Benchmarking and Performance Evaluations

Todd Mytkowicz
Microsoft Research

Let’s pole for an upcoming election

I ask 3 of my co-workers who they are voting for.

Let's pole for an upcoming election

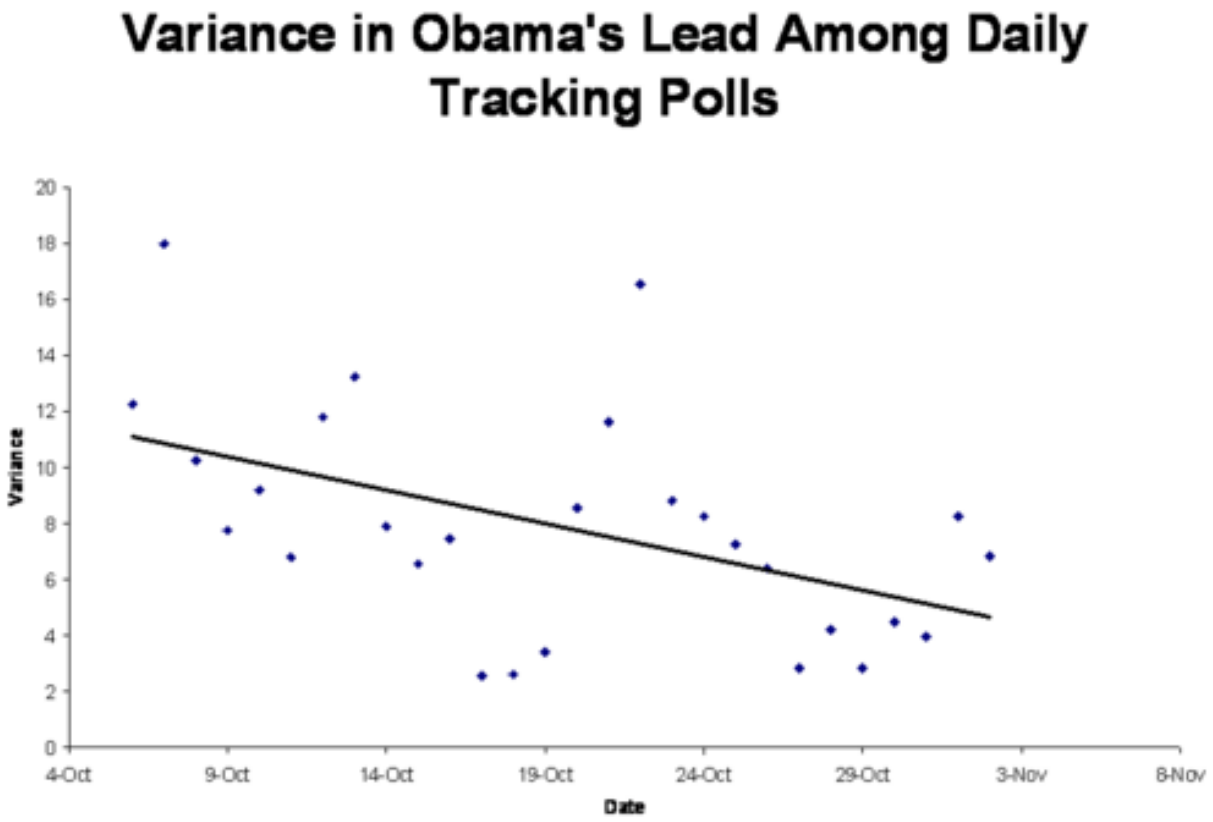
I ask 3 of my co-workers who they are voting for.

- **My approach does not deal with**
  - **Variability**
  - **Bias**

Issues with my approach

Variability

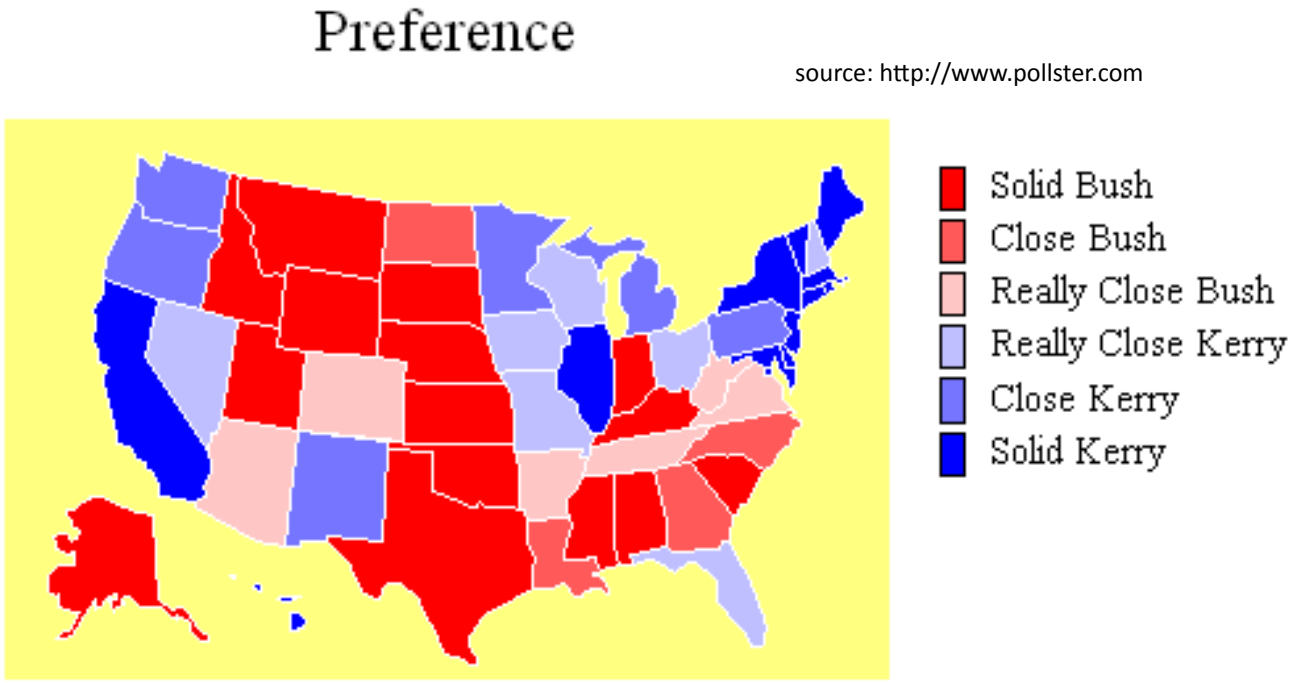
source: http://www.pollster.com



My approach is not reproducible

Issues with my approach(II)

Bias



My approach is not generalizable

Take Home Message

- Variability and Bias are two different things
  - Difference between reproducible and generalizable!

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Do we have to worry about Variability and Bias when we benchmark?

