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# Abstract

***LEAVE ABSTRACT TILL END….. NO REFERENCES IN ABSTRACT***

The purpose of the research is to establish the effectiveness and efficiency of Node.js as a development tool/environment not only in terms of its now well documented performance, an example of which is published by Lie et al. in their 2014 paper for the International Conference on Computational Science and Engineering (Lie, et al., 2014), but also in terms of the ease of development, including the full range of development tools and frameworks that are available in other languages, including scaffolding, database connection/communication and de-bugging. Notwithstanding Ionnas K. et al’s conclusion that end-to-end JavaScript is a viable option for building modern web apps (Chaniotis, et al., 2014), Netflix, another high profile internet goliath, discovered that their Node based application was eating up CPU resources while developing hourly endpoint latency increases of 10ms (Xiao, 2014), indicating that it's not all plain sailing for applications running on Node.js and leads me to ask the question:-

"……………………………Does Node.js use the Reactor Pattern or a similar pattern?.....................................

***What factors should a developer consider when deciding to build a web application in Node.js and at what point are the obvious performance benefits of Node outweighed by the practicalities, impracticalities and potentially costly and unforeseen pitfalls involved with the implementation of this, still relatively new, technology?***"

Is comparing a non-blocking technology with a blocking technology a fair and accurate comparison to make? For example comparing journey times between two points on a map using secondary roads going through towns as one test and using a three lane motorway as the other, will illustrate that the Motorway will offer the faster the faster journey time, however this is not comparing like with like. Similarly, when comparing Node.js which is using an asynchronous, non-blocking event loop with PHP, which is using threads to allow concurrency but still relying on synchronous requests, will illustrate that non-blocking, asynchronous technology is faster than synchronous, blocking technology. With the arrival of event driven technologies such as EventMachine and ReactPHP to the Ruby and PHP developer communities respectively, these technologies can now offer request/response times that compare favourably with those achieved using Node.js. In this paper it is planned to compare these technologies not only on the basis of speed, as this isn’t the only consideration when choosing a technology, but also in the areas of memory footprint and CPU consumption in order that a developer can make an informed choice when deciding which to use.

# Introduction

Introduction goes here

***Use text below as template to give breakdown of sections in dissertation***

<< This paper is broken down into seven sections. This section, the first, serves as the general introduction. Section two examines the related work to this paper. The third section discusses approaches to concurrent programming. The fourth section presents the problem domain of instant messaging. The fifth section looks at plugin design. The sixth section presents our results. The seventh and final section is our conclusion >>

# Acknowledgements

<http://rumpetroll.com/wtfisrumpetroll/> Rumpetroll was implemented using Ruby and EventMachine

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# Definitions, Acronyms and Abbreviations

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# Literature Review

## Node.js

Node.js of itself is relatively new in the world of Web Technologies, “*It’s a platform built on Chrome’s JavaScript runtime”* (Node.js, 2015)*,* and was launched by its creator Ryan Dahl to an unsuspecting JavaScript Conference in Berlin in November 2009 (Dahl, 2011). By Dahl’s own admission in his 2011 video presentation to meet up group in Phoenix, Node is still very much in its infancy and is far from perfect. But in addressing some of Node’s shortcomings, Dahl is keen to emphasise that there are certain things that Node will never address if it’s to remain true to its core “non-blocking” philosophy (Dahl, 2011). Within a relatively short space of time Node was adopted by some major players in the greater e-commerce community and now boasts goliaths Walmart, PayPal, Netflix, LinkedIn and New York Times amongst its ever increasing list of users (Joyent/Node, 2015). Chaniotis et al., after extensive testing, conclude that despite some shortcomings, JavaScript via the Node platform is a viable option for building modern web apps (Chaniotis, et al., 2014). Lie et al. concur with Chaniotis et al’s findings, highlighting that Node’s bias is toward IO-intensive scenarios as opposed to Compute-intensive ones (Lie, et al., 2014).

Outside of the academic world, whilst as the list above would suggest, Node’s rise in popularity could arguably be described as meteoric. PayPal clearly are impressed by its performance, stating that during the research phase before fully adapting Node, an application with the equivalent functionality of a corresponding Java application could be built in almost half the time, with a third less lines of code and only 60% of the files necessary for the Java app (Harrell, 2013).

