Research and Analysis of the Front-end Frameworks and Libraries in E-Business Development

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ABSTRACT
With web technology rapidly expands out in recent years, there is a significant trend that Hypertext Markup Language(HTML)5 turns into a worldwide web consortium and leads the front-end development to stand on the front stage of internet history. However, there are numerous front-end development frameworks and libraries such as React, Angular and Vue. How to select a suitable framework or library to establish the e-Business and reach out to maximize the user experience becomes a priority operation in web development. This paper starts with introducing an overview of the leading frameworks and libraries in the field of front-end development and examine each performance in web services. By analyzing the research data on several aspects, this paper will list the pros and cons of each framework and library under separate commercial criteria. Finally, the paper summarizes the contributions and concludes with some possible future of front-end development in e-Business.

CCS Concepts
Information systems~Electronic commerce

Keywords
Front-end; JavaScript; Web Development; e-Business; HTML5.

1. PREFACE
With internet technology rapidly grows up in the last decade, consumers show more and more dependence on e-Business to carry out daily life such as shopping, property loan and returning tax. One of the most critical reasons lead to this result is that HTML5 technologies appear and change the entire internet development ecosphere as an innovation. HTML5 technology is a markup language used for establishing layout and rendering content on global websites [1]. Compared to previous HTML standard, HTML5 extends and improve many semantic elements such as <footer>, <aside>, <nav> to define the web structure clearly, and it helps web developers to build their website under distinct structure [2]. Furthermore, HTML5 adds more elements gained access application programming interfaces (APIs). For instance, <canvas> element allows the website to access the mobile phone's canvas section [2]. Based on HMTL5 powerful access features, web programmers can construct a website with more complicated functions.

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Although HTML5 brings many innovations, it still has a limitation that any published HTML version's rendering efficiency is very low even its some performance is worse than FLASH. In 2008, Google released the Chrome V8 engine which adequately addresses the issue which brings JavaScript to the front with HTML5 [3]. Before Chrome V8 launch, JavaScript's primary function in a website is working with Cascading Style Sheets (CSS) to build a better user interface and take responsibility for some ordinary script actions like form validation. Chrome V8 appearance redefines JavaScript because Chrome V8 JavaScript engine has such an extraordinary speed that more than 56 times faster than any version of Internet Explorer (IE) [3]. Traditional web browsers usually use some complicated process to compile JavaScript like interpreting byte-code and compiling the entire web project to generate the code then execute it from a file system [4]. Consequently, their JavaScript running time is much longer than compiled languages like Java and C++ [4]. V8 engine's optimized solution is using inline caching technology to improve performance without traditional compiling [5].

After V8 engine released, JavaScript can have similar running performance as well as Java or C++. Therefore, web project can meet the comparable speed as traditional desktop software by V8 JavaScript engine. Because of V8 JavaScript engine's superiority, various JavaScript platform based on V8 engine appeared and raised the new age of internet development history. In 2009, Node.js were released which combine with V8 JavaScript engine as a development platform [6]. Node.js extends developers' eyesight that JavaScript cannot only carry out a simple script in a website but also use in writing an event-driven server-side application with simpleness [7]. Although Node.js was launched nine years ago, there are many new JavaScript frameworks appear and affect internet development. In the following section, the paper will trace on the major front-end frameworks and libraries.

2. Front-end Frameworks and Libraries
There are numerous front-end frameworks and libraries based on JavaScript due to the V8 engine's innovation. In order to find leading front-end frameworks and libraries under the industry standard, we collect usage data from Github which is the largest Git-repository hosting service globally. The Github's usage statistics can reflect global front-end developers' tendency on each front-end frameworks and libraries.

Table 1. Github front-end frameworks usage statistics in May 2018

	Angular 1	Angular 2	React	Vue
Downloads	1.4 million	2.6 million	9.2 million	1.5 million

Table 1 shows that React occupied the dominated position, and Angular 2 is in the second position while Vue sits in the third chair. Consider Angular has published its updated version, the paper will combine the technical detail with Angular 1 and Angular 2. In the following sections, the paper will focus on React, Angular 1&2, and Vue.

2.1 React.js and React Native

In order to establish Facebook and Instagram website with better user experience, Facebook developed the React JavaScript library [8]. Due to React's powerful features, Facebook released React as an open source JavaScript ES6 based library to global developers and companies in 2013 [8]. Besides, Facebook also launches React Native to develop a mobile application with React under major mobile platforms such as IOS and Android in 2015 [9].