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What do we do
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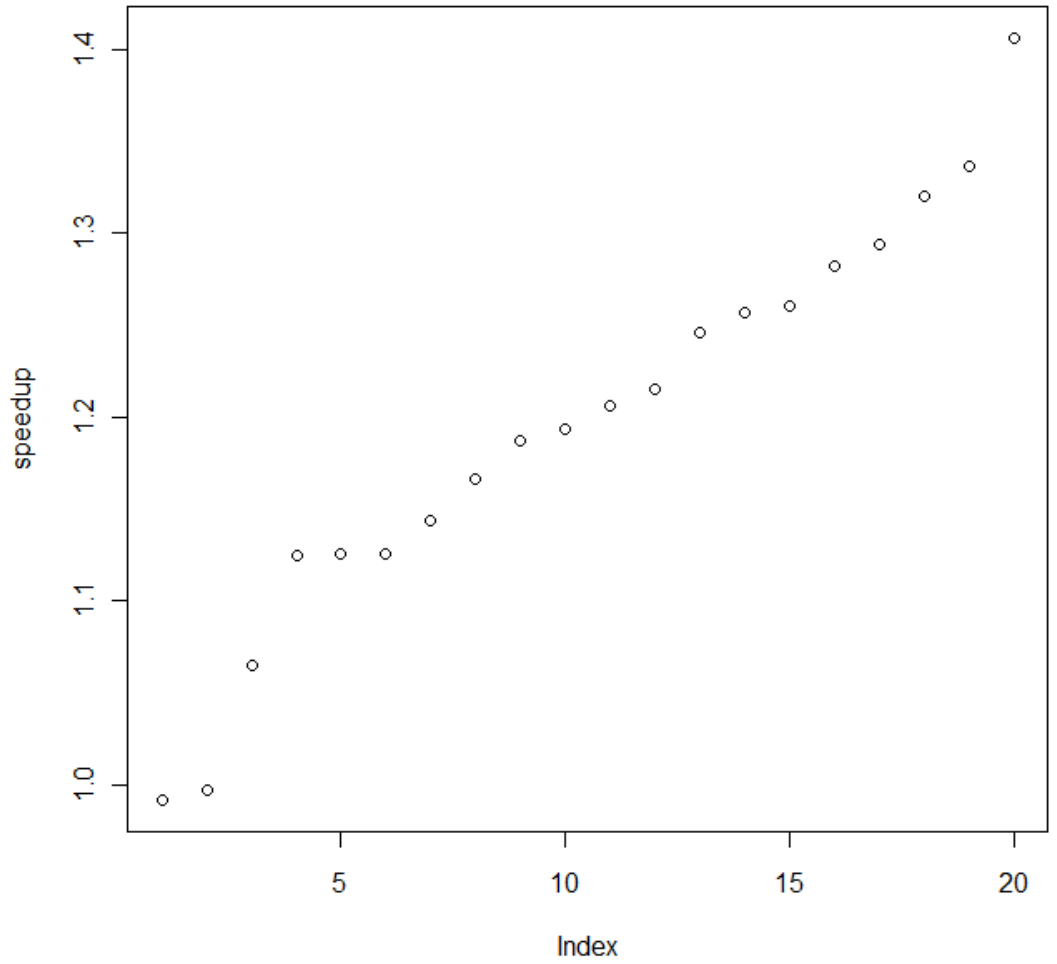

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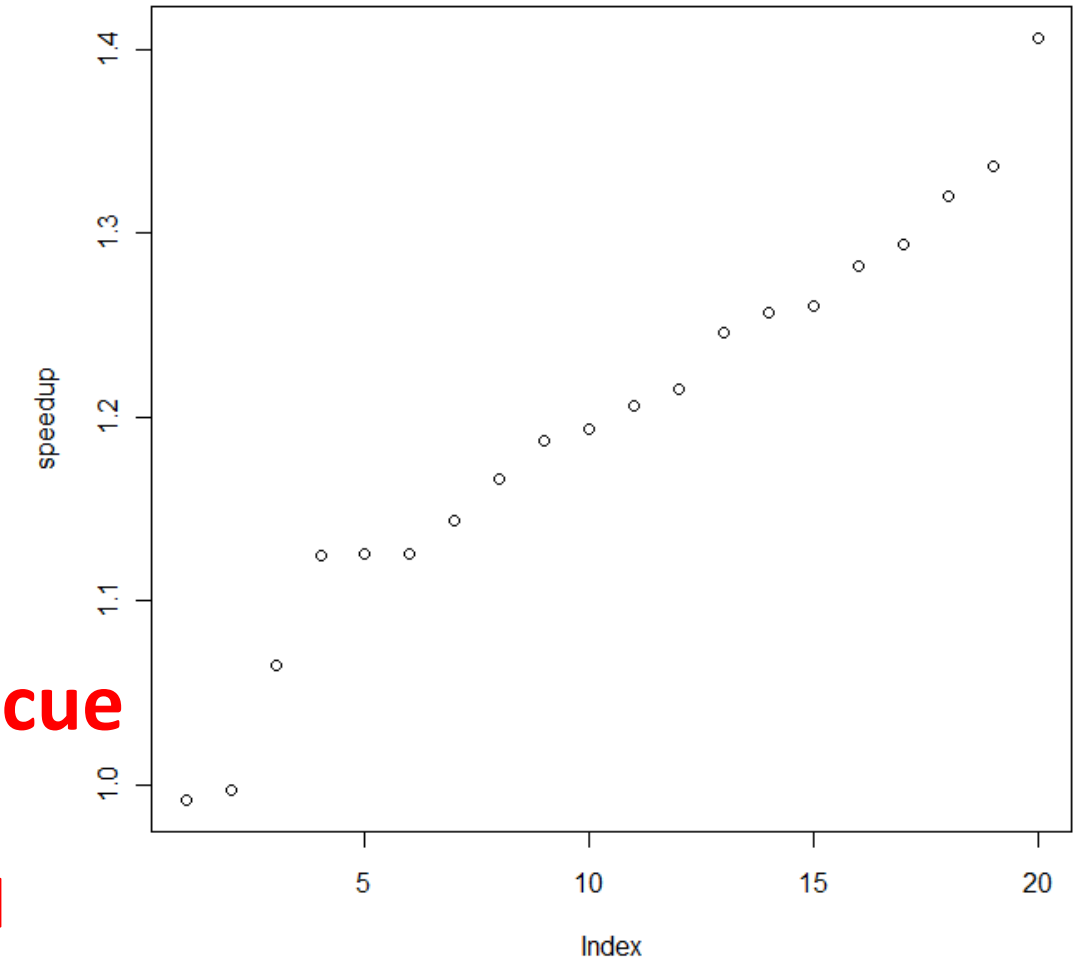
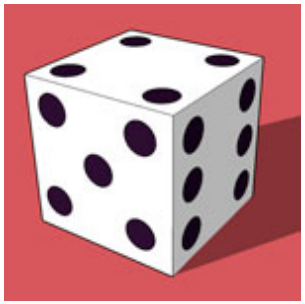


- **Statistics to the rescue**
  - **mean**
  - **confidence interval**

Intuition for T-Test



- 1-6 is uniformly likely (p = 1/6)
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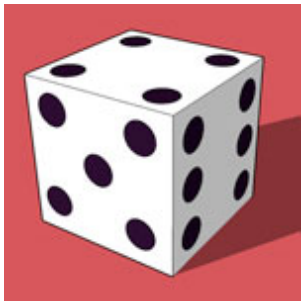

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Trial	Mean of 10 throws
1	4.0
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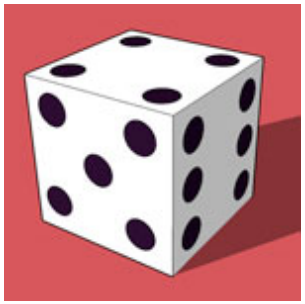

