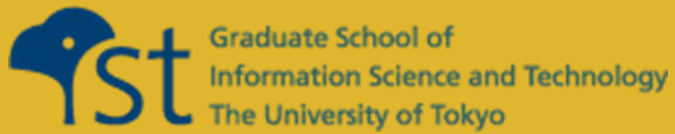
Can you see me?

Future of Ruby VM

Talk about Ruby VM Performance.

Ruby VMの未来，とかなんとか



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The University of Tokyo

Summary of My Talk

“Scaling Ruby (without the Rails)“ Seems Interesting!

“Monkeybars: easy cross platform GUIs” Also Does!

On My Performance Interesting,

Former is Preferred ☺

Anyone make a Log?

Summary

CRuby/YARV is
NOT a "BEST" Solution
for Ruby VM Performance.

However, CRuby/YARV is
"GOOD" Enough Solution for Us,
the Pragmatic Ruby Programmers,
at least **Several Years**.

Self Introduction
Recent Report about Me

- ko1 - Koichi (Given Name) Sasada (Family Name)
  - From Japan, 5th RubyConf since 2004, 4th Speach
  - YARV Developer
- **Lecturer**
  - Department of Creative Informatics, Graduate School of Science and Technology, The University of Tokyo.
  - Lecture: Programming System, but only 3 students attend
- **SASADA-lab**
  - If you want to research about Ruby or Virtual Machine, Systems Software **in Japan**, please contact me.
  - 2 students are there, but no one want to hack YARV.

Caution! (**re-re-re**view)

- I can’t speak English well
  - If I say strange English, you can see the slide page
    - Or ask another Japanese. They can speak English well.
    - My Slides uses Small Characters (against Takahashi-san’s Presentation Method)
  - If you have any question, ask me with:
    - Japanese (recommended)
    - Ruby, C, Scheme, Java, ⋯, Python, Haskell, ...
    - Or Easy English

Agenda

- Perspective of Ruby VM Performance
  - VM Performance Discussion
  - Our Performance Policy
- Introduction of Our Research
  - Hidden Optimization Techs.
  - Ricsin Project
  - Ruby to C AOT Compiler Project
  - atomic-Ruby Project
  - MVM Project
- Summary

Remember The Evan's Classification

JRuby is for Java Programmers

IronRuby is for .Net Programmers

Rubinius is for Ruby Programmers

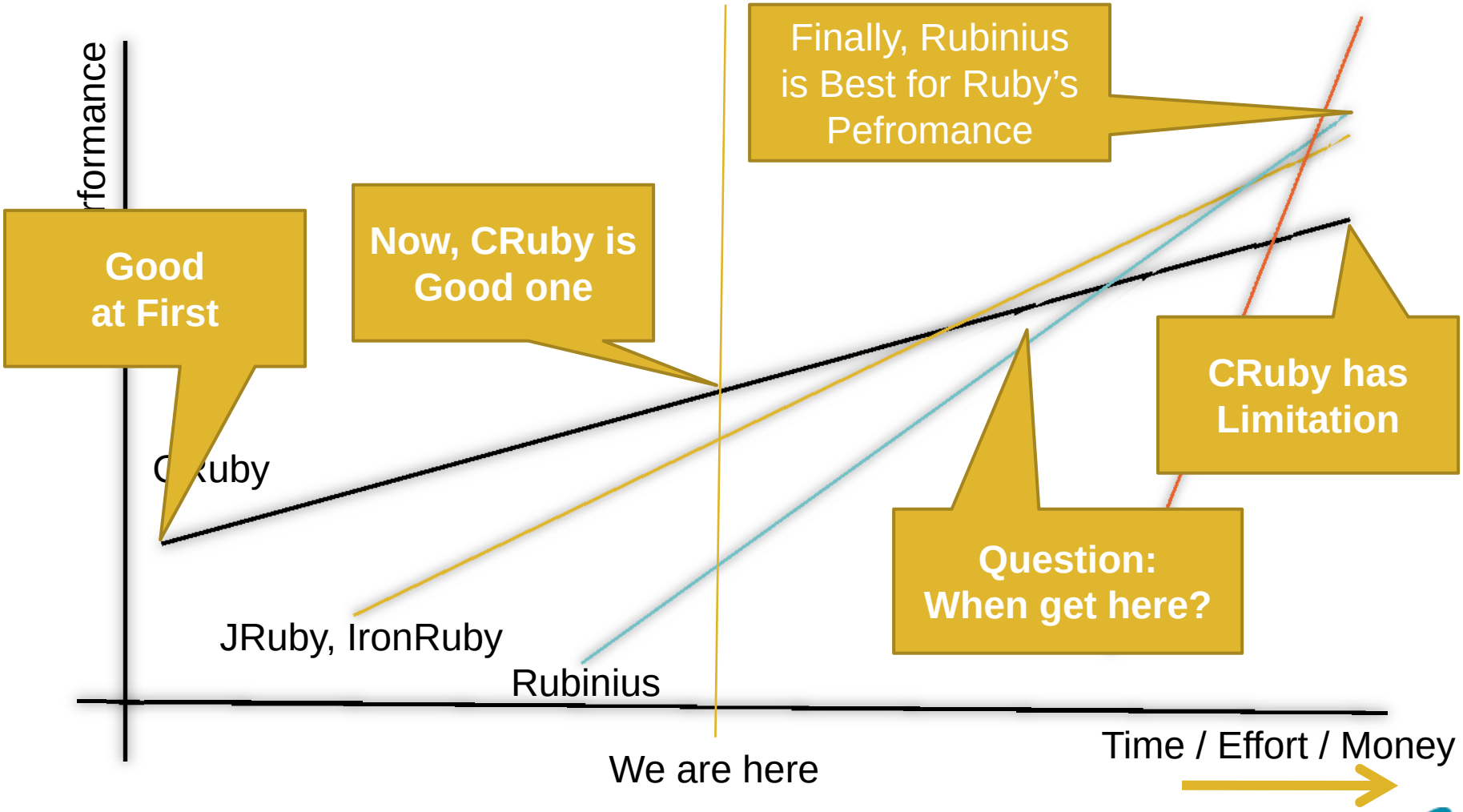
CRuby is for C Programmers

OK.

Let's Talk about the "C",

The Benefits and Limitation

Evolution of VM Performance
My Prediction



Techniques for VM Performance

- Simple Optimization Techniques
  - C-level VM Techniques
- Advanced Optimization Techniques
  - Dynamic Code Generation
    - Speed-up using Native Machine code Compiler
    - Just in Time Compilation
    - Polymorphic Inline Cache
    - Selective Inlining
  - Online Feedback Optimization
    - HotSpot JIT Compiler
    - Tracing JIT

Pros and Cons of JRuby/IronRuby

- Using Awesome VM
- Pros.
  - Many Clever People Working on each VM
  - No Code is Good Code.
    - No Bugs are Generated.
  - Many Libraries on Each Environments
  - Easy (?) to Use Parallelization
- Cons.
  - Not Only Focused on Ruby, Semantics Gap
  - Can’t Use C Extensions Directly

Pros and Cons of Rubinius

- Most of Code is Written in Ruby
  - Like Java
- Pros.
  - Ruby in Ruby
    - Meta-Circular Interpreter
  - **Best Way** to Improve Performance in the Long Run Because They Can Analyze Most of Programs.
  - Mainly Focus on Ruby
- Cons.
  - **Long Way** to Get High Performance VM

Pros of “C” Ruby

- **Portability**
  - Most of Environments have GCC Porting.
- Maintainability
  - Everyone Know C.
- Extensibility
  - Easy to Write Extension with C.
- Performance Improvement
  - Easy to Write Simple (Machine Independent) Optimization.

