Ruby Language Optimization Techniques[[1]](#footnote-1)

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NICHOLAS BENDER, BOISE STATE UNIVERSITY

JOHN OTANDER, BOISE STATE UNIVERSITY

BEN NEELY, BOISE STATE UNIVERSITY

The Ruby programming language has experienced a recent period of intense adoption and growth due to its excellent speed of iteration and due in no small part to the acceptance of the Ruby on Rails web framework within the startup sphere. While support is growing steadily for the language, it is largely dismissed as not having effective scalability, or having far slower runtimes than more traditional strongly-typed complex languages. In this article, we propose that many sophisticated techniques exist to enhance Ruby’s performance both in using existing runtimes to compile ruby to statically typed languages, and in using common anti-patterns to improve performance natively. Through experimentation and thorough research we conclude that Ruby performs competitively against it’s similar scripting language counterparts, and can see increases of [XXXXX]% in many cases.

Categories and Subject Descriptors: **D.2.3 [Coding Tools and Techniques]**: Object-oriented programming, **B.6.3 [Design Aids]:** Optimization

General Terms: Optimization, Algorithms, Performance

Additional Key Words and Phrases: Ruby, Web Development, JRE, C++,

**ACM Reference Format**:

Gang Zhou, Yafeng Wu, Ting Yan, Tian He, Chengdu Huang, John A. Stankovic, and Tarek F. Abdelzaher, 2010. A multi-frequency MAC specially designed for wireless sensor network applications. *ACM Trans. Embedd. Comput. Syst.*9,4,Article 39 (March 2010), 6 pages*.*    
DOI:http://dx.doi.org/10.1145/0000000.0000000

# INTRODUCTION

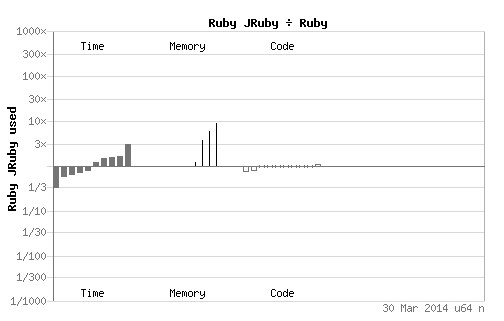
In recent years, the Ruby programming language has grown its community and established itself as a valuable and popular tool for many tasks [O’Donoghue, 2014]. The success of Ruby on Rails as a prototyping framework as well as a full-stack solution for some larger companies has brought forth a myriad of techniques to ensure that the language’s speed differences compared to similar languages are minimal. Ruby’s slower performance as compared to C or Java is attributed to interpreted execution, dynamic typing, meta-programming support, and the Global Interpreter Lock [Odaira, Castanos, and Tomari, 2014]. This increase in popularity has caused a large number independent optimization efforts to arise from large corporations such as IBM, as well as efforts from the Ruby open-source community.

With each of these techniques there exist certain sacrifices, but in this exploration we will conclude that the best practices for stable, performant Ruby code exist by utilizing the newest versions of the core language properly, and not by utilizing other third party interpreters or solutions.

# JRUBY

* 1. Purpose

Jruby endeavors to solve many Ruby performance issues by eliminating the standard interpreter and instead taking ruby syntax and compiling as much of the core libraries as possible to Java bytecode. Current versions of JRuby support both just-in-time compilation as well as ahead-of-time compilation to Java bytecode. In using these various stages of bytecode in addition to some portions of the standard interpreter, this allows for several advantages over the standard interpreter.

One of the more obvious improvements is the ability to call and use standard Java libraries and classes from within ruby projects. For larger organizations already using Java for core library support, this allows for improved flexibility of the development environment.

2.2. Performance

In 2007, JRuby’s overall performace was compared with Ruby 1.8.5, the Yarv interpreter (now merged into Ruby’s official interpreter), and Rubinius. In it, only 10% of tests performed had JRuby outperforming standard Ruby. These speed enhancements, however, still managed to run all Ruby benchmarks without timing out or producing an error, a claim that no other non-standard Ruby implementation could make [Cangiano, 2007].

(Figure 1)

However, benchmarks performed in 2014 between the latest implementations of JRuby and Ruby (Figure 1) are comparable to standard Ruby, but also ramp up significantly in comparison to Ruby in Memory usage (to almost 10x).