However all has not been entirely plain sailing for Node in industry, with Netflix experiencing problems where hourly latency increases of 10ms with some endpoints were eating up CPU resources (Xiao, 2014). After a great deal of digging, monitoring and lateral thinking, this turned out not to be a problem with Node per se but with Netflix’s usage of Express.js and how it handled routes. As with all problems, once the source was identified, it was quickly resolved. However this incident does highlight, firstly that Node.js is still in its infancy and as with all emerging and innovative technologies there are some “speed bumps” along the road to perfection.

One of the more fundamental problems with developing in Node is its poor level of debugging and exception handling facilities due to the fact that, by its single threaded nature, it’s always destroying the stack. Dahl has indicated that the Node development community are very much aware of this and it is in the pipe line, although no firm date has been set for this particular feature (Dahl, 2011).

### Node.js Frameworks

In and of itself Node.js is very light in terms of built in functionality and whilst it can be used to write elementary servers, it is heavily reliant on the many tens of thousands of modules to be found on NPM (Node Packet Manager), which is it’s official Packet Manager (joyent/node, 2015). There are numerous frameworks which can be used with Node, depending upon the developer’s needs, with Express.js, a Sinatra like framework, along with both Compound.js and Sails.js being Ruby on Rails like frameworks (joyent/node, 2015), and amongst the most commonly used.

### Conclusion

Given the plan to test Node.js against the Ruby on Rails framework, the Compound.js framework was selected to be used when developing the test application due to its close resemblance to Ruby on Rails (Joyent/Node, 2015), however, once again, given that the Node.js project, and by default it’s ecosystem of associated frameworks, is still in its infancy, Compound.js proved somewhat temperamental and more than a little bit problematic to implement, therefore Sails.js was chosen to replace Compound.js due to it being more robust and reliable.

## Ruby on Rails

Ruby on Rails is not one technology but a combination of two, namely the Ruby language which was created by Yukihiro “Matz” Matsumoto (McCarthy, 2013) and a web programming framework called Rails which was developed by David Heinemeier Hansson while working with a company called 37 Signals in 2003 for in-house projects (Heinemeier Hansson, 2015).

### Ruby

As a programming language Ruby is regarded in very high esteem by many programmers, not least among which is Ryan Dahl, of Node.js fame, who states in a video address, that “*Ruby is a beautiful language*” and that he prefers it to JavaScript (Dahl, 2011). Matsumoto himself describes Ruby as *“simple in appearance, but is very complex inside, just like our human body”* (Ruby.org, 2015). Geer notes that the Ruby language combines the clean, structured qualities of languages such as Java with the speed and convenience of scripting languages, specifically PHP (Geer, 2006).

### Ruby Frameworks

#### Rails

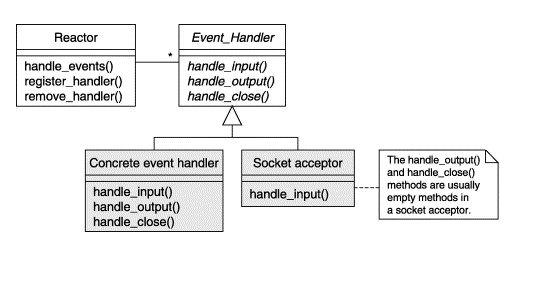
Heinemeier Hansson’s, and by default Rails’, approach to their framework is very rigidly “*Convention over Configuration*”, so much so that Heinemeier Hansson clearly states on his own website that, whilst he’s open to well informed criticism, he and his team, with few exceptions, know what’s best (Heineneier Hansson, 2012). However, as alluded to by Geer when quoting Boeing software developer Curt Hibbs (Geer, 2006), the Rails framework enables developers to achieve far more in less time, than could be achieved when working with combinations of other languages and technologies which have to be configured in order to fit together to achieve the same result.

#### Sinatra

Sinatra, created by Blake Mizerany in 2007 (Jones, 2012) is effectively a lighter version of Rails, following an almost identical structure (Hagerty, 2014). However, where Rails’ corner stone is “Convention over Configuration”, forcing developers to follow its rigid structure, Sinatra offers developers the ability to configure as required (Skillcrush, 2015) to build web applications which eliminate the unwanted and unnecessary folders and files that are often surplus to requirements in smaller projects built with rails.

