



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Comprehensive Analysis of web Application Development using MERN Stack

Sai Teja Labba, Mohammed Sharfuddin, Znanam Sai Praveen, Boche Sujitha, Dr Dinesh Reddy

Department of Computer Science and Engineering, Vignana's Institute of Information Technology, Visakhapatnam, India

Abstract- The MERN stack is a notable stack that has acquired prominence over different stacks in field of web development. This is due to its UI delivery and execution, cost-effectiveness, open-source, and ease of switching between consumer and server. Its main goal is to improve the application's overall performance. This stack considers online applications and programming to be rapidly grown and applying superior execution and adjusted improvements. The MERN stack, which consists of the front-end layer which manages user interfaces, the back-end layer which manages the server-side tasks, and the database layer which records the data, is a collection of powerful and outstanding inventions used to nurture adaptable expert online applications. It's an advancement stack that is a straightforward full-stack structure that is made with Javascript for making dynamic applications. To this end, it is the most favored stage for new ventures. This paper will show the MERN Stack, which consists of four advancements: MongoDB, Express, React, and Node.js. Every one of these four wonderful upgrades gives a beginning-to-end environment for the planners to work in. Each one of these advancements has a significant impact on the development of online web applications.

Keywords- Javascript, Software Stack, Framework, Library, MERN, React.js, MongoDB, Node.js, Express.js.

I. INTRODUCTION

MERN is an abbreviation for a specific set of JavaScript based technologies used in the web application development process. MERN Stack is a collection of powerful and robust technologies used to create scalable master web applications that include backend, frontend, and database components. Its goal is to make the development process as simple as possible.

Mern stack is made up of four components:

- 1) M stands for MongoDB, a No SQL (Non-Structured Query Language) Database System, used to record and manage data.
- 2) E stands for ExpressJS, a NodeJS framework for back-end web applications, used for building APIs and web applications.
- 3) R stands for ReactJS, a Javascript library, used to build user interfaces.

4) N stands for NodeJS, a Javascript runtime environment, used to run Javascript code outside a browser.

Every single technology among these four will greatly help the developer in providing the structure from start to finish. Even these four play important roles in improving web applications. Before the MERN stack, there exists only the MEAN stack. The MERN stack is a variation of MEAN, with MEAN added here. For the hub, assuming you notice here, you can see that at this point MEAN 'A', or Angular.js, has been replaced with R in MERN's i.e. React.js. MERN stack is a basic explanation of the fact that it is mainly used for speeding up. A more discreet application such as Contrast or MEAN, MEAN Stack is usually suitable for large applications. In either, in this case, more effort is spent on improving simpler applications. The two have unique structures relatively. It can be identified that MEAN depends on Angular js which is a Javascript framework, whereas the MERN stack has ReactJS which is a Javascript library. Both of them focus on front-end development. The MERN Stack expects that it can make the further development process more straightforward and smoother.

A. MERN has a three-level design framework comprising three layers.

The layers include:

- ReactJS - Front-end layer
- NodeJS and ExpressJS - Back-end layer
- MongoDB - Database layer

