Systems Programming

Computer arithmetic

Memory & caches; Debugging discussion

Rust and Go, Sergio

Veronica, Quinn Dunki

To Linux and beyond

Goals

Performance counters

Raspberry Pi (BCM2835) cache

Pointer chasing

- hits and misses

Special panel: Debugging

code/bench

Performance Counters

§3.2.51 in arm1176

http://sandsoftwaresound.net/raspberry-pi/raspberry-pi-gen-1/memory-hierarchy/

31 28	27 20	19 12	11	10	9	8	7	6	5	4	3	2	1	0
SBZ/UNP	EvtCount0	EvtCount1	X	CCR	CR1	CR0	SBZ	ECC	EC1	EC0	D	C	P	E

```
#define ARMV6_EVENT_ICACHE_MISS             0x00
#define ARMV6_EVENT_ISTALL                  0x01
#define ARMV6_EVENT_DATA_DEPENDENT_STALL    0x02
#define ARMV6_EVENT_IMICROTLB_MISS          0x03
#define ARMV6_EVENT_DMICROTLB_MISS          0x04
#define ARMV6_EVENT_BRANCH_EXECUTED         0x05
#define ARMV6_EVENT_BRANCH_MISPREDICT       0x06
#define ARMV6_EVENT_INSTRUCTION_EXECUTED    0x07
#define ARMV6_EVENT_DCACHE_CACHED_ACCESS    0x09
#define ARMV6_EVENT_DCACHE_ACCESS           0x0A
#define ARMV6_EVENT_DCACHE_MISS             0x0B
#define ARMV6_EVENT_DCACHE_WRITEBACK        0x0C
#define ARMV6_EVENT_SOFTWARE_PC_CHANGE      0x0D
#define ARMV6_EVENT_MAIN_TLB_MISS           0x0F
#define ARMV6_EVENT_EXTERNAL_DACCESS        0x10
#define ARMV6_EVENT_LSU_FULL_STALL          0x11
#define ARMV6_EVENT_WRITEBUFFER_DRAINED_DSB 0x12
#define ARMV6_EVENT_NOP                     0x20
#define ARMV6_EVENT_CPU_CYCLES              0xFF
```

