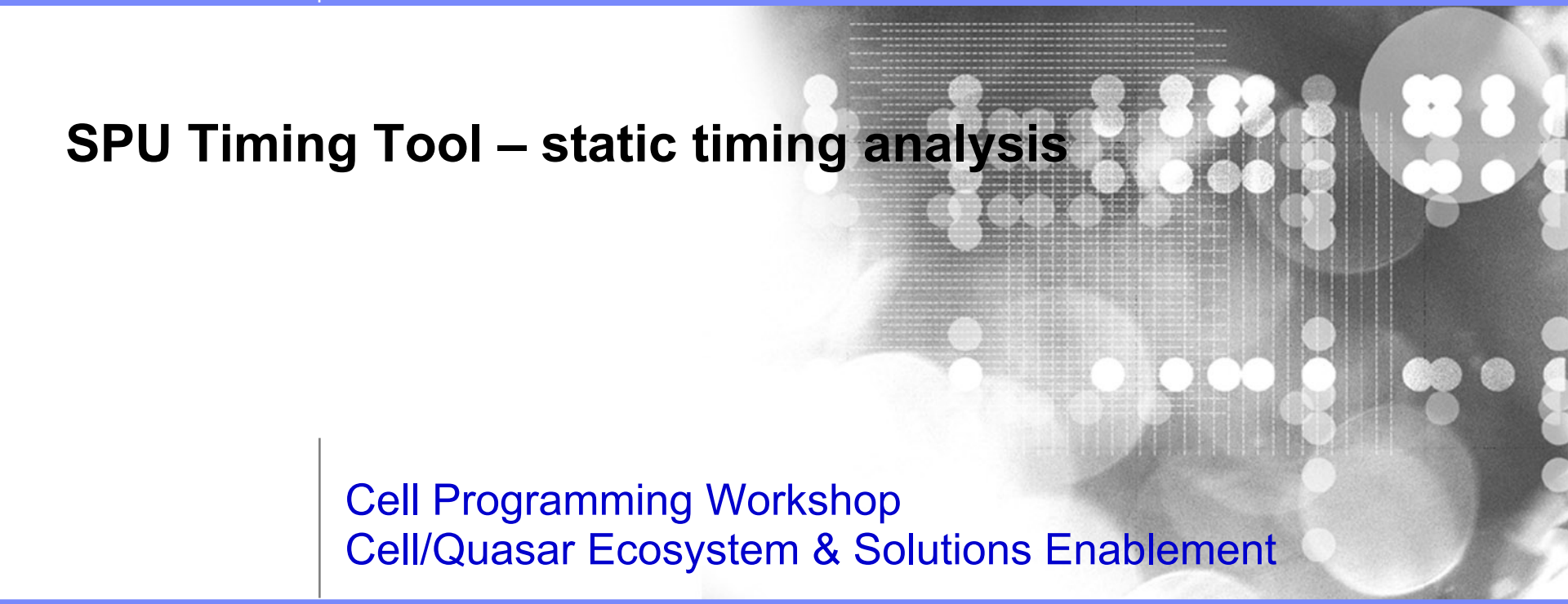


SPU Timing Tool – static timing analysis

Cell Programming Workshop
Cell/Quasar Ecosystem & Solutions Enablement

Class Objectives

- Learn how to use the static spu timing tool and analysis

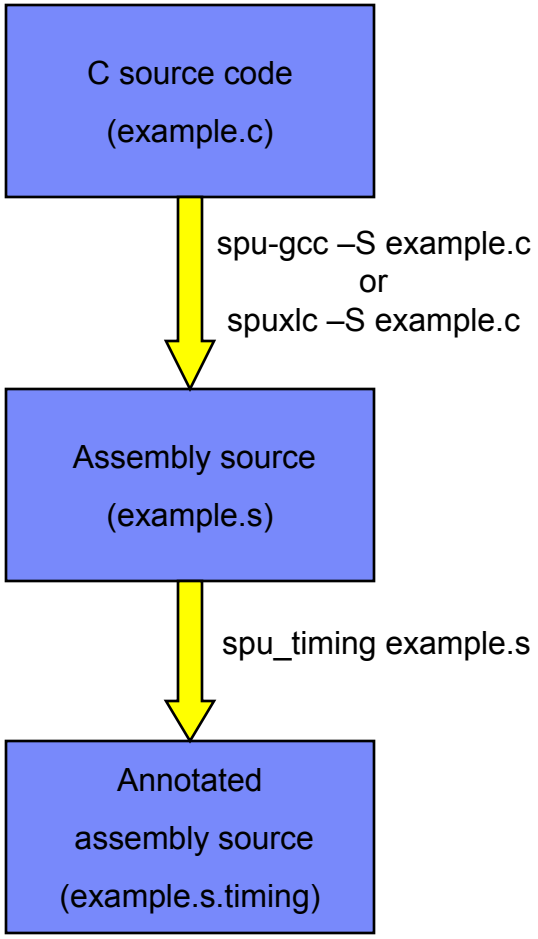
Class Agenda

- **What is the SPU timing tool?**
  - Features
  - Syntax
- **Sample output**
  - Interpreting the output
- **Useful Techniques**
  - Profile markers for locating code sections of interest
- **Functional Limitations**

- **References:**
  - Dan Brokenshire, Quasar Design Center

What is the SPU timing tool

- **Annotates an assembly source file with static analysis of instruction timing assuming linear (branchless) execution.**
  - Simplified pipeline model
  - Does not account for:
    - instruction fetch stalls
    - local store contention
    - branching
  - Supports Cell SDK 2.0 SPU models



Invocation Syntax

spu_timing [options …] [input_file]

- **options:**

  --help displays a verbose help screen.

  -march=<cpu> specifies the target architecture. <cpu> is either *cell* or *cell_edp*

  -o <file> specifies the output file. Default is <input_file>.*timing* or stdout if no input file is specified.

  -running-count include column of running cycles counts for start of each instruction.

- **<input_file> specifies the assembly input file. If not specified, *spu_timing* sources its input from stdin.**

Sample - C source (example.c)

```
#include <spu_intrinsics.h>

// Compute y = alpha * x + y, where alpha is a scalar and x
and
// y are 4*n element vectors.

void saxpy(int n, float alpha, vec_float4 x[], vec_float4 y[])
{
  int i;
  vec_float4 a;

  a = spu_splats(alpha);

  for (i=0; i<n; i++) {
    y[i] = spu_madd(a, x[i], y[i]);
  }
}
```

Sample - assembly source (example.s)

```
            .file     "example.c"
