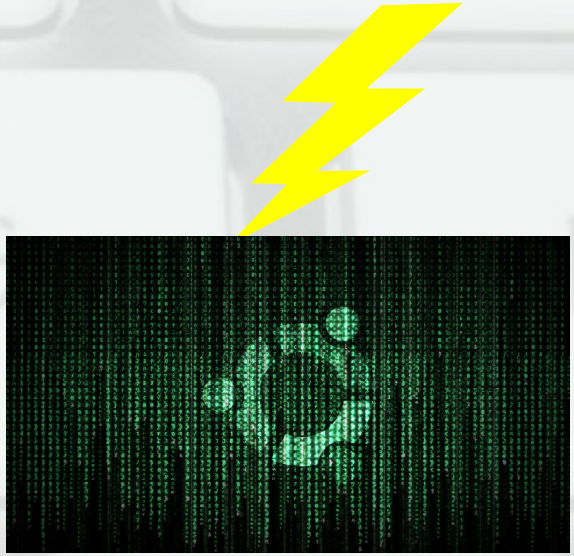
Estimating the Impacts of Scheduling Algorithms on Energy Consumption



Cesar Augusto Marcelino dos Santos
Mentor: Jim Deverick

Topics

- Motivation
- Previous work
- Simulator
- Measurements
- Future work
- Conclusion

Motivation

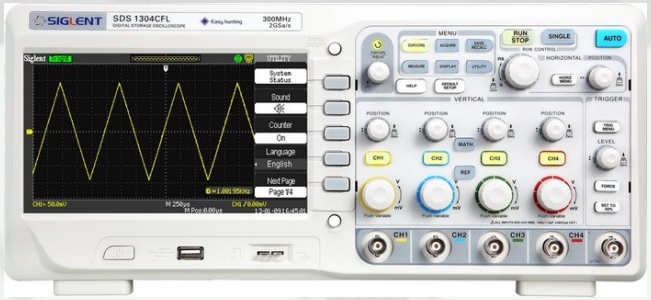
- Real Time Systems are becoming more requested by the market

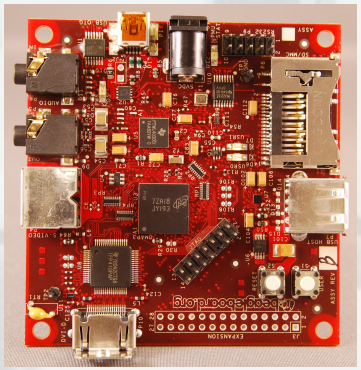
Motivation

- Power becomes a concern
- Process scheduler policy can impact on energy consumption

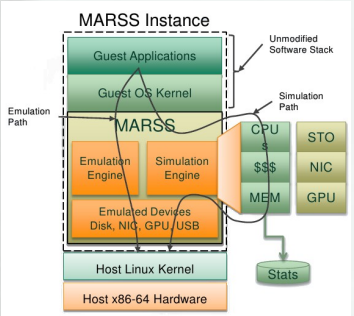
Previous work

- Measuring power is a complicated task
  - Hardware support
  - Development boards
  - Proprietary simulators





Simulator

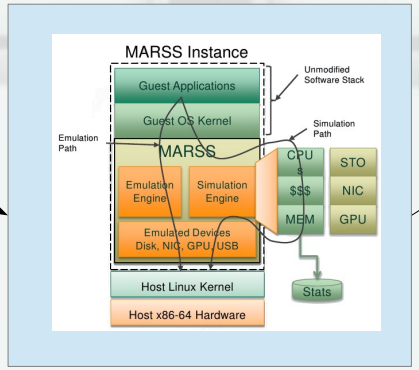


- MARSSx86
  - Micro-Architectural and System Simulator
  - Based on QEMU and PTLSim
  - Provides cycle accurate full system simulation
  - Limited to x86 architecture
  - Requests an x86-compatible OS