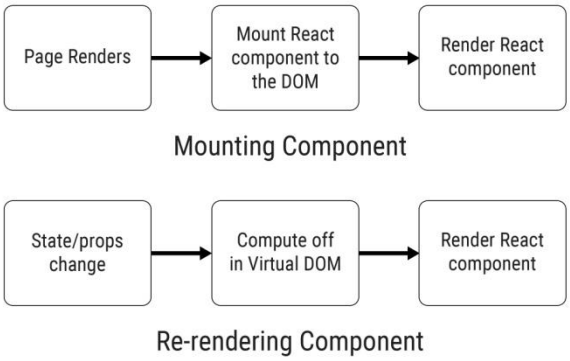

Figure 2. Mounting components in React & Re-rendering components in React [9]

Fig. 1 illustrates how to render page by React technology. React mounts website content as different components into the Document Object Model(DOM). The browser will render the component by JavaScript. With Chrome V8 technology, the JavaScript rendering speed will be more effective than rendering traditional dynamic websites. Another React's core wisdom is creating a virtual DOM [8]. In traditional HTML websites, the page will be re-rendered entirely when the user refreshed the data or visit other subpages. The re-render process spends more browser's resources and effects the website speed. Compared to the traditional method, React uses a different way to address the issue that it creates a virtual DOM with one-way data binding. When the user jumps to another subpage, React creates an updated virtual DOM first then compares the difference between virtual DOM and displayed DOM. After it summarizes the difference in each component, it will re-render the actual transform part, and other uniform parts will not be re-rendered.

The most significant advantage for the virtual DOM is that the website gets faster with React framework. Another advantage is that React leads developers to design the User Interface(UI) under module standard. For instance, there are two different pages with text form with the same function but different properties. When the consumer clicks a link and visits another page, the page still re-render the text form due to their differences. However, if the development team builds the UI module standard and selects the text form from the module then apply to different pages, the text form will not be re-rendered because React will recognize both two forms are the same without transforming. In short, React does not only change the front-end development but also build up a new standard in UI design and development.

2.2 Angular 1&2

Angular is a famous JavaScript ES5 based open source front-end web application framework and developed by Google in 2010 [10]. Angular's first development intention is assisting web designer in creating a persistent web form with more efficiency [10]. With the front-end history moves forward, Angular gradually transforms its position to fit into more development criteria, and web developers can develop more complicated applications under Angular framework. However, the Angular has many limitations due to its initial design model and far left behind other front-end frameworks in recent years. In order to upgrade Angular to fit with modern, its second version called Angular 2 was released which is completely rewritten by Google development team in 2016 [11].

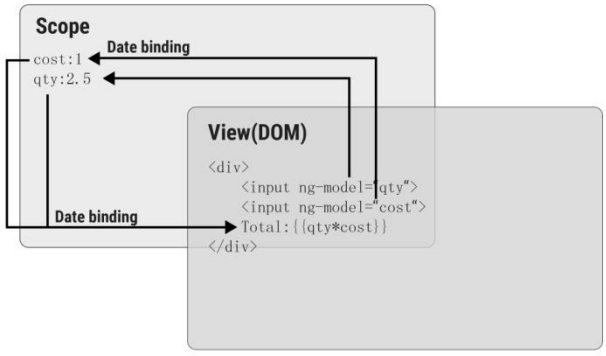

Figure 2. Angular 1 two-way binding [12]

Angular 1's core concept is two-way data binding in web browsers with largely reducing the back-end's data processing responsibility in web servers [10]. Fig. 2 illustrates how Angular 1 works in data binding. The custom tag attributes have been embedded into JavaScript Object Notation(JSON), and Angular 1 indicates those attributes as directives to bind input or output parts of the website page to a model represented by Scope [10]. If websites get interactive actions to occur from users, the values of those JavaScript variables will be updated from dynamic JSON resources and submit the data to the server [10]. Angular's two-way data binding makes entire interactions completed in web browsers so that the website updates do not have to wait for data processing from the back-end server and directly rendering the updated data in front-end by HTML. Consequently, the HTML rendering speed can be faster without waiting for back-end response due to Angular 1 technology.

