Qualcomm TECHNOLOGIES, INC

HEXAGON™

Hands-on Hexagon Toolchain Training

80-VB419-42 N

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Structures, padding and alignment – Example1

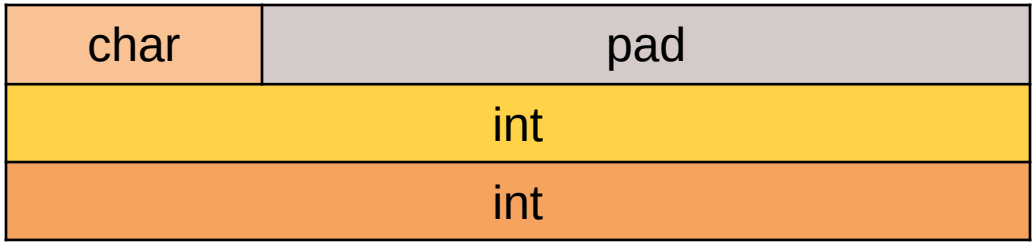
```
// this structure will have 4 byte alignment
// because it's largest value is int
struct unpacked_struct
{
     char a;
     int i1;
     int i2;
};

// declare and initialize the unpacked struct
struct unpacked_struct my_unpacked_struct = { 'a', 0x11, 0x22 };

// this structure will have 1 byte alignment
// because it is packed
struct packed_struct
{
     char a;
     int i1;
     int i2;

} __attribute__ ((__packed__));

// declare and initialize the packed struct
struct packed_struct my_packed_struct = { 'b', 0x33, 0x44 };
```

Structures, padding and alignment

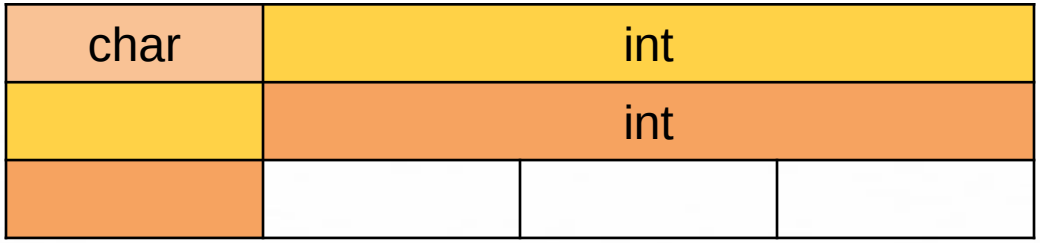
- `hexagon-readelf -s main | grep packed`

```
 462: 0000d430     9 OBJECT  GLOBAL DEFAULT    7 my_packed_struct
 501: 0000d424    12 OBJECT  GLOBAL DEFAULT    7 my_unpacked_struct
```

- my_unpakced_struct



- my_packed_struct



Structures, padding and alignment

```
>hexagon-llvm-objdump -d main.o

main.o: file format ELF32-hexagon

Disassembly of section .text:
.text:
main:
       0:       00 40 00 00 00004000 { immext(#0)
       4:       10 3c 00 68 68003c10   r0 = ##0; allocframe(#8) }
       8:       00 40 00 5a 5a004000 { call 0x20
       c:       00 40 00 00 00004000   immext(#0)
      10:       42 40 80 49 49804042   r2 = memw(##2)
      14:       00 d2 bd a1 a1bdd200   memw(r29 + #0) = r2.new }
      18:       00 40 00 00 00004000 { immext(#0)
      1c:       a2 40 00 78 780040a2   r2 = ##5
      20:       00 40 00 00 00004000   immext(#0)
      24:       00 c0 00 78 7800c000   r0 = ##0 }
      28:       24 11 23 10 10231124 { r3 = memub(r2 + #0); r4 = memub(r2 + #1) }
      2c:       c3 48 44 8e 8e4448c3 { r3 |= asl(r4, #8)
      30:       22 12 25 13 13251222   r5 = memub(r2 + #3); r2 = memub(r2 + #2) }
      34:       c2 c8 45 8e 8e45c8c2 { r2 |= asl(r5, #8) }
      38:       c3 50 42 8e 8e4250c3 { r3 |= asl(r2, #16)
      3c:       00 40 00 5a 5a004000   call 0x38
      40:       00 d4 bd a1 a1bdd400   memw(r29 + #0) = r3.new }
      44:       40 3f 00 48 48003f40 { r0 = #0; dealloc_return }
```

Structures, padding and alignment – Example2

```
struct unpacked_struct
{
   char a;
   int i1;
   int i2;
};

struct packed_struct
{
   int i;
   char c;
   struct unpacked_struct s;
} __attribute__ ((__packed__));
struct packed_struct my_packed_struct = {0x33, 'a', 'b', 0x55, 0x66 };

// create a pointer to the packed structure
struct packed_struct *ptr_to_packed = &my_packed_struct;
// create a pointer to the unpacked structure
struct unpacked_struct *ptr_to_unpacked = &my_packed_struct.s;

int main(int argc, char **argv)
{
   printf("\nVariable i2 = %x\n", ptr_to_packed->s.i2);
   printf("\nVariable i2 = %x\n", ptr_to_unpacked->i2);
   return 0;
}
```