Cons (Limitation) of “C” Ruby

- C Extension Libraries or Methods written in C
  - GC Problem
    - Conservative Mark & Sweep Stop The World GC
  - Inlining Problem
    - Can’t Inline C code into Ruby Code
  - Limitation of Program Analysis

Our Performance Policy

- CRuby is Not “Best” Solution but “Good” One
- Continue to Improve CRuby’s Implementation
  - in C
  - in Machine Dependent Way
- Pragmatic, Practical Selection
  - at least several years

Keywords for Success

- “Embedding”
- Parallelization

Introduction of Our Research

- To Take Advantage of “C”, Some Projects are Running
  - Hidden Optimization Techs on YARV
  - Ricsin: Mix-in C to Ruby Project
  - Ruby to C AOT Compiler Project
  - atomic-Ruby Project
  - Multi-VM Project

Hidden/Left Optimization Techs

- Turned Off on 1.9.1 by Default
  - Tail call Optimization
  - Optimization using Unification
  - Stack Caching
- Left Easy Optimization
  - Efficient Method Caching
  - Efficient Fiber Implementation using Platform dependent way such as makecontext()
- These Optimizations will be Merged into 1.9.2

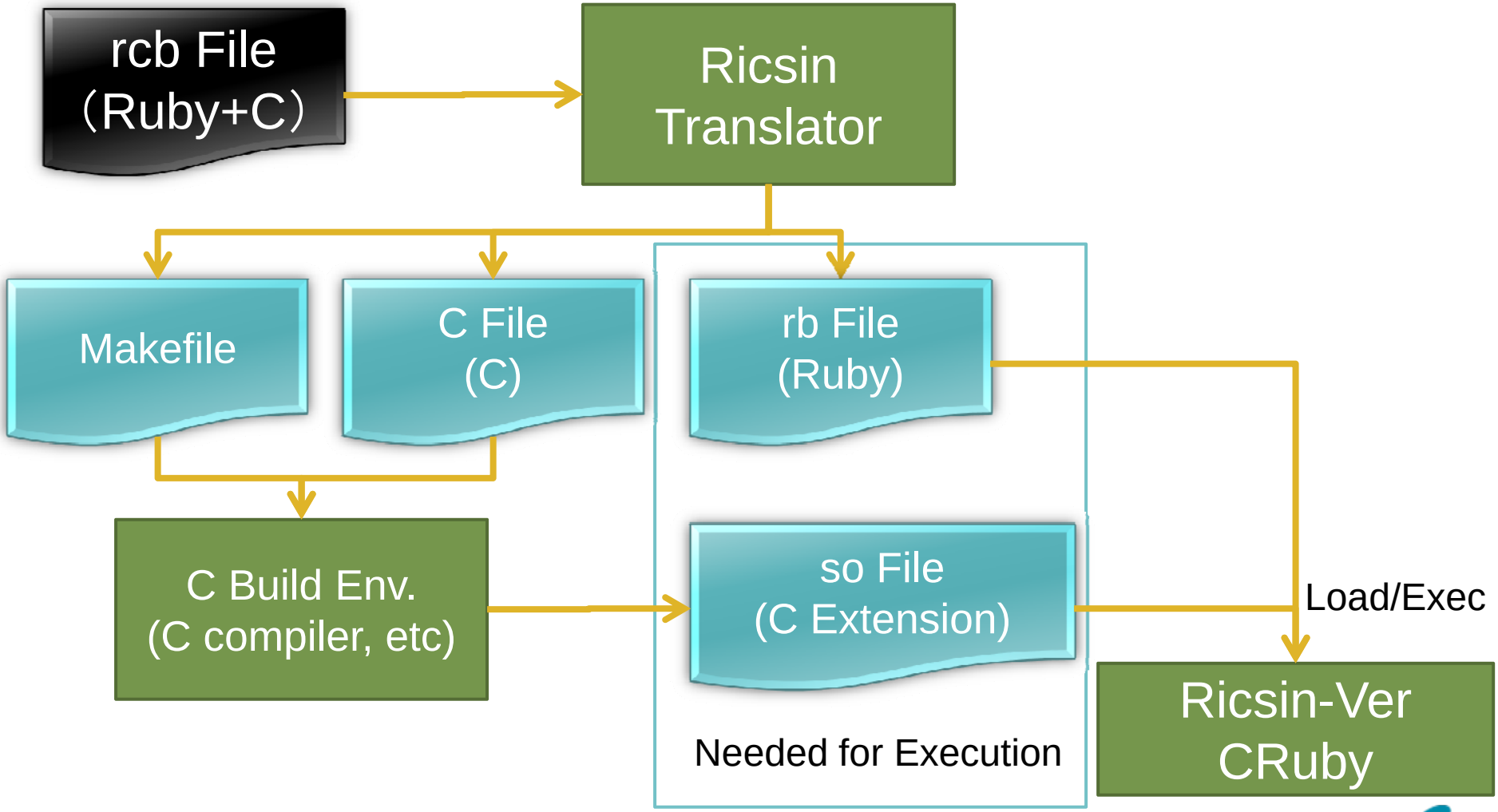
Ricsin: Mix-in C to Ruby

- Embed a part of C Program into Ruby
- Like an RubyInline, but Embed Directly
- Usage Example
  - Use C Libs Directly
  - Replace All Built-in Classes/Methods
  - Test Ruby C APIs
  - Performance Improvement Continuously

Ricsin Notation

```
def open_fd(path) # Ruby
  fd = _C_(%q{
    /* C */
    return INT2FIX(open(RSTRING_PTR(path), O_RDONLY));
  })
  raise 'open error' if fd == -1
  yield fd
ensure
  raise 'close error' if -1 == _C_(%q{
    /* C */
    return INT2FIX(close(FIX2INT(fd)));
  })
end
```

Ricsin Total View



Ricsin Translation and Execution

```
# rcb
v = 42
r = __C__(%q{
  /* Embed C Body */
  rb_p(self); /* show "main" */
  return INT2FIX(
    FIX2INT(v) + 1);
})
p r #=> show "43"
```

Generate

```
/* A Part of Generated C Source */
#define v (cfp->lfp[3])
#define r (cfp->lfp[2])
VALUE ricsin_func_1(
  rb_control_frame_t *cfp)
{
  const VALUE self = cfp->self;
  {
    /* Embed C Body */
    rb_p(self);
    return INT2FIX(FIX2INT(v) + 1);
  }
  return Qnil;
}
#undef v
#undef r
```

Built to Extension Library

Bytecode Compile

Function Call

```
[ADDR] [INSN]              [OPERAND]
0000 putobject             42
0002 setlocal              v
0004 opt_call_ricsin       <funcptr>
0006 setlocal              r
0008 putnil
0009 getlocal              r
0011 send                  :p, 1
0017 leave
```

Ricsin: Evaluation

- Performance Evaluation (Not a Usability)
- Evaluation Environment
  - Env.1 : Intel Xeon E5335, Linux
  - Env.2 : SPARC T2, SunOS 5.10
- Evaluation Items
  1. Calling C Function (null call)
  2. Example on Iterator
  3. Matrix Multiprior