.text
            .align    3
            .global   saxpy
            .type     saxpy, @function
saxpy:
            ila       $2,66051
            shlqbyi   $7,$3,0
            cgti      $3,$3,0
            shufb     $8,$4,$4,$2
            nop       $127
            biz       $3,$lr
            ori       $4,$7,0
            hbra      .L8,.L4
            il        $7,0
            lnop
.L4:
            ai        $4,$4,-1
            lqx       $2,$7,$5
            lqx       $3,$7,$6
            fma       $2,$8,$2,$3
            stqx      $2,$7,$6
            ai        $7,$7,16
.L8:
            brnz      $4,.L4
            bi        $lr
```

Sample – annotated source (example.s.timing)

```
000000 0D 01
000000 1D 0123
000001 0d  12
000002 1d  -2345
000003 0D    3
000003 1D    3456
000004 0D     45
000004 1D     456789
000005 0D      56
000005 1D      5

000006 0d       67
000007 1d       -789012
000008 1          890123
000014 0           -----456789
000020 1                -----012345

000022 1                      2345
000023 1                       3456
```

```
                .file     "example.c"
.text
                .align    3
                .global   saxpy
                .type     saxpy, @function
saxpy:
                ila       $2,66051
                shlqbyi   $7,$3,0
                cgti      $3,$3,0
                shufb     $8,$4,$4,$2
                nop       $127
                biz       $3,$lr
                ori       $4,$7,0
                hbra      .L8,.L4
                il        $7,0
                lnop
.L4:
                ai        $4,$4,-1
                lqx       $2,$7,$5
                lqx       $3,$7,$6
                fma       $2,$8,$2,$3
                stqx      $2,$7,$6
.L8:
                brnz      $4,.L4
                bi        $lr
```

