the letter s is a standard value, and h is a high value.

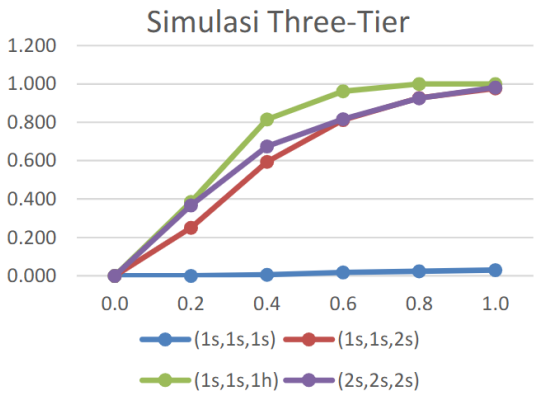

Diagram 3 – Moodle performance curves on MariaDB depending on the system configuration for server request times from 0.0 to 1.0 seconds. The Diagram is taken from the source.

Furthermore, scenarios involving the concurrent utilization of Moodle by disparate faculties at Kremenchuk Mykhailo Ostrohradskyi National University, the simultaneous administration of examination tests, and some additional regulations were also examined, resulting in a reduction of

the load on Moodle by up to 20%. The migration of the server to a Microsoft Azure cloud server, as outlined in the paper, demonstrated the absence of any performance issues concerning the simultaneous administration of tests by 300 users. However, this solution entails financial expenditure on the part of the educational institution.

In the context of organizations with high workloads and a cloud-based solution, software-defined networking (SDN) technology can also be beneficial. This enables the prioritization of Moodle traffic over other traffic, manually or automatically. It is possible to enhance the performance of Moodle by employing clustering, distributing traffic between primary and backup servers in a balanced manner, and utilizing multiple database servers. However, this approach necessitates a considerable escalation in infrastructure maintenance costs, as evidenced in the references. Coimbra Polytechnic and Viseu Polytechnic authors employed the Galera Cluster, HAPROXY, and KeepAlived tools to construct a database cluster. In addition, three Linux-based virtual machines were installed for the web server, and NGINX was employed to facilitate its functionality. Before 2020, the preceding Moodle implementation exhibited a daily attendance of 30,000 to 130,000 users. After the introduction of clusters and the surge in online distance education precipitated by the global pandemic, the daily number of users of LMS increased from 220,000 to one million. Concurrently, the system demonstrated remarkable stability, even in the context of a record number of active users. The authors did not observe system crashes, prolonged loading times, or delays in response to requests. Diagram 4 shows a schematic of the entire Moodle cluster.

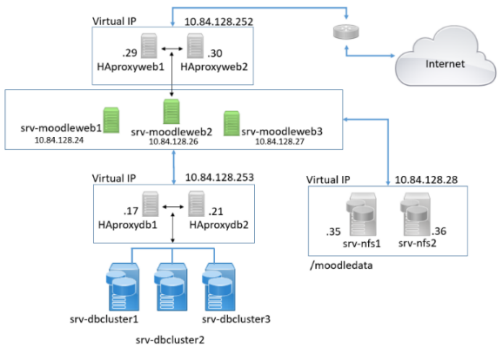

Diagram 4 – Schematic representation of MariaDB database clusters and Moodle web servers used in

A further study has comprehensively analyzed Moodle's performance, utilizing two distinct

server configurations. The first employs a single server system for the web server, file server, and database server, while the second employs a multi-server system, wherein a single server is designated for the web server and file server. In contrast, another server is utilized for the database, employing MariaDB's Galera Cluster feature and an HAProxy load balancer on the web server. The test results, some of which are presented in Table 1, demonstrate that a multi-server configuration is, on average, 297% more productive than a single-server configuration. This is evidenced by the significant increase in both write and read times and the notable enhancement in database performance, which is now almost three times faster. The findings of this study demonstrate that utilizing a dedicated server for the database is an effective approach to enhancing Moodle performance.

Table 1. Write time, read time, and database performance for two Moodle server configurations. The data are taken from.

	Configuration "1 server"			Configuration "Several servers"		
No.	read, sec	write, sec	DB, sec	read, sec	write, sec	DB, sec
1	0.415	0.162	0.212	0.119	0.071	0.105
2	0.411	0.165	0.236	0.108	0.086	0.095
3	0.418	0.136	0.202	0.108	0.081	0.097
4	0.452	0.172	0.212	0.110	0.073	0.096
5	0.426	0.137	0.211	0.119	0.074	0.098
6	0.407	0.149	0.217	0.108	0.082	0.097
7	0.425	0.160	0.425	0.109	0.072	0.096
8	0.413	0.141	0.212	0.109	0.073	0.098
9	0.403	0.152	0.213	0.115	0.082	0.096
10	0.469	0.157	0.225	0.107	0.072	0.096

CONCLUSION AND FINDINGS

The data mentioned above illustrates that the fundamental criterion for selecting software to construct a web server is the selection of an operating system. In the case of Linux distributions, Apache is the recommended option, whereas in Windows systems, IIS is the preferred choice due to

several inherent advantages. In comparative tests, MariaDB has demonstrated superior performance compared to MySQL. It offers a broader range of data storage options and tools for managing the load on cluster nodes, enhanced fault tolerance, and promising future development prospects, which collectively favour its selection. Furthermore, studies have demonstrated favourable outcomes when Moodle is utilized on cloud servers and a cloud database. However, this approach entails significant financial costs and a dependable internet connection. These are significant responsibilities for the infrastructure of an educational institution, which will facilitate the enhancement of distance learning processes, which have gained considerable popularity following the advent of the SARS-CoV-2 pandemic. The findings of the research, which entail the installation of Moodle using IIS/MariaDB, offer a comprehensive solution for Windows OS. This approach encompasses the advantages of clustering database servers and load balancing with a load balancer, ensuring optimal quality of Moodle, high speed, and the absence of delays and security issues.

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Ethics approval and consent to participate: *Not applicable.*

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Competing interests*: The authors declare that they have no competing interests.*

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