Structures, padding and alignment – Example2

```
hexagon-sim -mv5 main
Hexagon-sim INFO: the rev_id used in the simulation is 0x00002105 (v5A)

Variable i2 = 0x66
CRASH from thread 0!
I think the exception was: 0x20, Misaligned Load @ 0xd431

Register Dump (r0 clobbered, pc subject to prior action by the exception handler):
r00=000000cd r01=00000001 r02=0000d429 r03=00000000
r04=00000000 r05=00000000 r06=00000000 r07=00000000
r08=0000ffff r09=00000000 r10=fffffffe r11=ffffffff
r12=00000004 r13=00000000 r14=0000e339 r15=ffff1cc8
r16=0000b200 r17=00000001 r18=babebeef r19=babebeef
r20=babebeef r21=babebeef r22=babebeef r23=babebeef
r24=babebeef r25=babebeef r26=babebeef r27=babebeef
r28=000053a0 r29=0410e2c0 r30=0410e2c8 r31=000050f0
sa0=00008a34 lc0=7fffffff sa1=00000000 lc1=00000000
p30=ff00ffff  m0=00000000  m1=00000000 usr=00010000
 pc=00000954 ugp=00000000  gp=00000000 elr=00005100
badva0=0000d90c badva1=0000d431
ssr=80740020 ccr=00130000 tid=00000000 imask=00000000
evb=00005000 modectl=00000001 syscfg=0083a07f ipend=00000000
```

Hexagon-lldb – Example2

```
>hexagon-lldb.cmd main
Current executable set to 'main' (hexagon).
Hexagon utilities (run, start, pagetable, tlb, pv) loaded
(lldb) start
Hexagon-sim INFO: the rev_id used in the simulation is 0x00002105 (v5A)
hexagon-sim WARNING: StartGDBserver:Setting up GDB server on port 33099
Process 1 stopped
(lldb) Breakpoint 1: where = main`main + 4 at main.c:41, address = 0x000050c4
Process 1 stopped
* thread #1: tid = 0x0001, 0x000050c4 main`main(argc=1, argv=0x0000f740) + 4 at
main.c:41, stop reason = breakpoint 1.1
    frame #0: 0x000050c4 main`main(argc=1, argv=0x0000f740) + 4 at main.c:41
   38
   39   int main(int argc, char **argv)
   40   {
-> 41           printf("\nVariable i2 = 0x%x\n", ptr_to_packed->s.i2);
   42
   43           printf("\nVariable i2 = 0x%x\n", ptr_to_unpacked->i2);
   44
(lldb)
```

Hexagon-lldb – Example2

```
(lldb) b *0x5104
Breakpoint 2: where = main`main + 68 at main.c:43, address = 0x00005104
(lldb) c
Process 1 resuming
(lldb)
Variable i2 = 0x66
Process 1 stopped
* thread #1: tid = 0x0001, 0x00005104 main`main(argc=<unavailable>, argv=<unavailable>)
+ 68 at main.c:43, stop reason = breakpoint 2.1
    frame #0: 0x00005104 main`main(argc=<unavailable>, argv=<unavailable>) + 68 at
main.c:43
   40   {
   41           printf("\nVariable i2 = 0x%x\n", ptr_to_packed->s.i2);
   42
-> 43           printf("\nVariable i2 = 0x%x\n", ptr_to_unpacked->i2);
   44
   45           return 0;
   46   }
```

Hexagon-lldb – Example2

```
(lldb) re r
Thread Registers:
       r00 = 0x0000c000  main`
       r01 = 0x00000001  main`_start + 1
       r02 = 0x0000d429  my_packed_struct + 5
       r03 = 0x00000000  main`_start

(lldb) disassemble -s 0x5104
main`main + 68 at main.c:43:
-> 0x5104:  {      call 21040                ; printf
   0x5108:  r2     = memw(r2 + #8)
   0x510c:  memw(r29 + #0) = r2.new }
   0x5110:  {      r0 = #0; dealloc_return }
```