Sample – annotated source (example.s.timing)

running-count – cycle count for which each instruction starts. Useful for determining the cycles in a loop. For example, our loop is 17 cycles (23-6).

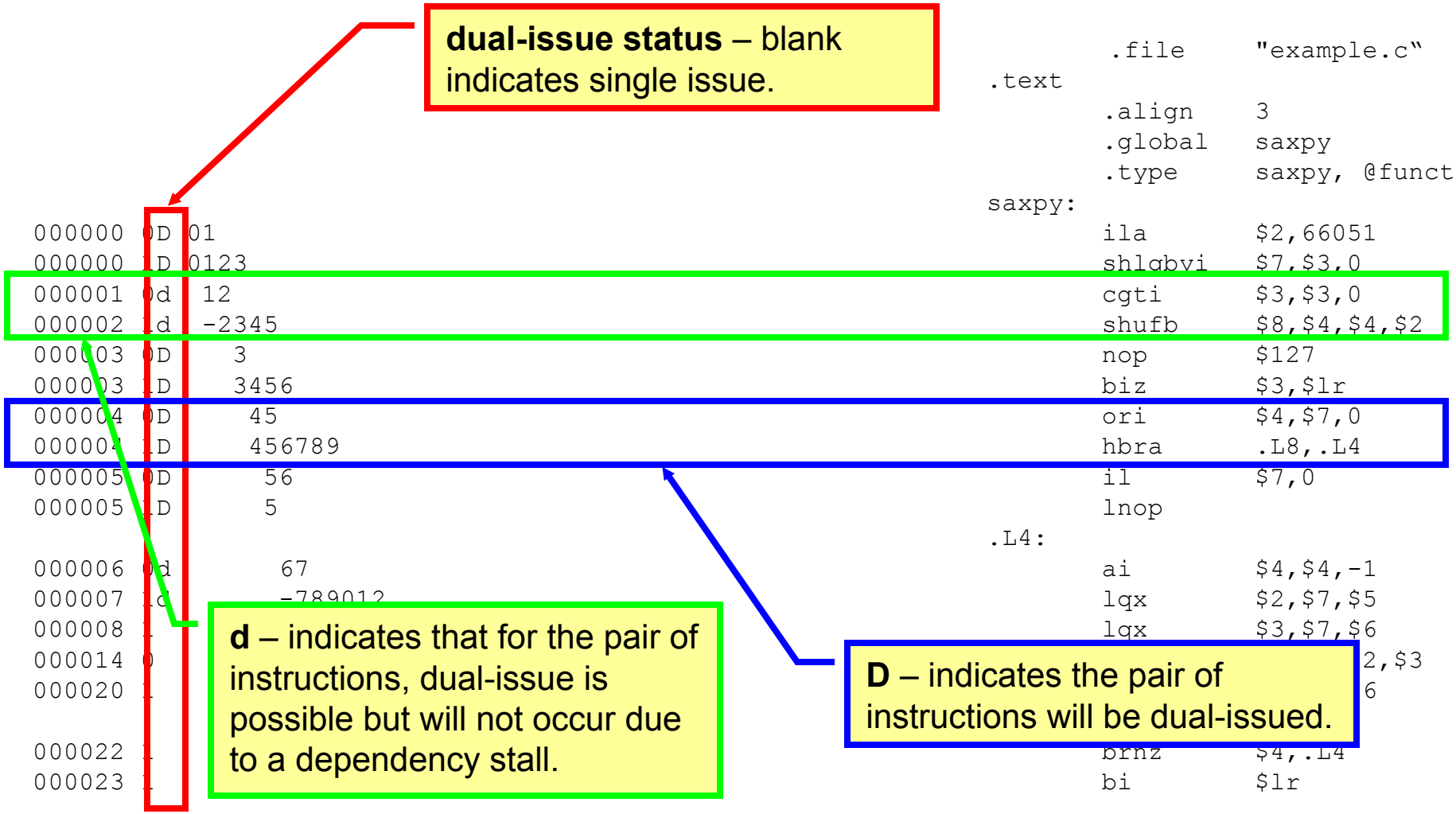
```
000000 0D 01                                        .file     "example.c"
000000 1D 0123                                      .text
000001 0d  12                                               .align    3
000002 1d  -2345                                            .global   saxpy
000003 0D    3                                              .type     saxpy, @function
000003 1D    3456                                   saxpy:
000004 0D     45                                            ila       $2,66051
000004 1D     456789                                        shlqbyi   $7,$3,0
000005 0D      56                                           cgti      $3,$3,0
000005 1D      5                                            shufb     $8,$4,$4,$2
                                                            nop       $127
000006 0d       67                                          biz       $3,$lr
000007 1d       -789012                                     ori       $4,$7,0
000008 1          890123                                    hbra      .L8,.L4
000014 0           -----456789                              il        $7,0
000020 1                -----012345                         lnop
                                                    .L4:
000022 1                      2345                          ai        $4,$4,-1
000023 1                       3456                         lqx       $2,$7,$5
                                                            lqx       $3,$7,$6
                                                            fma       $2,$8,$2,$3
                                                            stqx      $2,$7,$6
                                                    .L8:
                                                            brnz      $4,.L4
                                                            bi        $lr
```

