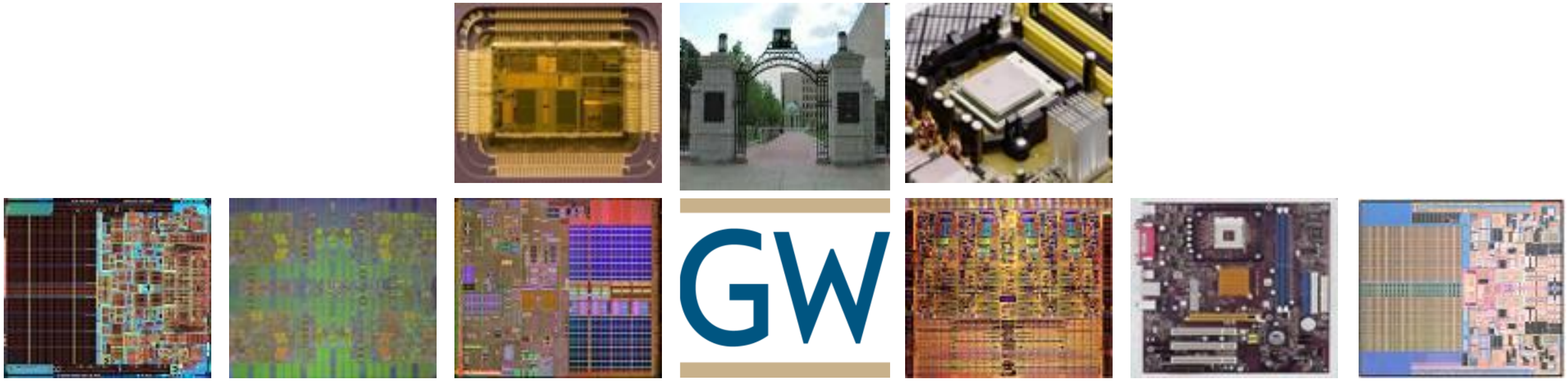

Introduction to SESC Simulator

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Outline

- Introduction to Simulator
- Environmental Settings
- Building SESC executable
- Running benchmark apps
- SESC code structure

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Why Do We Need a Microprocessor Simulator?

- **When building a new REAL microprocessor, you need**
  - Large teams of experts and supported fund
  - Architecting the functionality of the chip
  - Front end logic design and implementation
  - Back end synthesis, place and route
  - Exhaustive verification and testing
  - Expensive fabrication
- **What can we do if we want to evaluate a new design?**
  - Researchers use microprocessor simulators
    - They are written in software
    - They can run applications
      - like real processors, but slower
    - Using them to evaluate new designs becomes much easier
      - changing configurations
      - adding new components

What is SESC?

- **SuperESCalar Simulator**
  - Developed primary by i-acoma group at UIUC
  - Widely used in Academia
- **Microprocessor architectural simulator**
  - MIPS instruction set
  - Uniprocessors
  - Chip Multi-processors (CMP)
- **Implemented in software**
  - Open source, available at Sourceforge website
  - Modularized source code structures
  - Written in C++ and high optimized for speed
- **Event-Driven Simulation**
  - Function simulation (done by emulation part)
  - Timing simulation (done by the rest parts)

Documentation

- **High level explanation of SESC**
  - http://iacoma.cs.uiuc.edu/~paulsack/sescdoc/
- **README files in SESC source package**
  - sesc/docs
- **SESC source code**
  - The best documentation
- **Google "sesc simulator" online**