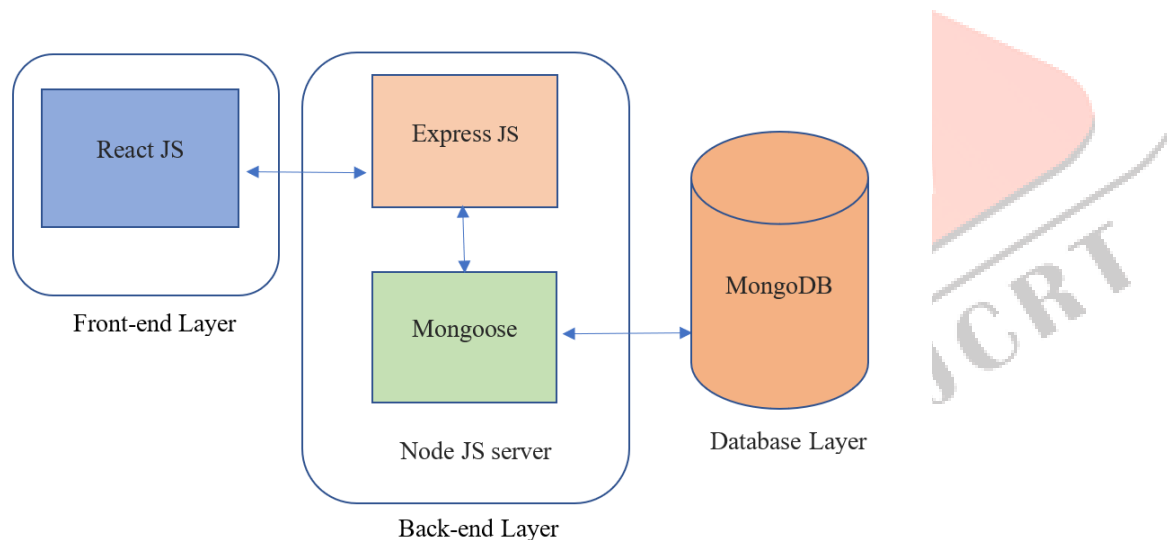


Figure 1. The three-layer framework of the MERN stack

- 1) ReactJS - Front-end layer: The topmost layer of the architecture is occupied by ReactJS. It is perhaps the most irrefutable used Javascript library, that helps to build user interfaces. It is developed by Facebook in 2011 but it is made public in 2013. A ReactJS application consists of components that are reusable and easy to use. Each component contains JSX (Javascript XML), with enables us to use HTML directly inside React. The best part about ReactJS is, that it enhances the performance of the application by using virtual DOM.
- 2) NodeJS and ExpressJS - Back-end layer: The second and center layer of the architecture is occupied by NodeJS as well as ExpressJS. NodeJS is a Javascript run time environment, that helps us to use Javascript outside a browser to develop applications. As discussed, earlier ExpressJS is a NodeJS framework, used for designing APIs (Application Programming Interface). It handles requests from the front end. Therefore, it helps us to develop cross-platform applications quickly and easily. The main advantage of using NodeJS at

the back end is, that it enables a developer to create a whole web application in Javascript with ease. Mongoose also operates at this layer, is a NodeJS-based Javascript library, that helps ExpressJS to interact with MongoDB, which operates as a database layer. It is a simple and object-oriented library with robust features and is easy to use.

- 3) MongoDB - Database layer: The last and third layer of the framework is the database layer, which is occupied by MongoDB. It is a No-SQL database that stores the data that is brought from the front-end in the form of collections and documents. A No-SQL database means a database that can store data uniquely in contrast to relational databases. A collection is similar to the table in relational databases. A collection contains documents similar to records inside a table. A database contains many collections. Each document has key-value pairs, and one document may or may not be the same as the other in a single collection in terms of key-value pairs they contain.

II. EXAMINATION OF MERN STACK PARTS AND THEIR EXECUTION

A. NodeJS

NodeJS which operates at the middle layer in the 3-layer framework is a runtime environment for Javascript that is built on chrome's V8 engine [1]. This enhances the performance of the application. It is developed in the C++ programming language [2]. As mentioned earlier, NodeJS assists us with executing Javascript outside the browser. It is one of the broadly utilized open-source technology which can be used to develop both front-end and back-end applications. For our situation in MERN, it is used for back-end development. Node is expanding its notoriety since it makes a method for making an entire web application in a solitary language which is Javascript. Its single-threaded and event-driven architecture has made it not quite the same as other advancement dialects and methods. It additionally upholds asynchronous programming and non-blocking I/O [2]. These highlights made it more helpful in I/O intensive work rather than in CPU intensive work. Single-threaded implies all the client demands are dealt with by a single thread at the server, which empowers it to save the RAM for other tasks. This single thread further gives the undertakings to its workers to perform I/O operations like interacting with databases, other servers, etc thus not-bounding itself to a single client request. The concept of workers is executed with the assistance of the Libuv library, which is written in C language. NodeJS uses asynchronous programming to return the response to the client when the workers get done with the task of executing the callback function. NodeJS has many built-in packages developed by the community and npm (node package manager) to manage all its packages which make the whole development process simpler.

Now we will portray the comparison chart between NodeJS and Python, which are the tending advances in the field of web improvement [3][4].

Function	NodeJS	Python
Processing Speed	It has a higher processing speed than python.	The processing speed of python is lesser than that of NodeJS.
Scalability	Applications made with NodeJS are more easily scalable than python.	Applications made with Python are less scalable as compared to NodeJS.
Universality	It has innated cross-platform functionality.	It requires an interpreter to make itself support cross-platform functionality.
Size of Projects	For the most part, it is used in small projects.	It can be seen in large projects also.
Type of Projects	It plays a crucial part in memory-intensive projects.	It tends to be found in projects having high computations.

Architecture	It has event-driven architecture by default.	It requires the modules to have event-driven architecture.
Code size	One has to write more code to implement a feature than that of python	It requires less code than NodeJS for the same feature to be implemented.

