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JSON and MySQL Databases for Spatial Visualization of Polygon and Multipolygon Data in Geographic Information Systems: A Comparative Study

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Abstract.
Purpose: Spatial data is used to display digital maps. Geographic information systems' access performance depends on spatial data formats. This study compared JSON and MySQL database data display speeds. Open-source RDBMSs work with various programming languages. JSON displays data in text format. The purpose of this study is to select spatial data for polygon and multipolygon Geographic Information Systems (GIS).
Design of study: access speed to the GIS determined the method. This study evaluated how effectively JSON and MySQL displayed digital maps in GIS using two types of geographical data. JSON was in the server directory, and MySQL was on the database server. To measure performance, these two spatial data sets were compared using the same server parameters. Testers employed various tools, operating systems, devices, and browsers.
Result: JSON data is stored on a live server and is easier to access while having more data. This test compares file size and speed on three online devices. This test generates JSON as the fastest geographic data, with an average access time of 3.9 seconds and 8.5 MB loaded. MySQL, which averages 9.7 seconds, loads 6.3 MB of files. Despite its larger file size, JSON is faster for spatial data, according to tests.
Originality: Its comparison of JSON and MySQL databases based on its application for geographical data display in GIS is unique. This test offers geographic data in JSON faster than MYSQL. JSON can be used to choose location data that GIS can readily access.

Keywords: JSON, MySQL, GIS, Spatial data
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INTRODUCTION

In contemporary society, technological progress has an impact on all facets of existence, encompassing sectors such as health, tourism, and business. Everything that humans do can be facilitated by technology [1], [2]. The development of Geographic Information Systems (GIS) is one use of this technology [3], [4]. The geographic information system is one of the systems that can be utilized to convert spatial data presented as digital maps into information that is practical and comprehensible to others [5]–[7]. Geographic Information Systems (GIS) have the capability to input, store, retrieve, process, analyze, and process essential data that facilitates decision-making during the process of mapping a given area [8]–[10]. Mulvenon et al. [11] addressed data on state wide educational outcomes that were made interactively accessible through the Internet. Thematic maps produced by geographic information Systems (GIS) present statistical summaries that emphasize spatial relationships.

One way in which GIS can assist individuals in the administration of spatial data is by exhibiting digital maps that satisfy the criteria for graphical representations of spatial data [12], [13].

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Information systems composed of map data and map elements constitute geographic information systems. Spatial data for planning and problem-solving is processed, modified, analyzed, described, and presented through the collaboration of these two components. Spatial data comprises particulars regarding physical characteristics such as rivers, roads, structures, and administrative regions. A variety of sources, including photographs, maps, satellite images, aerial imagery, and statistical data, are utilized to compile this information.

The data collection process commences with a physical survey of the location to acquire the necessary attributes for spatial data. Following this, all of the survey data is compiled in QGIS using the processed data, and the information is subsequently exported from QGIS to JSON and MySQL [14]. The most practicable instruments for acquiring, presenting, and analyzing spatial (geo-referencing) data are geoinformation systems [15].

In recent years, other scholars have demonstrated an interest in the application of geographic information systems to address a wide range of challenges. One instance of the application of a framework derived from a geographic information system was by Azzam et al. [16], who examined the interconnections among water, energy, and food. To evaluate the amount of sediment loss. Medjani et al. [17] analyzed soil erosion in the Mafragh catchment in northern Algeria by utilizing a Geographic Information System. With respect to the GIS Framework. In order to evaluate the potential hazards of drought, Penny et al. [18] performed a multi-criteria decision analysis. Popular solutions in the field of facility management include geographic information systems [19]. A comprehensive analysis of flood vulnerability was performed by Chan et al. [20] through the utilization of a geographic information system. Facilitating the synthesis of high-resolution scenarios in geographic information systems for offshore network development research [21]. Solar power facilities were geolocated in accordance with Ecuador's energy legislation through the utilization of geographic information system (GIS) methodologies and multi-criteria decision making (MCDM) [22]. By utilizing a geographic information system to optimize a logistics model, a combined case study of biomass-based heat and electricity generation in China [23] illustrates this. In contrast to previous investigations, the principal aim of this study is to conduct an analysis and comparison of the spatial data employed in GIS. This is as a result of the utilization of disparate spatial data in several prior investigations [24].

The choice of spatial data type influences the efficacy of geographic information system access. Using spatial data types such as JSON and MySQL, digital maps are displayed. MySQL is stored on the database server, whereas JSON is stored in the server directory.