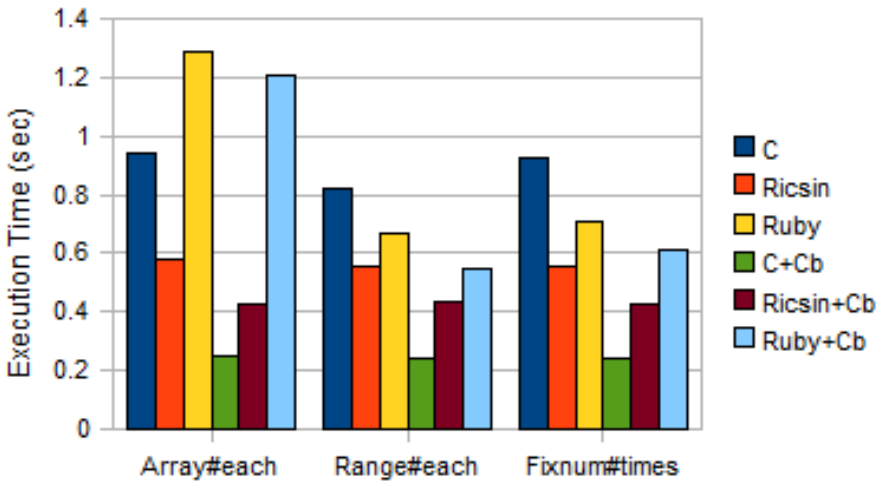
Ricsin
Evaluation of Calling Null Function

- Calling Null C Function
  - Null C Method
  - Null __C__ Embed

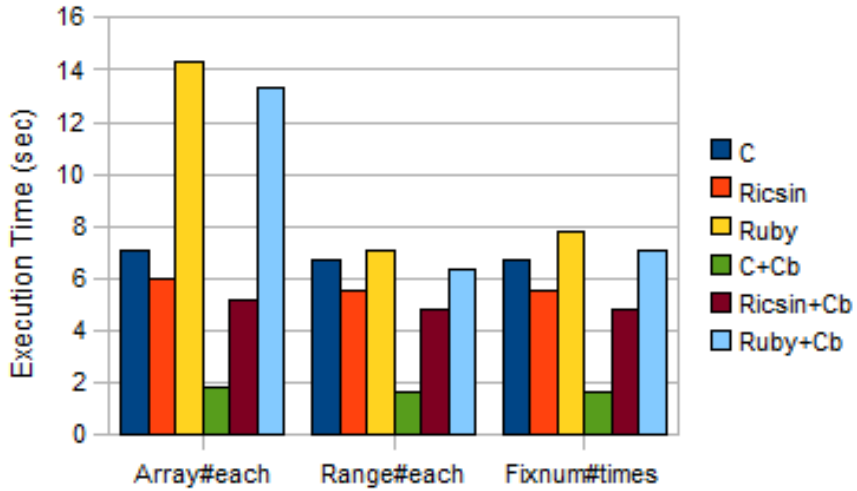
	C (sec)	Ricsin (sec)	C/Ricsin
Env.1 (Intel)	0.44	0.05	8.8
Env.2 (SPARC)	4.56	0.44	10.4

Ricsin
Evaluation: Iterator Optimization

- Rewrite Iterators with Ricsin
  - C: Current Iterator
  - Ricsin: Rewriting with __Ccont__
  - Ruby: Rewriting with Pure Ruby



Env.1 (Intel)



Env.2 (SPARC)

Ricsin
Evaluation: Matrix Multiplier

- Matrix Multiplier with Fixnum Elements
- Replace 12 Lines Ruby Code to 36 Lines C Code Directly

	Ruby (sec)	Ricsin (sec)	Ruby/Ricsin
Env.1 (Intel)	10.57	0.57	20.33
Env.2 (SPARC)	85.31	6.73	12.68

Ricsin

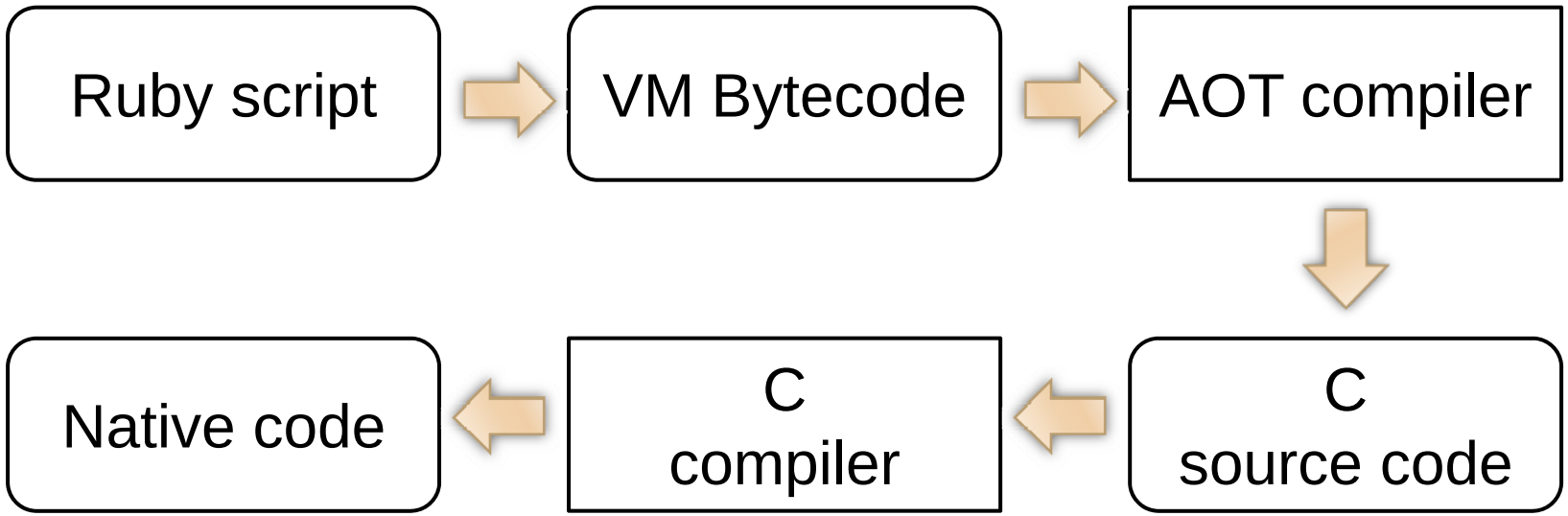
svn co
http://svn.ruby-lang.org/repos/ruby/branches/ricsin

Ruby to C AOT Compiler

- Translate Ruby Script to C Source Code at Ahead of Time
  - Compile Ruby to Bytecode
  - Translate Bytecode to C Source Code
- Performance Improvement by
  - Eliminate VM Instruction Dispatch
  - Optimization by C Compiler
  - Eliminate Parse/Compile Time