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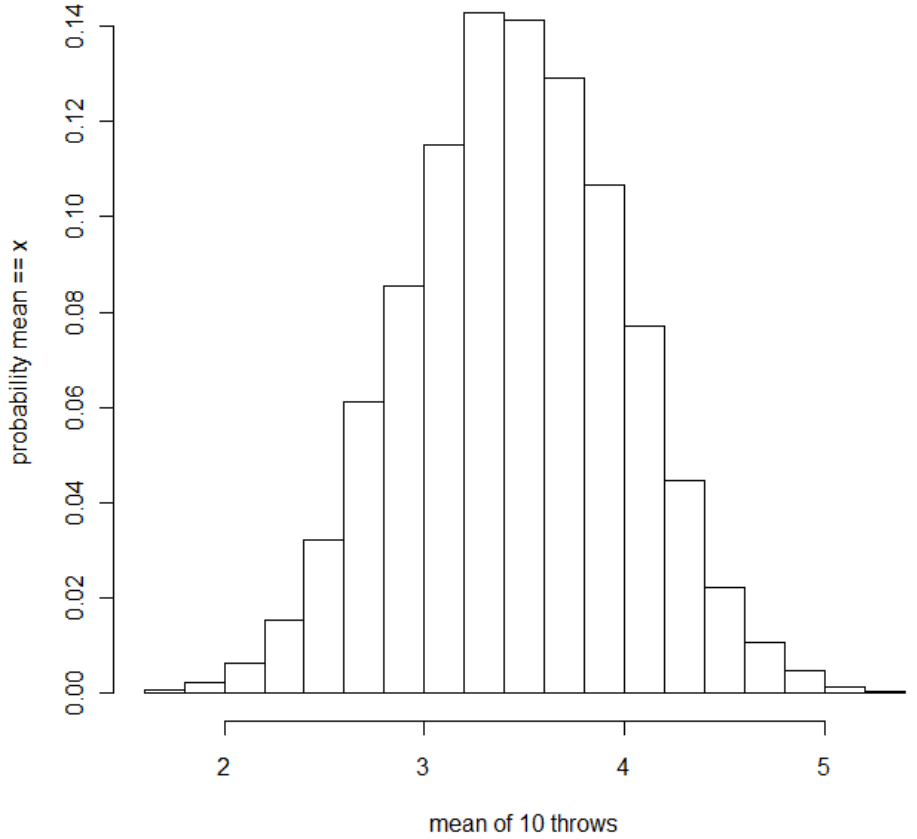
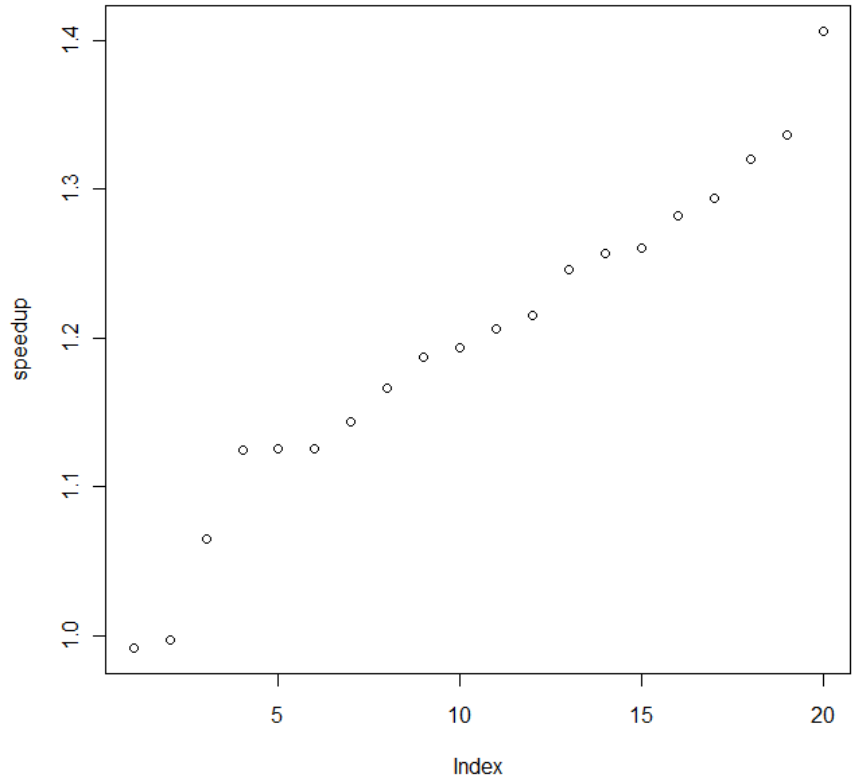


Back to our Benchmark: Managing Variability



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Read 20 items
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        One Sample t-test

data:  x
t = 49.277, df = 19, p-value < 2.2e-16
95 percent confidence interval:
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sample estimates:
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 1.197383
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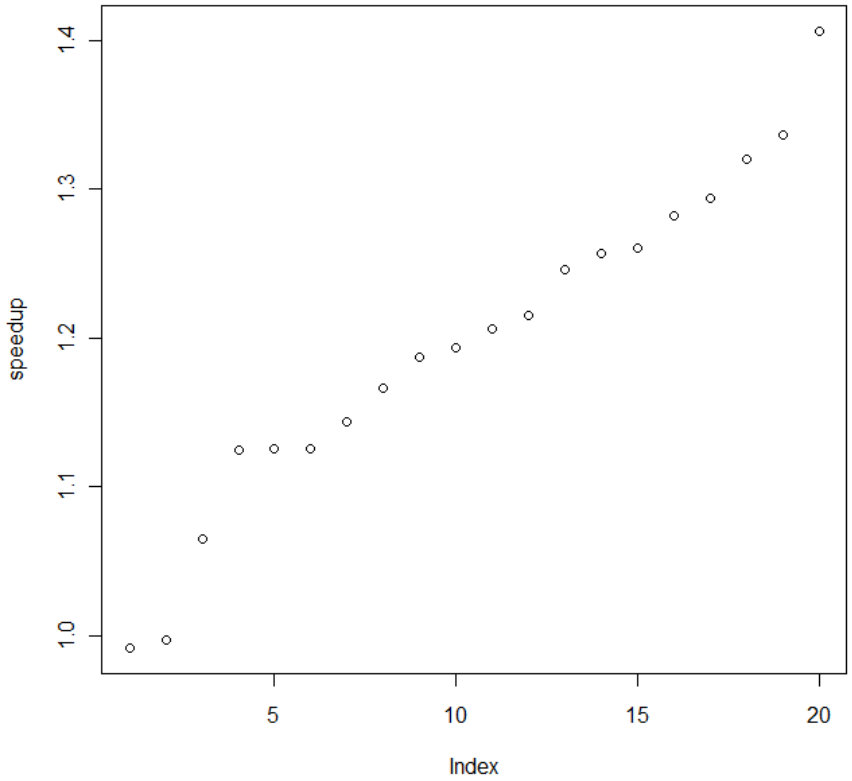

So we can handle Variability. What about Bias?

Evaluating compiler optimizations

System = gcc -O2 perlbench
System + Innovation = gcc -O3 perlbench

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speedup = 0.84 ± 0.0002

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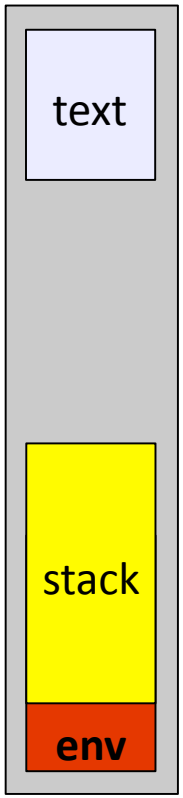
Why does this happen?

