Freescale FAE75 Training Genesi Pegasos II: Using SimG4+

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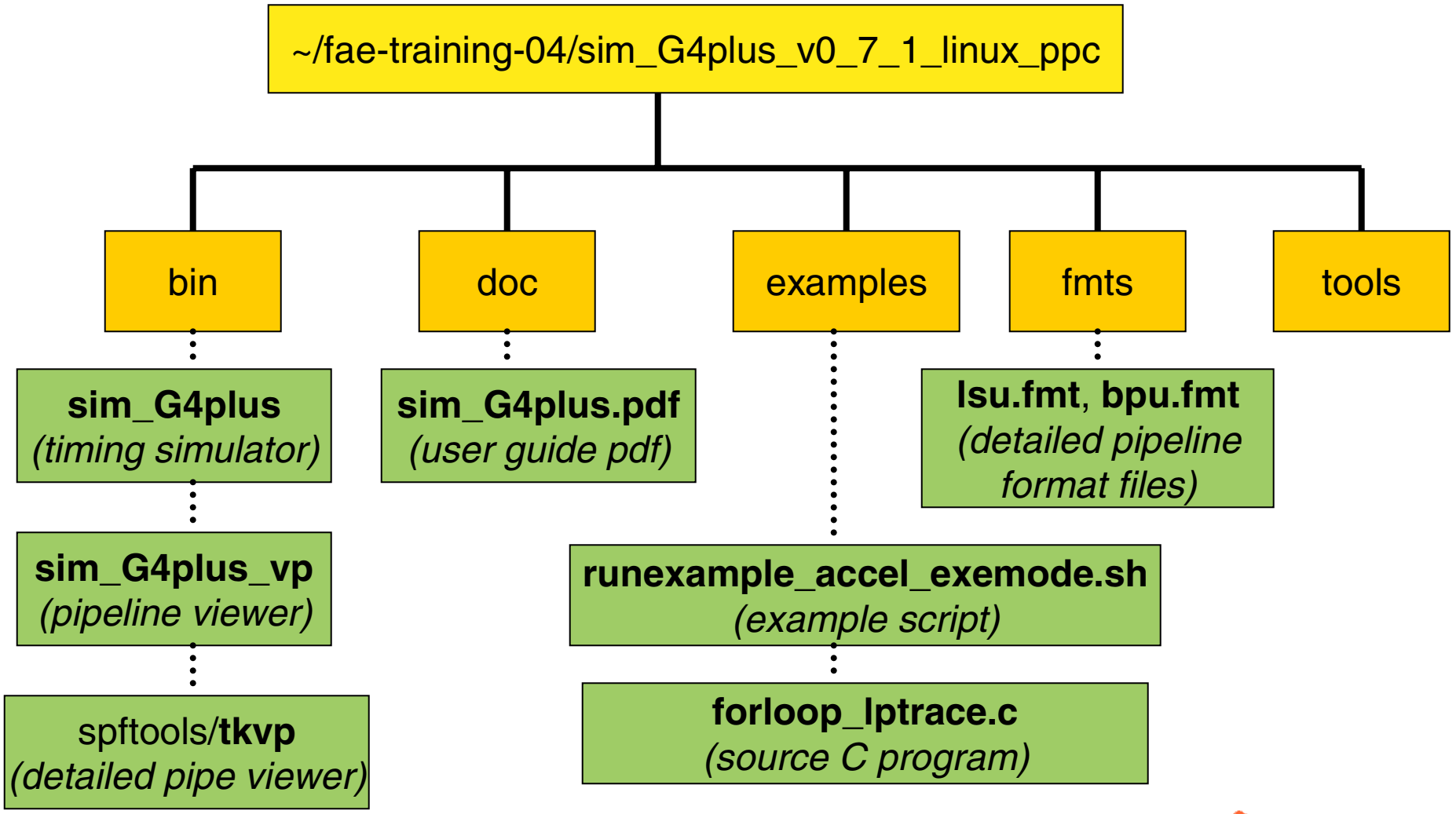
Presentation Overview

- What is SimG4+?
- Preparation
  - Directory layout
  - Examples and tool flow
- Step 1: Compile source code
- Step 2: Run simulator
- Step 3: View pipeline
- *(Optional)* Analysis example

What is SimG4+?

- **SimG4+ is a cycle-accurate, execution-driven timing simulator of the G4+ microprocessor**
  - **“cycle-accurate” = hardware is simulated at cycle-by-cycle granularity**
  - **“execution-driven” = simulator consumes an executable program**
- **Uses**
  - **Application tuning**
  - **Library development/tuning**
  - **Compiler optimization development**

Directory Layout



Login!

1. login as username: guest password: guest
2. $ which sim_G4plus

Go to example directory!

1. $ cd ~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
2. $ ls

(TIP: to use command and filename completion, type first few characters of name, then press <tab> to complete)

```
guest@debian:~$ which sim_G4plus
/home/guest/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/bin/sim_G4plus
guest@debian:~$ cd ~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples/
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$ ls
GNUmakefile                    forloop_lptrace
README.examples                forloop_lptrace.c
forloop.reference.output       hello.tte
forloop_accel_exemode.pipeout  runexample_accel_exemode.sh
forloop_accel_exemode.stats    runexample_exemode.sh
forloop_accel_exemode.txt      runexample_lptrace.sh
forloop_exemode.c
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$
```

View the Example Script

$ less runexample_accel_exemode.sh

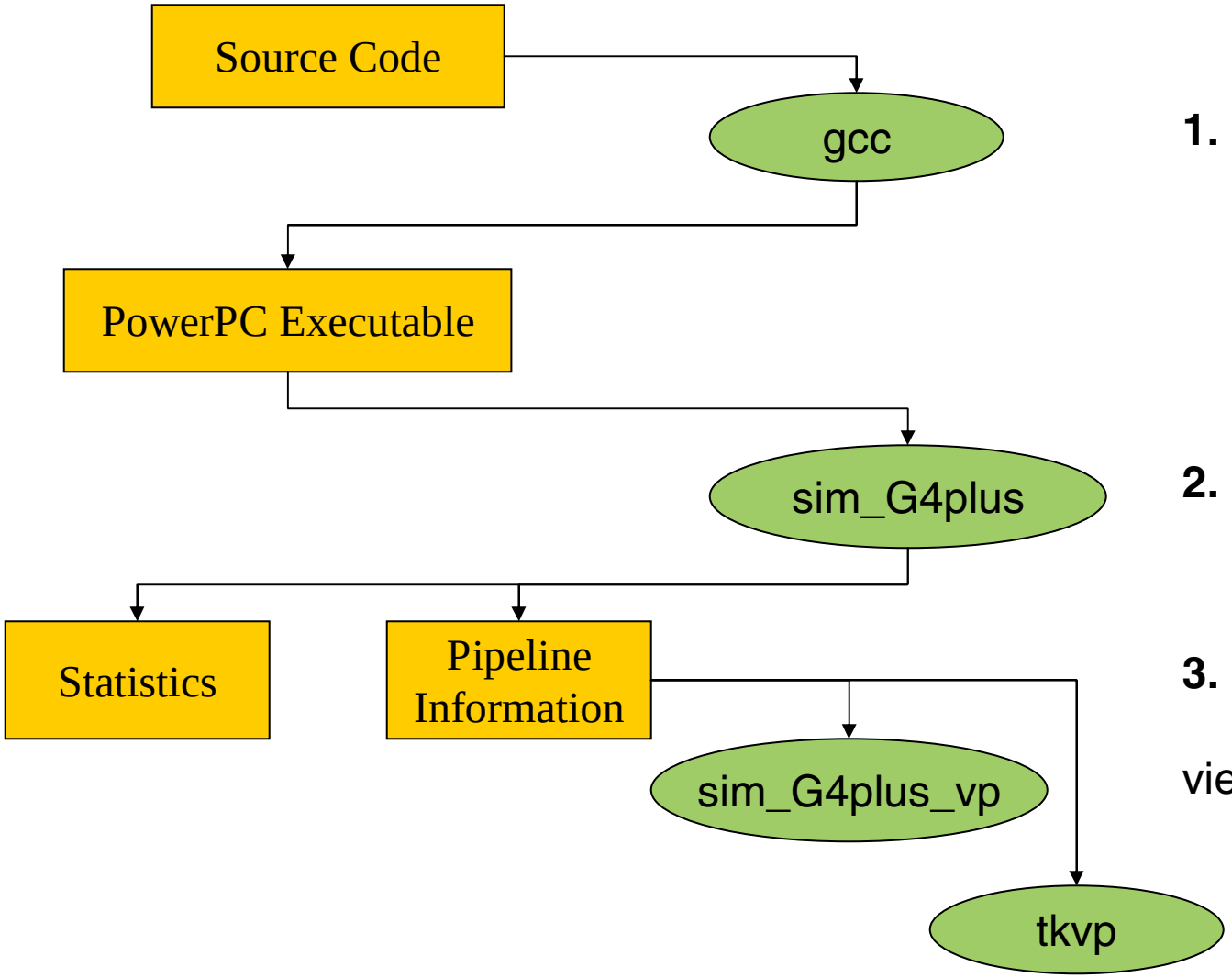
(TIP: scroll up and down with arrow keys, pgup/pgdown, ‘q’ to quit)

