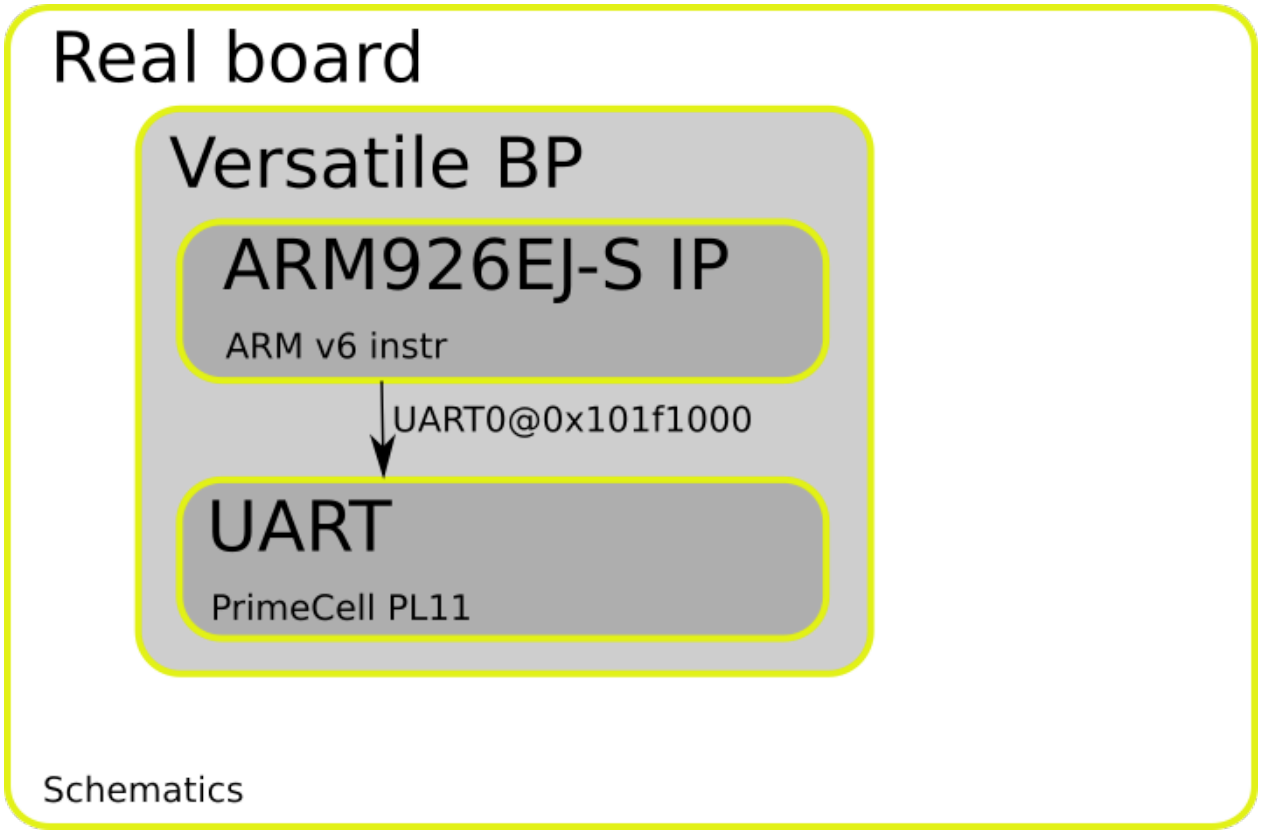
data-transition-duration: 500

skip-help: true



The serial hello world

```
    .text   @ tell the assembler this is a text section.
    adr r0,hello
    ldr r2, = UART0_BASE
write:
    ldrb r1 , [r0] , #1  @  r1 = *r0++

    cmp r1,#0
    strne r1, [r2] @ write to the UART not even waiting for the buffer
            @ to be empty.
    bne write
    b end
end:
    b end
    .align
hello:
    .string "Hello,from Qemu\n"
    .equ    UART0_BASE,0x101f1000 @define a constant that points to the UART register
```