Advantages:

- It is extremely efficient due to the usage of the V8 engine.
- It is open-source and furthermore has enormous community support.
- It raises the performance of the application with its single-threaded capabilities.
- It can deal with many parallel requests as it supports non-blocking I/O.
- Scalability is easy as we can scale the application up and down according to our utilization.

Disadvantages:

- The performance of the application gets down when the application contains high computation and CPU-intensive tasks.
- It is not compatible with large projects.
- The reliability of API is an issue for developers, which is due to its asynchronous nature.
- The changes that occur in APIs are so incessant and are backward incompatible which often creates a problem for developers.
- Some of the npm packages are inadequate and are ineffectively portrayed.

B. MongoDB

MongoDB is a No-SQL database that is based on documents [5]. It stores the data in the form of JSON documents. It is acquiring prevalence due to its convenience and power. No-SQL means Not only SQL. Before diving deep into its concepts

let's see a few essential terminologies in MongoDB:

- **Database:** It is similar to a database in the relational database. It is a holder that holds the collections. A project has a database in general that contains numerous collections [5].
- **Collection:** It resembles a table in the relational database. A database contains a huge number of collections. A collection accumulates the group of documents [5].
- **Document:** It resembles a row in the relational database. A collection can have uncountable documents where each document has key-value pairs. Each document can contain sub-documents. In MongoDB document is nothing but a JSON object [5].
- **Field:** It is the equivalent of a column in the relational database. It is a key-value pair in MongoDB. The main distinction between MongoDB and SQL is each document in a collection may or may not have same fields whereas each row in a table has the same columns and are of the same type [5].

In MERN, the data that is gathered from the front end is passed to the back end. The ExpressJS collects the data and uses the mongoose to store and manage the data that is held by MongoDB. In the end, MongoDB converts the JSON data into a binary format called BSON, making the operations faster.

In relational databases, where all the records in a table must contain the same columns, the records which don't have any data for a column, will still occupy some space. To overcome this, many tables are created, and relationship is maintained between them with the assistance of foreign keys. But this makes managing and accessing data incredibly troublesome when the quantity of tables increases. To overcome this No-SQL databases came into existence, in which each document can contain the required fields. This makes managing and working with databases easier.

MongoDB is a distributed database, which means the data is distributed over various servers. This makes fault tolerance and scalability more straightforward. Keeping up with the replications of the information empowers adaption to fault tolerance. At the point when the volume of the data expands, the addition of servers can be done instead of upgrading the mainframes. Consequently, scalability is made simplified here.

Now we will portray the comparison chart between MongoDB and MySQL, to figure out the distinctions between SQL and No-SQL databases [6].

Function	MongoDB	MySQL
Model	It is a relational model.	It is a non-relational model.
Structure of data	Data can be structured or unstructured	Data is structured.
Query Language	Javascript.	SQL (Structured Query Language).
Data storage	Data is stored in the form of collections and documents.	Data is stored in the form of tables and rows.
Schema	It supports dynamic schema.	It supports predefined schema i.e. schema must be defined before usage.
Scalability	It can be scaled horizontally by adding servers.	It can be scaled vertically by adding more RAM.
Difficulty	It is easy to write queries.	It is difficult to write queries.
Data Access and update	Accessing the data is slow but updating is fast.	Accessing the data is fast but updating is slow.
Triggers	It does not support triggers and stored Procedures.	It has the support of triggers.
Foreign keys and joins	It has the concept of foreign keys and joins.	It has the concept of foreign keys and joins.
Properties	ACID properties (atomicity, consistency, isolation, durability).	CAP (consistency, availability, partition tolerance).

Advantages of MongoDB:

- It is less expensive and savvy.
- It has support for adaptation to failure.
- It is easy to scale according to our needs.
- It has a dynamic schema, hence each document in a collection can contain different fields.
- It shows better performance than a relational database on unstructured data.

Disadvantages of MongoDB:

- Since it uses the replication mechanism, it needs more storage space.
- The size of a document is limited to 16MB.
- It requires a lot of time to execute a select query as compared to relational databases.