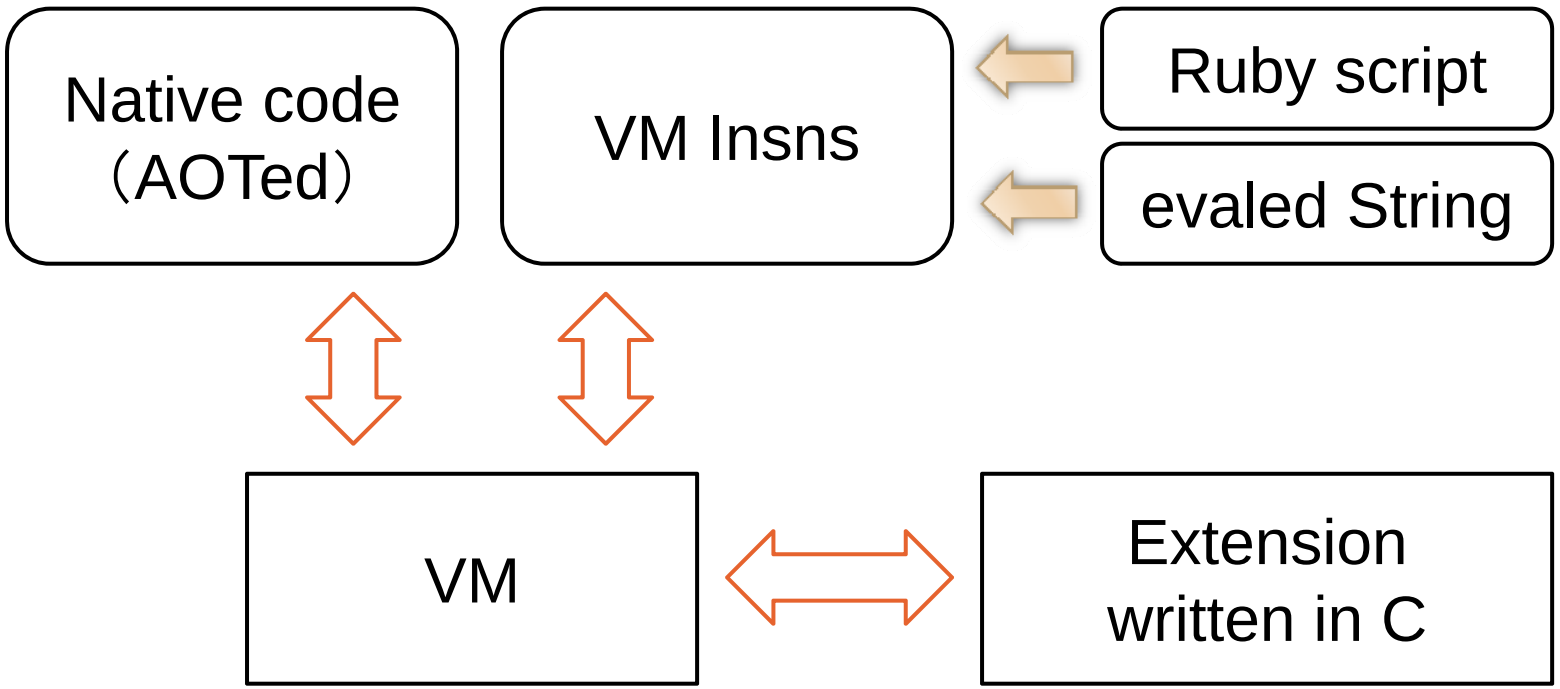
Ruby to C AOT Compiler

- Ahead of Time Compilation
  1. Compile Ruby Script to VM Bytecode
  2. VM Bytecode to C



Ruby to C AOT Compiler

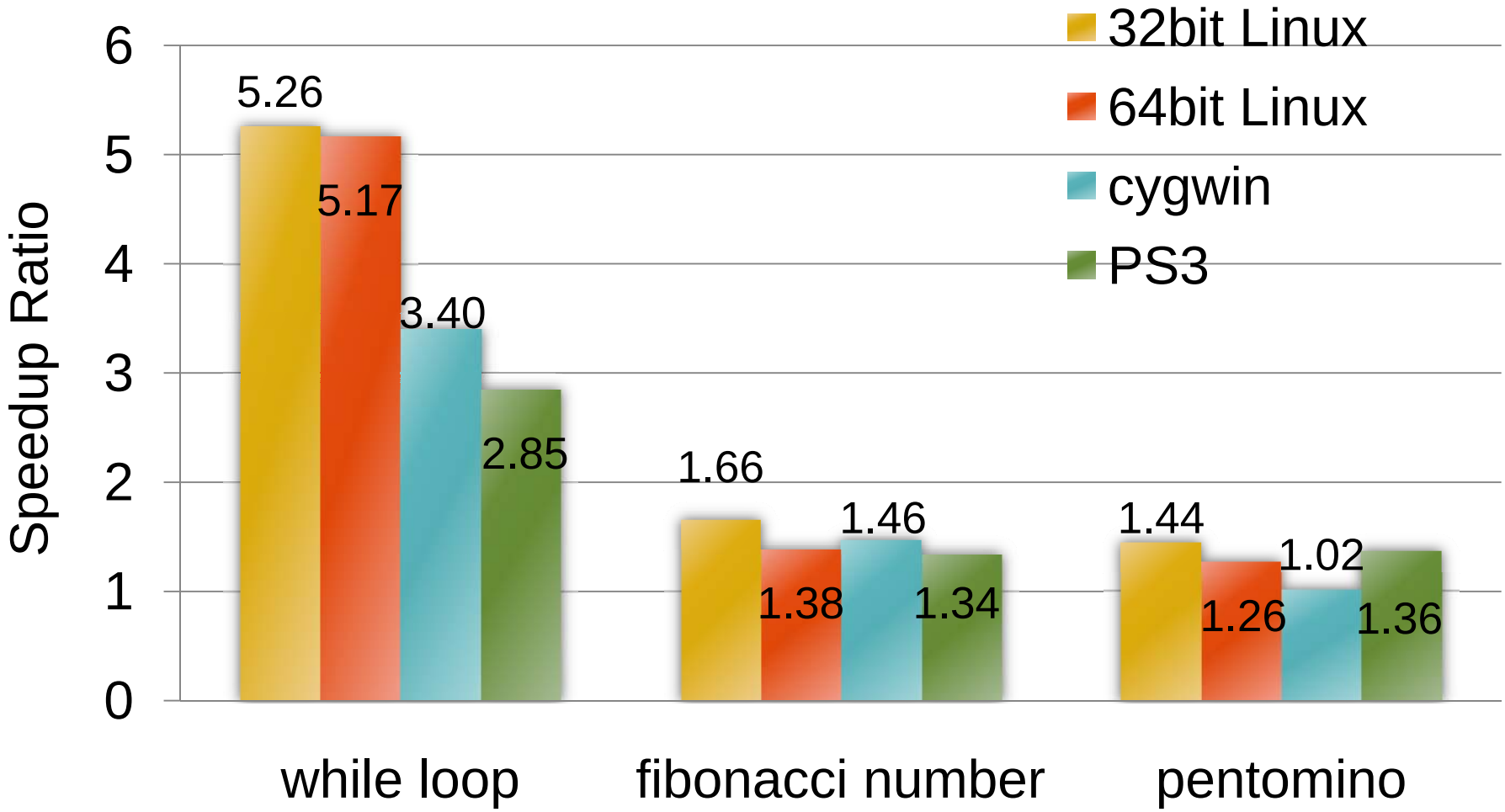
- Execution with Ruby VM



Evaluation Environment

Env	CPU	Memory	OS	C Compiler
32bit Linux	Intel PentiumD 2.80GHz	2 GB	Linux 2.6.24	gcc 4.2.3
64bit Linux	Intel Xeon 3060 2.40GHz	1 GB	Linux 2.6.18	gcc 4.1.2
cygwin	Intel Core Duo U2400 1.06GHz	1.5 GB	Windows Vista SP1	gcc 3.4.4
PS3	Cell Broadband Engine 3.2GHz	256 MB	Linux 2.6.16	gcc 4.1.1

Ruby to C AOT Compiler Evaluation Results



Related Work

- ruby2c by Eric, Ryan
  - Subset Ruby to C
- yajit by Shinh
  - JIT (yarv bytecode to IA-32 with Xbyak)
- yarv2llvm by Miura-san
  - JIT (yarv bytecode to LLVM asm)

atomic-Ruby Project

- Issue: Ruby is too Fat
  - Involves Convenient Functions.
  - Complex and Rational will be Built-in at Ruby 1.9