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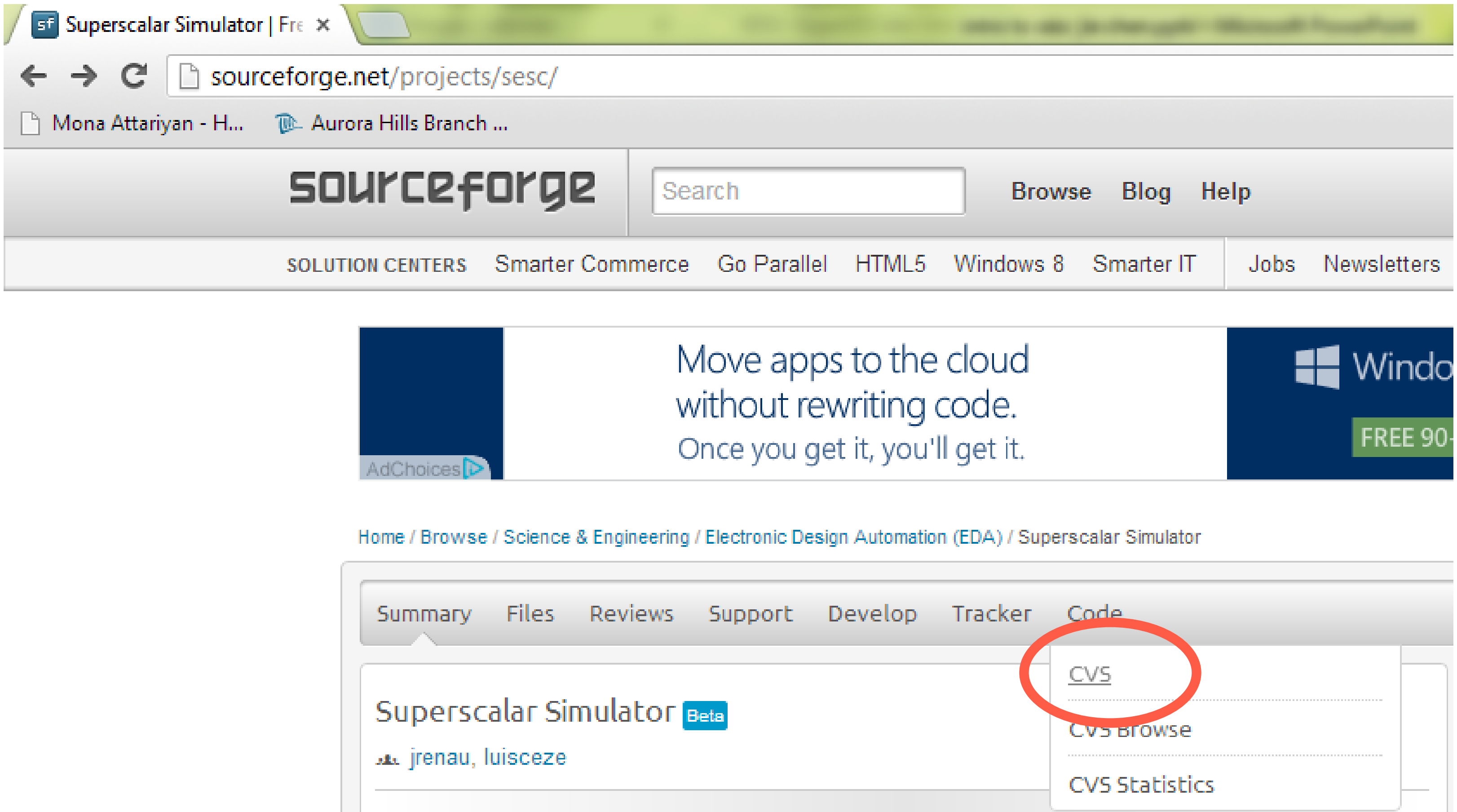
OS settings

- **SESC runs on Linux machines**
  - Linux machines with GCC installed
- **If you have a SEAS account**
  - seas.shell.gwu.edu
  - Redhat Linux 5
- **If you don't have a SEAS account**
  - Go and grab one in Tompkins 4th floor, front desk
- **If you want to play with SESC on your own machine**
  - For Mac
    - install Xcode developer tools package
  - For PC
    - install a virtualization software, e.g., Virtualbox, in your PC
    - In virtualbox, install a Linux virtual machine

Where to download SESC?