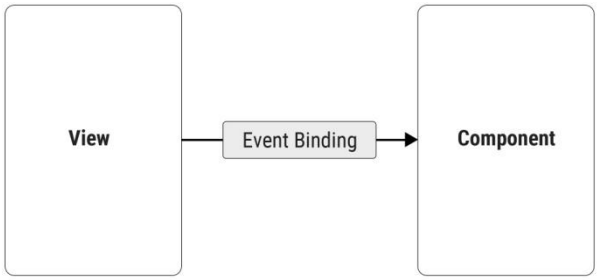

Figure 3. Angular 2 one-way binding

Compared to Angular 1, Angular 2 has been entirely rewritten its concept and optimize Angular 1's binding process. Firstly, Angular 2 cancels template directive and controller. It uses a new module called 'Component' to combine both parts [13]. Fig. 3 illustrates that Angular 2 adds event binding as one-way binding from view to component which is non-exist in Angular 1 [13]. Thirdly, Angular 2 changes its language from 'JavaScript Based' to 'TypeScript Based' which is a strict syntactical superset of JavaScript developed by Microsoft [13]. Fourthly, Angular 2 uses zone.js instead of Scope to monitor interactive activities [13]. Last but not least, Angular 1's initial target is desktop web applications with insufficient support in mobile platforms, and Angular 2 pays more attention to mobile platforms. By optimizing and integrating different features, Angular 2 has smaller size and faster speed which is essential in mobile development.

2.3 Vue.js

Vue.js is a popular JavaScript ES6 based open source frameworks developed by Evan You in 2014 [14]. Vue's first development intention is to achieve responsive data binding and UI components with easy Application Programming Interface(API) [14]. Although Vue is supposed to apply in a single-page application usually considered as limited functions and hard to adopt in commercial usage, the open source community provide strong third party supporting library and packages to support Vue to drive complex single page application with routing, state management and build tooling [14].

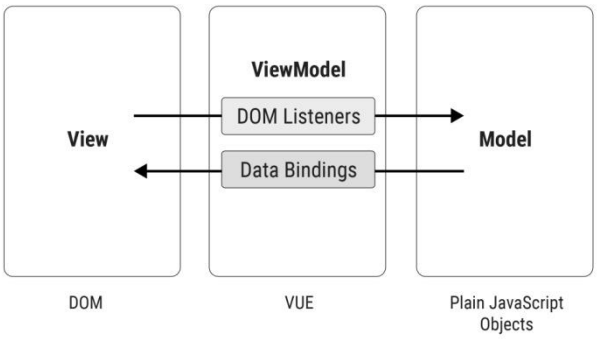

Figure 4. Vue.js data-driven concept [15]

Fig. 4 illustrates that Vue.js contains three sections to process data-driven includes View, View Model and Model. View section is a displayed DOM to show the website content. View Model section contains DOM listeners and Data Bindings. It becomes a data agent between View and Model. When users trigger the data processing in View [16]. Vue will use DOM listeners to monitor and update the Model section's data. When Model's data is updated, Vue will use DOM binding to update the website content appearance. In short, Vue uses one-way binding with DOM listeners to achieve the result of two-way binding.

3. Analysis of the Front-end Solution

There is no doubt that React, Angular and Vue are popular front-end development solutions in modern web development. However, they have different characteristics and driven concept. It means that different commercial criteria need to select a suitable framework or library to maximum their application usage and efficiency.

3.1 Data Processing

Data processing is the essential part in front-end development because the data processing efficiency and quality decide the user experience in visiting the application.

Table 2. Date Binding in front-end frameworks

	Angular 1	**Angular 2**	**React**	**Vue**
Data Binding	Two-way	One-way&Two-way	One-way	One-way/Two-way

Table 2 shows the data binding way in each framework and library. Vue can use DOM listeners to achieve two-way binding or use one-way binding without DOM listeners. The most significant difference between React and Angular 1 is selecting one-way or two-way data binding. Compared to Angular 1, React needs to process more complicated data flow due to check the difference between virtual DOM and displayed DOM. However, using two-way method between component and view may result in component transitionally into unexpected states because of conflicting data being spread from multi sources while one-way binding can avoid the conflict issues in multi data sources especially in event-based circumstance. Therefore, Angular 2 team upgrades the concept that developers can use both one-way and two-way binding. Choose the hybrid method in different circumstances is the best solution to absorb one-way and two-way's advantages.