Steps:

1. Compile source code
2. Run simulator
3. View pipeline

```
#!/bin/sh

# This script demonstrates the tool sequence for generating a pipeline
# output from an lptrace instrumented .c program using the accelerated
# execution-driven mode of sim_G4plus.  No trace files are generated
# in this sequence.
#
# This script expects to be run on a Linux PowerPC platform because
# the binary needs to be built using gcc for PowerPC.
#

if [ "`uname -sm`" != "Linux ppc" ]; then
    echo
    echo This script must be run on a Linux PowerPC platform
    echo Please examine this script to understand how to invoke the tools
    echo for performance analysis.
    echo
    exit 1
fi


# Compile instrumented program (.c -> executable)

echo "Compiling forloop_lptrace.c..."

gcc -O -o forloop_lptrace forloop_lptrace.c -static

if [ ! -x ../bin/sim_G4plus ]; then
    echo "ERROR: Expected sim_G4plus to be here: ../bin/sim_G4plus"
    exit 1
fi

echo "Running on the simulator..."
../bin/sim_G4plus -a -p forloop_accel_exemode.pipeout \
            forloop_lptrace > forloop_accel_exemode.stats
if [ ! -x ../bin/sim_G4plus_vp ]; then
    echo "ERROR: Expected sim_G4plus_vp to be here: ../bin/sim_G4plus_vp"
    exit 1
fi

echo "Generaing pipeout dump..."
../bin/sim_G4plus_vp -r 60 -n forloop_accel_exemode.pipeout > forloop_accel_exem
ode.txt
```

SimG4+ Tool Flow



1. Compile source code

2. Run simulator

3. View pipeline

view overall pipeline

view detailed pipeline

Step 1: Compile Source Code

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View Source Code Before Compiling

$ less forloop_lptrace.c

or

$ vi forloop_lptrace.c

- **start and stop markers are illegal opcodes understood by the simulator**
  - **start code: 0x14000001**
  - **stop code: 0x14000002**

- **the resulting executable will run only on the simulator**

```
/*
 * forloop.c
 *
 * Compile using:
 *      gcc -O forloop.c -o forloop -static
 *
 * The purpose of this program is to demonstrate the
 * instrumention for tracing a for loop.
 *
 */


int main (void) {
        unsigned int i;
        unsigned int j;
        unsigned int x = 0x0000100;

        /* start tracing */
        asm (".long 0x14000001");
        j = 0;
        for (i = 0; i < 32; i++) {
                if (x & 0x1) {
                        j++;
                }
                x >>= 1;
        }

        /* stop tracing */
        asm (".long 0x14000002");
        return j;
}
forloop_lptrace.c (END)
```

start marker

stats/pipeline collected

stop marker

Compile Source Code

1. $ gcc -o forloop_lptrace forloop_lptrace.c -static

specify executable to output

specify input source file

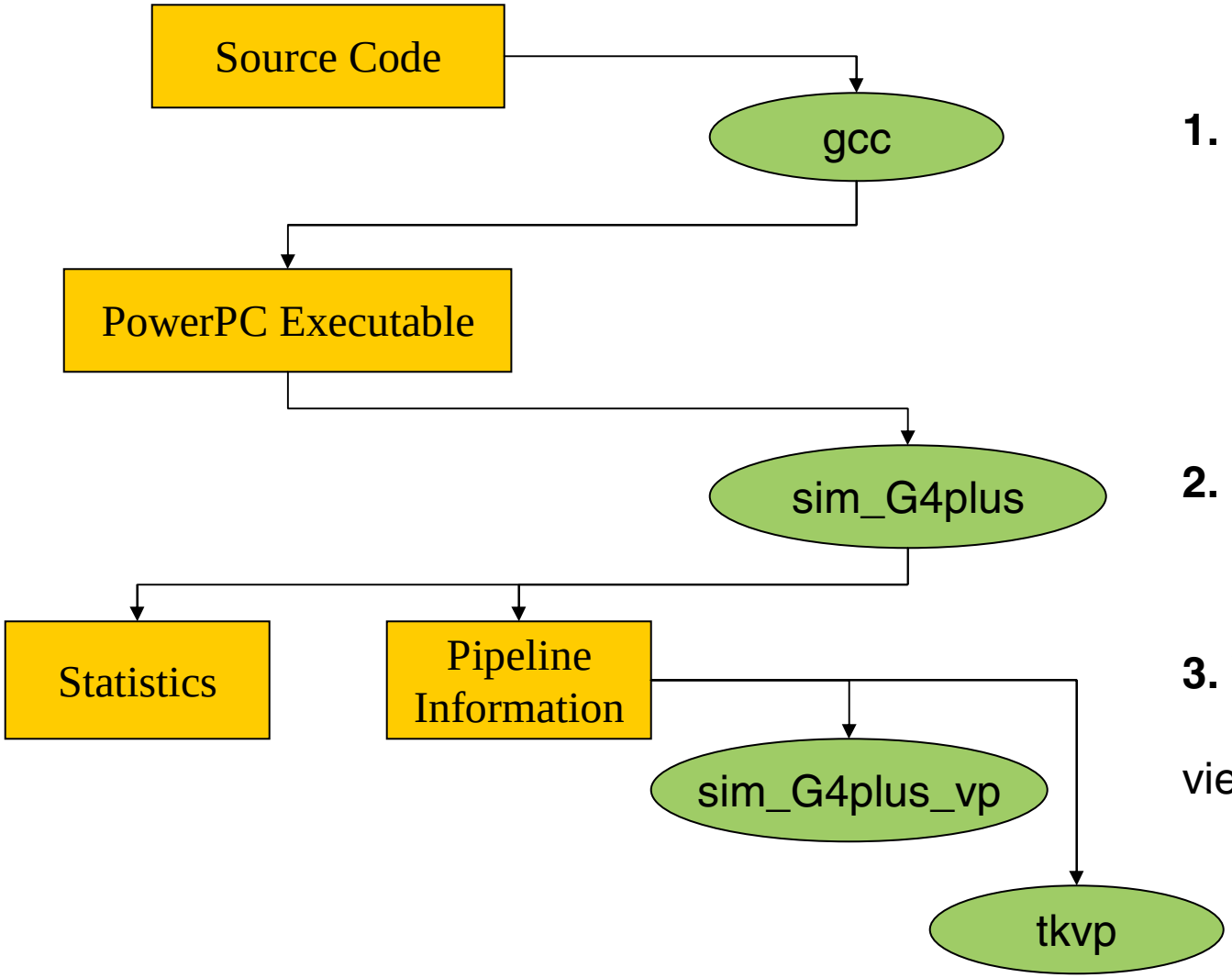
must link statically
(simulator complains if it is given a dynamically-linked executable)

- $ file forloop_lptrace

(Optional) **verify the file type of the executable generated**
(ELF, 32-bit MSB, PowerPC, statically linked)