- **Go to http://sourceforge.net/projects/sesc/**
  - Click CVS



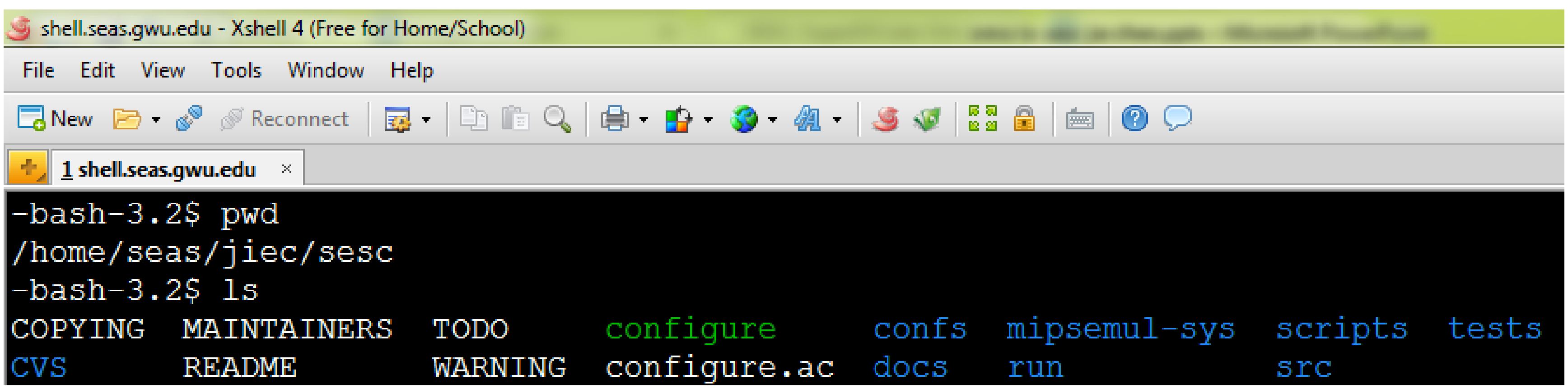
Download SESC to your Linux Machine

- **In your Linux machine, activate a new Linux shell**
  - Copy and paste
  - Simply press Enter key

```
cvs -d:pserver:anonymous@sesc.cvs.sourceforge.net:/cvsroot/sesc login
```

  - Copy and paste
  - Replace *modulename* with *sesc*

```
cvs -z3 -d:pserver:anonymous@sesc.cvs.sourceforge.net:/cvsroot/sesc co
-P modulename
```



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Building SESC executable

- **Create new directory in sesc root directory**
  - Give it any name you like, e.g., *run*
- **Build a SESC executable**
  - In the *run* directory, type *../configure* and press ENTER key

```
-bash-3.2$ pwd
/home/seas/jiec/sesc/run
-bash-3.2$ ../configure
```

1

  - You find 4 files have been created

2

```
-bash-3.2$ ls
Make.defs  Makefile  config.log  config.status
-bash-3.2$
```

  - Type *make*

3

```
-bash-3.2$ make
```

  - GCC will build the sesc executable: *sesc.mem*

```
-bash-3.2$ pwd
/home/seas/jiec/sesc/run
-bash-3.2$ ls
Make.defs  Makefile  config.h  config.log  config.status  obj  sesc.mem
```

4

Troubleshooting

- **For Mac OS users**
  - By default, Mac OS does not come with *cvs* software, you have two options
    - use apple's own *cvs*, or
    - download the software management tool *fink,* and use fink to install a *cvs* tool
  - When doing the make command, you may run into an error message "… not support x86_64 instructions …", to solve it
    - edit /sesc/src/Makefile.defs.Darwin
      - go to line 55
      - replace "COPTS   += -march=pentium-m -mtune=prescott"
      - with "COPTS   += -march=core2 -mtune=core2"

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Run Benchmark Apps with SESC

- **Go to *tests* directory**
  - Copy mem.conf and share.conf from *confs* directory to *tests* directory

```
-bash-3.2$ pwd
/home/seas/jiec/sesc/tests
-bash-3.2$ ls
CVS      crafty.outorder  mcf.in   mcf.outorder  rst_trace.rz2.gz    rst_trace3.rz3.gz  smatrix
crafty   mcf              mcf.out  mem.conf      rst_trace2.rz3.gz   shared.conf        tt.in
```

- **Three precompiled benchmark Apps**
  - crafty, mcf, smatrix
- **Running benchmark app with command lines**
  - ../run/sesc.mem –cmem.conf crafty < tt.in
  - ../run/sesc.mem –cmem.conf mcf mcf.in
  - ../run/sesc.mem –cmem.conf smatrix
- **Every run will generate a report file**
  - E.g., sesc_crafty.gxYmlM [sesc_benchName.randomLetters]

Read Report files

- **Get report summary**
  - Use the convenient tool *report.pl* to interpret report file

```
-bash-3.2$ ../scripts/report.pl sesc_crafty.gxYmlM
```

  - There are more options in using *report.pl*

```
-bash-3.2$ ../scripts/report.pl --help
```