Simulator

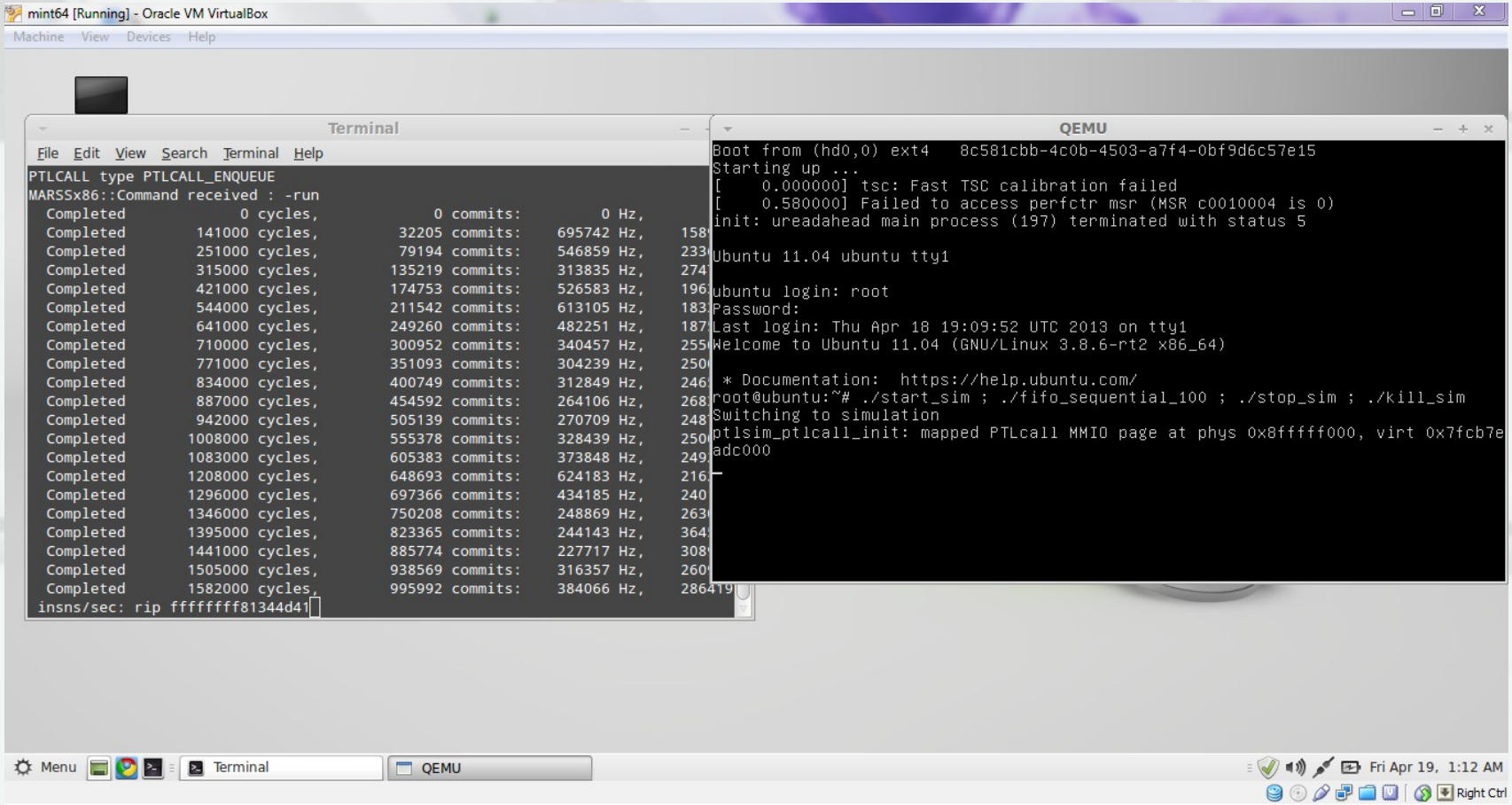
- McPAT
  - Provides power, area and timing analysis
  - Offers architecture description profiles for Alpha, ARM, Penryn, etc.
  - Requests a resource access profile input