Differences in our experimental setup

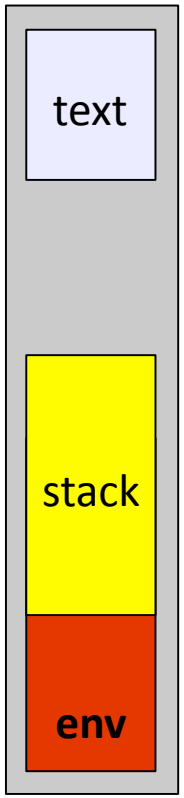
Madan:

HOME=/home/madan

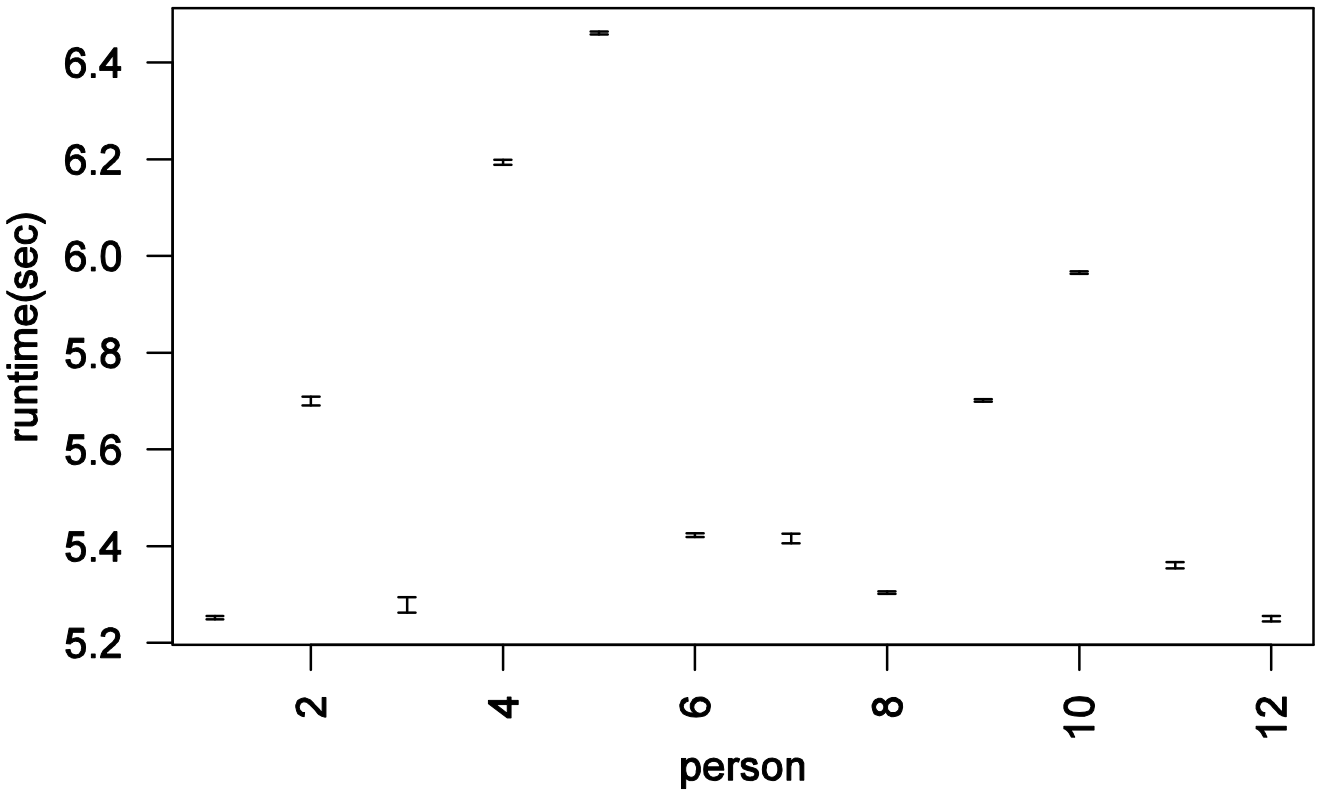


Todd:

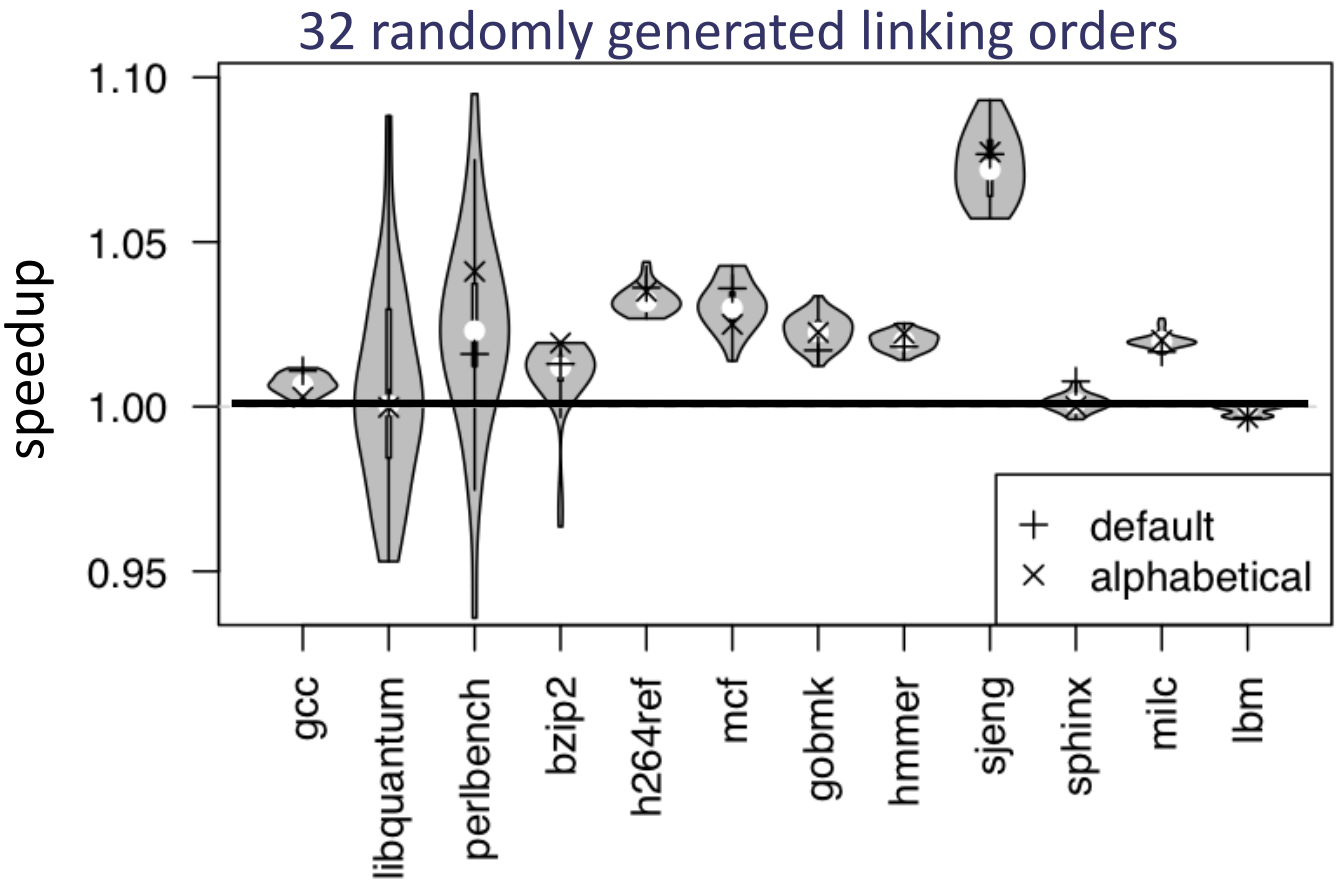
HOME=/home/toddmytkowicz



Runtime of SPEC CPU 2006 perlbench depends on who runs it!