3.2 Volume and Performance

Larger volume means the framework or library contains more features and functions, but it will spend more time on loading the framework or library.

Table 3. Front-end frameworks and library memory allocation performance [17]

Activity	**Angular 2**	**React**	**Vue**
ready memory	4.8±0.0 (1.4)	4.5±0.1 (1.3)	3.8±0.0 (1.1)
run memory	10.9±0.1 (2.7)	9.7±0.1 (2.6)	7.5±0.1 (1.9)

Angular 2 has the most significant volume of 143 kilobyte(KB) while Vue has 23KB and React is 43KB. The enormous volume means that Angular 2 has more advanced comprehensive functions and features. However, complicated structure leads to a potential risk that Angular 2's running performance is worse than React or Vue especially in memory allocation. Table 3 shows that Angular 2 requires more time to prepare and run the memory

while Vue spends less time due to its flexible and efficient advantages.

3.3 Language-based

Language-based is another important considerate aspect because different languages have different circumstances in developing the project such as difficulty and efficiency.

Table 4. Language-based in front-end frameworks and library

	Angular 1	Angular 2	React	Vue
Language-based	JavaScript ES5	Type Script	JavaScript ES6	JavaScript ES6

Table 4 shows the current language-based situation in different frameworks and library. React and Vue use JavaScript ES6 as their based language which is the newest JavaScript industry standard from 2015. Angular 1 uses the JavaScript ES5 which is the previous version. Angular 2 relies on TypeScript provides an excellent experience for type inference and reduces all sorts of bugs from web applications. Furthermore, TypeScript assists developers to get rid of traditional JavaScript programming format with optimizing language structure. However, TypeScript has limited user communities. There is a potential risk that TypeScript may disappear due to another new syntactical strict superset of JavaScript appear. JavaScript ES6 can be updated but not disappear because it is the industry criterion in developing JavaScript.

3.4 Technical Support

Technical support is also necessary because better support can build up a better relationship with developer communities which is an essential part to expand the framework's reputation. React provides strong technical support and its API is very stable. Upgrade and immigration are very simple due to the official scripts to assist developers to finalize the related update. In short, React provides persistent technical services. Angular also provides similar services, but the API is not so durable as React. Some previous version's APIs have been banished. Although Vue has simple immigration and update between different versions, there is no expected update plan from the official team due to the financial limitation.

3.5 E-Business Solutions

Based on the above analysis of diverse aspects of front-end frameworks and library, it stands to reason that each framework or library has its unique superiority and weakness.

Angular 2 provides the most suitable solution in data processing combined one-way and two-way binding. Furthermore, its official technical support is stable and reliable with the Google development team. However, its volume is too enormous to play appropriate running performance due to its abundant functions, and its based language has limited communities. Therefore, Angular 2 is suitable in large scale e-Business solutions which require complicated functions and sophisticated data processing method.

React has high efficiency in rendering updated DOM and its powerful technical support and durable API allow developers to avoid the worried in update and immigration. Besides, developers can directly develop React Native mobile application after learning the knowledge of React. However, React is a JavaScript library and its volume is not the same as Angular 2 means that React cannot provide comprehensive features and developers need to deploy by themselves. Social media and communication applications usually request to re-develop more customize features and functions with fast rendering speed. Therefore, they are the potential customers for React.

Vue provides both two-way and one-way binding option in data processing. Compared to Angular 2 and React, its minimum volume occurs in the most efficient rendering and processing. Although Vue has its significant flexible superiority in front-end development, its technical support is not too reliable due to its development team scale limitation with unexpected official updated plans. Furthermore, its smallest volume means that it includes the minimum features. Considered various circumstances, Vue is suitable for small and medium web project which requires flexibility and simplified to develop with the fastest data processing speed.

4. Conclusion

This paper describes both three different front-end development frameworks and library in developing web applications and list potential solutions for developing a web application. By analyzing the comparison data between React, Angular 2 and Vue in various aspects include data binding, language-based, technical support, volume and performance. It can be possible to conclude that Angular 2 contains the most comprehensive functions and features that suitable for enormous commercial projects, especially in e-Business. React and Vue are suitable to live stream, communication, blog and small or medium scale applications.

Developing an entire front-end section also needs to use a UI framework to illustrate the professional UI design. Future work will extend our research field to discuss more front-end development approaches and analyze their working principles to develop web applications.

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