#### EventMachine

EventMachine is a library which, when added to the Ruby environment as a gem, offers event driven non-blocking I/O to the Ruby developer (McCune, 2011). As specified on the EventMachine github repository README file, event-driven I/O is dealt with using the Reactor Pattern (EventMachine, 2015). However whilst a certain level of non-blocking asynchronous I/O is achieved using this pattern, there are limits to its capabilities, namely a default limit on concurrent requests of 20 (Igvita, 2008), also the Reactor Pattern effectively gives an illusion of asynchronous behaviour whilst in the background delivering requests concurrently to a service handler, demultiplexing them and distributing them synchronously to their various relevant handlers.

Figure 1 Class Diagram of Reactor Pattern (Chein-Chih & I. -Chen, 2006)

### Ruby on Rails

This pairing of a well-structured framework with a well written language in the form of Ruby on Rails makes for a very powerful web development tool which is in effect greater than the sum of its parts. However An et al. (An, et al., 2009) note that, not unlike Node.js, Ruby on Rails isn’t without its shortcomings when it comes to debugging. Specifically dynamic typing, meaning that type errors are difficult to identify due to their remaining latent until runtime. And although An et al.’s paper was written in 2009, Voelker’s June 29th 2014 Blog would suggest that this is still a live issue within the Ruby on Rails development community (Voelker, 2014).

### Conclusion

***Ruby conclusion here***

## PHP

By far the older of the three languages being explored, PHP’s origins date back to 1994 when Rasmus Lerdorf created his “*Personal Home Page Tools”* in the form of several C based CGI (Common Gateway Interface) binaries (PHP.net, 2015). Originally referred to as PHP Tools, the language has had several name changes, ranging through FI, Construction Kit and PHP/FI before finally settling on PHP with the release of PHP 3.0 in June 1998 (PHP.net, 2015). In its current version at the time of writing (Aug. 22nd 2015), PHP 5 accounts for 81.2% of all websites whose server-side languages are known (W3TECHS, 2015). That being said, with the explosion of network traffic and users’ apparently insatiable appetite for more and more interactive functionality placing greater and greater demands on servers, PHP is beginning to show its limitations, particularly in the area of high concurrency I/O intensive functions (Lie, et al., 2014).

### PHP Frameworks

As with Ruby and Node.js, where there are several Frameworks that can be used in association with the chosen scripting language, PHP is no different in this regard but the fact that it has been around for many more years means that the choice of Frameworks is far greater.

#### Prado

Prado (PHP Rapid Application Object-oriented) was created in 2004 by Qiang Xue and has been through many iterations since then, at its core is event-driven programming ***more to be found on this framework***

#### Yii

The Yii (Yes It Is) framework was created in 2008 by Qiang Xue (yiiframework.com, 2015) who, having worked on previous PHP framework projects, developed Yii in response to needs he identified over many years. Yii offers developers benefits of what Xue saw as the best qualities of other frameworks, including Rails’ “Convention over Configuration”. Equally Yii offers event-driven programming, a feature of the Prado framework and is something Dahl hit upon when creating Node.js a year later.

### Conclusion

## Technology Comparisons

Having corresponded via e-mail with Jim Brikman, previously a senior developer at LinkedIn, in relation to comparing Node.js with other frameworks, he suggested that technologies can’t be compared on any one single point but must be measured against each other according to a number of different criteria and offered the following list as a suggestion (Brikman, 2015):

1. **Learn**: getting started, ramp up, overall learning curve.
2. **Develop**: routing, templates, i18n, forms, json, xml, data store access, real time web.
3. **Test**: unit tests, functional tests, integration tests, test coverage.
4. **Secure**: CSRF, XSS, code injection, headers, authentication, security advisories.
5. **Build**: compile, run tests, preprocess static content (sass/less/CoffeScript), package.
6. **Deploy**: hosting, monitoring, configuration.
7. **Debug**: step by step debugger, profilers, logging,
8. **Scale**: throughput, latency, concurrency.
9. **Maintain**: code reuse, stability, maturity, type safety, IDEs.
10. **Share**: open source activity, mailing lists, popularity, plugins, commercial support, jobs.