JSON database implementation in system development

Previous research on the utilization of JSON and MySQL in GIS has established the following: At present, there exists no definitive scientific comparison regarding the scalability and efficacy of database technologies that store and query content in XML versus the more recent JSON format [25]. JSON is a simple data format that constructs a tree with atomic values in the leaves using nested records and arrays. Currently, JSON is widely employed for data exchange on the Internet [26]. Xu and Zhu [27] introduced a vector data structure based on JSON and a method for visualizing vector data that is HTML5-based and compliant with W3C web standards in their 2011 paper. Test systems provide evidence that the new model exhibits favorable usability and addresses the deficiencies present in the initial WebGIS. By incorporating JavaScript into the Coverage Implementation Scheme, Maso et al. [28] present a novel geographic coverage JSON model. Through the integration of an HTML5 canvas and a comprehensive JSON implementation strategy, they empower web browsers to generate web maps in JavaScript in an inherent manner. JSON scheme was established as the standard language with the assistance of JSON [29]. Notwithstanding the fact that JSON is presently among the most widely employed formats for data transmission over the Internet [30]. The text-based JSON format enables attributes and values to be modified on computer systems to correspond with human text formats [31]. Felipe da Costa and Jorge [32] introduce an innovative system that utilizes GeoJSON in MongoDB to store spatial data in a standardized format. This system aims to enhance the efficacy of retrieving large quantities of spatial data through the Internet. Da Costa Rainho and Bernardino [32] implemented Web GIS in the MongoDB database system as an innovative method for storing spatial data in the GeoJSON format. Mobile GPS and GeoJSON Web Services were utilized in research described in [33] to administer Surabaya city road assets. [34] A GeoJSON-based framework for heterogeneous vector space data integration from multiple sources.

MySQL database implementation in system development

Prior research has utilized a single type of spatial data; nevertheless, this study presents an expedited approach for utilizing spatial data in GIS in comparison to MySQL or JSON [8].

By incorporating findings from Gupta et al. [35], a WebGIS was developed to facilitate infrastructure planning at the village level. MySQL is utilized to store security and non-spatial portions of data, ArcGIS is utilized to create geographic databases, ALOV is utilized to deploy geospatial web capabilities, and Apache Tomcat is utilized to deploy geospatial web capabilities. With the intention of aiding local governments in the cartographic and analytical determination of infrastructure facility locations at the village level, WebGIS was developed.

The Mapserver cartographic service and MySQL database formed the basis for the development of the Black Sea GIS [15]. Singh et al. [36] created a WebGIS-based framework for a citizen-based solid waste visualization, monitoring, and reporting system. A WebGIS-based system for visualizing and tracking geospatial data is presented. It makes use of open-accessed tools like Open Layers, Javascript, Apache Tomcat, Geoserver, PostgreSQL/PostGIS, and MySQL.

The work of Kulkarni et al. [37] introduced an integrated flood assessment model (IFAM) specifically designed for simulating urban floods along the coast. The user interface of the open-source MySQL DBMS is constructed using open layers, and the attribute data is stored within it.

An analysis of the relational database structures of NoSql Firebase and MySql was conducted by Sudiartha et al. [38]. Firebase provides support for tourist monitoring applications that handle substantial volumes of coordinated data and dynamically update information. In contrast to MySQL, Firebase is a more viable option for applications involving tourist monitoring owing to its uncomplicated data associations.

An additional study that examined database performance comparisons was conducted by Ohyver et al. [39] in their mobile application for determining the daily nutritional needs of toddlers. They compared the Firebase Realtime Database and MySQL. The response time of the database is contrasted. Comparative efficacy to CRUD operations is assessed. The data for each operation underwent Wilcoxon Signed-Rank testing. Due to its quicker response times, they discovered that Firebase Realtime Database is the superior option for database management systems in mobile applications that provide daily nutrition requirements.

Prior studies have presented a single spatial data point [40]. This differs from the results of other studies that utilized a distinct type of spatial data, the primary objective of this analysis is to evaluate and contrast how effectively JSON and MySQL may be utilized to obtain data when working with GIS. In light of these issues, a study comparing the capabilities of JSON and MySQL in accessing geographic data on Geographic Information Systems (GIS) was carried out in order to draw conclusions on which platform is superior in terms of performance. The results of this enquiry will be published in the form of suggestions for the utilization of spatial data access technologies in geographic information systems when it is finished.