If memory usage isn’t a priority for a given Ruby project, the biggest additional downside in performance of JRuby has to do with the speed of initializing the JVM to begin with. A simple ruby script that would take the MRI a fraction of a second to run would require several additional seconds just due to JVM launch times.

2.3 Lack of C Support

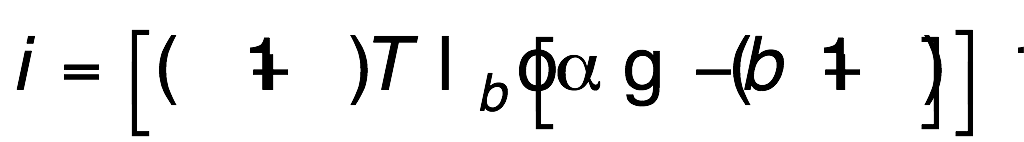
While JRuby allows for enhanced support and compatibility with Java libraries and applets, the majority of Ruby users (especially those using Ruby on Rails) are used to using libraries that contain native C support. In choosing to support Java, JRuby forces the incompatibility with native C extensions. Most notably are a variety of database interfaces and web servers.

2.4. Development Lag

Due to JRuby’s implementation being dependent on Ruby releases prior to implementation and support, this has created an unfortunately long lag time, with the most recent release of JRuby only supporting Ruby version 1.9.3, which was initially released in 2011.

2.5 Summary

While JRuby does offer some improved benchmark performance in a minority of cases, the slow development cycle and potential for a massive increase to memory footprint make it an unsuitable option for pure ruby development stacks.



It can be easily proven that the distribution of *i* conforms to Equation (1).

So protocols [Bahl et al. 2004; Culler et al. 2004; Zhou et al. 2008; Adya et al. 2004; Culler et al. 2004; Tzamaloukas and Garcia-Luna-Aceves 2000; Akyildiz et al. 2002] that use RTS/CTS controls1 for frequency negotiation and reservation are not suitable for WSN applications, even though they exhibit good performance in general wireless ad hoc networks.

Algorithm 1. Frequency Number Computation

**Input:** Node *α*’s ID (*IDα*), and node *α*’s neighbors’ IDs within two communication hops.

**Output:** The frequency number (*FreNumα*) node *α* • gets assigned.

*index* = 0; *FreNumα* =−1;

**repeat**

*Rndα* = Random(*IDα*, *index*);

*Found* = *TRUE*;

**for** *each node* *β*• *in* *α’s two communication hops* **do**

*Rndβ* = Random (*IDβ*, *index*);

**if** (*Rndα* < *Rndβ*) or (*Rndα* = = *Rndβ* and *IDα* < *IDβ*)

**then**

*Found* = *FALSE*; *break*;

**end**

**end**

**if** *Found* **then**

*FreNumα* = *index*;

**else**

*index* ++;

**end**

until *FreNumα* > −1;

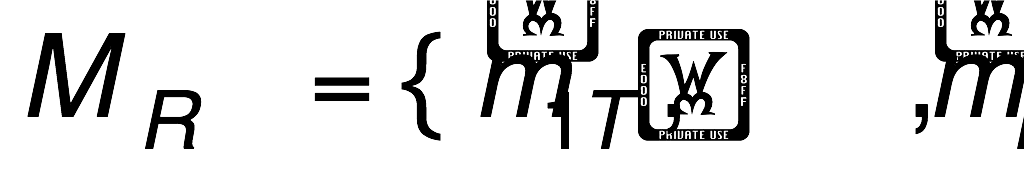
*2.1.1. Exclusive Frequency Assignment.* In exclusive frequency assignment, nodes first exchange their IDs among two communication hops so that each node knows its twohop neighbors’ IDs. In the second broadcast, each node beacons all neighbors’ IDs it has collected during the first broadcast period.