Simulator

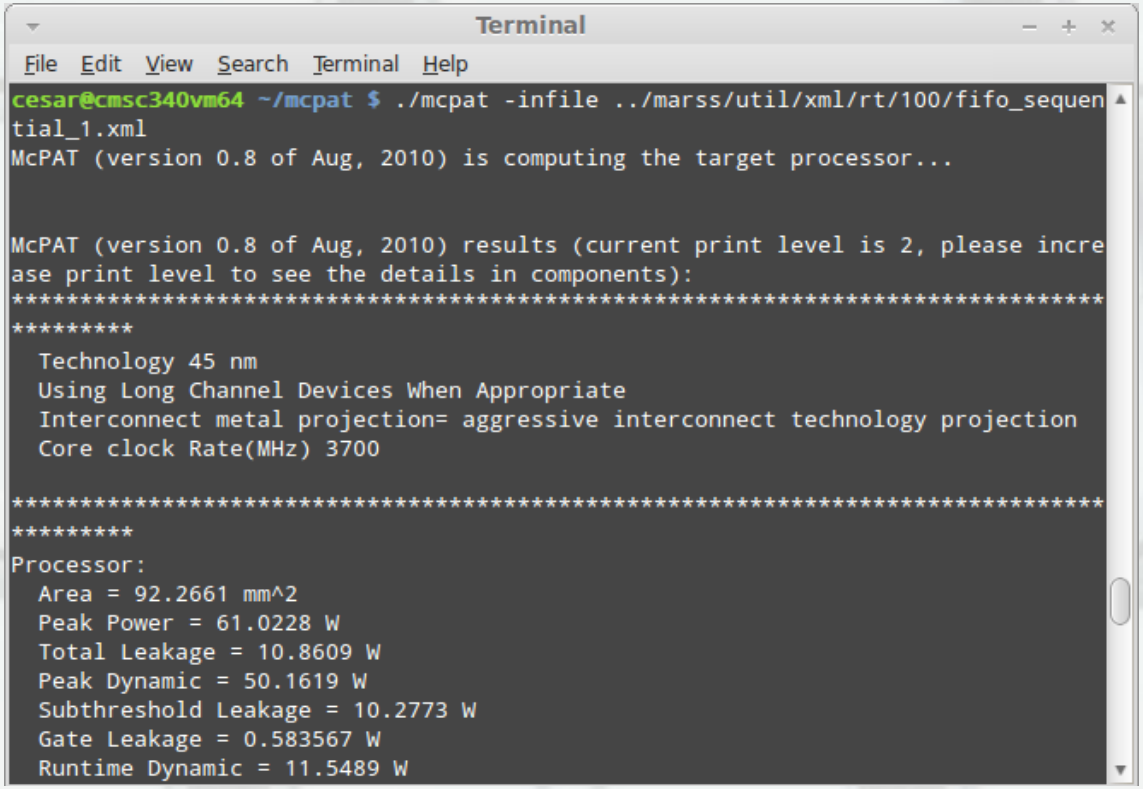

MARSS Instance
Guest Applications
Guest OS Kernel
MARSS
Emulation Engine
Simulation Engine
Emulated Devices
Disk, NIC, GPU, USB
Host Linux Kernel
Host x86-64 Hardware
Unmodified Software Stack
Simulation Path
Emulation Path
CPU
$
$$$
MEM
STO
NIC
GPU
Stats