METHODS

A few of the items and apparatus that were utilized during the course of this investigation. This study utilized a total of 292 data points derived from primary sources, which were survey results collected in 2020. Data collection was the first step in the process flow; data processing with QGIS follows; and the data was subsequently exported to MySQL and JSON. The software applications were the LeafletJS framework, the PHP programming language, and the CodeIgniter framework. A personal computer with the following specifications was utilized by AMD Ryzen 7 2200, 16 GB RAM, and 8 GB VGA.

This study can serve as the foundation for a case study that develops a geographic information system to map green open areas using leaflet technology and a strategy that makes use of JSON and MySQL databases, based on prior research. The study's findings contrasted the effectiveness of the two alternative database management techniques employed. A Geographic Information System (GIS) was created using the waterfall method to map green open spaces. Figure 1 can be viewed here and shows how this Geographic Information System has evolved.

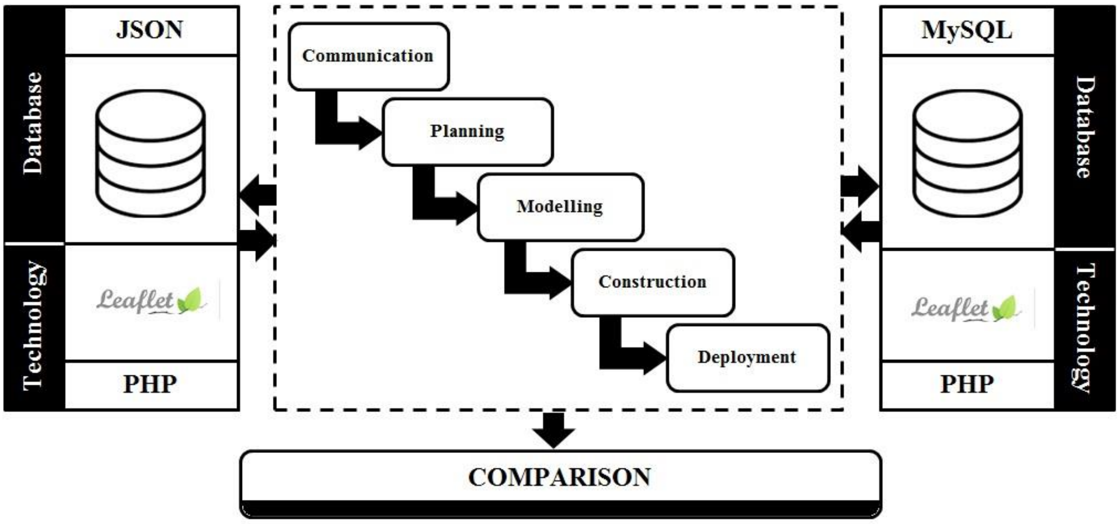

Figure 1. Stages of GIS development research

The process of communicating with users is the initial step in constructing this geographic information system. Conduct a requirements analysis by having conversations with customers at this point in the process. This research aimed to investigate alternative approaches to incorporating spatial data into the development of digital maps in the field of GIS. The outcomes of the communication led to the initialisation of the problem, the collection of the required data, the definition of the features of the system, and the analysis of the needs for both the hardware and the software. The creation of a geographic information system to serve as a map of green open space in a number of different cities is the primary objective of this project. The data that is used comes from the surrounding area and is stored in Shapefile (SHP) files. These files are then transformed into MySQL or JSON format. The development of this system required the use of many pieces of hardware, such as desktop computers, laptops, and printers. As an engine for digitising maps, XAMPP is the program that is used, whereas MySQL and JSON are the software that is used for the database.

The planning stage is the second one. This section addresses the planning and estimation of technical projects. A one-month survey period was followed by a two-month data processing phase. The ensuing stage comprised the implementation of the system, which extended over a period of four months. In conclusion, the duration of the data comparison procedure was three months. This planning process explains the estimation of technical tasks that must be carried out, the work scheduling that must be carried out, and the process of system development. This stage is a continuation of the communication stage. As part of this investigation, a prototype of user requirements will be developed using the information obtained via dialogue with the user. At this point, the customer has a requirement for a geographic information system that produces output in the form of SHP files that can be accessed online. This output must be derived from the findings of earlier data processing.

The modelling step is the third stage. This modelling is accomplished by developing a system design according to requirements in the form of a Green Open Space Geographic Information System display dashboard.

System design and implementation in accordance with specifications using the prototype system development methodology.

The fourth stage is construction. In this stage, the system design that has been designed is then translated into a programming language (coding). Coding is done using PHP, MySQL, JSON, and Leaflet applications for mapping. Leaflet, as a mapping technology, provides various modules to display spatial data in the form of polygons on the web. How leaflets work in this geographic information system can be described in Figure 2.