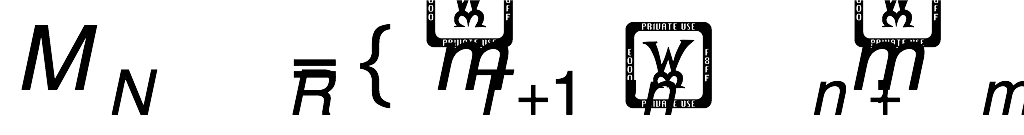
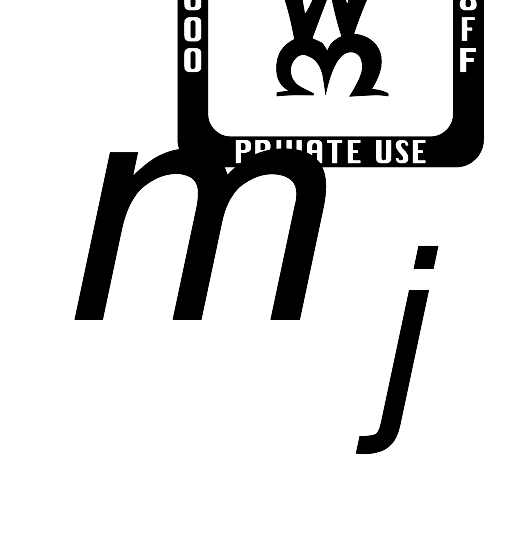
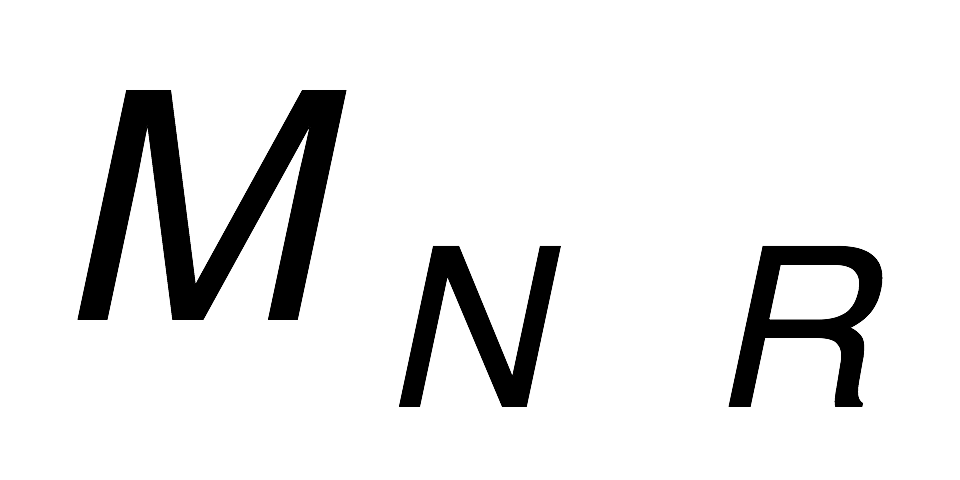
*Eavesdropping.*  Even though the even selection scheme leads to even sharing of available frequencies among any two-hop neighborhood, it involves a number of twohop broadcasts. To reduce the communication cost, we propose a lightweight eavesdropping scheme.

## Basic Notations

As Algorithm 1 states, for each frequency number, each node calculates a random number (Rnd) for itself and a random number (Rnd) for each of its two-hop neighbors with the same pseudorandom number generator.

Bus masters are divided into two disjoint sets,MRT andMNRT .

RT Masters.  denotes the n RT masters issuing real-time constrained requests. To model the current request issued by an mi in M, three parameters—the recurrence time (ri), the service cycle (ci), and the relative deadline (di)—are used, with their relationships.

NRT Masters.  is a set of m masters issuing nonrealtime constrained requests. In our model, each  in  needs only one parameter, the service cycle, to model the current request it issues.

Here, a question may arise, since each node has a global ID. Why don’t we just map nodes’ IDs within two hops into a group of frequency numbers and assign those numbers to all nodes within two hops?

# SIMULATOR

If the model checker requests successors of a state which are not created yet, the state space uses the simulator to create the successors on-the-fly. To create successor states the simulator conducts the following steps.

(1) Load state into microcontroller model.

(2) Determine assignments needed for resolving nondeterminism.

(3) For each assignment.

(a) Either call interrupt handler or simulate effect of next instruction, or

(b) Evaluate truth values of atomic propositions.

(4) Return resulting states.

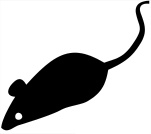


Fig. 1. Code before preprocessing.

Figure 1 shows a typical microcontroller C program that controls an automotive power window lift. The program is one of the programs used in the case study described in Section 3. At first sight, the programs looks like an ANSI C program. It contains function calls, assignments, if clauses, and while loops.