LABS hp

Simulator


mint64 [Running] - Oracle VM VirtualBox
Machine View Devices Help
Terminal
File Edit View Search Terminal Help
PTLCALL type PTLCALL_ENQUEUE
MARSSx86::Command received : -run
Completed 0 cycles, 0 commits: 0 Hz,
Completed 141000 cycles, 32205 commits: 695742 Hz,
Completed 251000 cycles, 79194 commits: 546859 Hz,
Completed 315000 cycles, 135219 commits: 313835 Hz,
Completed 421000 cycles, 174753 commits: 526583 Hz,
Completed 544000 cycles, 211542 commits: 613105 Hz,
Completed 641000 cycles, 249260 commits: 482251 Hz,
Completed 710000 cycles, 300952 commits: 340457 Hz,
Completed 771000 cycles, 351093 commits: 304239 Hz,
Completed 834000 cycles, 400749 commits: 312849 Hz,
Completed 887000 cycles, 454592 commits: 264106 Hz,
Completed 942000 cycles, 505139 commits: 270709 Hz,
Completed 1008000 cycles, 555378 commits: 328439 Hz,
Completed 1083000 cycles, 605383 commits: 373848 Hz,
Completed 1208000 cycles, 648693 commits: 624183 Hz,
Completed 1296000 cycles, 697366 commits: 434185 Hz,
Completed 1346000 cycles, 750208 commits: 248869 Hz,
Completed 1395000 cycles, 823365 commits: 244143 Hz,
Completed 1441000 cycles, 885774 commits: 227717 Hz,
Completed 1505000 cycles, 938569 commits: 316357 Hz,
Completed 1582000 cycles, 995992 commits: 384066 Hz,
insns/sec: rip ffffffff81344d41
QEMU
Boot from (hd0,0) ext4 8c581cbb-4c0b-4503-a7f4-0bf9d6c57e15
Starting up ...
[0.000000] tsc: Fast TSC calibration failed
[0.580000] Failed to access perfctr msr (MSR c0010004 is 0)
init: ureadahead main process (197) terminated with status 5
Ubuntu 11.04 ubuntu tty1
ubuntu login: root
Password:
Last login: Thu Apr 18 19:09:52 UTC 2013 on tty1
Welcome to Ubuntu 11.04 (GNU/Linux 3.8.6-rt2 x86_64)
* Documentation: https://help.ubuntu.com/
root@ubuntu:~# ./start_sim ; ./fifo_sequential_100 ; ./stop_sim ; ./kill_sim
Switching to simulation
ptlsim_ptlcall_init: mapped PTLcall MMIO page at phys 0x8fffff000, virt 0x7fcb7e
adc000
Menu
Terminal
QEMU
Fri Apr 19, 1:12 AM
Right Ctrl

Simulator

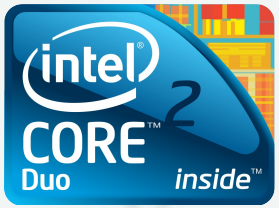

Terminal
File Edit View Search Terminal Help
cesar@cmsc340vm64 ~/mcpat $ ./mcpat -infile ../marss/util/xml/rt/100/fifo_sequential_1.xml
McPAT (version 0.8 of Aug, 2010) is computing the target processor...
McPAT (version 0.8 of Aug, 2010) results (current print level is 2, please increase print level to see the details in components):
Technology 45 nm
Using Long Channel Devices When Appropriate
Interconnect metal projection= aggressive interconnect technology projection
Core clock Rate(MHz) 3700
Processor:
Area = 92.2661 mm^2
Peak Power = 61.0228 W
Total Leakage = 10.8609 W
Peak Dynamic = 50.1619 W
Subthreshold Leakage = 10.2773 W
Gate Leakage = 0.583567 W
Runtime Dynamic = 11.5489 W

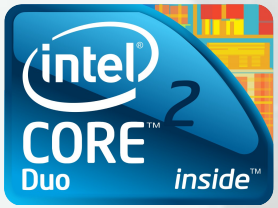
Measurements

- Image used was an Ubuntu 11.04, recompiled with kernel 3.8.6
  - Two versions:
    - a pristine one
    - RT-patch applied to provide hard-real time scheduling

Measurements

- For McPAT, the hardware chosen was Penryn
  - Intel Core 2 series, started in 2006
  - The x86 option offered by McPAT





Measurements

- Linux offers different schedulers
  - OTHER: has the minimum priority, but is dynamically changed (non-real time)
  - FIFO: also called FCFS
  - RR: Round-Robin, so a time quantum is defined by the system. If not finished until that time, is rescheduled for later