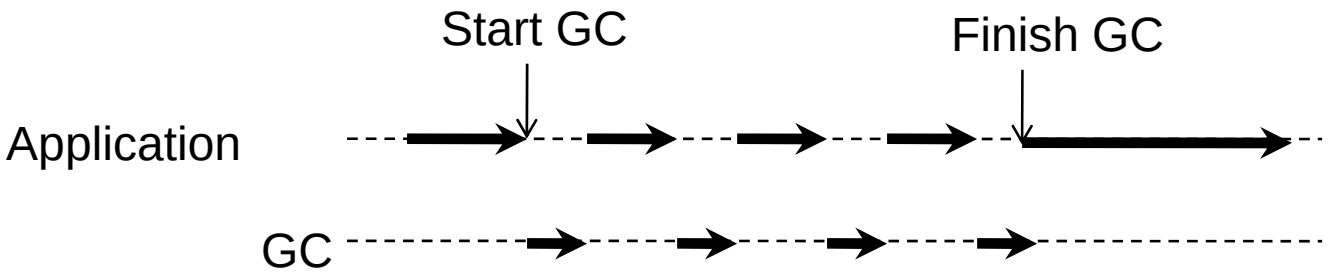
  → Difficult to Use “Embedded” Environment
- **“Embedded”**
  - Embedded System such as Resource Limitation Devs.
    - In Many Case, Numeric Tower or m17n are not needed.
  - Application Embedded Ruby
    - Application needs “DSL Engine”, doesn’t Full-set Ruby

atomic-Ruby Project (cont.)

- We Need Slim Ruby Interpreter
- atomic-Ruby makes “Suitable Ruby Interpreter”
  - Ruby Interpreter for Application
  - Ruby Interpreter for Environment (such as Embedded Systems)
  - Ruby Interpreter for Driver Application
- Utilize CRuby’s Portability
- 3 Sub-Project with 3 Students
  - Plug-in/out Built-in Classes/Methods
  - Pre-Compilation and Remove Parser/Compiler
  - Switch Core-Feature such as GC, Regex, Thread, etc

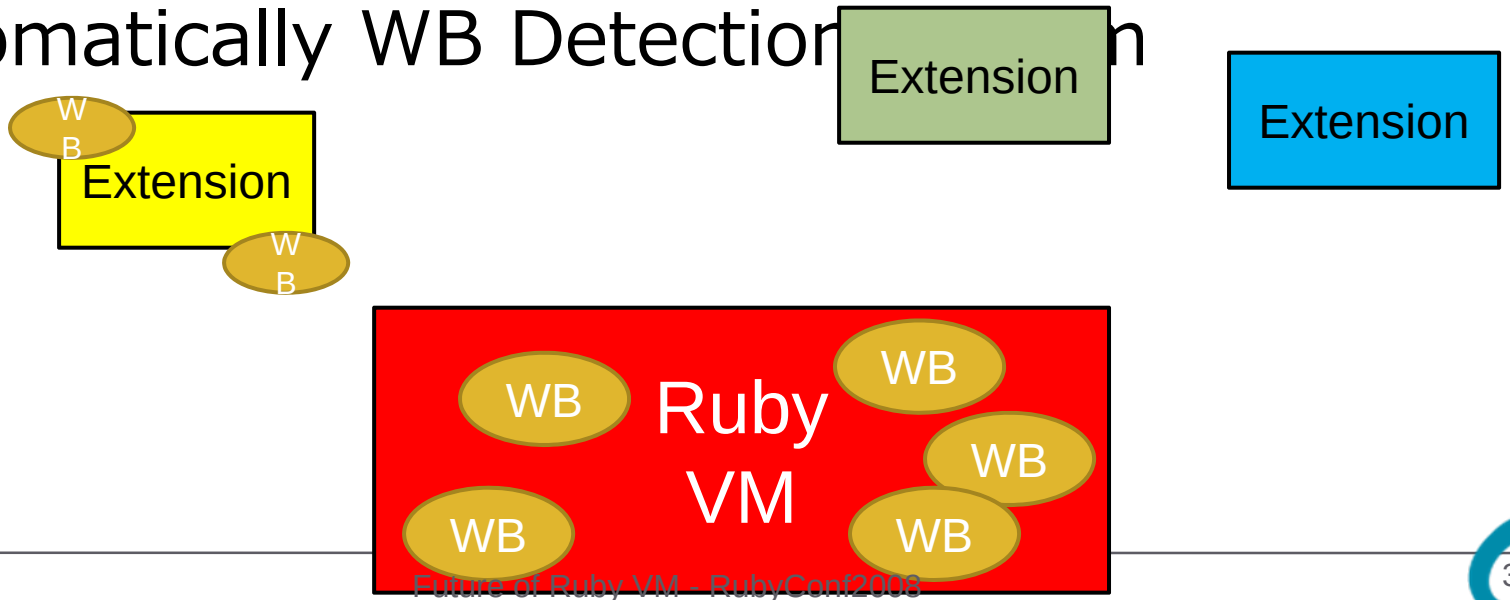
atomic-Ruby Incremental GC

- Switch GC Algorithm
- Mark Partially
  - Execute App and Mark partially
  - Reduce Application Stop Time



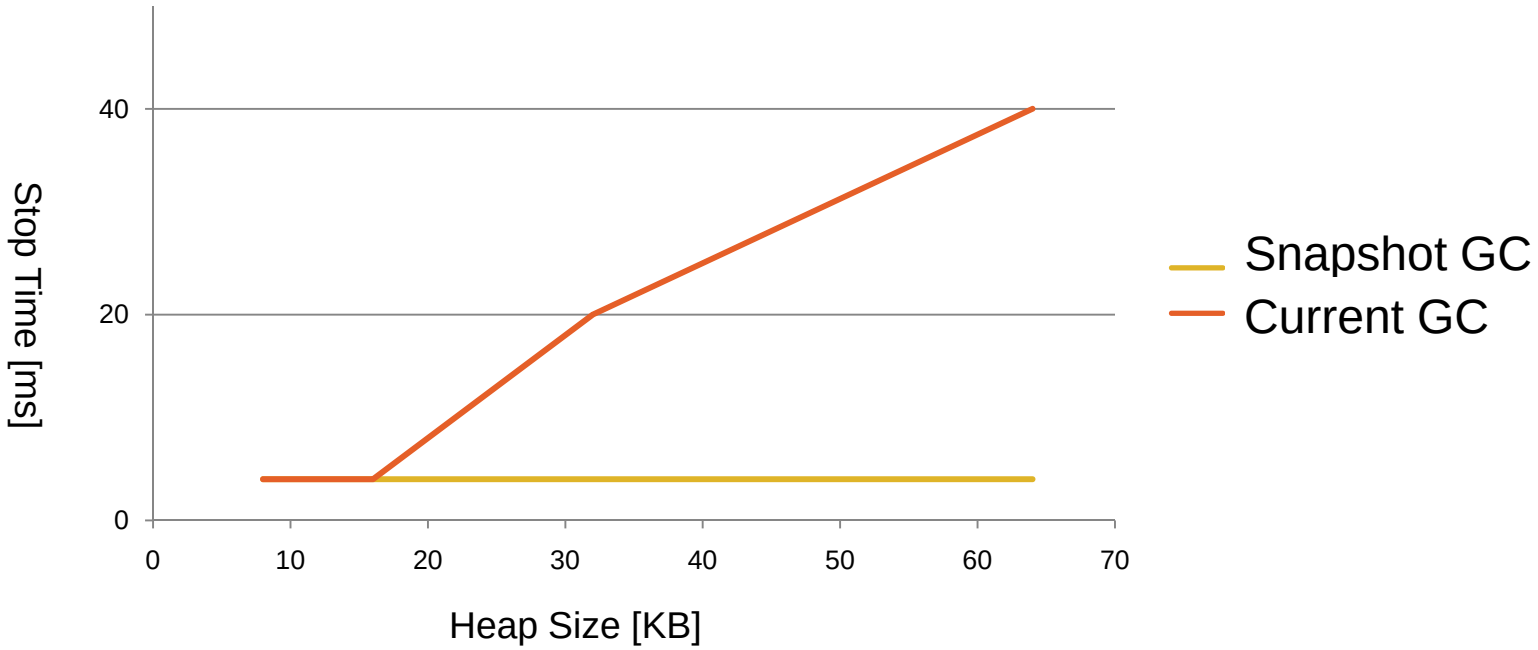
Auto Write Barrier Detection

- Write Barrier is Needed for Several GC Algorithms.
  - Need Interpreter and Extensions.
  - Need Special Knowledge of VM and GC.
  - Cause Critical Bugs if WB Insertion Miss.
- Automatically WB Detection