C. ExpressJS

EXPRESS is a NODEJS Web application framework that offers a comprehensive range of functionality for both web and mobile applications. Complex routing, better request, and response handling adding middleware, server-side rendering, and other features are all included in Express. NODE applications can be organized into MVC architecture using Express. When we use the internet, the most typical things we come across are a browser and a server to which we send a request. Browsers will use the HTTP protocol to send requests to the server. This browser will receive an HTML page as a response from the server. The web server will receive a

request from the browser and respond to it. Accepting a request and responding to it is a time-consuming task. As a result, developers have invented web frameworks such as ExpressJS to make our coding and job easier. Web frameworks develop web apps or web servers that handle requests and respond to us on physical servers. Express is a wrapper for the NodeJS HTTP module that allows you to quickly establish a web server. The NodeJS HTTP module is a native module that comes with NodeJS and may be used to create a web server, although it takes a long time and generates a lot of errors. That is why we utilize ExpressJS, which simplifies coding by providing a wrapper over the HTTP module and allowing us to code quickly. It gives you access to APIs that you can use to communicate with the webserver or intercept requests. When we send a request to a web server, there will be a request object that contains the data about the request, which you can intercept using the request body. Request IP is used to determine from which IP the request originates. Request query can be used to see what query is being sent in the request. Response JSON is an express object that will assist you in sending a JSON response. Response render is a function that can be used to render an HTML page. Response redirect is used to redirect the browser to a different location. Using this express, you can easily intercept a request and respond to it. Express helps in the creation of an MVC architecture for your application. Model in MVC architecture refers to model-related data such as database calls contained within a certain file or module. All view-related information that is visible to the end-user should be included within my view. A controller states that all business logic should be included in the code. The most significant feature of the express is its robust error handling. If your server does not have graceful error handling, it will crash. We can create a rest API in seconds with express. We can easily construct the rest APIs using express because it has a good wrapper for it.

Organizations that use express for their web framework are:

- Twitter
- Intuit
- OpenTable
- IBM

Advantages:

- ExpressJS is simple to use and could be customized to meet our specific requirements.
- It's really quick to connect to databases like MySQL and MongoDB.
- Frontend and backend development is done in the same language, Javascript.

Disadvantages:

- There is no way to organize things structurally.
- There are numerous problems with callbacks.
- The error messages are really difficult to comprehend.

D. ReactJS

ReactJS is designed to make creating user interfaces incredibly simple and intuitive, especially when working with complicated interfaces. React is an open-source, component-based front-end library. React-based apps are generally thought of as components and states rather than workflows. The most essential factor of ReactJS is the components. Component-based architecture divides this into reusable code segments. React separates the user interface into numerous components, making debugging easier, and each component has its own set of properties and functions. If you want to add some extra HTML to the inner text, you'll need to conceal and reveal stuff at random, but that's all done with events. In general, react components return some HTML for you. We don't need to change the HTML in our component because it changes when we pass it anything different. This is the declarative's ability to react. React is a library that allows us to not only write HTML for how we

want to interact with our state, but also to manage that information within our application and do a variety of other things related to state, rendering, and user interaction in any online application. It's a lot easier to make minor incremental changes to your application with react without worrying about breaking anything outside of the scope of a single component.

React Features:

- **Javascript syntax extension (JSX):** This is used with react to express how the user interface should look. You can write HTML structures in the same file as Javascript code with JSX. JSX is a mix of Javascript and HTML.
- **Virtual Dom:** Dom (data object model) is an acronym that describes how documents are retrieved and managed on a web page. It depicts the whole structure of a web page as a tree. A virtual dom is created by React. It impacts the speed of the web application
- **One-way Data Binding:** When creating a react app, it's common to nest child components within parent components.
- **Extensions:** React goes beyond simple UI and supports a wide range of application architectures with a variety of extensions. The application is rendered on the server rather than in the browser.

Function	REACT	ANGULAR
Introduction	React is designed to make creating user interfaces incredibly simple and intuitive, especially when working with complicated interfaces, developed by Facebook.	Typescript-based and open-source web application framework for front-end web development, created by Google.
Performance	The virtual dom idea is used by React to reduce the load on the browser.	Even if a single element changes, Angular uses standard DOM, which refreshes the entire webpage.
Community Support	React is one of the most widely used Javascript frameworks.	Angular was released before its adoption is lesser.
Testing	To test the entire project, you'll need a set of tools.	Only one tool is necessary to test the entire project.
Data Binding	One way Data Binding	Two-way Data Binding
Use Cases	Single page web applications	large-scale, rich-featured applications.
Usage	Companies like Facebook, Twitter, Netflix, Airbnb, and others use React.	Companies such as Apple, Nike, McDonald's, and others use Angular.

Advantages:

- It makes use of JSX (Javascript Extension), a syntax that allows HTML quotes and HTML tags syntax to generate specific sub-components.
- React components can be used everywhere and have their own rendering logic. You can start simple with ReactJS and work your way up to more complex applications.
- ReactJS solves this issue. Reading JavaScript-heavy applications allows developers to explore search engines more easily.
- ReactJS comes with a slew of design and debugging tools that make it easy for developers to create a dependable and efficient online application. Chrome and Firefox now include React Developer Tools.