Sample – annotated source (example.s.timing)

Execution pipeline – the pipeline in which the instruction is issued. Either 0 (even pipeline) or 1 (odd pipeline).

```
000000 00 01                                .file   "example.c"
000000 10 0123                      .text
000000 10                                   .align  3
000000 10                                   .global saxpy
000000 10                                   .type   saxpy, @function
000000 10                           saxpy:
000000 10                                   ila     $2,66051
000000 10                                   shlqbyi $7,$3,0
000000 10                                   cgti    $3,$3,0
000000 10                                   shufb   $8,$4,$4,$2
000000 10                                   nop     $127
000000 10                                   biz     $3,$lr
000000 10                                   ori     $4,$7,0
000000 10                                   hbra    .L8,.L4
000000 10                                   il      $7,0
000000 10                                   lnop
000000 10                           .L4:
000000 10                                   ai      $4,$4,-1
000000 10                                   lqx     $2,$7,$5
000000 10                                   lqx     $3,$7,$6
000000 10                                   fma     $2,$8,$2,$3
000000 10                                   stqx    $2,$7,$6
000000 10                           .L8:
000000 10                                   brnz    $4,.L4
000000 10                                   bi      $lr
```

Sample – annotated source (example.s.timing)



Sample – annotated source (example.s.timing)

```
000000 0D 01
000000 1D 0123
000001 0d  12
000002 1d  -2345
000003 0D    3
000003 1D    3456
000004 0D     45
000004 1D     456789
000005 0D      56
000005 1D      5

000006 0d       67
000007 1d       -789012
000008 1          890123
000014 0           -----456789
000020 1                -----012345

000022 1                      2345
000023 1                       3456
```

```
mple.c"


y
y, @function

6051
3,0
3,0
4,$4,$2

lr
7,0
.L4


4,-1
7,$5
7,$6
ima       $2,$8,$2,$3
stqx      $2,$7,$6
.L8:
brnz      $4,.L4
bi        $lr
```

Instruction clock cycle occupancy – A digit (0-9) is displayed for every clock cycle the instruction executes. Operand dependency stalls are flagged by a dash (“**-**”) for every clock cycle the instruction is expect to stall.