Assemble

- arm-none-eabi-as -o uart.o uart.S
- arm-none-eabi-objdump -S uart.o

```
uart.o:     file format elf32-littlearm


Disassembly of section .text:

00000000 <write-0x8>:
0:      e28f0018        add     r0, pc, #24
4:      e59f2028        ldr     r2, [pc, #40]   ; 34 <hello+0x14>

00000008 <write>:
8:      e4d01001        ldrb    r1, [r0], #1
c:      e3510000        cmp     r1, #0
10:     15821000        strne   r1, [r2]
14:     1afffffb        bne     8 <write>
18:     eaffffff        b       1c <end>

0000001c <end>:
1c:     eafffffe        b       1c <end>

00000020 <hello>:
20:     6c6c6548        .word   0x6c6c6548
24:     72662c6f        .word   0x72662c6f
28:     51206d6f        .word   0x51206d6f
2c:     0a756d65        .word   0x0a756d65
30:     00000000        .word   0x00000000
34:     101f1000        .word   0x101f1000
```

Link

- arm-none-eabi-ld -Ttext=0x10000 -o out.elf uart.o
- arm-none-eabi-objdump -S out.elf

```
out.elf:     file format elf32-littlearm


Disassembly of section .text:

00010000 <write-0x8>:
10000:  e28f0018        add     r0, pc, #24
10004:  e59f2028        ldr     r2, [pc, #40]   ; 10034 <hello+0x14>
```

```
00010008 <write>:
10008:  e4d01001        ldrb    r1, [r0], #1
1000c:  e3510000        cmp     r1, #0
10010:  15821000        strne   r1, [r2]
10014:  1afffffb        bne     10008 <write>
10018:  eaffffff        b       1001c <end>

0001001c <end>:
1001c:  eafffffe        b       1001c <end>

00010020 <hello>:
10020:  6c6c6548        .word   0x6c6c6548
10024:  72662c6f        .word   0x72662c6f
10028:  51206d6f        .word   0x51206d6f
1002c:  0a756d65        .word   0x0a756d65
10030:  00000000        .word   0x00000000
10034:  101f1000        .word   0x101f1000
```

Strip

- arm-none-eabi-strip out.elf
- arm-none-eabi-objdump -S uart.elf

```
uart.elf:     file format elf32-littlearm


Disassembly of section .text:

00010000 <.text>:
   10000:       e28f0018        add     r0, pc, #24
   10004:       e59f2028        ldr     r2, [pc, #40]   ; 0x10034
   10008:       e4d01001        ldrb    r1, [r0], #1
   1000c:       e3510000        cmp     r1, #0
   10010:       15821000        strne   r1, [r2]
   10014:       1afffffb        bne     0x10008
   10018:       eaffffff        b       0x1001c
   1001c:       eafffffe        b       0x1001c
   10020:       6c6c6548        cfstr64vs       mvdx6, [ip], #-288      ; 0xfffffee0
   10024:       72662c6f        rsbvc   r2, r6, #28416  ; 0x6f00
   10028:       51206d6f                        ; <UNDEFINED> instruction: 0x51206d6f
   1002c:       0a756d65        beq     0x1d6b5c8
   10030:       00000000        andeq   r0, r0, r0
   10034:       101f1000        andsne  r1, pc, r0
```

Convert to bin

- arm-linux-gnueabi-objcopy -O binary uart.elf uart.bin

- hexdump -e '4/1 "%02X "' -e '"n"' uart.bin

```
18 00 8F E2
28 20 9F E5
01 10 D0 E4
00 00 51 E3
00 10 82 15
FB FF FF 1A
FF FF FF EA
FE FF FF EA
48 65 6C 6C
6F 2C 66 72
6F 6D 20 51
65 6D 75 0A
00 00 00 00
00 10 1F 10
00 00 00 00
*
04 00 00 00
14 00 00 00
03 00 00 00
47 4E 55 00
B7 A6 BE 0C
09 2C 2B 2F
D6 B7 E1 9E
BC E2 47 18
01 55 E8 9D
```