ARM Caches

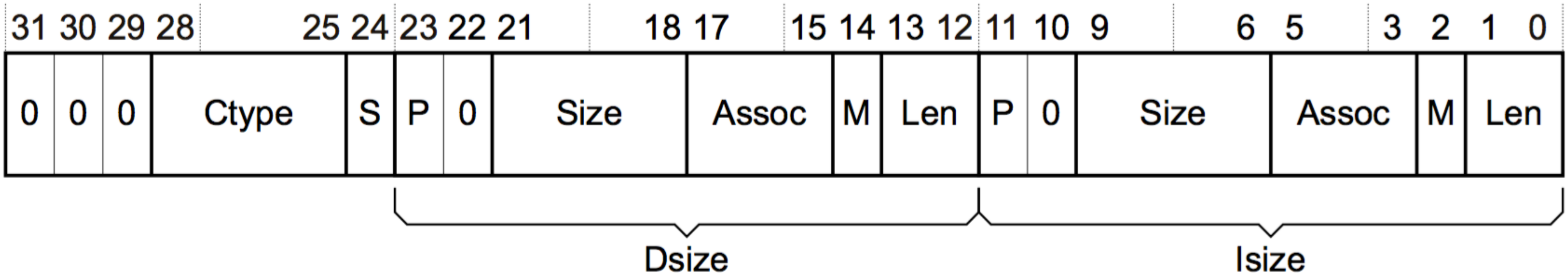
code/cache

Chapter B6: Caches and Write Buffers

armv7 arm

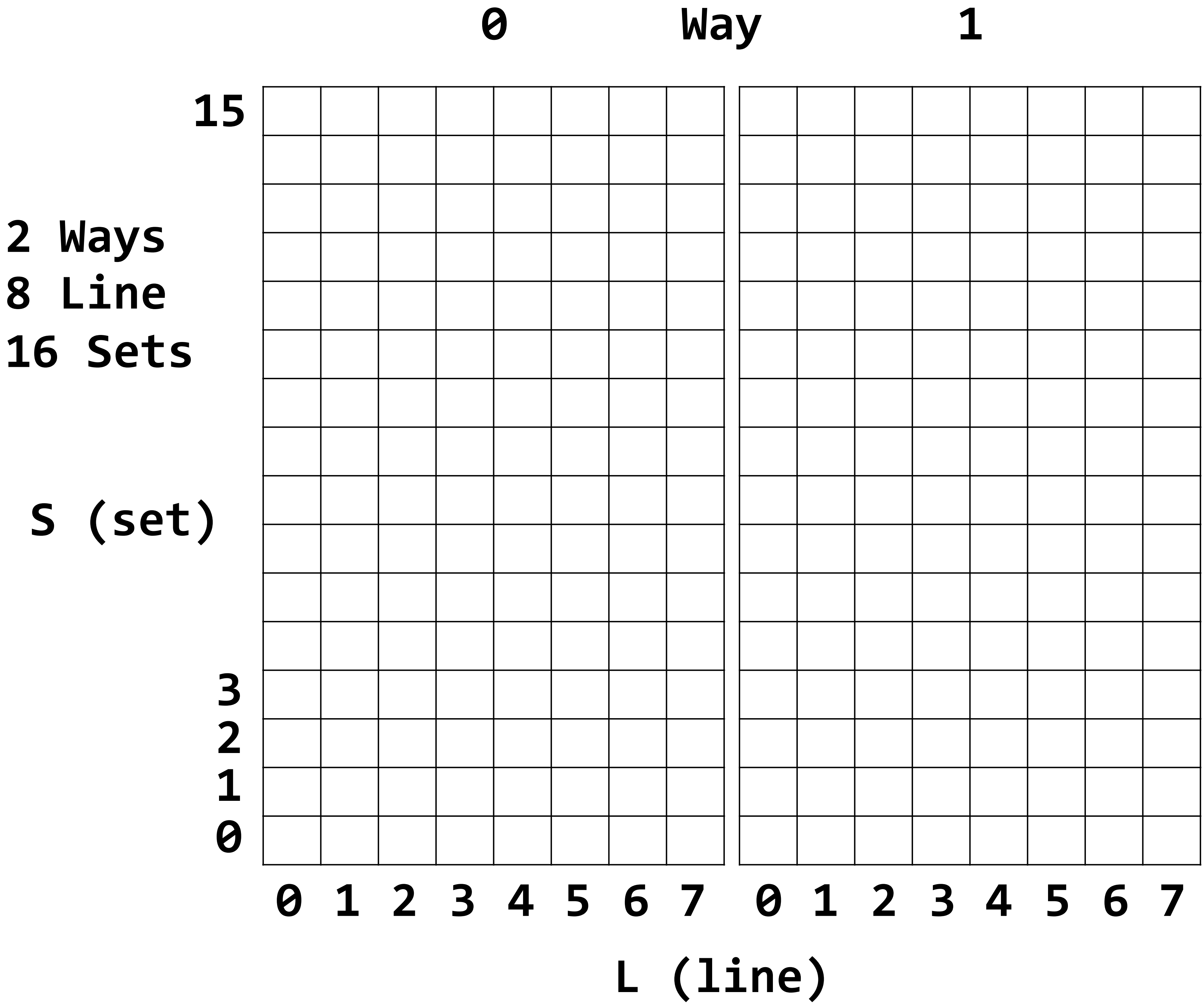
Cache Type Register

```
unsigned system_get_cache_type(void)
{
  unsigned reg;
  __asm__ volatile("mrc   p15, 0, %0, c0, c0, 1" : "=r"(reg));
  return reg;
}
```