## Problem Formulation

The objective of variable coalescence-based offset assignment is to find both the coalescence scheme and the MWPC on the coalesced graph. We start with a few definitions and lemmas for variable coalescence.

*Definition 3.1 (Coalesced Node (C-Node)).*A C-node is a set of live ranges (webs) in the AG or IG that are coalesced. Nodes within the same C-node cannot interfere with each other on the IG. Before any coalescing is done, each live range is a C-node by itself.

*Definition 3.2 (C-AG (Coalesced Access Graph)).*The C-AG is the access graph after node coalescence, which is composed of all C-nodes and C-edges.

Lemma 3.3. The C-MWPC problem is NP-complete.

Proof. C-MWPC can be easily reduced to the MWPC problem assuming a coalescence graph without any edge or a fully connected interference graph. Therefore, each C-node is an uncoalesced live range after value separation and C-PC is equivalent to PC. A fully connected interference graph is made possible when all live ranges interfere with each other. Thus, the C-MWPC problem is NP-complete. □

Lemma 3.4 (Lemma Subhead). The solution to the C-MWPC problem is no worse than the solution to the MWPC.

Proof. Simply, any solution to the MWPC is also a solution to the C-MWPC. But some solutions to C-MWPC may not apply to the MWPC (if any coalescing were made). □

Table I. Simulation Configuration

|  |  |
| --- | --- |
| TERRAINa | (200m×200m) Square |
| Node Number | 289 |
| Node Placement | Uniform |
| Application | Many-to-Many/Gossip CBR Streams |
| Payload Size | 32 bytes |
| Routing Layer | GF |
| MAC Layer | CSMA/MMSN |
| Radio Layer | RADIO-ACCNOISE |
| Radio Bandwidth | 250Kbps |
| Radio Range | 20m–45m |
| *Source*: This is a table source note. This is a table source note. This is a table source note.  *Note*: This is a table footnote.  aThis is a table footnote. This is a table footnote. This is a table footnote. | |

# PERFORMANCE EVALUATION

During all the experiments, the Geographic Forwarding (GF) [Akyildiz et al. 2002] routing protocol is used. GF exploits geographic information of nodes and conducts local data-forwarding to achieve end-to-end routing. Our simulation is configured according to the settings in Table I. Each run lasts for 2 minutes and repeated 100 times. For each data value we present in the results, we also give its 90% confidence interval.

# CONCLUSIONS

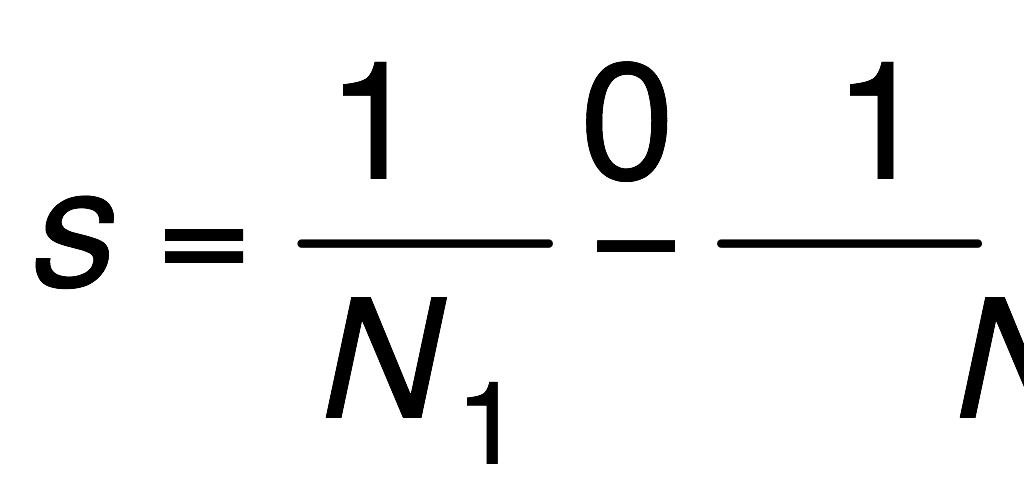
In this article, we develop the first multifrequency MAC protocol for WSN applications in which each device adopts a single radio transceiver. The different MAC design requirements for WSNs and general wireless ad-hoc networks are compared, and a complete WSN multifrequency MAC design (MMSN) is put forth. During the MMSN design, we analyze and evaluate different choices for frequency assignments and also discuss the nonuniform back-off algorithms for the slotted media access design.