Measurements

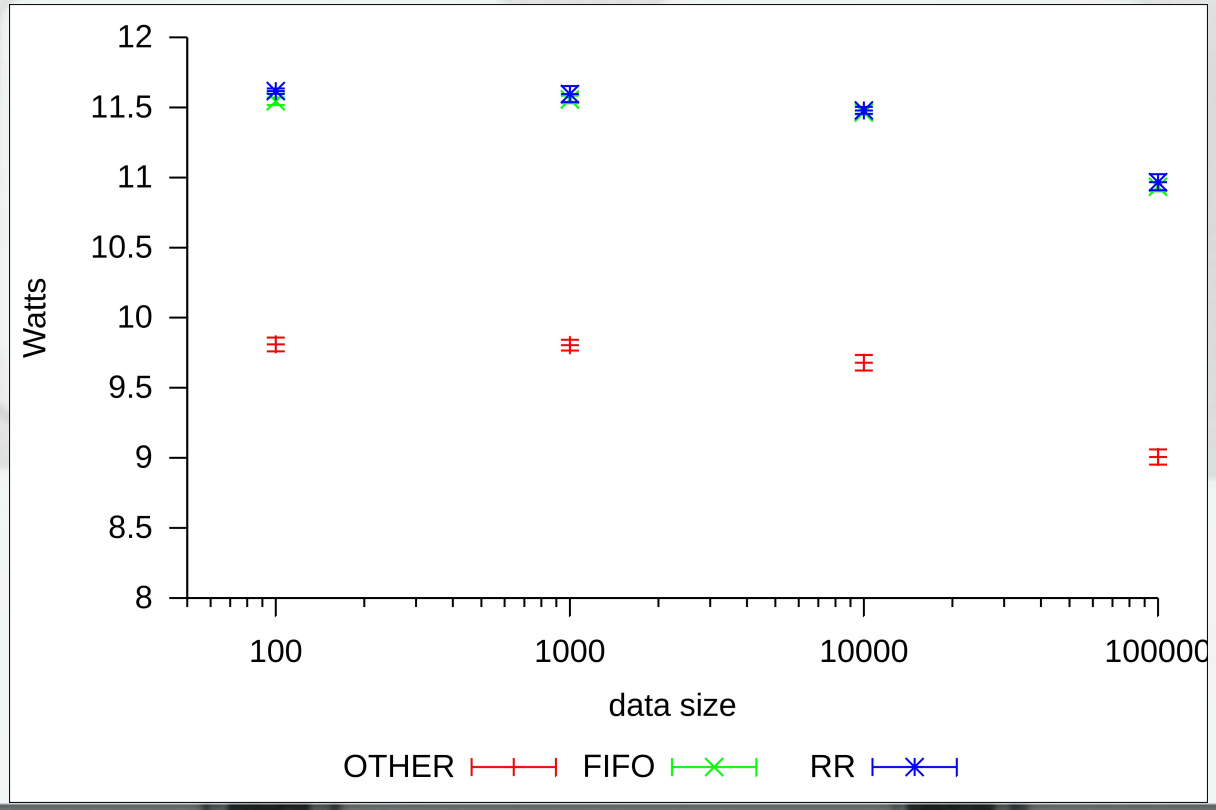
- As long as hard-real time execution is not supported on a pristine kernel, all the processes will be treated as OTHER
- On the RT version, tests will be scheduled using FIFO and RR

Measurements

- Software programs were done with 5 processes, testing different combinations of:
  - Scheduling policy
  - $\sum_{i=0}^{n} x$
  - Spawning processes in sequence, parallel with same priority or parallel with different priorities