Disadvantages:

- React mainly focuses on the view of an application, so if you're working on a large project, you'll need to use other libraries to handle the rest.
- Because React uses JSX, Babel is used to convert it into plain Javascript, and Webpack and npm are used to build and run the program. If you are unfamiliar with these technologies and encounter an issue in code, handling and resolving the error will be challenging.
- Fewer features than a monolithic framework like AngularJS. In Angular, for example, routing is built-in, whereas, in React, routing requires the inclusion of additional files.

III. MERN STACK IS USED BY SOME COMPANIES

1. **Walmart:** The professionals here used React to improve the speed of their web app. 94 percent of the codebase for mobile apps is now common between iOS and Android platforms.
2. **Instagram:** Instagram, like Facebook, follows the same path and benefits from all of the React features. Push notifications were added to React, as well as a new option that allows users to store content that they find interesting. This framework also makes it simple to use the Post Promote feature. React enables you to achieve a quicker startup time and a more engaging user experience.
3. **UberEATS:** UberEats updated their restaurant dashboard with the React framework to make it more beautiful and engaging. Developers worked hard to improve the communication between the driver and the food outlets.

IV. Company Benefits of MERN STACK

There are numerous benefits of the MERN stack, here we have discussed a few of them:

- **Open-Source:** It is open-source. The developers can code without facing the issues related to licensing.
- **Availability of free packages:** There are numerous npm packages available that are free to use. This makes the development process more straightforward and quicker.
- **Simpler to learn and utilize:** The whole development is done in Javascript, an individual with a piece of essential information on Javascript can work with MERN, and it is exceptionally simple to advance as well as to use.
- **Cost-effective:** The availability of packages and backing of open-source decreases the general expense of the undertaking.
- **Efficiency:** The utilization of Javascript for entire development evades context-switching subsequently making the application productive and efficient.

V. CONCLUSION

This paper shows up a point-by-point examination of the execution of the MERN stack which is the foremost later innovation. It besides considers the internet improvement utilizing particular advancements and frameworks. It joins the plan of the MERN stack, the components it has, and their usage. We discussed the significance of NodeJS and afterward contrasted it and python. We showed how MongoDB played a vital role in holding the data in the database by comparing it with MySQL, which is a relational database. Then we inspected ExpressJS alongside its upsides and downsides. Finally, we examined ReactJS by comparing it with Angular. At last, it considers the focuses of intrigued of MERN stack and the best brands utilizing it. There are still numerous issues to handle, such as the human side, especially within the shape of end-user encounters.

Future work will incorporate a longitudinal inquiry about considering investigating framework development, as well as an in-depth point of view on user interface plan and interaction.

VI. ACKNOWLEDGMENT

We would like to express our gratitude to Prof. Dinesh Reddy of the Vignan's Institute of Information Technology in Visakhapatnam, who has been extremely supportive not only for his comments and feedback on the paper during this research, but also for our career goals, and has worked tirelessly to ensure that I have the time to pursue them. I will be eternally grateful to my family and friends for their assistance. Without everyone's assistance, this project would not have been possible. As our teacher and mentor, he has taught us far more than we could ever give back to him. In the pursuit of this paper, our family members have been more important to us than anyone else. We would like to thank our parents, who have always encouraged and guided us in our endeavors. They are the very definition of positive role models. This paper has assisted us in conducting extensive research and learning a lot about this field.

VII. REFERENCES

- [1] "NodeJS official documentation," [Online]. Available: <https://nodejs.org/en/>.
- [2] S. M. Malewade and A. Ekbote, "Performance Optimization using MERN stack," *International Journal of Engineering Research & Technology (IJERT)*, vol. 10, no. 06.
- [3] J. Hartman, "Node.js Vs Python: What's the Difference?," Gurur99, 23 4 2022. [Online]. Available: <https://www.guru99.com/node-js-vs-python.html#:~:text=KEY%20DIFFERENCE&text=Node%20is%20better%20for%20web,uses%20CPython%20as%20an%20interpreter>
- [4] madhav_mohan, "Difference Between Node.js and Python," GeeksForGeeks, 20 8 2020. [Online]. Available: <https://www.geeksforgeeks.org/difference-between-node-js-and-python/>.
- [5] "MongoDB Ultimate Guide," Web dev simplified, 7 2 2022. [Online]. Available: <https://blog.webdevsimplified.com/2022-02/mongo-db/>.
- [6] D. Taylor, "MongoDB vs. MySQL: What's the difference?," guru99, 30 4 2022. [Online]. Available: <https://www.guru99.com/mongodb-vs-mysql.html>.