Subsequently, this code underwent scrutiny and verification utilizing Firebug, a browser plugin that provides comprehensive information regarding the codes embedded in the digital map and reveals broken links in the event of programming errors [31].

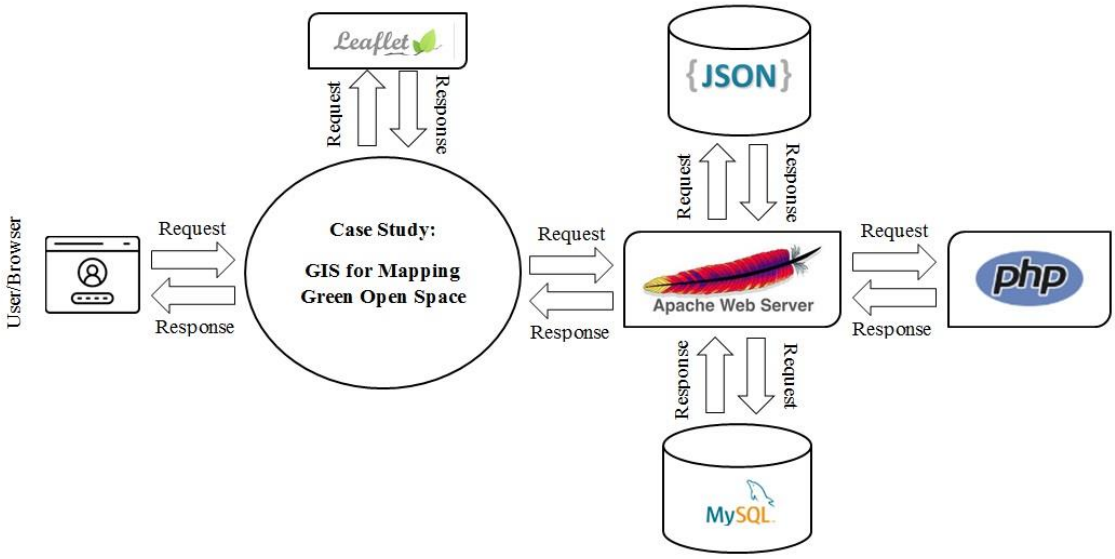

Figure 2. GIS development architecture

The design of the user interface poses a challenge for developers when it comes to Web GIS. Incorporating consumers throughout the aspects of analysis, design, testing, and construction/redesign constitutes the application of the user-centered design methodology. User requirements inform the development of the conceptual model that ultimately results in the creation of a highly precise prototype. This facilitates the process of redesigning it for the benefit of other users and developers.

Deployment is the fifth stage. This step, known as the implementation of the system for the customer, is the last one in the creation of a system. In this instance, users will be provided access to a geographic information system for the purpose of mapping green open spaces.

So, the effectiveness of JSON and MySQL databases can be judged by comparing the results of GIS development applied to a case study of mapping green open spaces using a leaflet technology strategy and both of these database types.

RESULTS AND DISCUSSIONS

Prior research implemented MySQL for data display; however, they encountered issues with the sluggish access time. Consequently, this study presents an alternative data display method utilizing JSON [8]. Afterwards, a comparison was conducted by monitoring, testing, and analyzing the performance results of the two databases with a variety of instruments, including speed, security, scalability (file size), and so forth. The outcomes of case study GIS development for green open space mapping utilizing a leaflet technology approach, PHP, JSON, and MySQL databases formed the basis for this comparison. The case studies employed a leaflet-based methodology. MySQL and JSON databases were implemented.

The findings of the tests make use of several trending methods. The following is an analysis of the performance of WebGIS based on the findings of a website speed test conducted with MySQL's uptrends tool, as displayed in Table 1.

Table 1. Website speed test results on MySQL

Device	Speed	Load time	Size	Request	Connection
Dekstop Edge	54	18,6 S	6522,2 KB	76	Fiber
Dekstop Chrome	61	3,5 S	6576,9 KB	84	Native Speed

Table 2. Website speed test results on JSON

Device	Speed	Load time	Size	Request	Connection
Dekstop Edge	60	1,7 S	8657,6 KB	73	Fiber
Dekstop Chrome	60	4,4 S	8762,1 KB	95	Native Speed

Table 2 displays WebGIS performance, or the results of a website speed test using the uptrends tool. Table 3 displays how WebGIS performed with regard to the results of website speed tests using Uptrends tools on JSON Mobile and MySQL Mobile.