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ gcc -o forloop_lptrace forloop_lptrace.c -static
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ file forloop_lptrace
forloop_lptrace: ELF 32-bit MSB executable, PowerPC or cisco 4500,
version 1 (SYSV), for GNU/Linux 2.2.0, statically linked, not strip
ped
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$
```

SimG4+ Tool Flow



1. Compile source code

2. Run simulator

3. View pipeline

view overall pipeline

view detailed pipeline

Step 2: Run Simulator

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Simulator Options: “-h” to access help

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$ sim_G4plus -h
sim_G4plus expiration date: Sun Nov 14 23:59:59 2004


sim_G4plus v0_7_1

The performance model for the MPC7447A
Copyright 2003 Motorola.
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Usage: sim_G4plus [options] [input_tracefile]

Options for controlling simulation runs and output:
  -c <clocks>    How many clock cycles to run (default is seq.max_cycles)
  -d path1:path2 Search path for parameter files
  -e <eventfile> Set the param seq.pevents_file to <eventfile>
  -f <filename>  Use a parameter file
  -p <filename>  Write pipeline info for post-processing to <filename>
  -s param=value Set the runtime parameter 'param' to 'value'
  -a             Run a PowerPC ELF binary in accelerated mode

Options for displaying status (no simulation done):
  -E             Print the registered events, then exit
  -r             Print runtime parameters then exit
  -R             Print runtime parameters with descriptions then exit
  -v             Print version message then exit
  -h             Print help message then exit

guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$
```

Usage

Simulator Options: "-v" to access version

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$ sim_G4plus -v
sim_G4plus expiration date: Sun Nov 14 23:59:59 2004

sim_G4plus v0_7_1

The performance model for the MPC7447A
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Motorola Confidential Proprietary.

Run on host   : debian
Current Time  : Mon Jun  7 22:49:51 2004

guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$
```

Expiration Date

Version

Simulator Options: "-r", "-R" (verbose) to view parameters

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$ sim_G4plus -r
sim_G4plus expiration date: Sun Nov 14 23:59:59 2004


sim_G4plus v0_7_1

The performance model for the MPC7447A
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# *** General Simulation Parameters ***
sim.trace_type = auto
sim.max_cycles = 0
sim.pipeout_file =
sim.pipeout_start = 1
sim.pipeout_stop = 0
sim.pevents_file =
sim.pevents_enable = *.*
sim.pevents_append = false
sim.testcase_num = 0
# sim.bus_ratio = 1
sim.strace_on = false

# *** Sequencer Parameters ***
# seq.sanity_mode = false
seq.enable_data_dependent = true

# *** Fetch Parameters ***
fet.start_delay = 0
icache.mode = infinite

# *** Branch Parameters ***
bpu.perfect_direction_prediction_trace_mode = false
bpu.enable_bht = true
bpu.enable_link_stack = true
bpu.enable_btic = true
bpu.enable_branch_folding = true

# *** LSU Parameters ***
dcache.mode = infinite

# *** MSS Parameters ***
# l2cache.mode = infinite
# l2cache.first_beat_latency = 9
# l2cache.subsequent_beat_latency = 1
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$
```

Parameter

Default value

Run Simulator

$ sim_G4plus -a -p forloop.pipeout forloop_lptrace > forloop.stats

generate pipeline output file

start simulation in accelerated mode
(don't collect stats/pipeline until simulation reaches start marker)

executable to simulate

statistics output
(redirect from stdout to file)

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ sim_G4plus -a -p forloop.pipeout forloop_lptrace > forloop.stats
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ ls
GNUmakefile                 forloop_lptrace
README.examples             forloop_lptrace.c
forloop.pipeout             hello.tte
forloop.reference.output    runexample_accel_exemode.sh
forloop.stats               runexample_exemode.sh
forloop_accel_exemode.txt   runexample_lptrace.sh
forloop_exemode.c
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$
```

View Statistics (1/3)

$ less forloop.stats

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$ less forloop.stats
sim_G4plus expiration date: Sun Nov 14 23:59:59 2004


sim_G4plus v0_7_1

The performance model for the MPC7447A
Copyright 2003 Motorola.
Motorola Confidential Proprietary.

Run on host  : debian
Current Time : Mon Jun  7 22:58:08 2004

# ************************************
# *** BEGIN SIMULATION PARAMETERS ***
# ************************************

# *** General Simulation Parameters ***
sim.trace_type = auto
sim.max_cycles = 0
sim.pipeout_file = forloop.pipeout
sim.pipeout_start = 1
```

simulation parameters

View Statistics (2/3)

$ less forloop.stats

```
# *** MSS Parameters ***
# l2cache.mode = infinite
# l2cache.first_beat_latency = 9
# l2cache.subsequent_beat_latency = 1

# ************************************
# **** END SIMULATION PARAMETERS ****
# ************************************
```

simulation parameters

```
939524095 bytes are available for your program's heap and stack.
Running forloop_lptrace ...
SPORTAL: Recieved program exit System Call with exit status: 1
Program exited with status 1
```

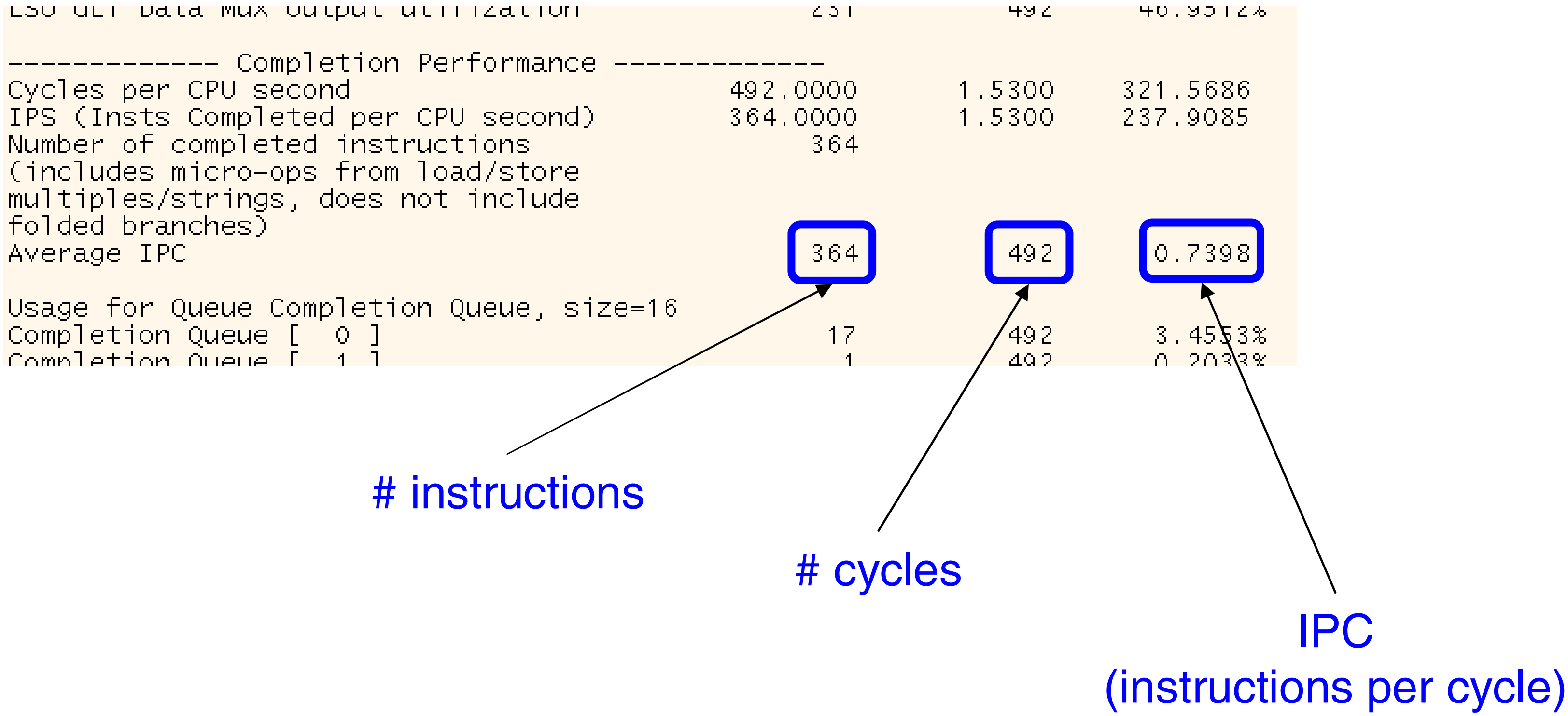
messages during simulation

```
Usage for Buffer Instruction Buffer, size=12
Instruction Buffer [  0 ]                    24          492       4.8780%
Instruction Buffer [  1 ]                    67          492      13.6179%
Instruction Buffer [  2 ]                    30          492       6.0976%
Instruction Buffer [  3 ]                    36          492       7.3171%
Instruction Buffer [  4 ]                    76          492      15.4472%
Instruction Buffer [  5 ]                    97          492      19.7154%
```

output statistics

View Statistics (3/3)