Snapshot (Real Time) GC

- Stop Time of Application (Mark Phase)
  - Insert Many WBs.



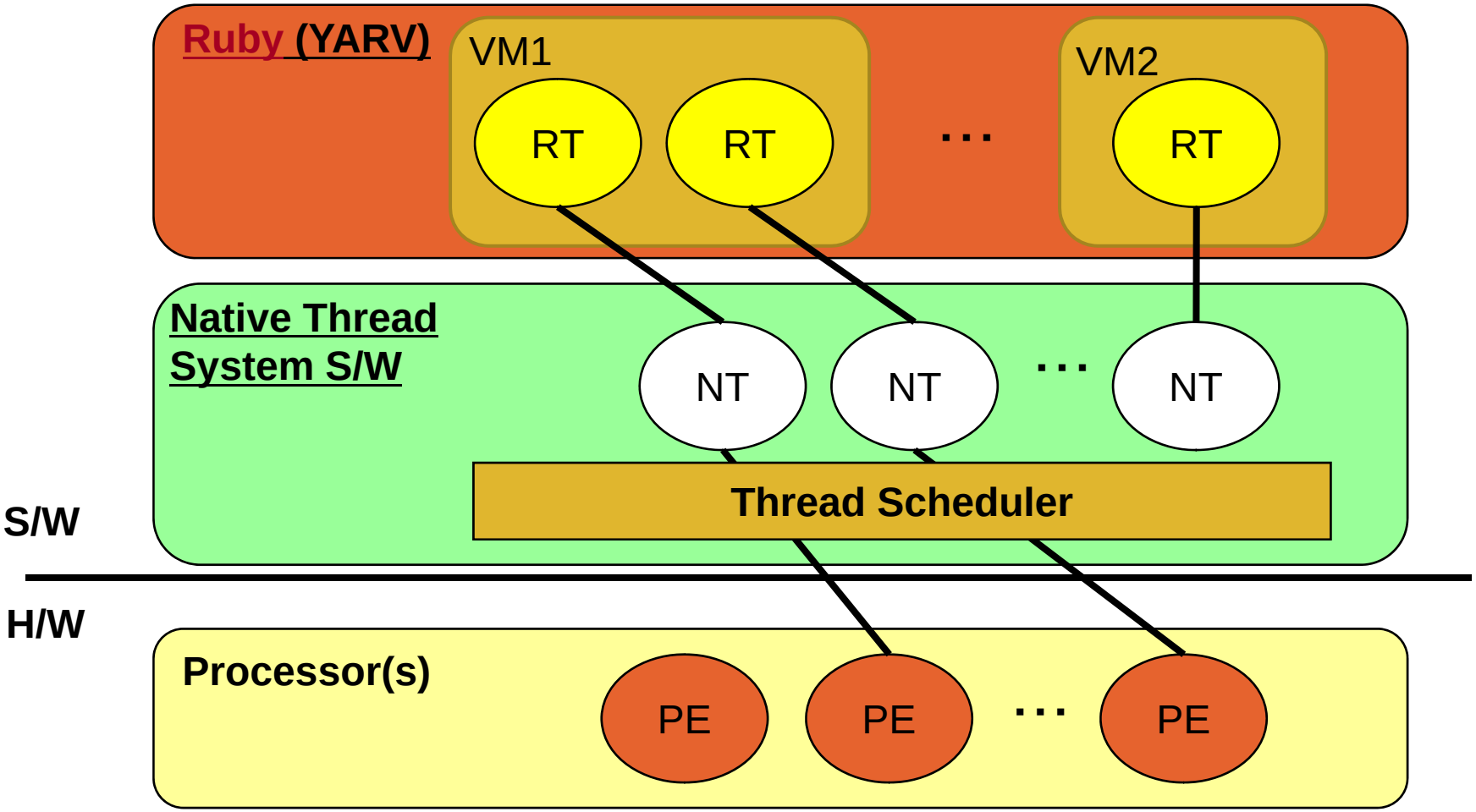
By The Way, Other CRuby GC Related Projects

- Generational GC (Kiyama)
- 1 bit Reference Count GC (Matz)
- Floating as Special Constant (ko1)
- Lazy Sweep (autherNari)
- Bitmap GC (Enterprise Ruby, autherNari)
- Mostly Copying GC (Ugawa)

Multi-VM (MVM) Project

- Multi Virtual Machine in One Process
- Each VMs are able to run in Parallel
  - Each VMs have Giant VM Lock.
- High Speed Inter-VM Communication
  - Inner Process Communication

Multi-VM Overview



PE: Processor Element, UL: User Level, KL: Kernel Level

Multi-VM (MVM) Project

Sponsored by
Sun Microsystems, Inc.

Nobu (a.k.a Patch Monster)
is Working for This Project

MVM

svn co
http://svn.ruby-lang.org/repos/ruby/branches/mvm

Summary

CRuby/YARV is
NOT "BEST" Solutuin
for Performance.

However, CRuby/YARV is
"GOOD" Solution for Us,
the Pragmatic Ruby Programmers,
at least Several Years.

Summary (cont.)

- CRuby is Enable to Evolve Moreover
- Some Projects to Take advantage of CRuby
  - Ricsin: mix-in C to Ruby Project
  - Ruby to C AOT Compiler Project
  - atomic-Ruby Project
  - Multi-VM Project

Fin.

Thank You for Your Attention.

Any Questions?

