Embedded Systems Design for Industry 4.0

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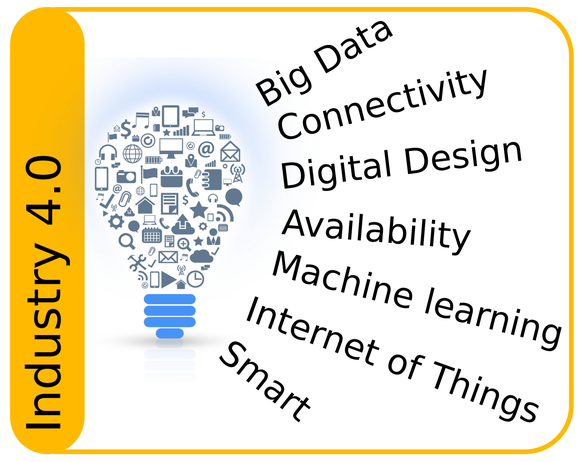
Abstract – Applications for Industry 4.0 face new challenges in the design of embedded systems. The increasing functional density requires a flexible design process to achieve a competitive time to market. Given the tight goals today, the key technologies to success are: reuse of modules, highly abstracted functional models, parallel hardware/software development, virtual prototypes, etc.



Specification Phase

- Tool based requirements engineering
- SystemC as a formal specification and modelling language
- Executable specification at a high abstraction level
- Models are used as virtual prototypes

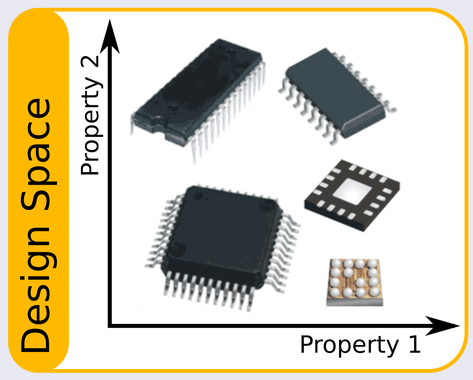
SystemC

```
#include "systemc.h"

SC_MODULE (first_counter) {
  sc_in_clk     clock ;
  sc_in<bool>   reset ;
  sc_out<sc_uint<4> > counter_out;

  void incr_count () {
   if (reset.read() == 1) {
     count =  0;
```

SYSTEMC™

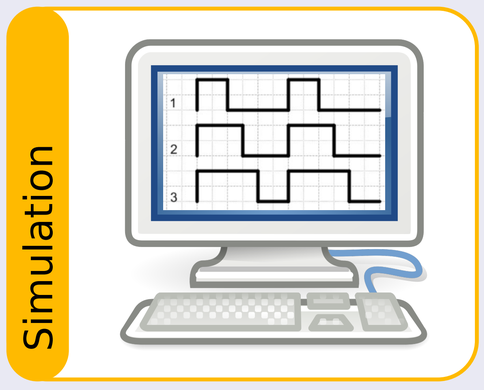
Architecture Exploration

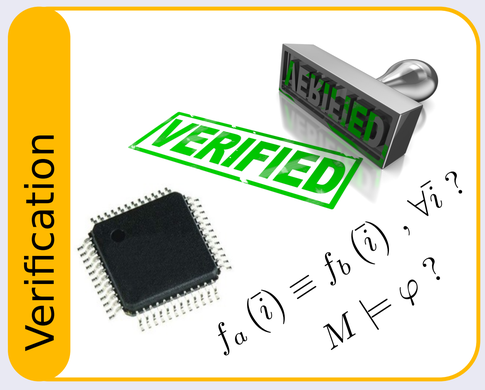
- Specified functions are mapped either to hard- or software modules
- Profiling and estimation methods to evaluate the properties of an architecture
- Design space exploration processes



Verification

- Specification- and design-errors have to be detected as early as possible
- Enhanced verification effort during design phase
- Simulation based methods evaluate the confidence
- Formal methods result in a mathematical proof
- Verification refinement from highly abstracted to netlist verification and software test processes