Bias from linking order



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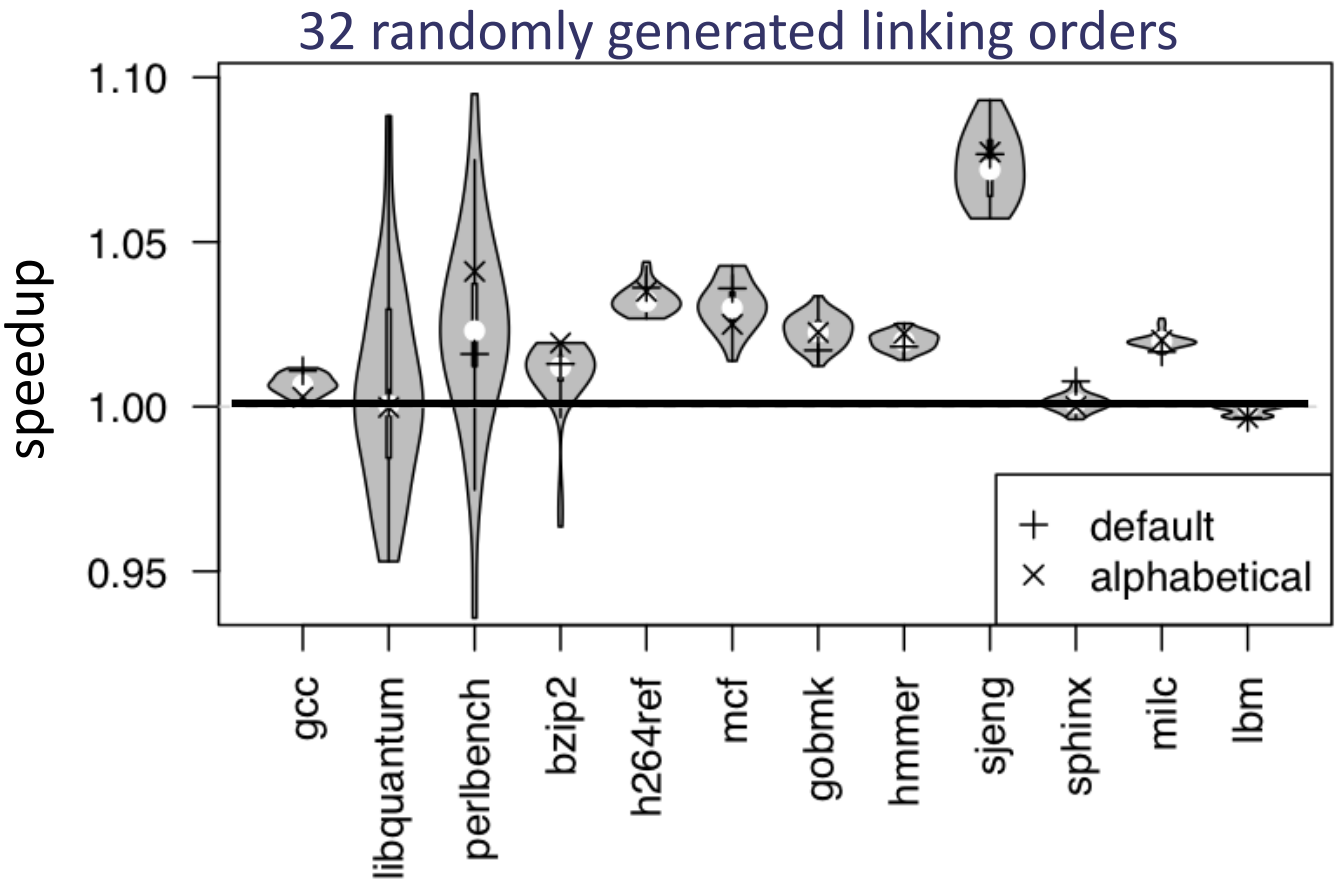
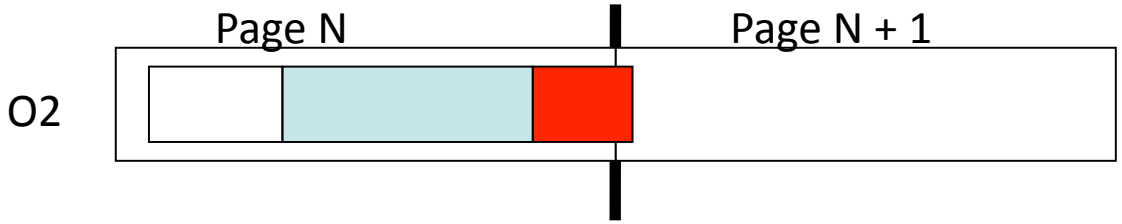


Order of .o files can lead to contradictory conclusions

Where exactly does Bias come from?

Interactions with hardware buffers



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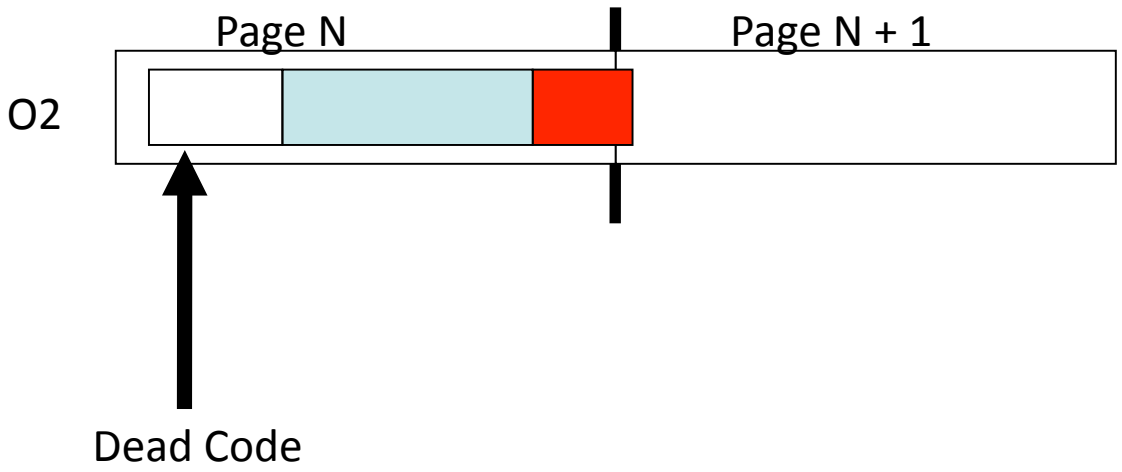

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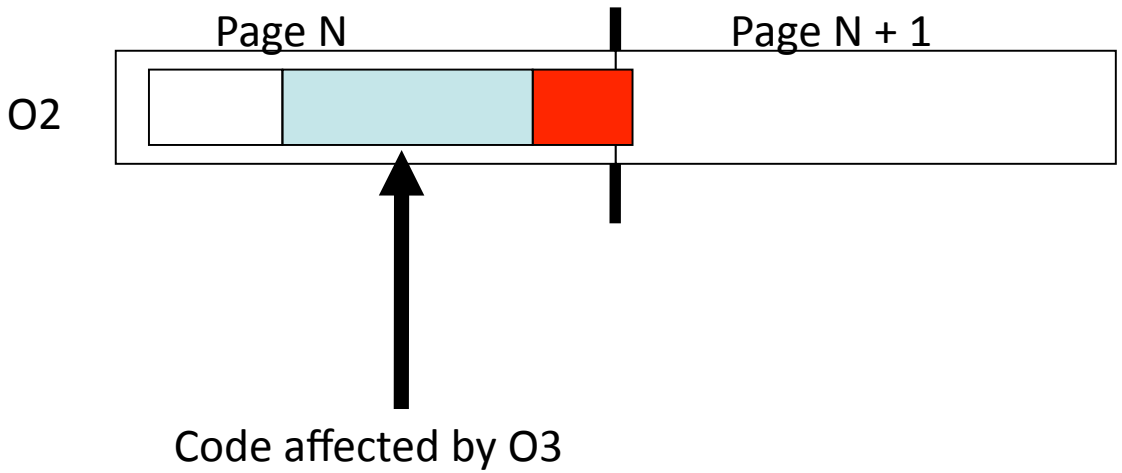