Steeply sloping cascading numbers signify good scheduling.

Shallow sloping (horizontal) numbers signify poor scheduling.

Sample – annotated source (example.s.timing)

Inner Loop – contains lots of dependency stalls.

The load of **y** stalls 1 cycle for address increment. The **fma** stalls 5 cycles waiting for the load to complete. The store of the resulting **y** stalls 5 cycles waiting for the fma to complete.

Dependency stalls could be eliminated by unrolling the loop. Loop unrolling could also result in moderate dual issue because the instruction mix is 1/3 pipe 0 and 2/3 pipe 1.

```
                                                                                    "example.c"

                                                                                    3
                                                                                    saxpy
                                                                                    saxpy, @function

000000 0D 01                                                                        $2,66051
000000 1D 0123                                                                      $7,$3,0
000001 0d  12                                                                       $3,$3,0
000002 1d  -2345                                                                    $8,$4,$4,$2
000003 0D    3                                                                      $127
000003 1D    3456                                                                   $3,$lr
000004 0D     45                                                                    $4,$7,0
000004 1D     456789                                                    nbra        .L8,.L4
000005 0D      56                                                       il          $7,0
000005 1D      5                                                        lnop
                                                                  .L4:
000006 0d       67                                                      ai          $4,$4,-1
000007 1d       -789012                                                 lqx         $2,$7,$5
000008 1          890123                                                lqx         $3,$7,$6
000014 0           -----456789                                          fma         $2,$8,$2,$3
000020 1                 -----012345                                    stqx        $2,$7,$6
                                                                  .L8:
000022 1                          2345                                  brnz        $4,.L4
000023 1                           3456                                 bi          $lr
```

Useful Technique – profile markers

- **For complex source code, insert profile checkpoint markers to locate specific code sections.**
  - #include <profile.h>
  - place prof_cp#() function in desired locations.
  - use unique # for improved identification.
  - prof_cp# results in "and $#, $#, $#" instructions, where # is 0 – 31.
  - When using spuxlc, the profile checkpoints are coded as mc_funcs. Therefore, to locate them, search for a ".word 0x########", where ######## corresponds to the encode and instruction.

Useful Technique – profile markers

```
#include <spu_intrinsics.h>
#include <profile.h>

// Compute y = alpha * x + y, where
alpha is a
// scalar and x and y are 4*n element
vectors.

void saxpy(int n, float alpha,
vec_float4 x[], vec_float4 y[])
{
  int i;
  vec_float4 a;

  a = spu_splats(alpha);

  prof_cp1();
  for (i=0; i<n; i++) {
    y[i] = spu_madd(a, x[i], y[i]);
  }
  prof_cp2();
}
```

```
        .align  3
        .global saxpy
        .type   saxpy, @function
saxpy:
        ila     $2,66051
        shlqbyi $7,$3,0
        and     $1,$1,$1; lnop
        cgti    $3,$3,0
        shufb   $8,$4,$4,$2
        nop     $127
        biz     $3,$lr
        ori     $4,$7,0
        hbra    .L8,.L4
        il      $7,0
        lnop
.L4:
        ai      $4,$4,-1
        lqx     $2,$7,$5
        lqx     $3,$7,$6
        fma     $2,$8,$2,$3
        stqx    $2,$7,$6
        ai      $7,$7,16
.L8:
        brnz    $4,.L4
        and     $2,$2,$2; lnop
        bi      $lr
```

Functional Limitations

- **Does not support multiple assembly instructions per line.**
- **Does not support generalized expressions. An expression will terminate the assembly parser.**
- **Does not support symbols and symbol substitution. Can terminate the assembly parser.**
- **Does not support completely the .repeat assembler directive.**

Works OK with compiled assembly, but often doesn't work for hand written assembly.

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IBM Microelectronics Division
1580 Route 52, Bldg. 504
Hopewell Junction, NY 12533-6351

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