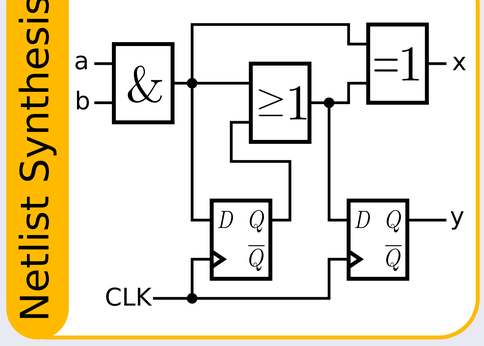
Hardware Development

- Refinement of abstract SystemC models
- Cycle accurate model in VHDL
- Synthesis processes
- Verification against the given specification

VHDL

```
architecture rtl of logic is
  signal s_a, s_b, s_x0 : std_logic;

  begin
    s_x0 <= s_a or s_b;
    s_x1 <= s_a xor s_b;

  p1 : process
  begin
    a <= '1';
    wait for 10ns;
    a <= '0'
  end process p1;
end rtl;
```

VHDL

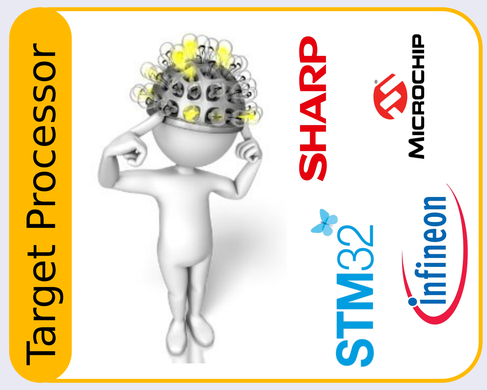


Software Development

- Operating System for memory management, task scheduling, communication, user interfaces, etc.
- Hardware abstraction layer
- Software testing procedures

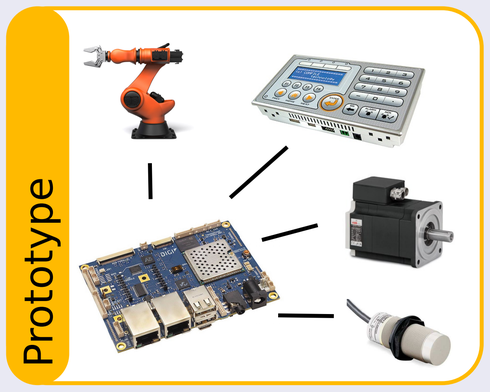
Software

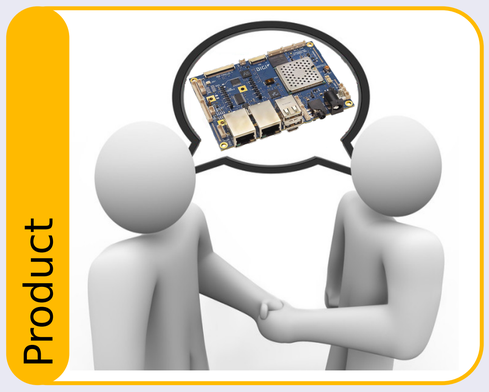
```
#include "stm32f4xx_hal.h"

int main(void) {
 RCC_OscInitStruct.PLL.PLLState
 = RCC_PLL_NONE;

HAL_RCC_OscConfig
 (&RCC_OscInitStruct);

 GPIO_TypeDef
 GPIO_TypeDefStruct;

__TIM4_CLK_ENABLE();
__GPIOD_CLK_ENABLE();
```



Deployment, Prototype Implementation, and Product

- Deployment to appropriate evaluation boards in a lab environment
- Hardware test, performance analysis, endurance test, usability test, etc.
- Prototype implementation in an industrial environment
- Product finalization and technical customer support





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