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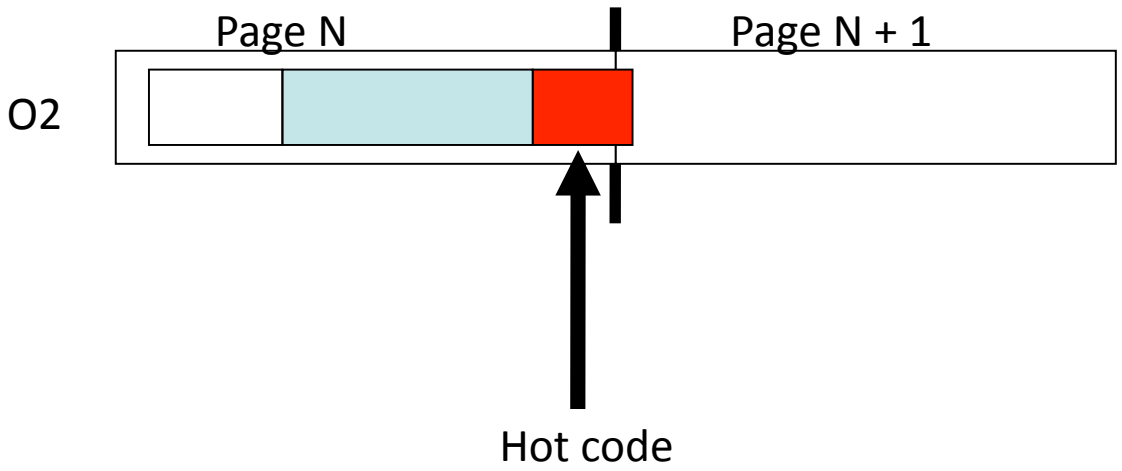

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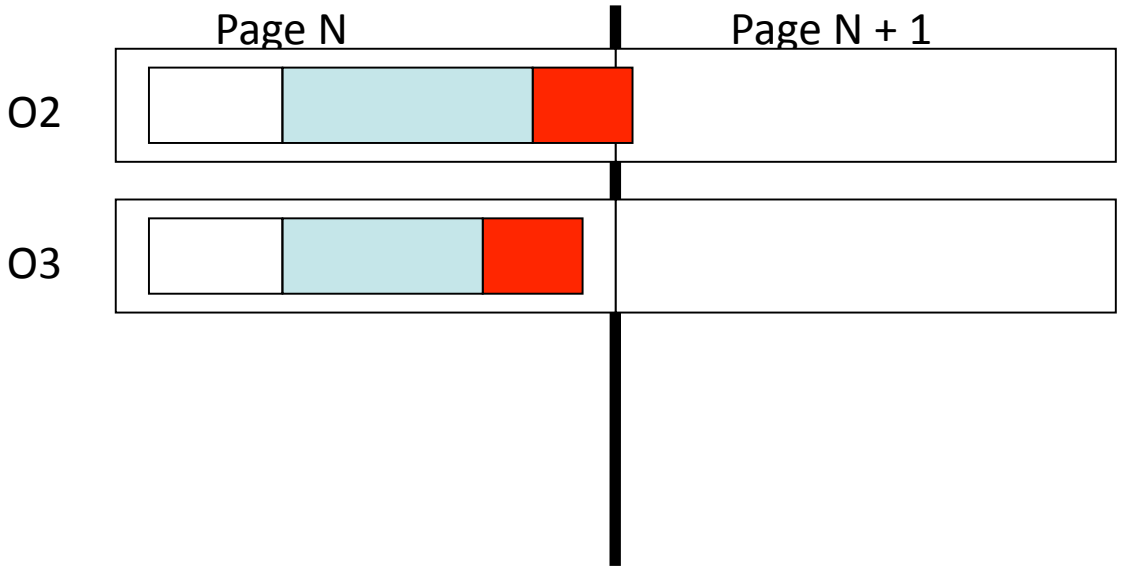
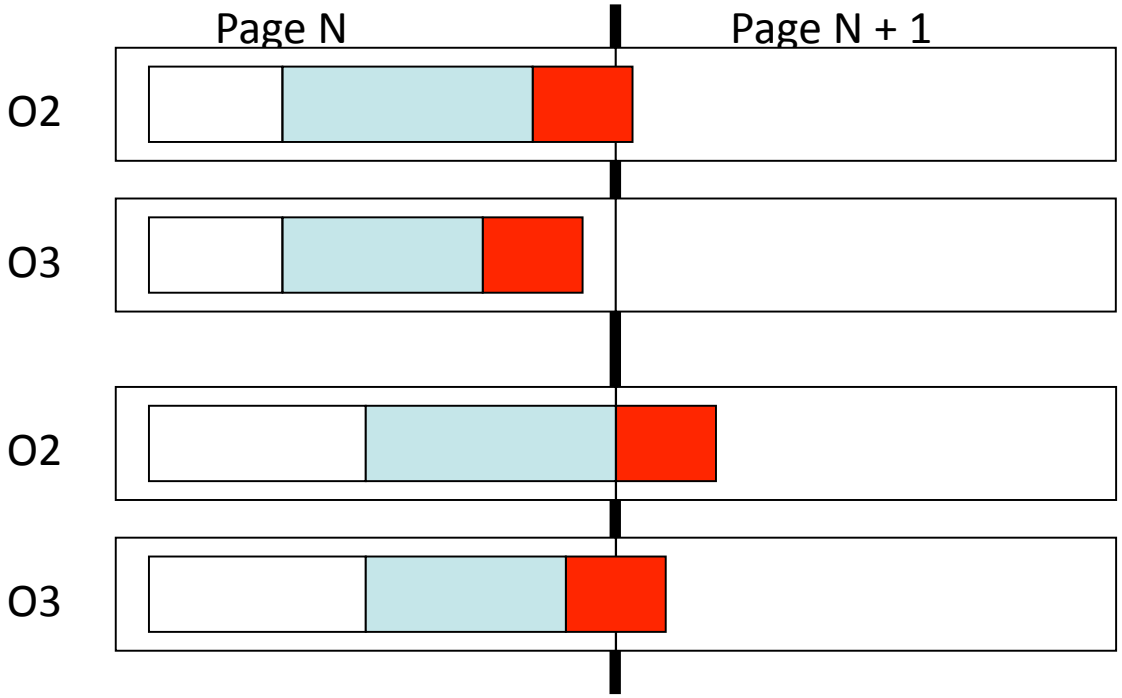