Whilst this is undoubtedly a very comprehensive set of comparison parameters, given the timescale available it will be necessary to limit the scope of this project to no more than two of the above headings (with some minor modifications), plus one more. These will be as follows:

1. **Learn**: Getting started, available resources, tutorials etc.
2. **Footprint**: Disc space occupied by base code plus dependencies, CPU consumption.
3. **Scale**: Concurrency, throughput, latency.

### Learn

Node.js, Ruby, Ruby on Rails, and PHP all have excellent resources available, both online, in the form of video tutorials and in soft and hard copy. A quick search on YouTube using just “Node.js Tutorials”, “PHP Tutorials” and “Ruby Tutorials” returned 174,000 results for Node, 118,000 results for Ruby and 990,000 results for PHP (YouTube.com, 2015). Whilst these results are far from scientific and assuming that there’s a full spectrum of content ranging in quality from excellent to extremely poor, one could possibly conceivably progress from a complete novice to gain a reasonable understanding of any of the above technologies from YouTube alone. Separate and apart from self-directed learning opportunities, Node.js, PHP and Ruby have vibrant online communities consisting of user groups who communicate via blogs and meetups, where they share knowledge, with, as well as learn from, each other.

The lack of a good IDE for Node.js, as expressed by Kiran Prasad of LinkedIn (Norton & Coatta, 2014), is something which sets Node at a disadvantage when compared to both Ruby on Rails and PHP. Although there are several cloud based IDE’s such as Cloud9 and Koding, as well as native text editors such as SublimeText and WebStorm. However, whilst these offer varying degrees of excellence in terms of text editing and syntax colour coding, there’s still a conspicuous absence of comprehensive debugging tools to enable a developer to trace bugs to a definable source, as can be found in NetBeans for Java development and Visual Studio for .NET and C#. Yet despite this shortcoming, Prasad still favours Node.js over Ruby on Rails, based on its greater performance, smaller [memory] footprint and the significantly fewer lines of code required to achieve a desired result (Norton & Coatta, 2014).

### Getting Started

#### Node.js

As stated by Brikman, installing Node.js and getting up and running is relatively quick and easy by comparison with other technologies (Brikman, 2015).

#### Ruby EventMachine

### Footprint

To be established when testing and comparing applications.

Griffin et al point out that the Node.js model of making extensive use of callbacks to deal with concurrent requests demands a high percentage of CPU power, however this is deemed to be a justifiable trade off given the higher performance delivered (Griffin, et al., 2011).

### Scale

#### Concurrency

Prior to the arrival of Node.js in 2009, Paulson, in 2007, identified dynamic programming languages as growing in popularity, she also quotes Tim Bray, the then director of Web Technologies at Sun, as noting that the requirements of large software projects are beyond the capabilities of many dynamic languages but that “*some of their agility-related features are slowly percolating into enterprise languages such as Java*” (Paulson, 2007).

### Threading/Threads

Ruby has had the capacity to generate multithreaded code from the beginning and, as an indication of how well thought out the language is, will support multithreading across all platforms irrespective of whether the OS upon which it’s operating supports this (ruby-lang.org, 2015). Despite the fact that Purer (Purer, 2009) in 2009 states that PHP doesn’t support threads, PHP’s own documentation would suggest this to be incorrect with references to threads and multithreads appearing in their changelog dating back to Version 4.0 Beta 2 in Aug. ’99 (PHP, 2008). Node.js on the other hand eschews multithreading and runs on a single thread operating a continuous event loop, this effectively dispenses with the need for concurrent threads, thereby freeing up resources, enabling I/O intensive applications to process requests in near real-time (Node.js, 2015). Although this approach offers unmatched performance, it also represents a single point of failure, with one blocking function, in the absence of threading, having the potential to bring the whole operation to a halt until this particular process has completed (Brikman, 2014).