R2 = 0xd429

R2 + 8 = 0xd431

R2 = memw(0xd431) will cause a misaligned load exception

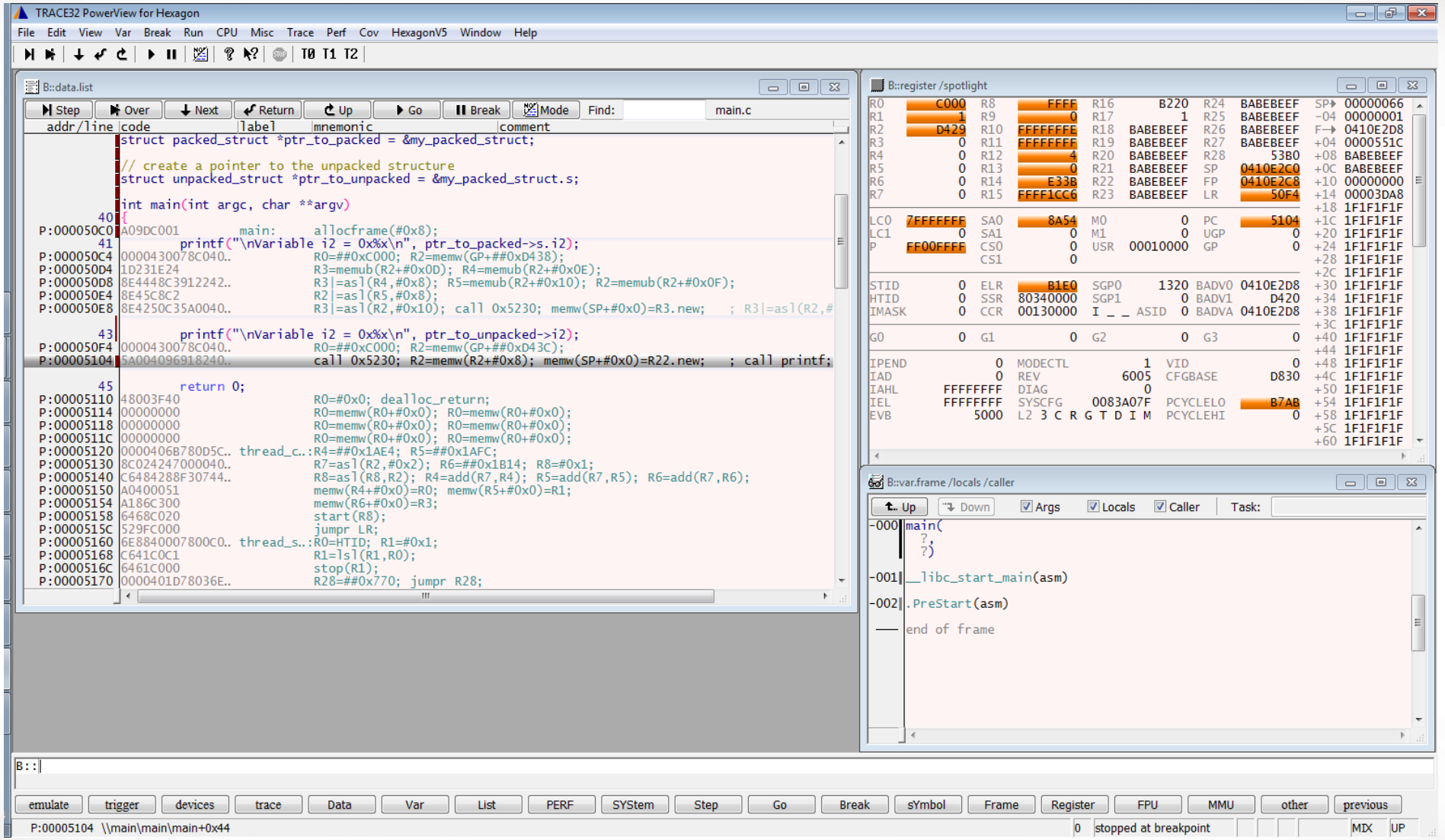
Hexagon-lldb – Example2

```
(lldb) s
Process 1 stopped
* thread #1: tid = 0x0001, 0x00005008 main`.EventVectors + 8, stop reason = step in
    frame #0: 0x00005008 main`.EventVectors + 8
main`.EventVectors + 8:
-> 0x5008:  {      jump 2676 }              ; event_handle_error
   0x500c:  {      jump 2688 }              ; event_handle_rsvd
   0x5010:  {      jump 2752 }              ; event_handle_tlbmissx
   0x5014:  {      jump 2688 }              ; event_handle_rsvd

(lldb) re r
Thread Registers:
 ...
 elr = 0x00005104  main`main + 68 at main.c:43
 badva0 = 0x0410e2c0
 badva1 = 0x0000d431  my_packed_struct + 13
 ssr = 0x80760020
```

Hexagon-lldb – Example2

```
(lldb) target variable *ptr_to_packed
(packed_struct) *ptr_to_packed = {
  i = 51
  c = 'a'
  s = (a = 'b', i1 = 85, i2 = 102)
}

(lldb) target variable *ptr_to_unpacked
(unpacked_struct) *ptr_to_unpacked = (a = 'b', i1 = 85, i2 = 102)


(lldb) target variable &ptr_to_unpacked.i2
(int *) &ptr_to_unpacked.i2 = 0x0000d431
```

Trace32 – Example3



Trace32 – Example3