O3 better than O2

Interactions with hardware buffers



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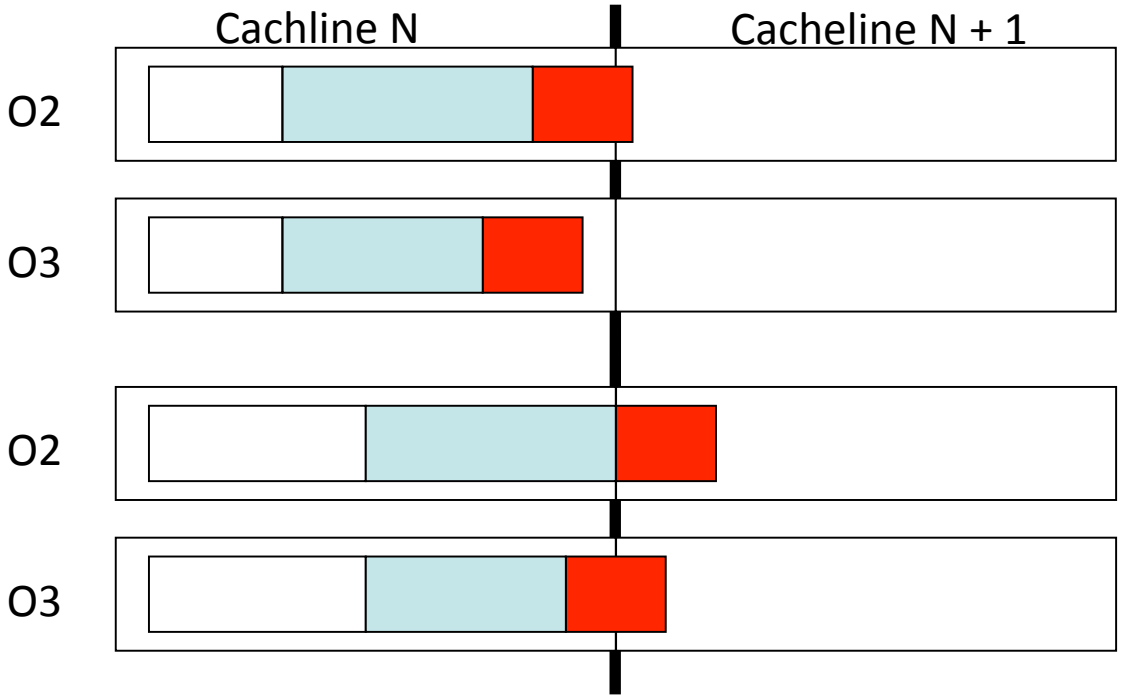

O3 better than O2

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Other Sources of Bias

- JIT
- Garbage Collection
- CPU Affinity
- Domain specific (e.g. size of input data)

- How do we manage these?

Other Sources of Bias

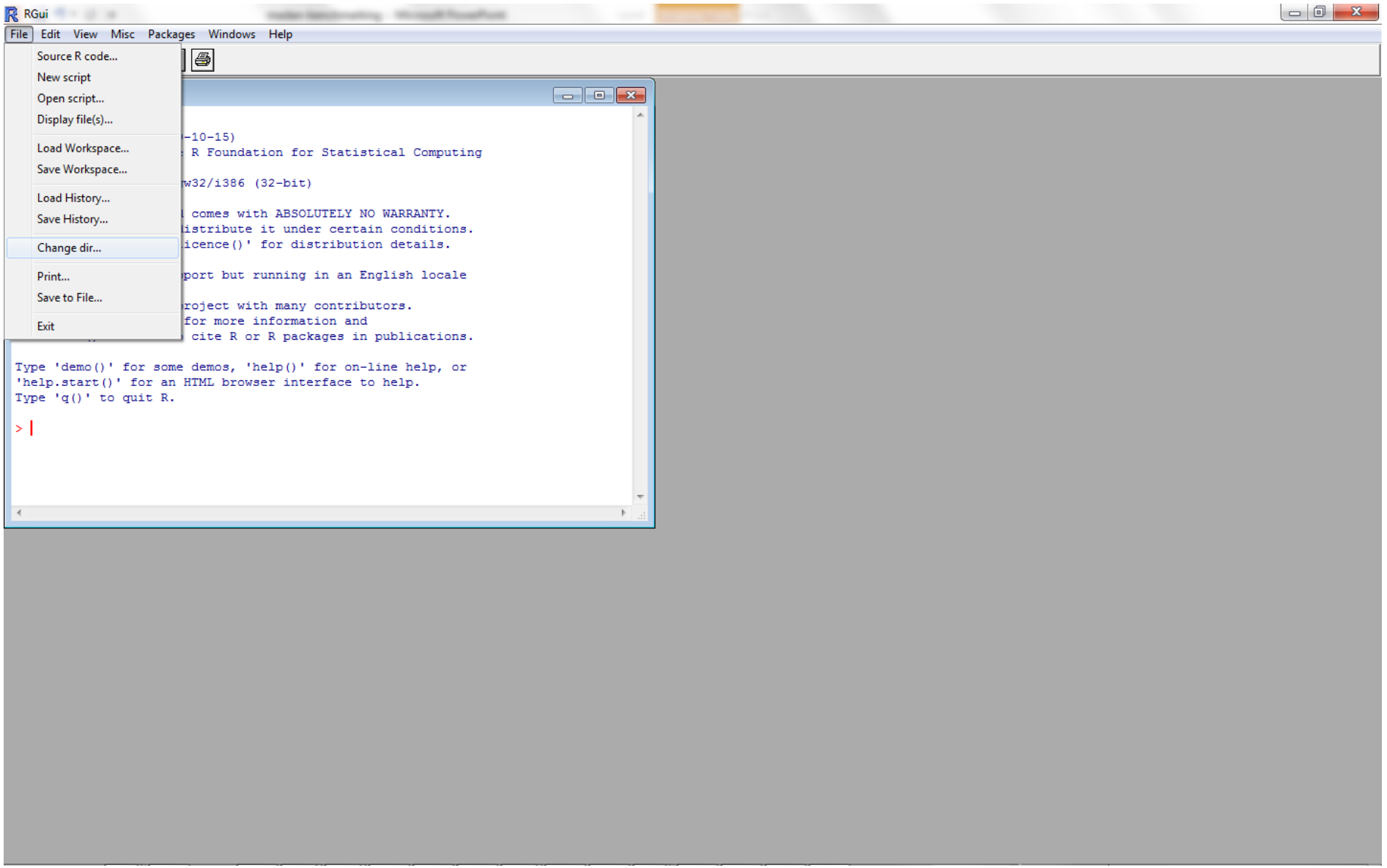
How do we manage these?

- JIT:
  - ngen to remove impact of JIT
  - “warmup” phase to JIT code before measurement
- Garbage Collection
  - Try different heap sizes (JVM)
  - “warmup” phase to build data structures
  - Ensure program is not “leaking” memory
- CPU Affinity
  - Try to bind threads to CPUs (SetProcessAffinityMask)
- Domain Specific:
  - Up to you!