$ less forloop.stats



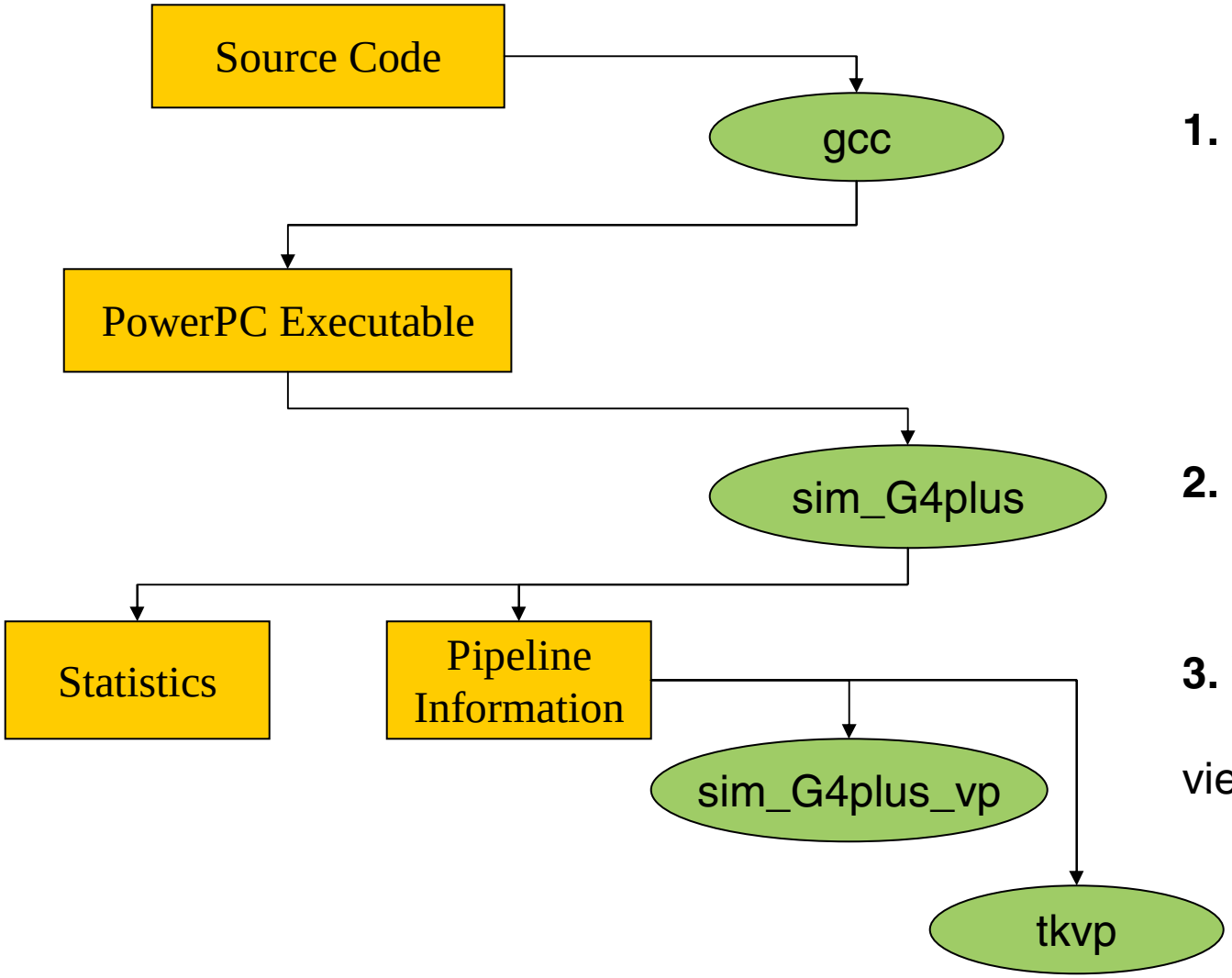
```
------------- Completion Performance -------------
Cycles per CPU second                              492.0000       1.5300     321.5686
IPS (Insts Completed per CPU second)               364.0000       1.5300     237.9085
Number of completed instructions                        364
(includes micro-ops from load/store
multiples/strings, does not include
folded branches)
Average IPC                                             364          492       0.7398

Usage for Queue Completion Queue, size=16
Completion Queue [   0 ]                                 17          492      3.4553%
```

Pipeline Output File

- **Pipeline Output file:**
  - **Is a text file**
  - **Shows status of simulated processor on each clock cycle**
- **Use a viewer**

SimG4+ Tool Flow



1. Compile source code

2. Run simulator

3. View pipeline

view overall pipeline

view detailed pipeline

Step 3: View Pipeline

Overall Pipeline Viewer Options

$ sim_G4plus_vp -h

```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples$ sim_G4plus_vp -h

   Usage /home/guest/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/bin/spftools/tksnp.pl [options
] <snapshot_def_file> <spf_file>

   Where options are one of:
      -f | --firstcycle <num> /* First cycle to display (Non-TK mode only) */
      -e | --endcycle <num>   /* Last cycle to display */
      -s | --showcols <list>  /* Colon-seperated list columns to display */
      -c | --cycwidth <num>   /* Number of characters for the cycle column */
      -m | --mapwidth <num>   /* Number of characters for the map column */
      -r | --rows <num>       /* Number of lines per page */
      -d | --deffile <file>   /* Used the deffile (instead of on cmd line) */
      -i | --ignoresize       /* In non-Tk mode, ignore the size of the
                                 terminal in which we were invoked */
      -n | --notk             /* Don't use the TK interface */
      -p | --printall         /* Print all cycles on a page in Non-TK mode.
                                 Default is to try to only print the number
                                 of rows */
      -D | --Delimiter <s>    /* Output using the specified
                                 string as the delimiter between columns. */
      -w | --warnings         /* Give warnings if we can't find a symbol
                                 in the snapshot file */
      -l | --list             /* List all known columns, then exit
                                 NOTE: This option requires both a
                                 snapshot_def_file AND an spf_file.  This
                                 is the only way that the columns for
                                 a specific spf can be properly displayed */
      -F | --Font <font>      /* Use the specified font. */
      -P | --P <Program>      /* Run Program on the input file */
      -h | --help             /* Print this message, then exit */

   The snapshot_def_file should be provided when this script
   is delivered.  The spf_file is the pipline output of the simulation.
```

