# Low-level C-programming and microprocessor architecture

## Theory 8

- Component device drivers
- Device driver modes of operation
- Writing component device drivers
- Integrate device driver into the HAL
- Training CASE 3

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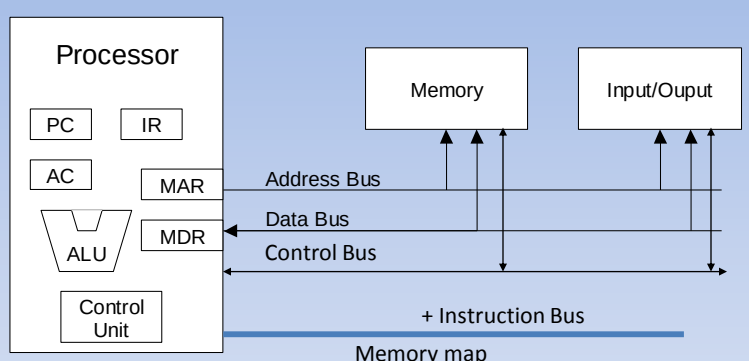
# Simple bus architecture




Memory map

| Addresses | Modules | Comments |
|---|---|---|
| FFFF 03FF | UART, terminal manager | Register |
| FFFF 0900 | | |
| FFFF 08FF | Other electronic units | Register |
| FFFF 0800 | | |
| FFFF 06FF | Interrupt routine and buffer | Interrupt routine |
| FFFF 0600 | | to terminal |
| FFFF 04FF | Terminal | Device driver for terminal |
| FFFF 0400 | | |
| 0000 7FFF | Block RAM (user program) | User program |
| 0000 0400 | | |
| 0000 03FF | Block RAM (xmdstub) | Debugging program |
| 0000 0000 | | |

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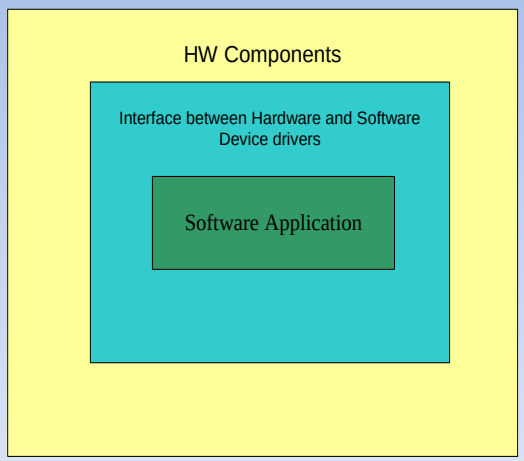
## Components instantiations

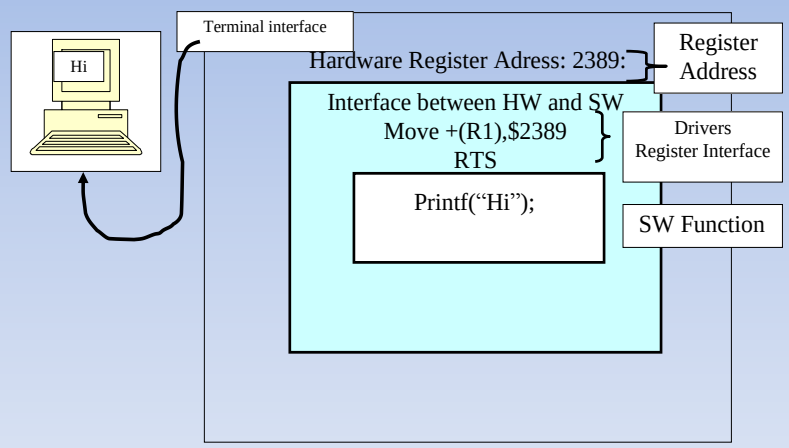
- Hardware components
  - Connect to data buss
- Software components
  - Connects to operating system (kernel)
  - Or to main();
- Device drivers
  - Interface between HW and SW