  - There are a lot of useful info in the report summary
    - Execution time, # of instructions, # of CPU cycles, instruction mix ratios, IPC, different cache miss rates, and etc.
- **Get the full report**
  - Simply *vim* or *vi* the report file and jump to the entry you want to read
  - E.g. the data cache miss and hit counts

```
P(0)_DL1:writeMiss=31815
P(0)_DL1:readMiss=57548
P(0)_DL1:readHit=1989888
P(0)_DL1:writeHit=1099538
P(0)_DL1:writeBack=47016
```

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Source Code Tree

- **Modularized source code structure**
  - libapp - application interface with SESC
  - libcore – processor core and its components, e.g., branch predictors, reservation stations, pipelines, etc.
  - libemul – MIPS instruction emulation
  - libll – interface between the timing and function simulation parts
  - libmem – non-shared caches
  - libpower – power and energy
  - libsescspot – thermal simulaiton
  - libsmp – shared memory associated structures (cache coherence)
  - libsuc – profiling classes, and some other special useful classes

```
-bash-3.2$ tree -d -L 1 src/
src/
|-- CVS
|-- libapp
|-- libcore
|-- libemul
|-- libll
|-- libmem
|-- libmint
|-- libnet
|-- libpint
|-- libpower
|-- librst
|-- libsescspot
|-- libsesctherm
|-- libsmp
|-- libsuc
|-- libsuperlu
|-- libtm
|-- libvmem
`-- misc
```

Important SESC Classes

- **libcore/Processor.h (Processor.cpp)**
  - Processor::advanceClock()
    - increments the CPU clock of the simulated processor
    - coordinates interactions between different pipeline stages
    - and does the following important work
    - fetch()
      - fetch instructions into the instruction queue
    - issue()
      - issue instructions from the instruction queue into a scheduling window (Reservation Station)
    - retire()
      - retire already executed instructions from the reorder buffer (ROB)

Important SESC Classes

- **libmem/Cache.h (Cache.cpp)**
  - Cache::access(MemRequest *mreq)
    - The common interface for accessing caches
    - When called, SESC will figure out the type of the access
      - If read request, call
        - Cache::read(MemRequest *mreq)
      - If write request, call
        - Cache::write(MemRequest *mreq)
      - If a cache writeback request, call
        - Cache::pushLine(MemRequest *mreq)
  - Cache::sendMiss(MemRequest *mreq)
    - This function gets called when cache access turns out to be a miss
    - This is also a virtual function
      - The detailed implementation depends on the type of cache
        - WBCache, WTCache, NICECache (inherited classes)

Other Classes to Look At

- **libmem/mtst1.cpp**
  - The main function entry point
- **libcore/GMemorySystem.cpp**
  - Building all cache-like structures, such as, DL1$, IL1$, L2$, TLBs …
- **libcore/OSSim.cpp**
  - Acting like an OS, booting and stopping the simulation

libcore/RunningProcs.cpp
  - AdvanceClock () gets called here
- **libcore/MemRequest.cpp**
  - Implements signals that traverse through the memory hierarchy
- **libcore/Gprocessor.cpp**
  - The basic processor components are defined in this class

CallBack Functions

- **SESC is an execution-driven simulator**
  - Functions are called to simulate parts of the processor every cycle
  - There are other functions called at a later time
    - E.g., the event that missed data is brought back to the cache from the lower level memory
- **CallBack class and its subclasses**
  - Libsuc/callback.h
    - let the programmer schedule the invocation of a function at a given time in the future

How Does CallBack Work?

- **Define the function you want to call in the future**
  - E.g., Cache::doRead(MemRequest * mreq) { … }
- **Define the callback class that wraps the function**
  - E.g., typedef CallbackMember1<Cache, MemRequest *, &Cache::doRead> doReadCB
- **Schedule a time to execute the callback function**
  - doReadCB::scheduleAbs(nextSlot(), this, mreq)
    - doRead is called at the nextSlot() time
  - Or, doReadCB::schedule(5, this, mreq)
    - doRead is called after 5 clock cycles

Suggestions

- **Get some background knowledge on C++ if you need**
  - The concept of class, inheritance, virtual function, etc.
- **Get familiar with Linux shell commands**
  - cd, pwd, ls, grep, etc.
- **Read header file first**
  - .h file defines the attributes and functions of a class
- **Start early**