Table 3. Test results using Uptrends tools on JSON mobile and MySQL mobile

Database	Score	Load time	Size	Request	Device	Connection
JSON	46	1,8 S	8688,6 KB	87	Kindle Fire HDX	4G
MySQL	31	1,8 S	6500,5 KB	76	Kindle Fire HDX	4G

Test outcomes with the KeyCDN tool

As demonstrated in Table 4, the performance results for the speed, security, and scalability of content delivery using KeyCDN products.

Table 4. Test results using KeyCDN tools on JSON and MySQL

Database	Score	Load time	Size	Request	Server
JSON	79	5,77 S	7,9 MB	157	Singapore
MySQL	79	5,63 S	5,7 MB	135	Singapore

The results of the PageSpeed tool's tests

The implications for the visualization of data in geographic information systems are suggested by the results of this research.

PageSpeed is a tool for improving page (website) speed on mobile and desktop devices. Not only can web sites be analyzed for content and recommendations on how to make them faster, but they can also be tested for speed. Table 5 shows performance data based on PageSpeed tools on MySQL Mobile and Desktop results for website page speed tests.

Table 5. PageSpeed test results on MySQL mobile and MySQL desktop

Device	Performance	Accessbility	Best practices	SEO
MySQL Desktop	55	87	83	82
MySQL Mobile	29	87	75	77

Table 6 illustrates the performance of the website page test results using PageSpeed tools on JSON mobile and desktop.

Table 6. PageSpeed test results on JSON mobile and JSON desktop

Device	Performance	Accessbility	Best practices	SEO
JSON Desktop	52	88	92	73
JSON Mobile	44	88	83	69

Test outcomes using Pingdom's resources

Table 7 displays the outcomes of tracking and evaluating website speed performance using Pingdom tools. Table 8 displays the average file size, while Table 9 displays the average page display speed.

Table 7. Pingdom tools test results on JSON and MySQL

Database	Performance	Load time	Page size	Request
JSON	68	4,33 S	8,9 MB	77
MySQL	68	4,80 S	6,8 MB	78

Table 8. File size

Number	File size		
	Tool	MySQL	JSON
1	Uptrends	6.5	8.6
2	KeyCDN	5.7	7.9
3	Pingdom	6.8	8.9
	AVERAGE	6.3	8.5

Table 9. Page speed

Number	Page speed		
	Tool	MySQL	JSON
1	Uptrends	18.6	1.7
2	KeyCDN	5.6	5.7
3	Pingdom	4.8	4.3
	AVERAGE	9.7	3.9

As the data structure is stored in JSON, Firebase processes the data more quickly in this instance, according to a comparison of MySQL and Firebase's data structure management performed by Sudiartha et al. [38].

A comparison is made between Firebase and MySQL with regard to the pace at which they access real-time data. The CRUD (Create, Read, Update, and Delete) principle of database manipulation is demonstrated by this test. Firebase was determined to be a quicker database than MySQL through a comprehensive evaluation of each CRUD process step [39].

Firebase's data processing strategy is more expeditious, whether for importing data from external sources or for real-time operations, according to the findings of the two studies cited previously. Firebase employs the JSON data structure for this purpose. Comparing the aforementioned database to an additional segment, this study examines spatial data captured in the Geographic Information System as digital imagery. Regarding the pace at which real-time data is accessed, the subsequent performance evaluation contrasts Firebase and MySQL. This scenario exemplifies the database manipulation principle known as CRUD (Create, Read, Update, and Delete). An assessment of each stage of the CRUD process revealed that Firebase is a quicker database than MySQL [39]. Implementing this approach will facilitate the differentiation of the results we present from those of previous investigations.

CONCLUSION

This study employs MySQL and JSON to present spatial data. Test results indicate that JSON processing expedites the display of geographical data in geographic information systems. In order to compare the two databases, uptrends, KeyCDN, and pingdom were utilized. Testing reveals that the average processing time for the given data is 3.9 seconds, whereas MySQL requires 9.7 seconds. MySQL is surpassed in performance evaluations by JSON, notwithstanding the latter's 8.5 MB average file size in contrast to MySQL's 6.3 MB. The JSON data structure is more straightforward and compact.

Future decisions regarding the selection of spatial data for Geographic Information Systems may benefit from consulting this study. In the interim, additional research may attempt to identify a variety of spatial data types that can be compared with JSON.

Therefore, it might be advised to WebGIS developers and potential researchers to use JSON in the construction of geographic information systems.

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