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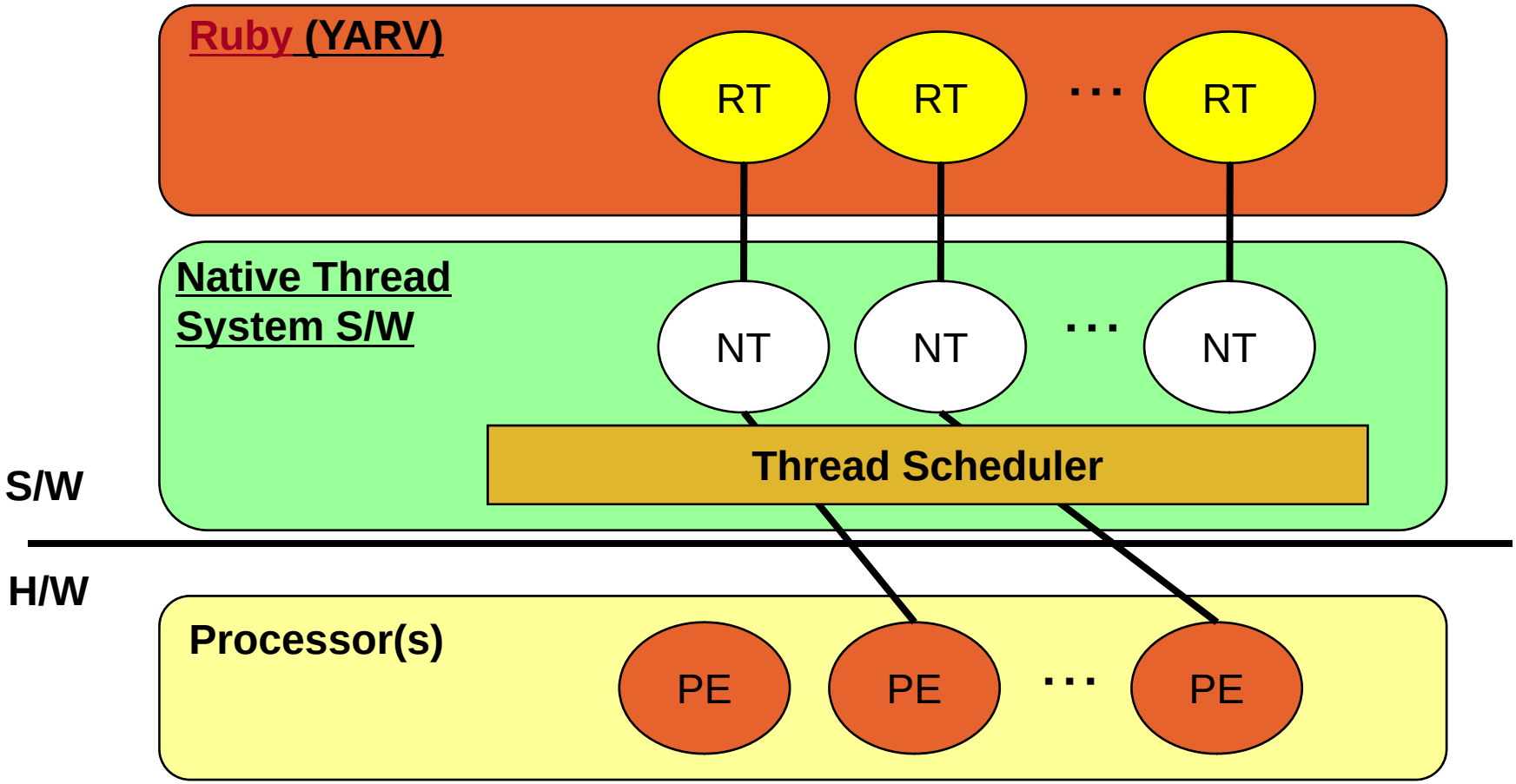
Graduate School of Information Science and Technology The University of Tokyo

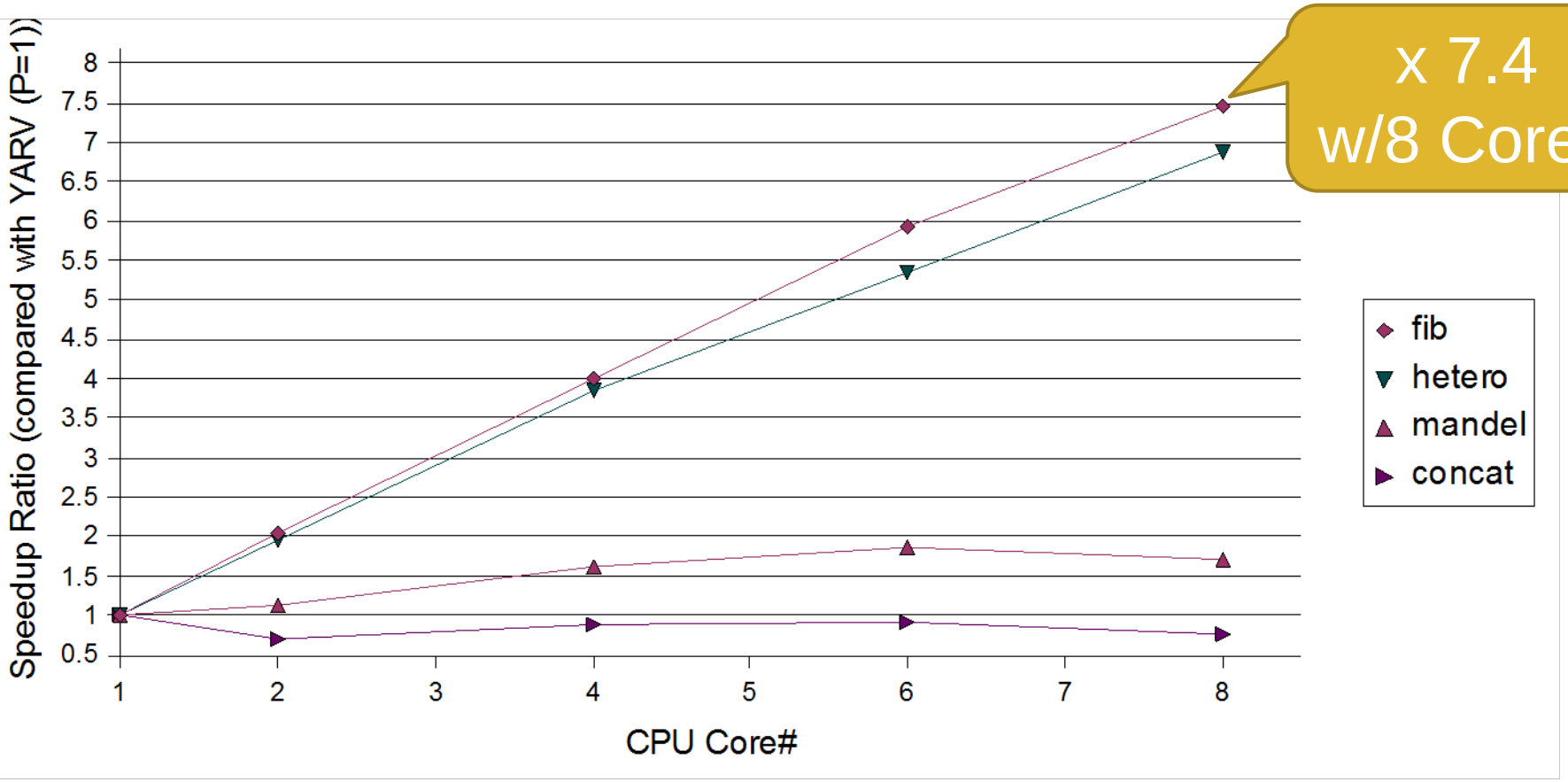
創造情報学専攻 Creative Informatics

Accepted Method:
Ruby Thread and Native Thread (1:1) ← Ruby 1.9/YARV



- PE: Processor Element, UL: User Level, KL: Kernel Level

Evaluation
Result (Micro-benchmark)