Run Overall Pipeline Viewer

$ sim_G4plus_vp forloop.pipeout &

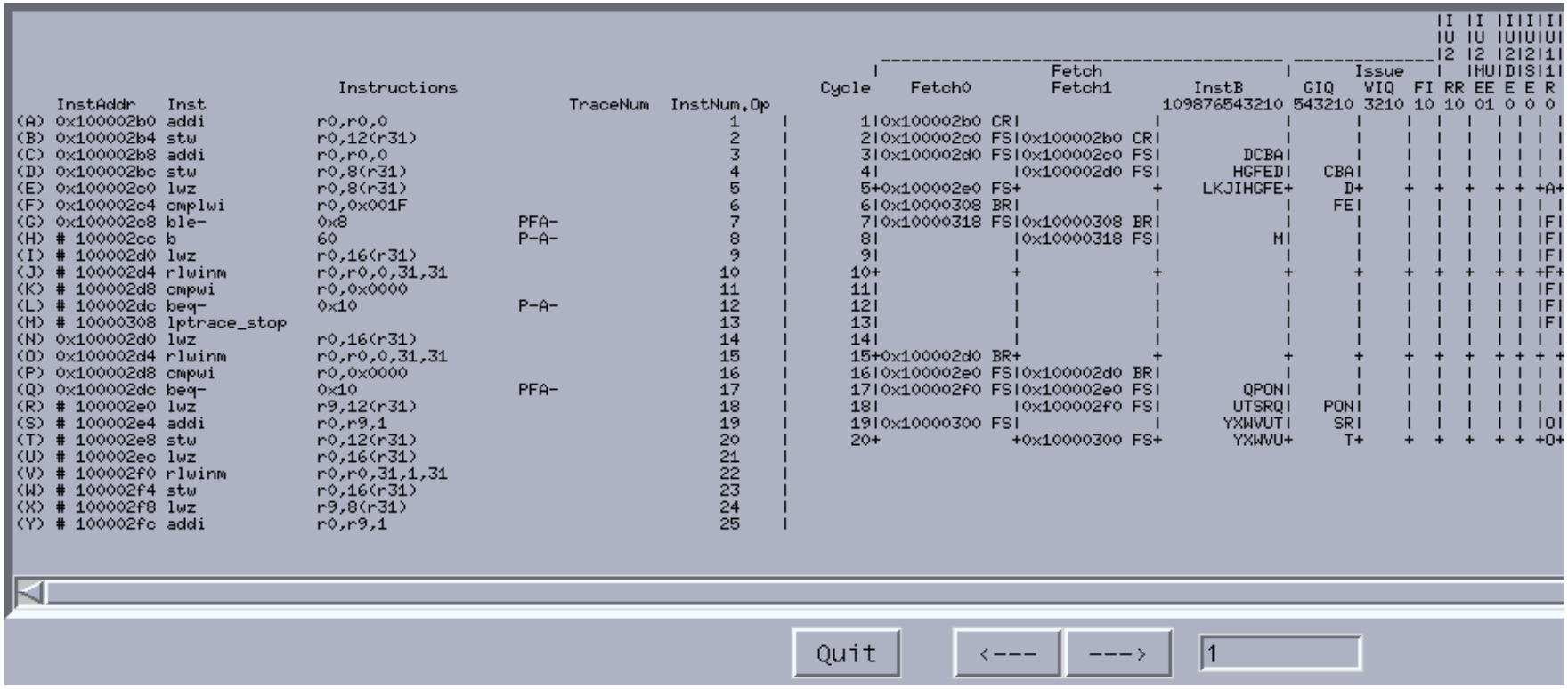
pipeline output file generated

run viewer as background process

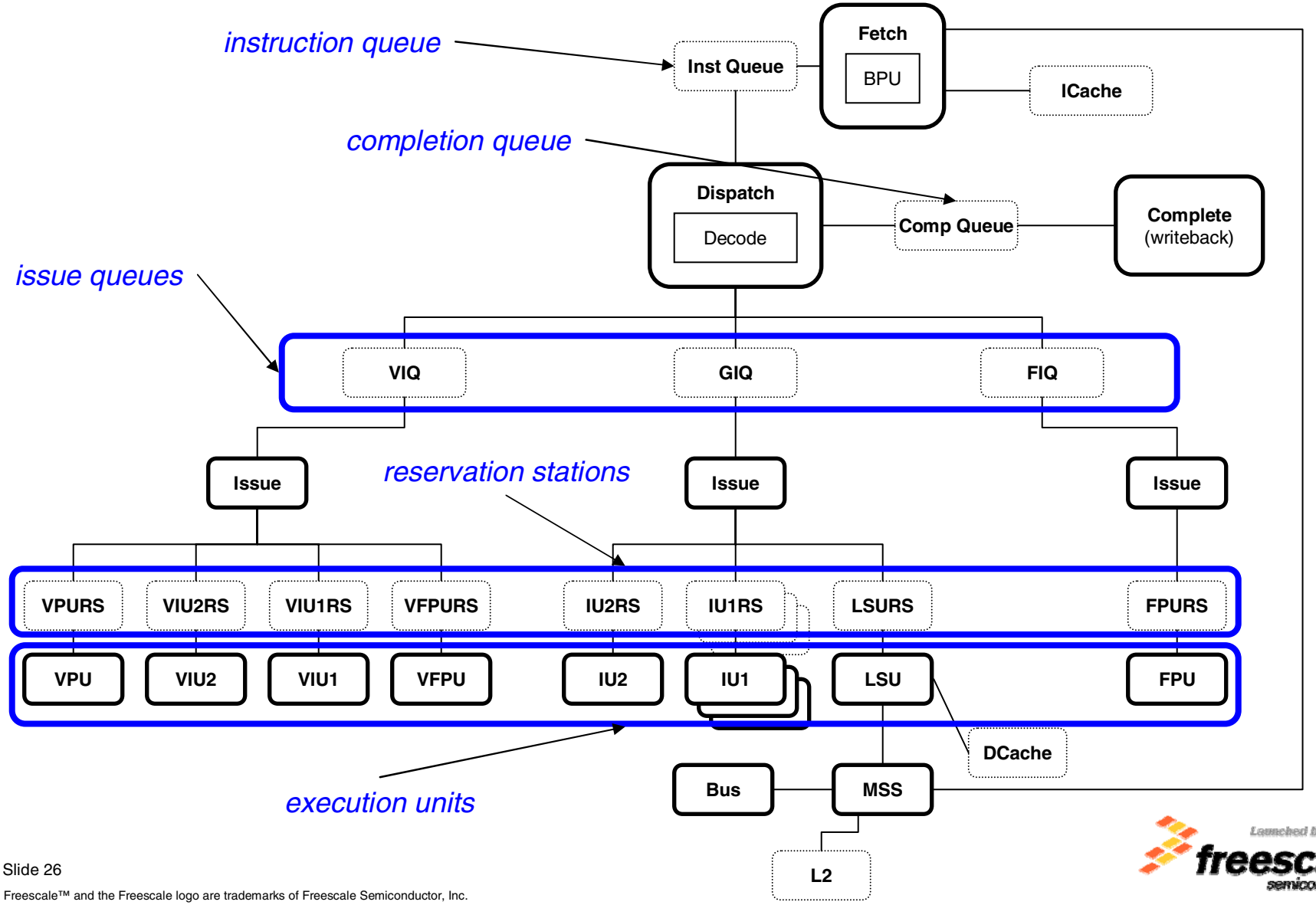
```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ sim_G4plus_vp forloop.pipeout &
[1] 2319
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ Reading pipeline file `/home/guest/fae-training-04/sim_G4plus_v0_
7_1_linux_ppc/bin/spftools/babehspf WriteBack.Buffer forloop.pipeou
t|'opened via `/home/guest/fae-training-04/sim_G4plus_v0_7_1_linux_
ppc/bin/spftools/babehspf WriteBack.Buffer forloop.pipeout|'...
Reading SPF 2.x file
Updating data values...
File read complete.
```