### Non-Blocking Event-Driven I/0

Node is the only technology, of the three being compared, which is built solely around the concept of event-driven non-blocking I/O (Dahl, 2011). The Ruby community offers a number of frameworks that can deal with concurrency using an event loop to give asynchronous non-blocking performance, EventMachine and Celluloid::IO being two examples (GitHub.com, 2011) whilst PHP enables its developers to produce event-driven non-blocking I/O functionality via ReactPHP (GitHub.com, 2012). Thruway is another PHP based non-blocking technology however this framework uses ReactPHP at its core and as such is simply an extension of ReactPHP (Dan, 2015). Both EventMachine and ReactPHP make use of the Reactor Design Pattern to achieve non-blocking, asynchronous I/O performance equivalent to that of Node.js. However whilst a certain level of non-blocking asynchronous I/O is achieved using this pattern, there are limits to its capabilities, namely a default limit on concurrent requests of 20 (Igvita, 2008), also the Reactor Pattern effectively gives an illusion of asynchronous behaviour whilst in the background delivering requests concurrently to a service handler, demultiplexing them and distributing them synchronously to their various relevant handlers.

### Memory Footprint

*The CPU utilization for the tests was also recorded. The*

*blocking I/O based plugins rarely troubled the CPU and did*

*not consume many CPU cycles. The Node.js based plugin*

*however consumed 100% of available CPU resources when*

*run on the single load generator tests. The multiple callbacks*

*to handle events and deliver messages required a lot of CPU*

*usage but delivered a far superior throughput for this trade*

*off. On the dual load generator tests the throughput of the*

*node.js plugin was directly related to the available CPU. The*

*average CPU usage for the node.js process was 68% with the*

*min and max results outlined earlier having a corresponding*

*CPU usage of 54% and 79% respectively. The chance to take*

*more CPU cycles was denied by the prioritsation of the*

*roster updates by the openfire server. This costly, but*

*necessary action limited the potential of the node.js*

*component. Running the node process on a separate machine*

*to the openfire server would increase the performance but*

*was not within the scope of this paper due to the nature of*

*the other plugins developed.* (Griffin, et al., 2011)

### Databases

### Popularity

TIOBE Software who, since 2001, have been maintaining an index of the popularity of A to Z spectrum of programming languages, ranging from little known languages such as ABAP, Boo, Yoric and Z shell to readily identifiable languages like Java, C#, Python and PHP, currently place PHP, JavaScript and Ruby at 7th, 9th and 13th respectively (TIOBE Software, 2015). On the other hand Carbonelles GitHub hosted ranking site, whose sorting criteria is based on how often a language tutorial is searched, ranks PHP at 2nd, JavaScript at 7th and Ruby at 10th (Carbonelle, 2015).

|  |  |
| --- | --- |
| Figure 2:-TIOBE Software Language Top 20 Aug 2015 | Figure 3:-PYPL Software Language Top 16 Aug 2015 |

Whilst neither source can be taken as definitive it’s noteworthy that, relative to each other, PHP, JavaScript and Ruby maintain the same order in both tables.

# Contributing Research/Investigations

# Background

# Architecture

## Server Architecture

# Testing and Evaluation

**DON’T FORGET ABOUT THE NODE.JS PERFORMANCE CHEAT SHEET.PDF!!**

**EXPLORE THE USE OF A LOAD GENERATOR**

**NOTE: WHEN TESTING NODE, USE THE PROJECT IN the CodeProjectTutorial folder**

Write piece on exploring and researching Load Testing Software and Include references (opensourcetesting.org, 2015) Here’s another Load Testing Application which could prove useful (Webtide, 2011)

## Testing Strategy

The plan is to build two separate server applications with identical functionality, one using Node.js and the other using Ruby on Rails running EventMachine. Both applications will generate a WebSocketServer listening on a specific port. WebSockets will be used, as they are now an integral part of HTML 5 and not only offer greater speed of communication than HTTP but are also fully duplex, meaning they can send and receive using the same connection. This protocol fully compliments the asynchronous non-blocking technologies offered by both Node.js and EventMachine. Aman Gupta

# Conclusion and Future Work

## Conclusion

## Future Work

Jansen (Jansen & TIOBE.com, 2015) made reference to the GWT (Google Web Toolkit) framework, which as the name would suggest is a Google project. GWT attempts to address the same problem as Node.js, namely offering web developers, from a non-programming background, the ability to write the front and back ends of an application in the same, easy to use, language (JavaScript) (GWT Project, 2015). At the time of writing, having already outlined the basis for the research, GWT was out of scope however, given that GWT and Node.js occupy a very similar space, it may be worth exploring their future progress in parallel to see which (if either) becomes the dominant development framework.

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