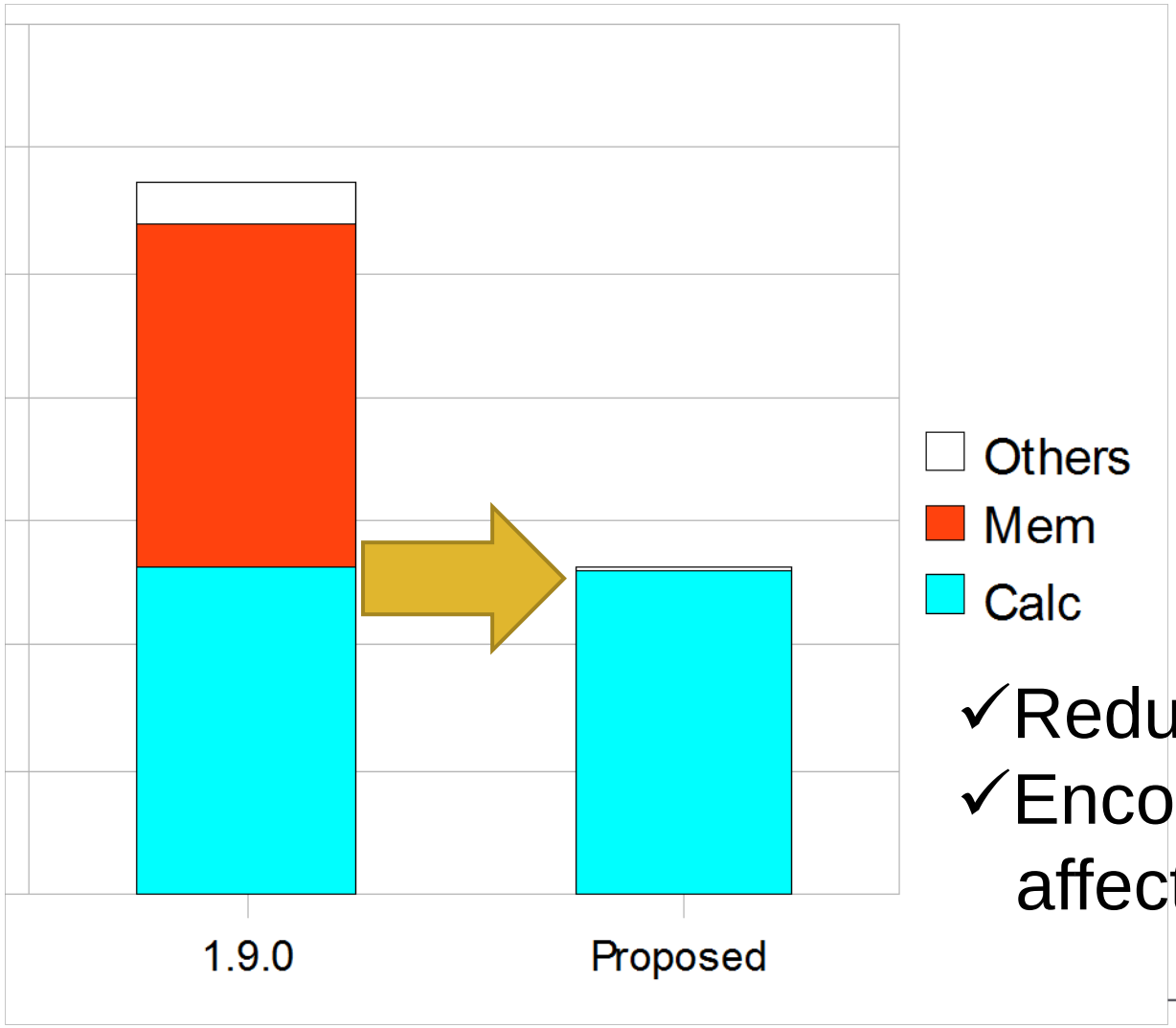


Discussion
How to Embed 64 bit Double?

- VALUE embed Object doesn't need memory overhead
- **64bit CPU have 64 bit pointer type**

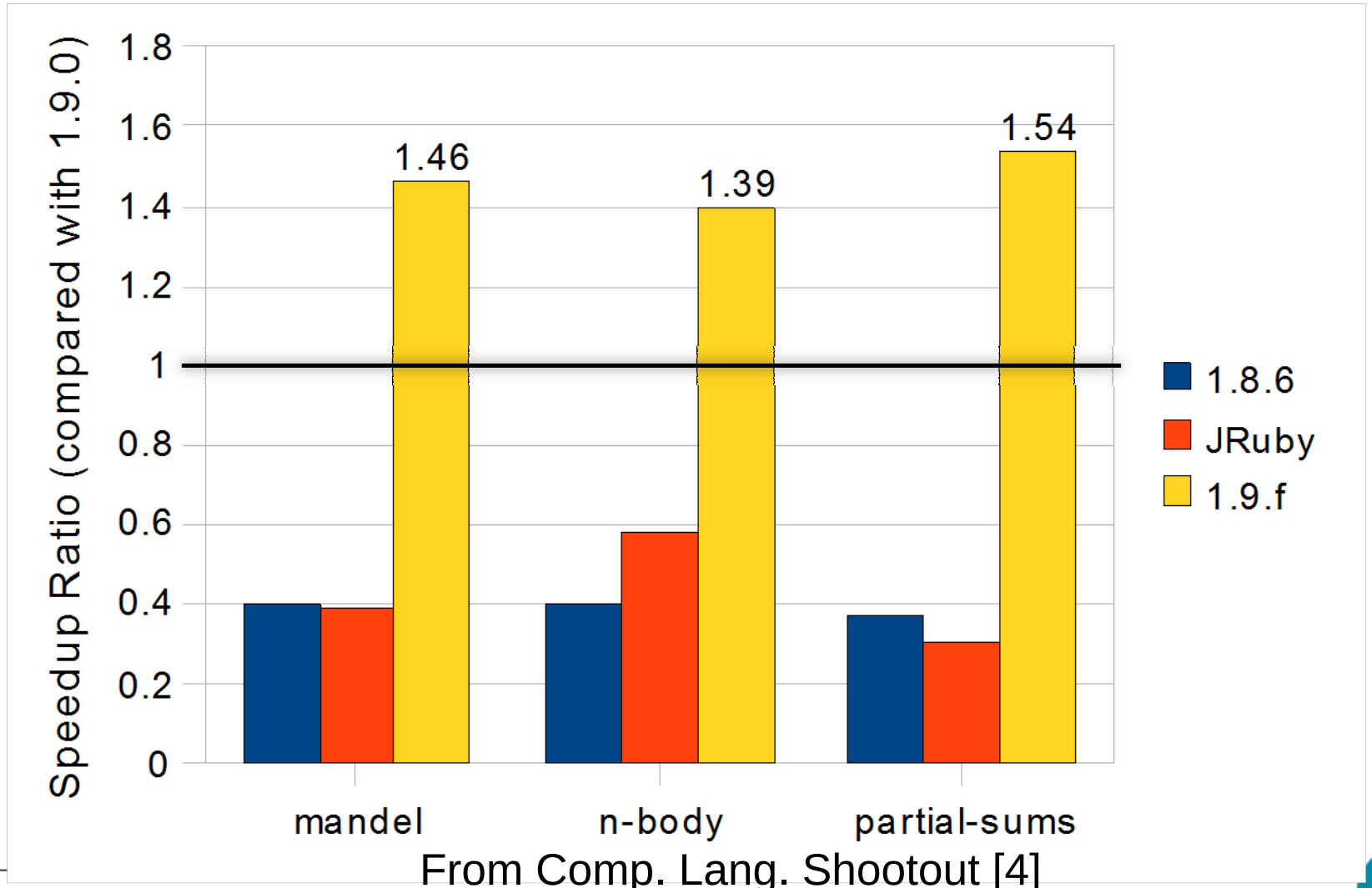
  → **Use 64 bit CPU**
- At least we need 1 bit for TAG bit
  - From Mantissa?
    - Decrease Precision
  - From Exponential?
    - Decrease Representation Range

Evaluation
Toy-Program



- ✓Reduce Mem Time
- ✓Encode/Decode don't affect to Performance

Evaluation
Compared with other Ruby Impl.



From Comp. Lang. Shootout [4]