Overall Pipeline Viewer Display

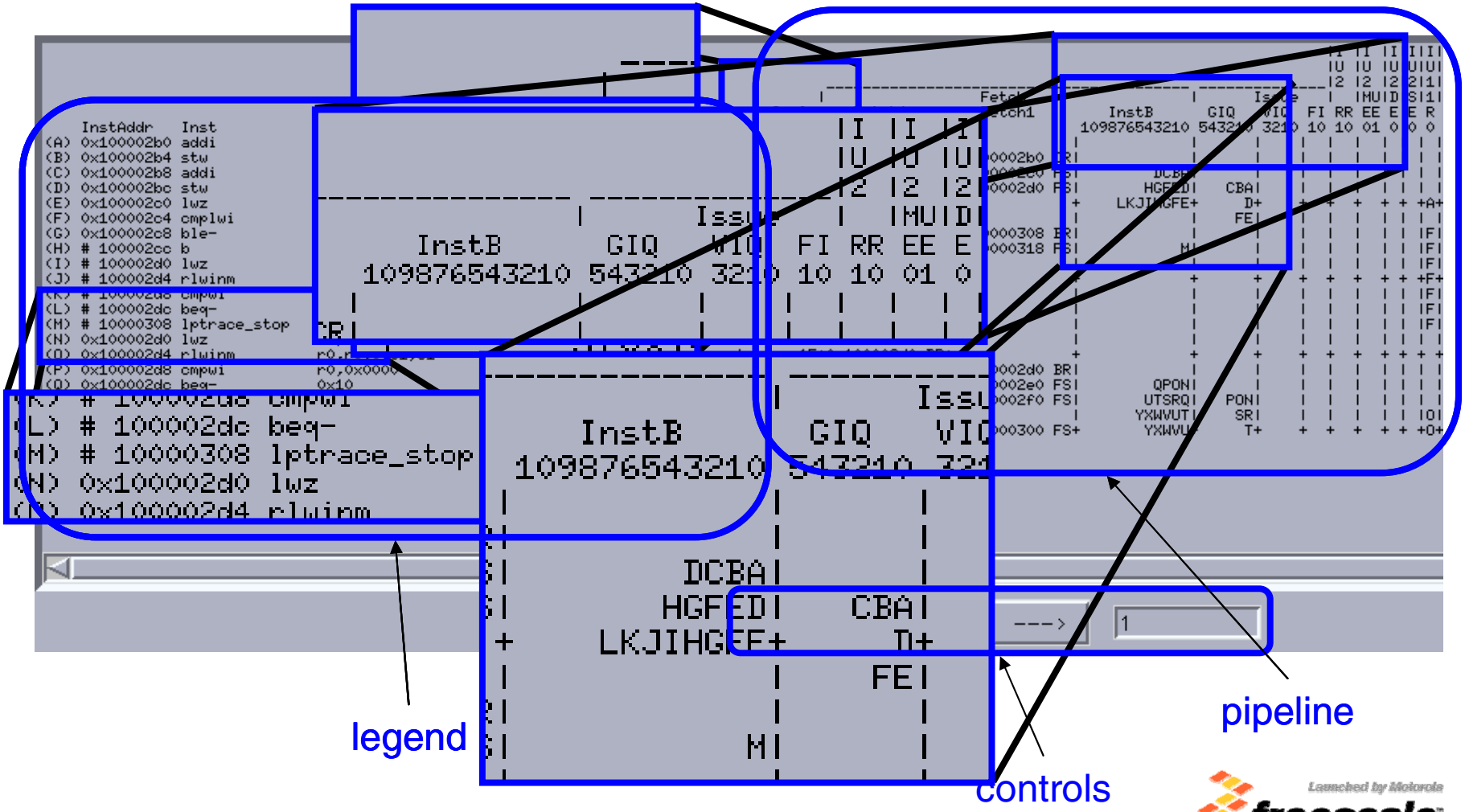
$ sim_G4plus_vp forloop.pipeout &



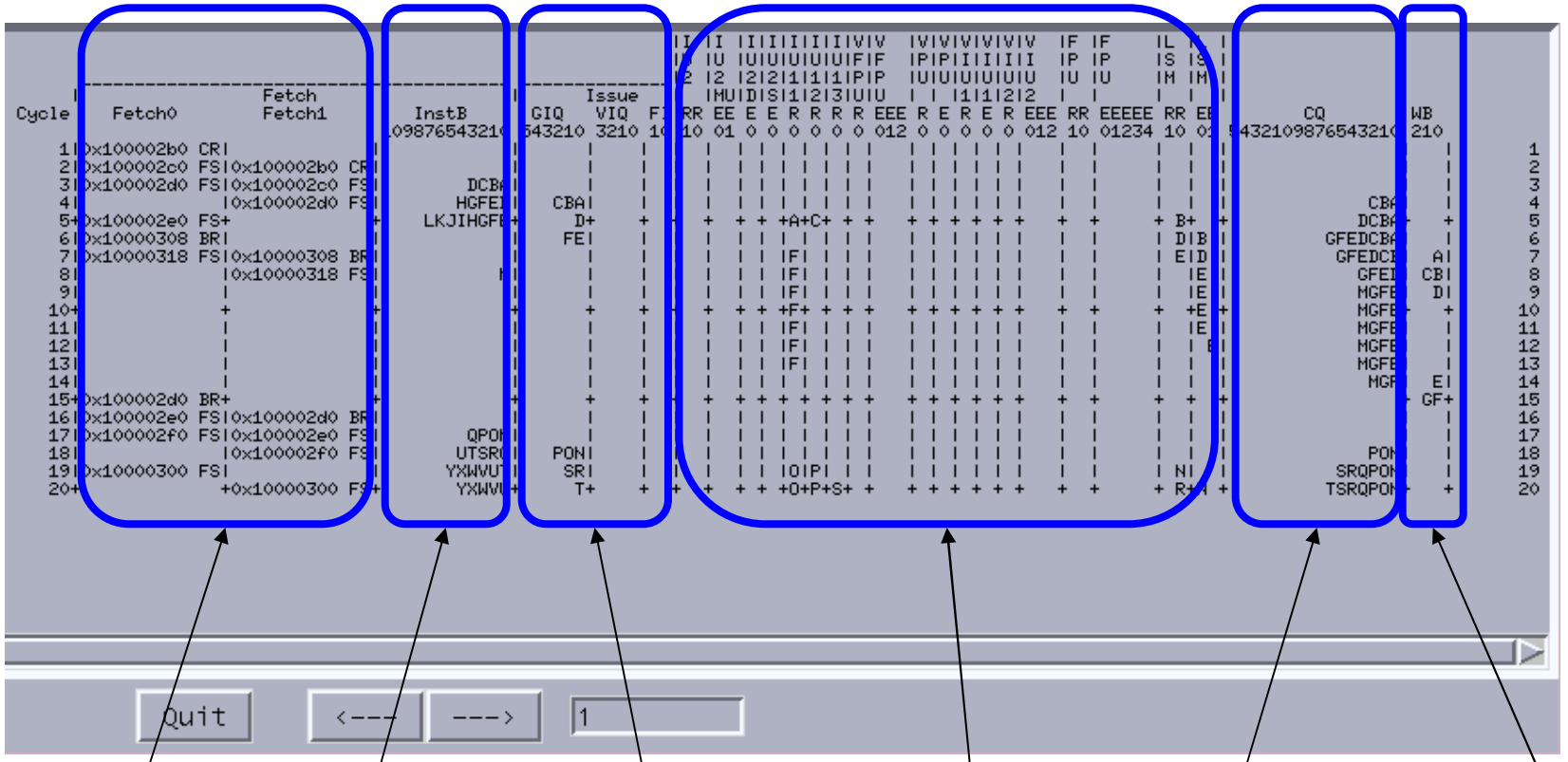
G4+ Block Diagram



Overall Pipeline Viewer Display: In-Depth (1/2)



Overall Pipeline Viewer Display: In-Depth (2/2)



fetch

instruction queue

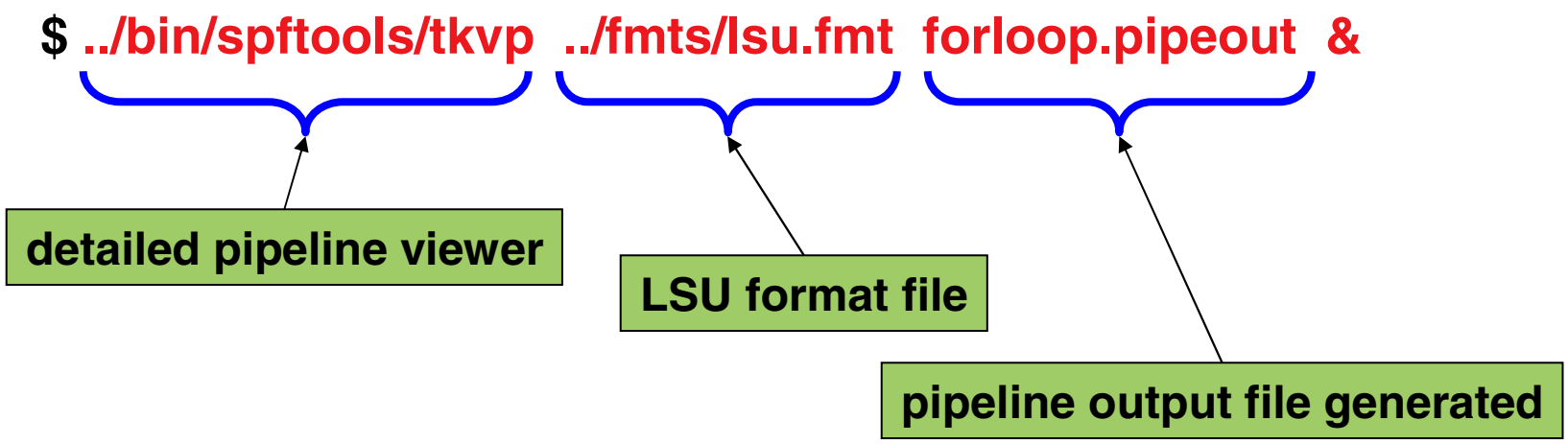
issue queues

execution units

completion queue

writeback (retiring insts)