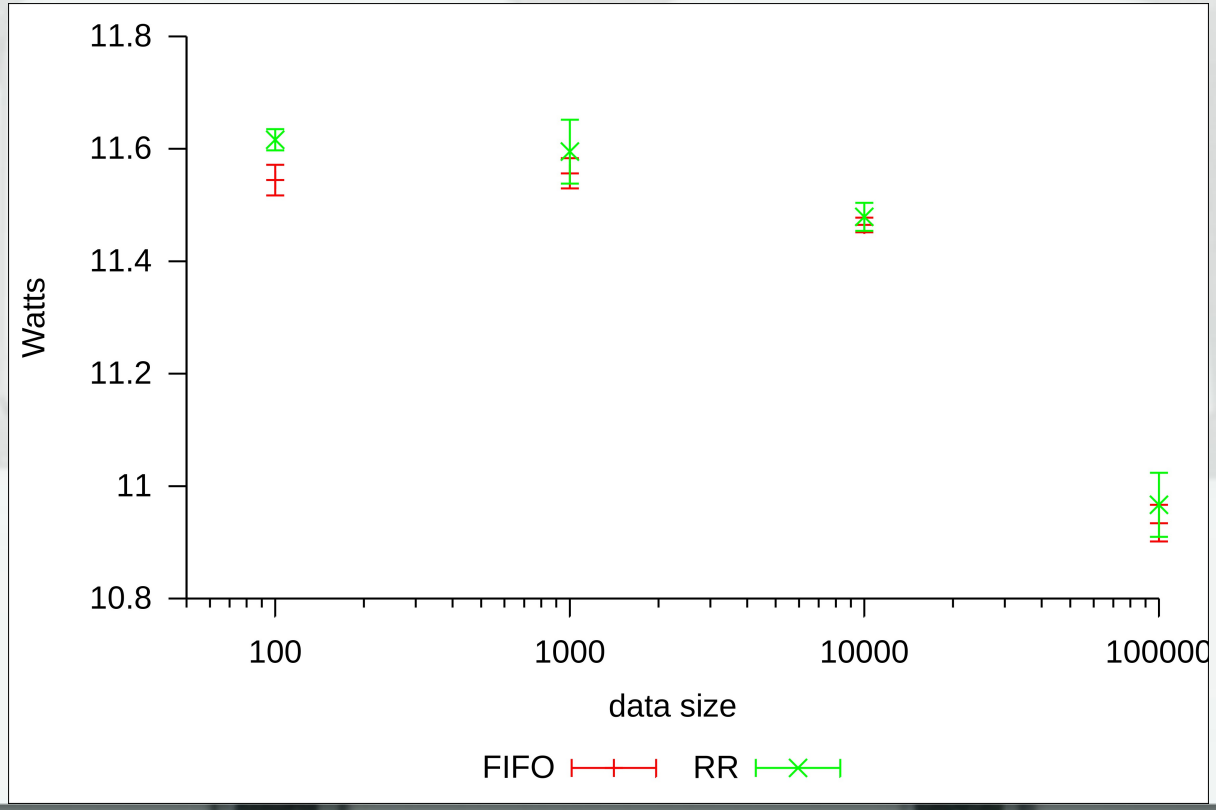
Measurements

- Sequential



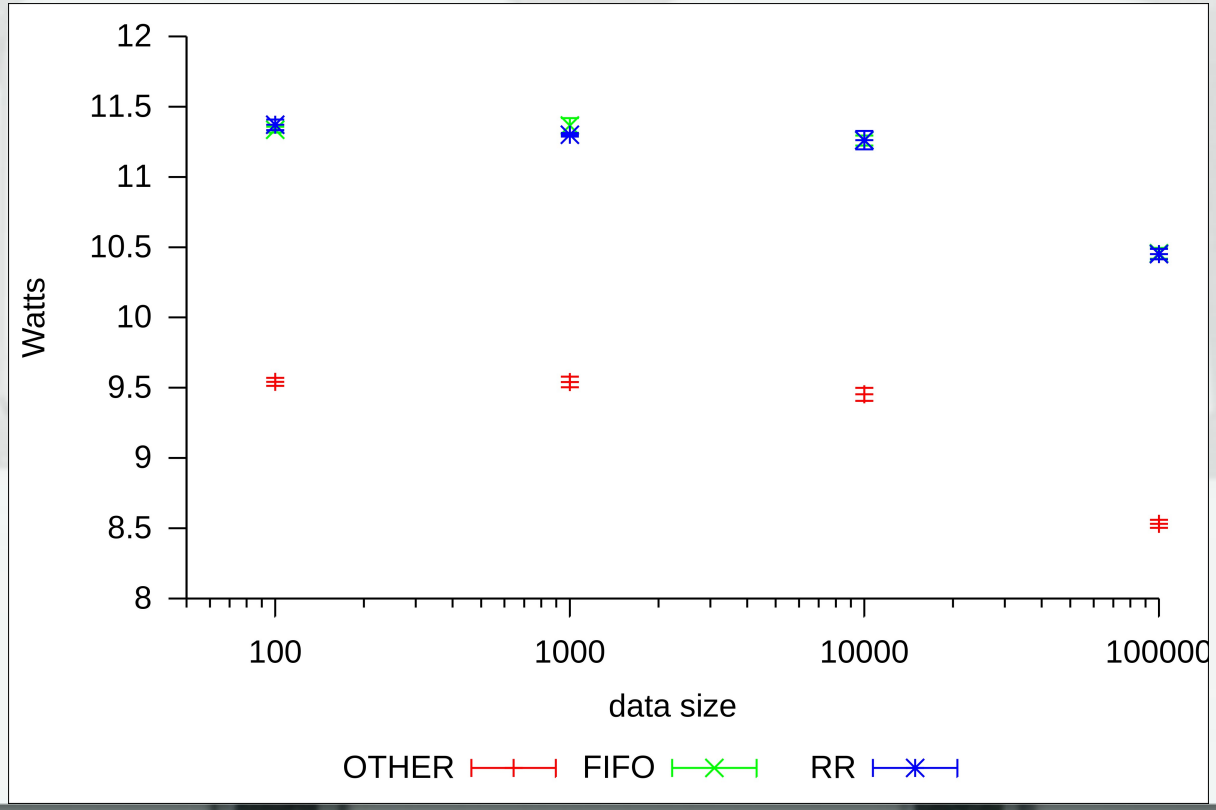
Measurements

- Sequential – zoom RT environment



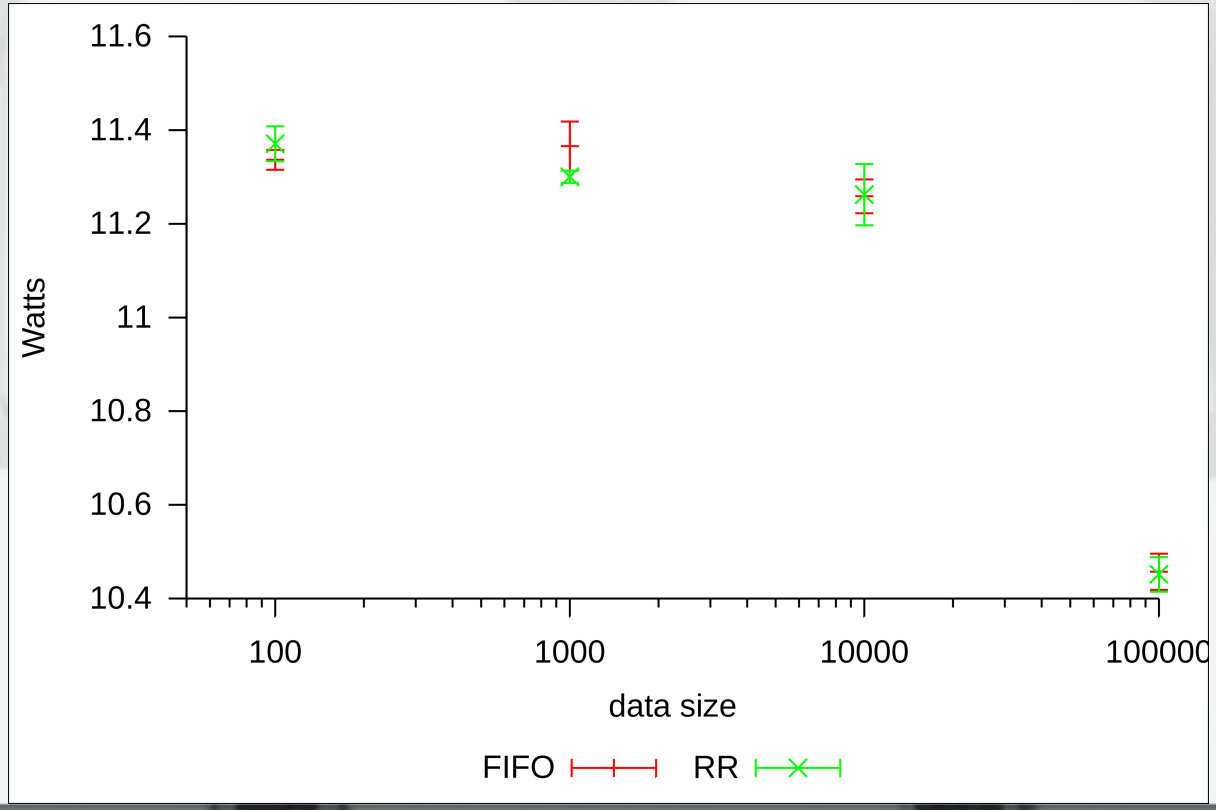
Measurements

- Parallel



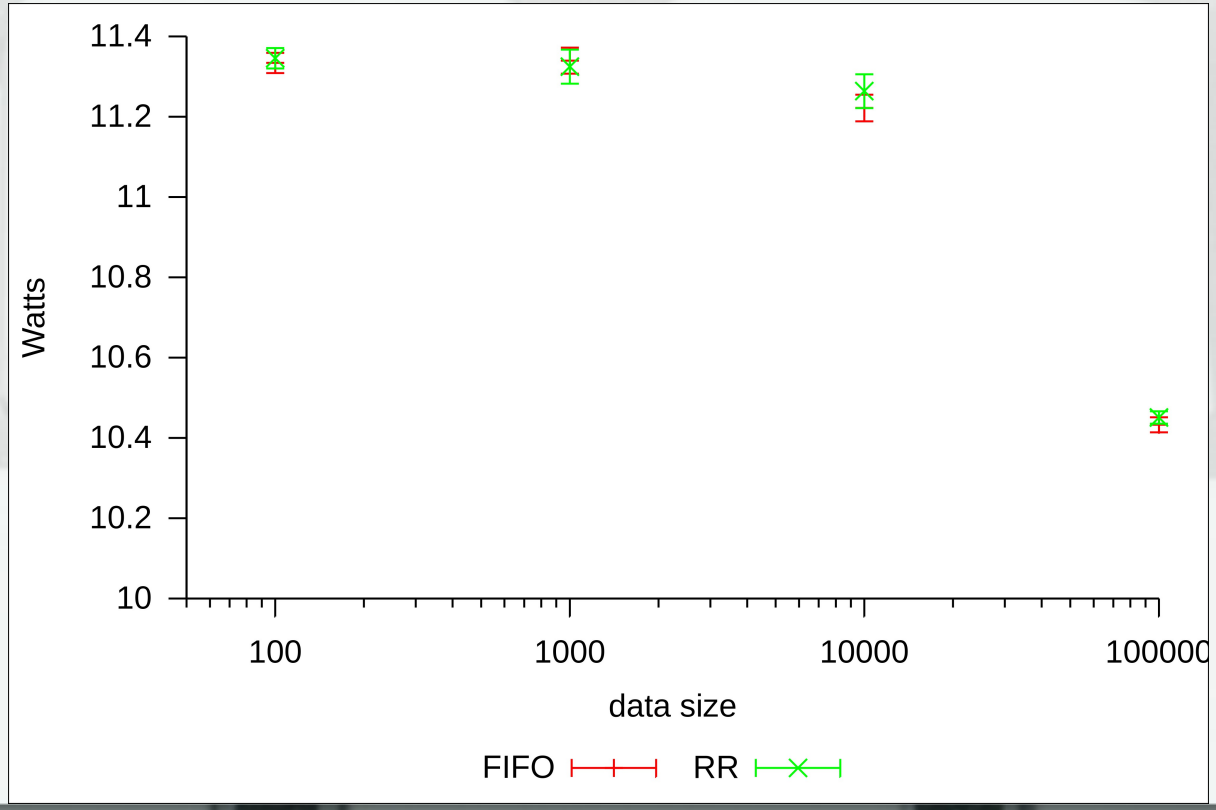
Measurements

- Parallel – zoom RT environment



Measurements

- Priority



Future work

- The limited option of schedulers can be changed in order to achieve a better performance (specific to the system workload)

Future work

- Responsiveness of the RT kernel could be analyzed, (how long does it take to the kernel “notice” and service a new request?)
- Can be tested on other processors (like ARM), but requires another simulator

Conclusion

- Pristine kernel numbers show that there's a cost on having real-time applications
- RR and FIFO are both suitable for RT systems, but provide slightly different power consumption behavior. Additional scheduling algorithms may also exhibit different behavior.

Thank you.

Any questions?