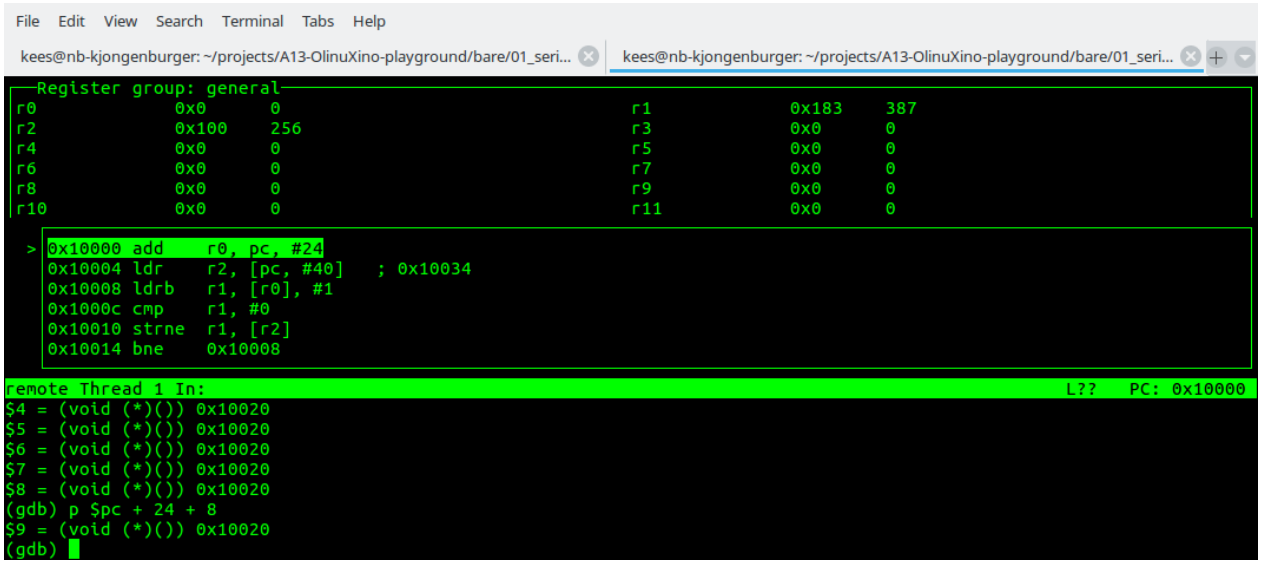
Execute

qemu-system-arm -M versatilepb -m 128M -nographic -kernel uart.bin

` Hello,from Qemu `

Step through

qemu-system-arm -M versatilepb -m 128M -nographic -kernel uart.bin -s -S arm-none-eabi-gdb uart.elf



Instruction & Encoding

Instruction set http://infocenter.arm.com/help/topic/com.arm.doc.qrc0001l/QRC0001_UAL.pdf

Instruction encoding http://infocenter.arm.com/help/index.jsp?topic=/com.arm.doc.ddi0210c/CACCCHGF.html

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Checklist

- Talking about the ARM 32 bits instruction set
- Load store archtitecture
- Relatively simple instruction set
- Fixed length
- Conditional execution
- Automatic index increment
- Direct addressing
- Indirect addressing
- SWI (aka system call)
- No BIOS type functionality
- Direct IO (no ioport)
- There are also CP instructions

Next step

- More examples (headers, stack and hacking?)

Resources

Code as presented

- https://github.com/keesj/A13-OlinuXino-playground/tree/versatilepb
- http://bravegnu.org/gnu-eprog/
- https://microcorruption.com/ (to learn about stuff in general)