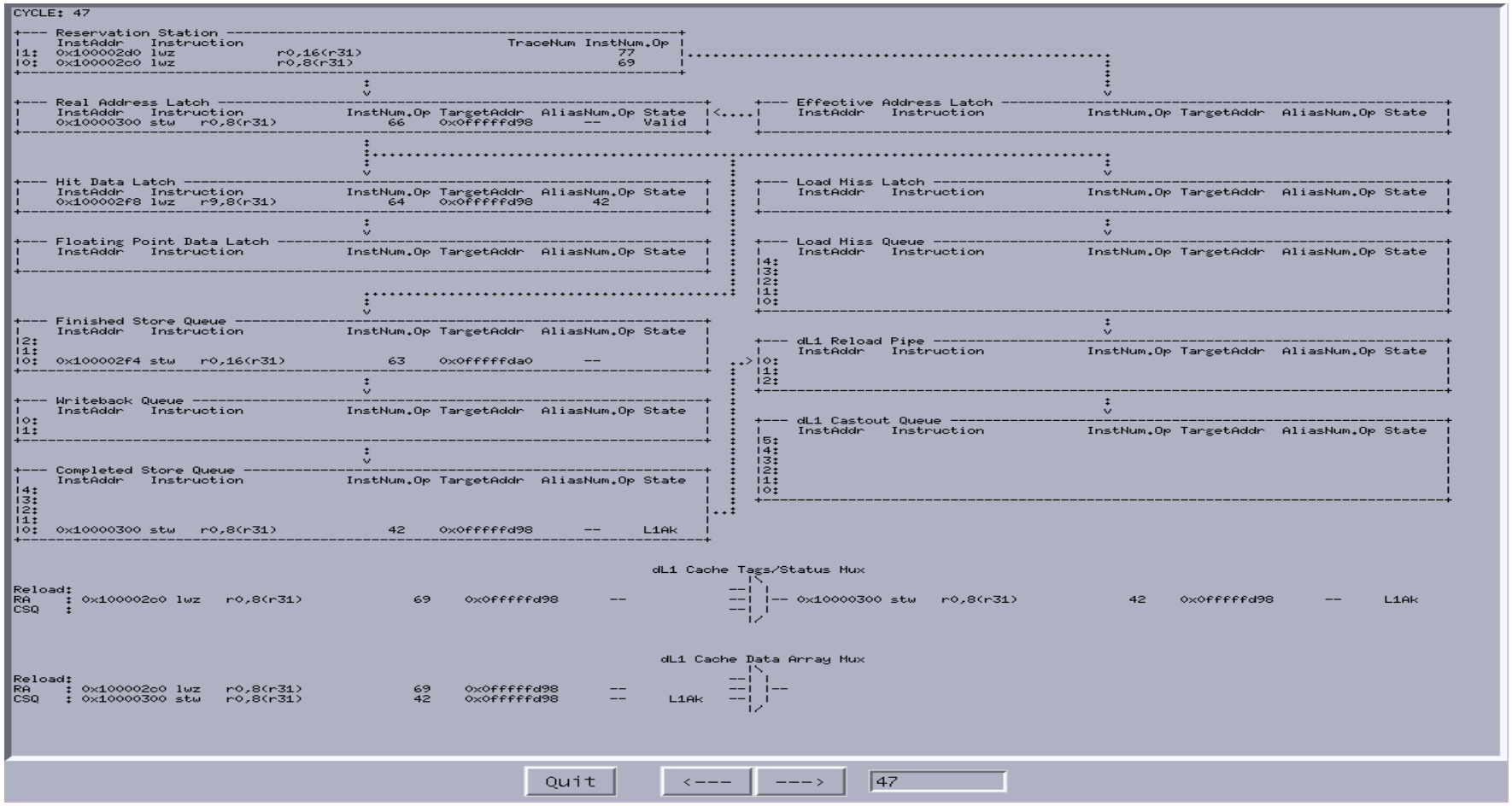
Detailed Pipeline Viewer: LSU (1/2)




```
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ ../bin/spftools/tkvp ../fmts/lsu.fmt forloop.pipeout &
[1] 2364
guest@debian:~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ Reading pipeline file `forloop.pipeout' opened via `<forloop.pipeo
ut'...
Reading SPF 2.x file
Updating data values...
File read complete.
```

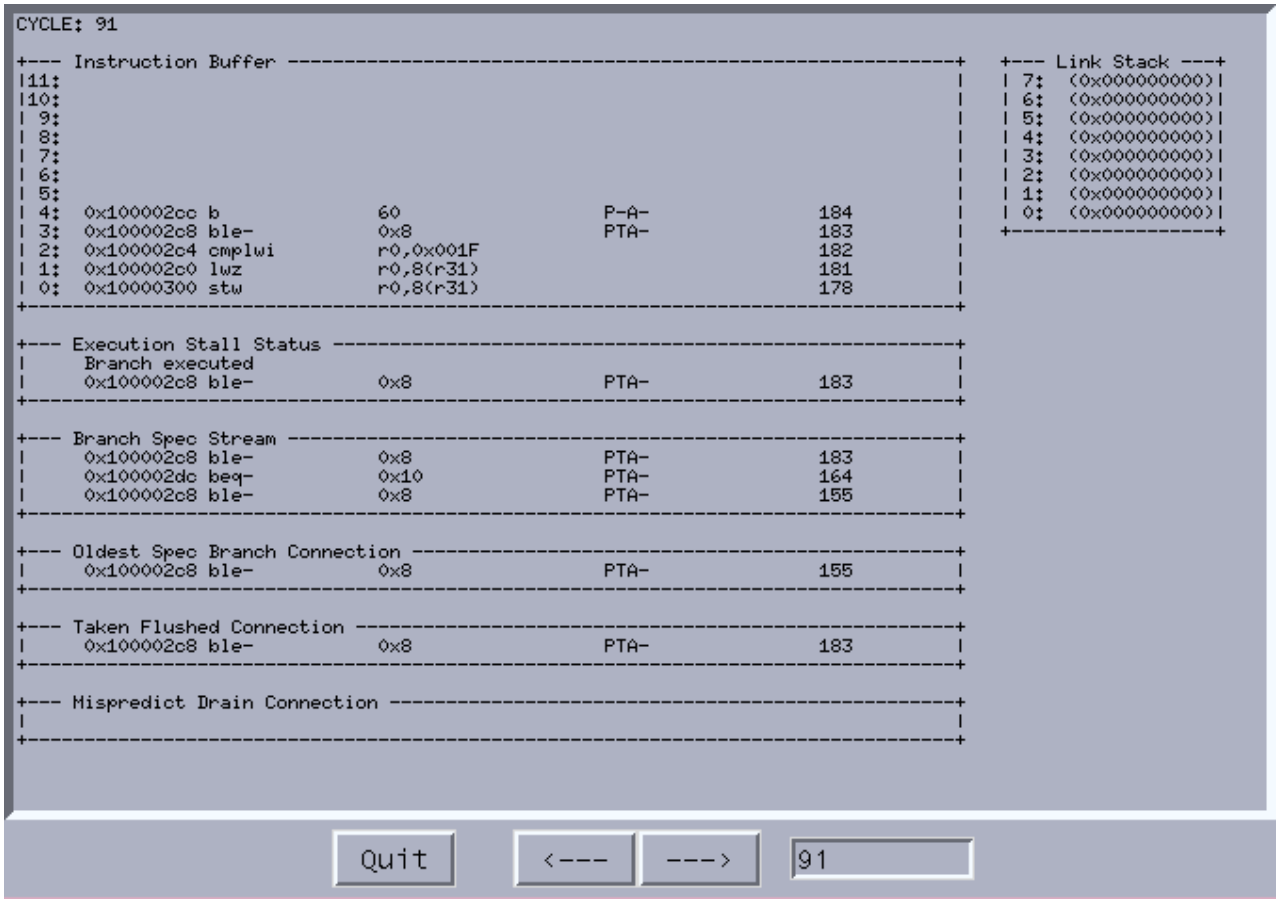
Detailed Pipeline Viewer: LSU (2/2)