R for the T-Test

- Where to download
  - http://cran.r-project.org

- Simple intro to get data into R
- Simple intro to do t.test


RGui
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View
Misc
Packages
Windows
Help
Source R code...
New script
Open script...
Display file(s)...
Load Workspace...
Save Workspace...
Load History...
Save History...
Change dir...
Print...
Save to File...
Exit
-10-15)
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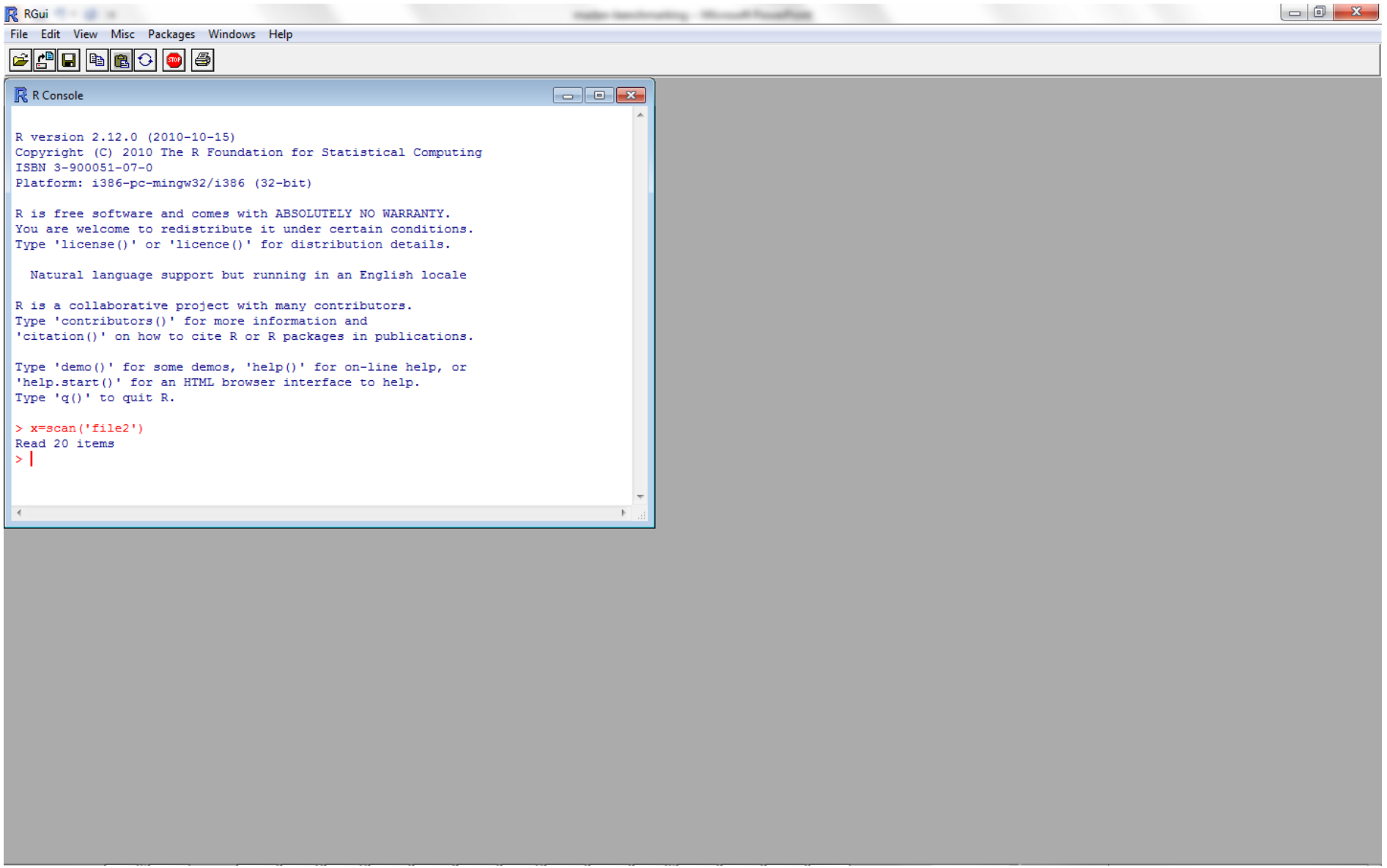
RGui
File Edit View Misc Packages Windows Help
R Console
R version 2.12.0 (2010-10-15)
Copyright (C) 2010 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: i386-pc-mingw32/i386 (32-bit)
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.
Natural language support but running in an English locale
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Read 20 items
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RGui

File History Resize Windows

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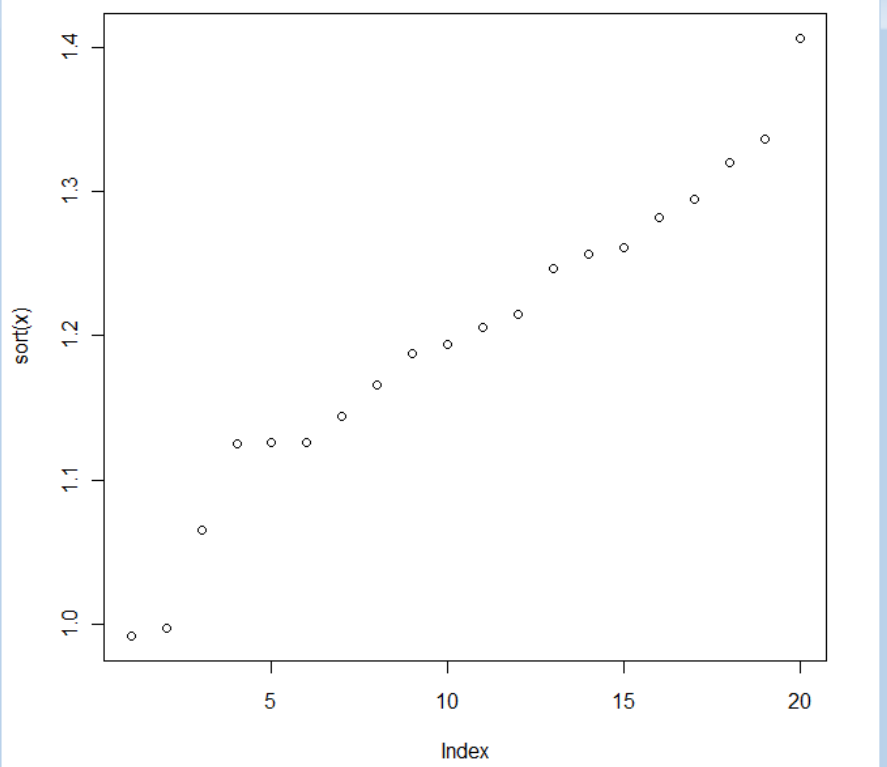
R Graphics: Device 2 (ACTIVE)



RGui

File Edit View Misc Packages Windows Help

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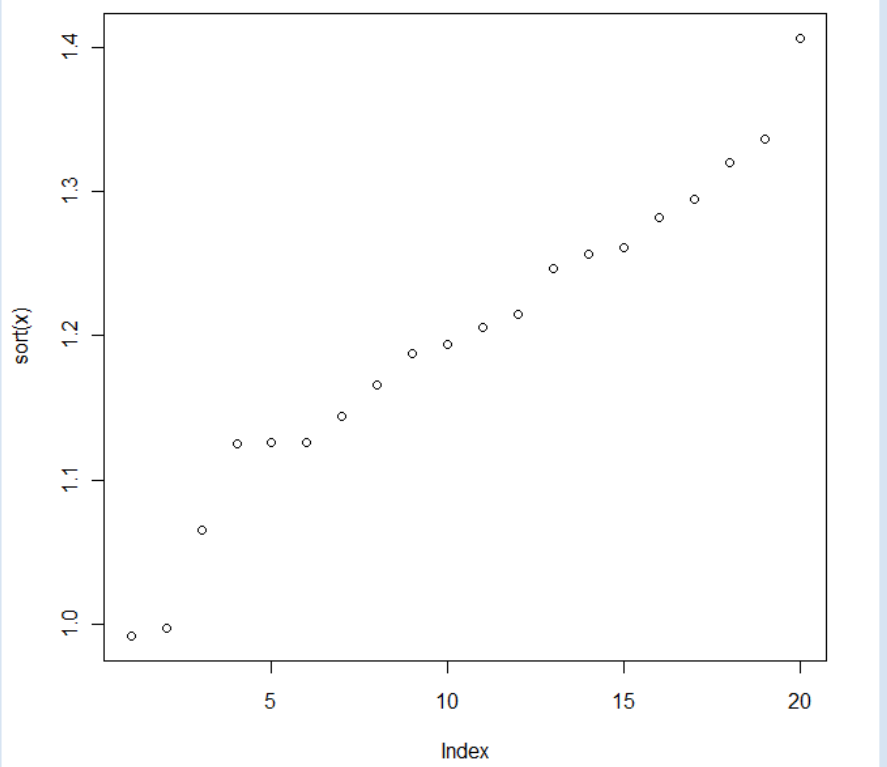

Some Conclusions

- Performance Evaluations are hard!
  - Variability and Bias are not easy to deal with

- Other experimental sciences go to great effort to work around variability and bias
  - We should too!