## SW and HW interface 1 (2)



## SW and HW interface 2 (2)

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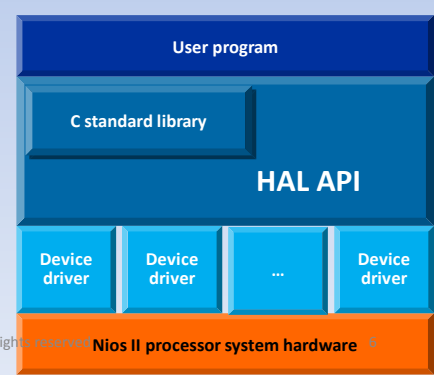
## Peripheral drivers

- All hardware peripherals require some kind of software driver
  - Perform bit manipulation and register accesses
  - Remove low-level access routines from application code

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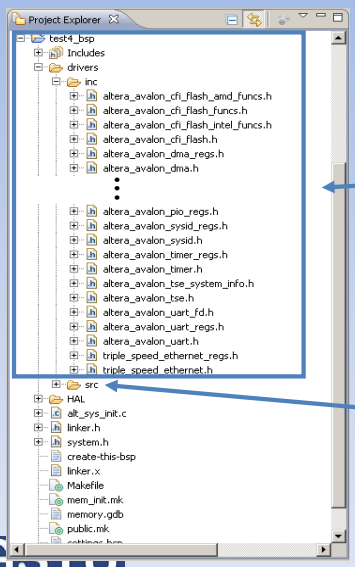
# Drivers are copied to BSP projects




"**drivers**" folder:

Header files for all components in system

"**src**" folder:

Source files for all components in system

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# Driver architectures

- Synchronous - simple "blocking"
  - Application must wait for I/O operation to complete before proceeding,
  - Device polled until it is ready.
- Asynchronous - more complex "non-blocking"
  - Application continues to run while device driver processes I/O operation,
  - Driver incorporates some kind of I/O buffer,
  - More code space,
  - Altera "fast" drivers use ISR to indicate when device is ready.

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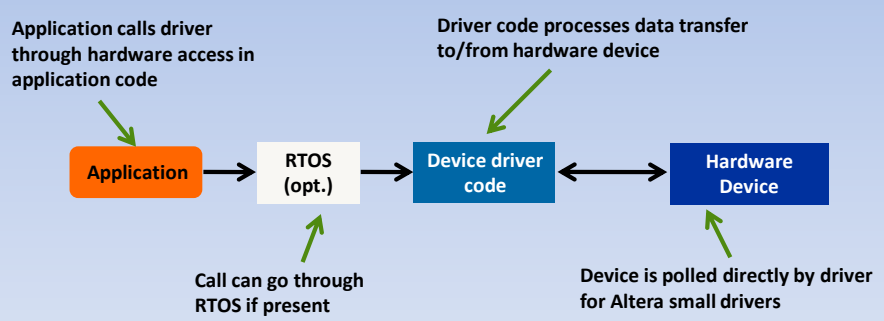
# HAL synchronous driver operation

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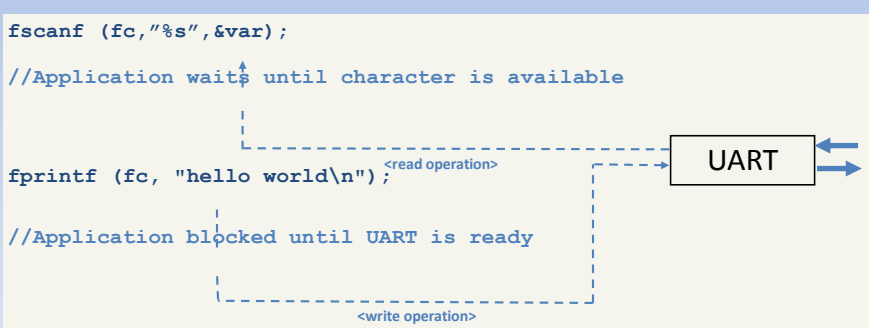
# Altera synchronous UART driver