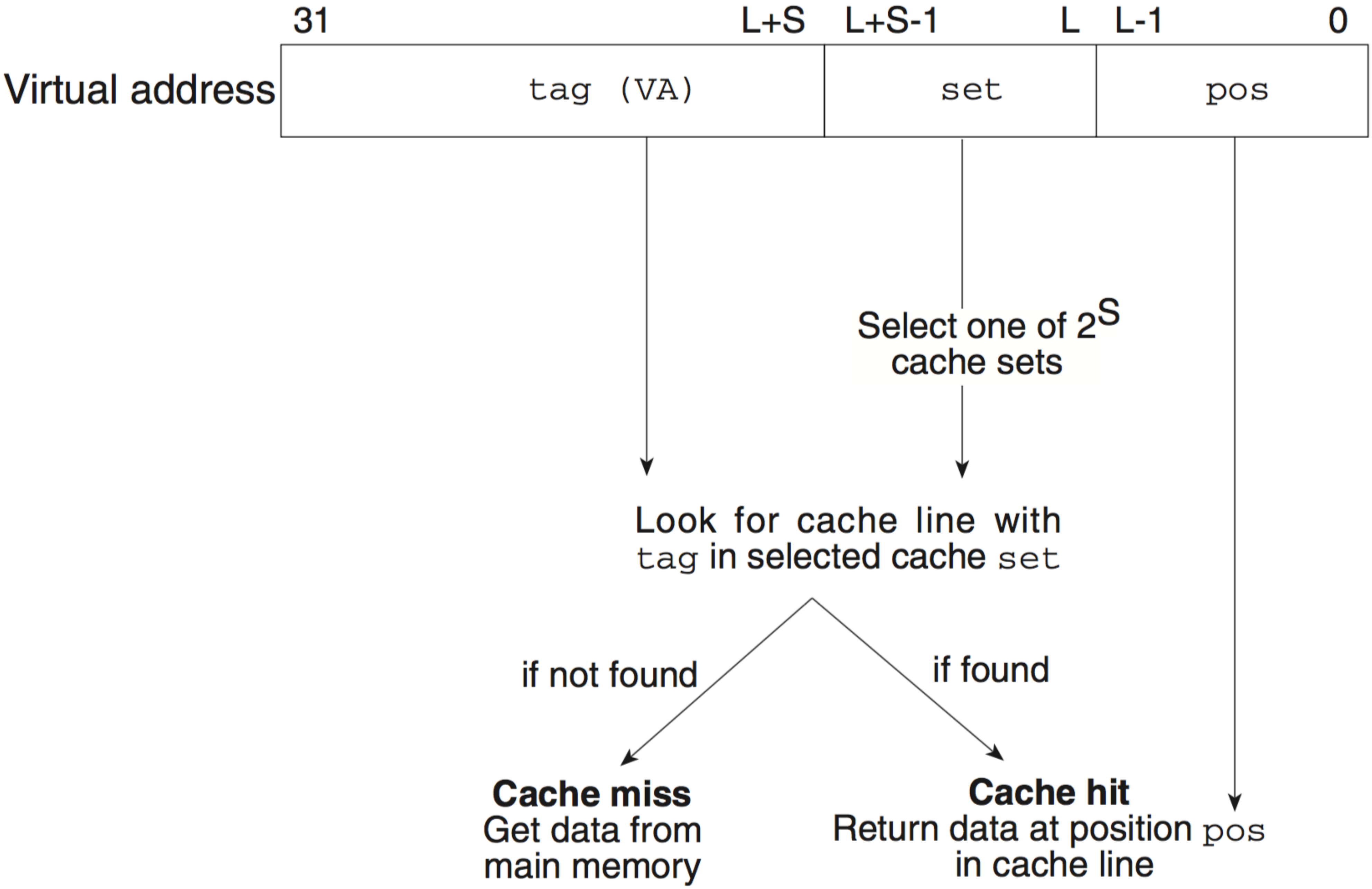


31	30	29	28 25	24	23	22	21 18	17 15	14	13 12	11	10	9 6	5 3	2	1 0
0	0	0	Ctype	S	P	0	Size	Assoc	M	Len	P	0	Size	Assoc	M	Len

§3.2.3 arm1176



2 Ways
8 Line
16 Sets


31
L+S
L+S-1
L
L-1
0
Virtual address
tag (VA)
set
pos
Select one of 2^S cache sets
Look for cache line with tag in selected cache set
if not found
if found
Cache miss
Get data from main memory
Cache hit
Return data at position pos in cache line

Cache Example

cacheaddr.py

Cache vs Memory

code/chase

Raspberry Pi specification

L1 cache access: 3 cycles

RAM access: 56 cycles (no TLB miss)

RAM access: 116 cycles (main TLB miss)

Debugging

Debugging discussion (due Mon)

Send me email with the answers to the following questions. Think of a memorable bug you encountered this quarter.

1. What was the bug?
2. What were the symptoms?
3. How did you figure out what the problem was?
4. How did you fix it?
5. What lessons did you learn from this experience?

Send the answers to hanrahan@cs.stanford.edu by 12 noon on Mon.

Note takers

- different kinds of errors
- methods to prevent errors
- approaches to testing
- techniques used to find bugs
- lessons learned

From: Kevin
Subject: libpi gl_draw_char not printing character to the screen

I'm trying to test the libpi gl_draw_char using the following code

```
  gl_init(500, 500, GL_DOUBLEBUFFER);
  gl_clear(GL_BLACK);
  gl_swap_buffer();
  gl_draw_char(10, 10, 'c', GL_WHITE);
  gl_swap_buffer();
```

and the character is not printing to the screen. I just see a bunch of scattered white dots across the screen.

Am I doing anything wrong? I'm referencing the Libpi one by not referenceing gl.h and by calling in extern functions like this

```
extern void gl_draw_char(int x, int y, char letter, color c);
```

Back to code/fb.c …

Fix to libpi/src/fb.c and gl.c

- More functions in fb.c
- fb_get_back_buffer
- fb_get_front_buffer
- gl_clear
- gl_draw_char