# TYPICAL REFERENCES IN NEW ACM REFERENCE FORMAT

A paginated journal article [Abril and Plant 2007], an enumerated journal article [Cohen et al. 2007], a reference to an entire issue [Cohen 1996], a monograph (whole book) [Kosiur 2001], a monograph/whole book in a series (see 2a in spec. document) [Harel 1979], a divisible-book such as an anthology or compilation [Editor 2007] followed by the same example, however we only output the series if the volume number is given [Editor 2008] (so Editor00a’s series should NOT be present since it has no vol. no.), a chapter in a divisible book [Spector 1990], a chapter in a divisible book in a series [Douglass et al. 1998], a multi-volume work as book [Knuth 1997], an article in a proceedings (of a conference, symposium, workshop for example) (paginated proceedings article) [Andler 1979], a proceedings article with all possible elements [Smith 2010], an example of an enumerated proceedings article [Gundy et al. 2007], an informally published work [Harel 1978], a doctoral dissertation [Clarkson 1985], a master’s thesis: [Anisi 2003], an online document / world wide web resource [Thornburg 2001], [Ablamowicz and Fauser 2007], [Poker-Edge.Com 2006], a video game (Case 1) [Obama 2008] and (Case 2) [Novak 2003] and [Lee 2005] and (Case 3) a patent Scientist 2009], work accepted for publication [Rous 2008], ‘YYYYb’-test for prolific author [Saeedi et al. 2010a] and [Saeedi et al. 2010b]. Other cites might contain ‘duplicate’ DOI and URLs (some SIAM articles) [Kirschmer and Voight 2010]. Boris / Barbara Beeton: multi-volume works as books [Hörmander 1985b] and [Hörmander 1985a].

APPENDIX

In this appendix, we measure the channel switching time of Micaz [CROSSBOW 2008] sensor devices. In our experiments, one mote alternatingly switches between Channels 11 and 12. Every time after the node switches to a channel, it sends out a packet immediately and then changes to a new channel as soon as the transmission is finished. e measure the number of packets the test mote can send in 10 seconds, denoted as 1. In contrast, we also measure the same value of the test mote without switching channels, denoted as N2. We calculate the channel-switching time s as



By repeating the experiments 100 times, we get the average channel-switching time of icaz motes: 24.3 *μ*s.

ELECTRONIC APPENDIX

The electronic appendix for this article can be accessed in the ACM Digital Library.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Maura Turolla of Telecom Italia for providing specifications about the application scenario.

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Received February 2007; revised March 2009; accepted June 2009

Online Appendix to:  
A Multifrequency MAC Specially Designed for Wireless Sensor Network Applications[[2]](#footnote-2)

GANG ZHOU, College of William and Mary

YAFENG WU, University of Virginia

TING YAN, Eaton Innovation Center

TIAN HE, University of Minnesota

CHENGDU HUANG, Google

JOHN A. STANKOVIC, University of Virginia

TAREK F. ABDELZAHER, University of Illinois at Urbana-Champaign

A. THIS IS AN EXAMPLE OF APPENDIX SECTION HEAD

Channel-switching time is measured as the time length it takes for motes to successfully switch from one channel to another. This parameter impacts the maximum network throughput, because motes cannot receive or send any packet during this period of time, and it also affects the efficiency of toggle snooping in MMSN, where motes need to sense through channels rapidly.

By repeating experiments 100 times, we get the average channel-switching time of Micaz motes: 24.3 *μ*s. We then conduct the same experiments with different Micaz motes, as well as experiments with the transmitter switching from Channel 11 to other channels. In both scenarios, the channel-switching time does not have obvious changes. (In our experiments, all values are in the range of 23.6 *μ*s to 24.9 *μ*s.)

B. APPENDIX SECTION HEAD

The primary consumer of energy in WSNs is idle listening. The key to reduce idle listening is executing low duty-cycle on nodes. Two primary approaches are considered in controlling duty-cycles in the MAC layer.

1. Author’s addresses: N. Bender, Boise State University, Computer Science Department, B Neely, Boise State University, Computer Science Department, J. Otander, Boise State University, Computer Science Department.

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