- Driver continually polls device
- Driver moves data to / from application

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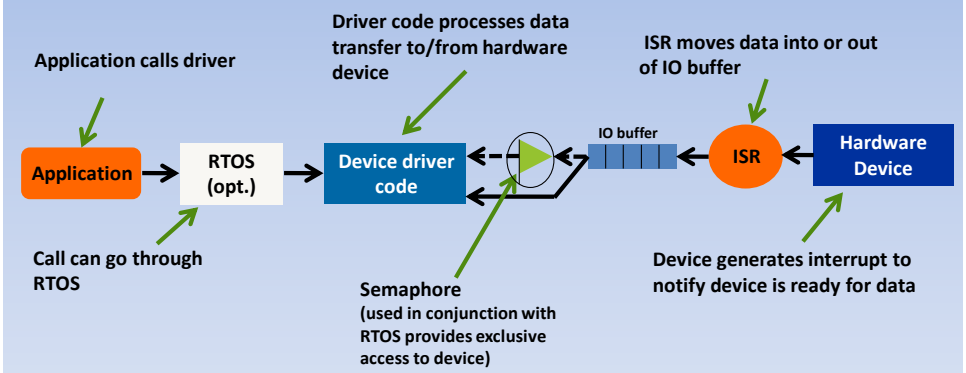
# HAL asynchronous driver operation

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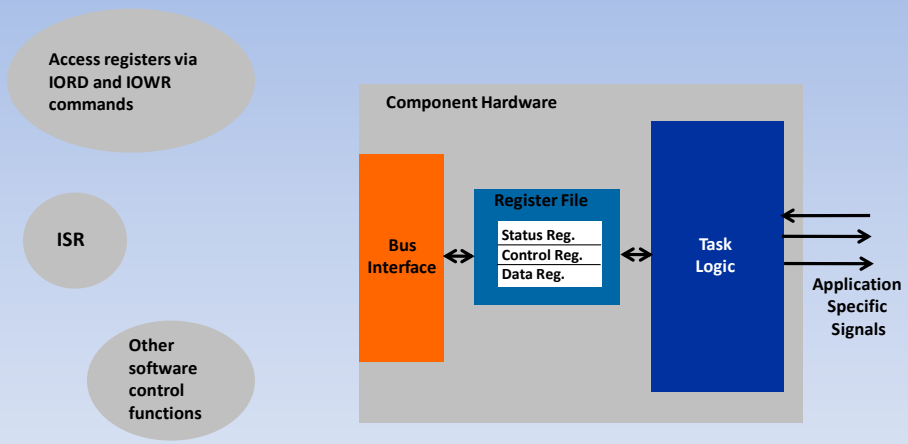
# Build up device driver

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# Altera-provided HAL types

| Data widths supported (#include <stdarg.h>) | |
|---|---|
| **Type** | **Meaning** |
| alt_8 | Signed 8 bit integer |
| alt_u8 | Unsigned 8 bit integer |
| alt_16 | Signed 16 bit integer |
| alt_u16 | Unsigned 16 bit integer |
| alt_32 | Signed 32 bit integer |
| alt_u32 | Unsigned 32 bit integer |
| alt_64 | Signed 64 bit integer |
| alt_u64 | Unsigned 64 bit integer |

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# NiosII-elf-gcc data widths

| Type | Meaning |
|---|---|
| char | 8 bits |
| short | 16 bits |
| int | 32 bits |
| long | 32 bits |
| float | 32 bits |
| long long | 64 bits |