$ ../bin/spftools/tkvp ../fmts/lsu.fmt forloop.pipeout &



Detailed Pipeline Viewer: BPU

$ ../bin/spftools/tkvp ../fmts/bpu.fmt forloop.pipeout &



Review of Commands

Preparation

$ which sim_G4plus
$ cd ~/fae-training-04/sim_G4plus_v0_7_1_linux_ppc/examples
$ less runexample_accel_exemode.sh
$ less forloop_lptrace.c

1. Compile source code

$ gcc -o forloop_lptrace forloop_lptrace.c -static
$ file forloop_lptrace

2. Run simulator

$ sim_G4plus -a -p forloop.pipeout forloop_lptrace > forloop.stats
$ less forloop.stats

3. View pipeline

$ sim_G4plus_vp -h
$ sim_G4plus_vp forloop.pipeout &
$ ../bin/spftools/tkvp ../fmts/lsu.fmt forloop.pipeout &
$ ../bin/spftools/tkvp ../fmts/bpu.fmt forloop.pipeout &

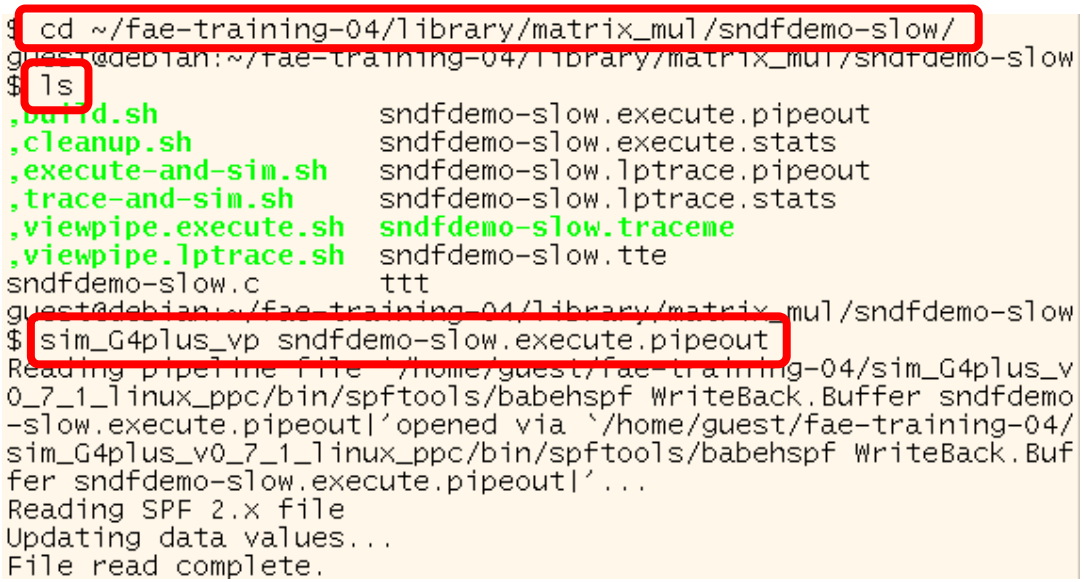
Analysis Example

View Pipeline

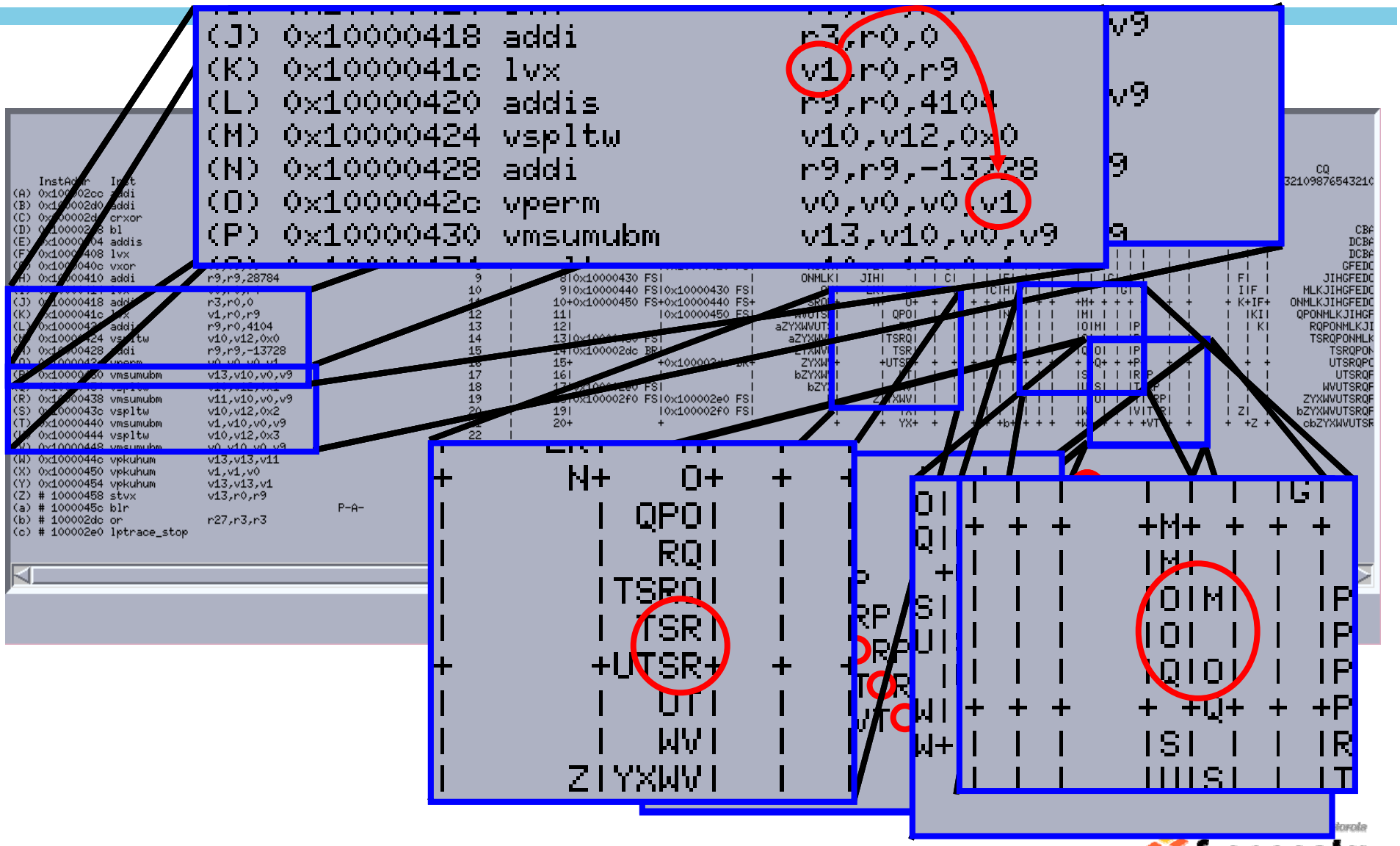
$ cd ~/fae-training-04/library/matrix_mul/sndfdemo-slow/

$ ls

$ sim_G4plus_vp sndfdemo-slow.execute.pipeout



Pipeline to Analyze



Analysis

1. There is a bubble in the VIU2 pipeline between R and T
2. T waits in the VIU2 reservation station 1 extra cycle
3. T depends on the result in register v10 from S
4. S is delayed from entering VPU reservation station because it is blocked in VIQ by R
5. R is held in VIQ for 1 extra cycle because the VIU2 reservation station is blocked by P
6. P depends on the result in register v0 from O
7. O stalls in VPU reservation station because it depends on v1 from K

Conclusion: If we can insert instructions between K and O, then O will not stall waiting for K