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# Available HAL IO macros

| HAL I/O Macros to Bypass the Data Cache (#include <io.h>) | |
|---|---|
| **Macro** | **Use** |
| IORD(BASE, REGNUM) | Read the value of the register at offset REGNUM within a device with base address BASE. Registers are assumed to be offset by the address width of the bus. |
| IOWR(BASE, REGNUM, DATA) | Write the value DATA to the register at offset REGNUM within a device with base address BASE. Registers are assumed to be offset by the address width of the bus. |
| IORD_32DIRECT(BASE, OFFSET) | Make a 32 bit read access at the location with address BASE + OFFSET |
| IORD_16DIRECT(BASE, OFFSET) | Make a 16 bit read access at the location with address BASE + OFFSET |
| IORD_8DIRECT(BASE, OFFSET) | Make a 8 bit read access at the location with address BASE + OFFSET |
| IOWR_32DIRECT(BASE, OFFSET, DATA) | Make a 32 bit write access to write the value DATA at the location with address BASE + OFFSET |
| IOWR_16DIRECT(BASE, OFFSET, DATA) | Make a 16 bit write access to write the value DATA at the location with address BASE + OFFSET |
| IOWR_8DIRECT(BASE, OFFSET, DATA) | Make a 8 bit write access to write the value DATA at the location with address BASE + OFFSET |

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# Code layout for altera_avalon_uart

- HAL Device Driver location

  **C:\altera\<ver>\ip\altera\sopc_builder_ip\altera_avalon_uart**

altera_avalon_uart

- HAL
  Contains software files required to integrate the device with the HAL system library.
  - inc
    Contains header file(s) that define the device driver
  - src
    Contains source code and make files to build the device driver
- inc
  Contains header files(s) that define the device's hardware interfaces.

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## Recommendations and tips

- Take advantage of generic HAL API if possible
- Learn by available device models
- Integrate driver into HAL. The benefits are;
  - Hardware abstraction,
  - C standard library functions to manipulate devices,
  - Code portability due to Hardware Abstraction Layer.

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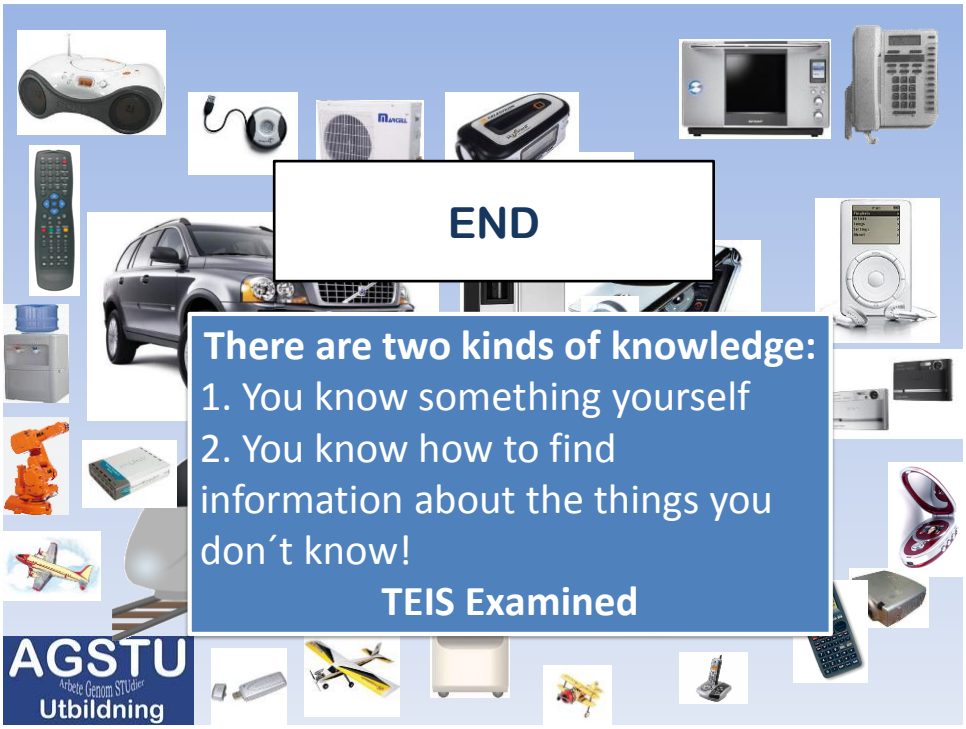

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