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W-development model extension for embedded system design

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Abstract:
At present time, when complexity of the developed devices rises, the developing models became very important [1], [4]. Following of the defined steps, especially during continuously testing, increase reliability of the developed device and then decrease quality cost. It's mainly due to the error repairing cost exponentially rises depending on the project stage. About 30-40% of the software developing time is spend by testing of the written code [5]. Thanks to the majority of the developing models are oriented on software developing models. Even if we can use them for embedded system testing, they have some imperfections for this purpose. The article describes propose of the W-model extension that includes specialized operations for the embedded systems. Using examples are presented as well.

INTRODUCTION

Embedded systems are electronic devices with integrated processor where processor provides device correct function. It results in software and hardware inseparability. At present time, about 90% of processors are used in embedded systems [2]. The traditional development models can be used for embedded system development. Nevertheless, they don't include all design and development aspects. Even if, the embedded systems can be separated into hardware and software part, use of the common development models are not suitable. It's due to that in case of common development models the hardware and software are tested separately. New issues are arising in case of embedded systems because of though connection of hardware and software. For example, the mobile telephone is a member of embedded systems. Inside the mobile phone the microcontroller controls its own power supply voltage and even clock frequency. The article describes W-model extension possibility. The extension introduces into the W-model specification of operations based on system hardware and software design.

W-MODEL

Paul Herzlich introduced application development model called W-model in 1993 [1]. The purpose of the W-model was to extend V-model about development and testing connection. Against V-model, W-model is not only oriented on checking of successful testing but focuses on main product [3]. In the fundamental form, the W-model represents standard development cycle where each development stage is shadowed by adequate testing stage.

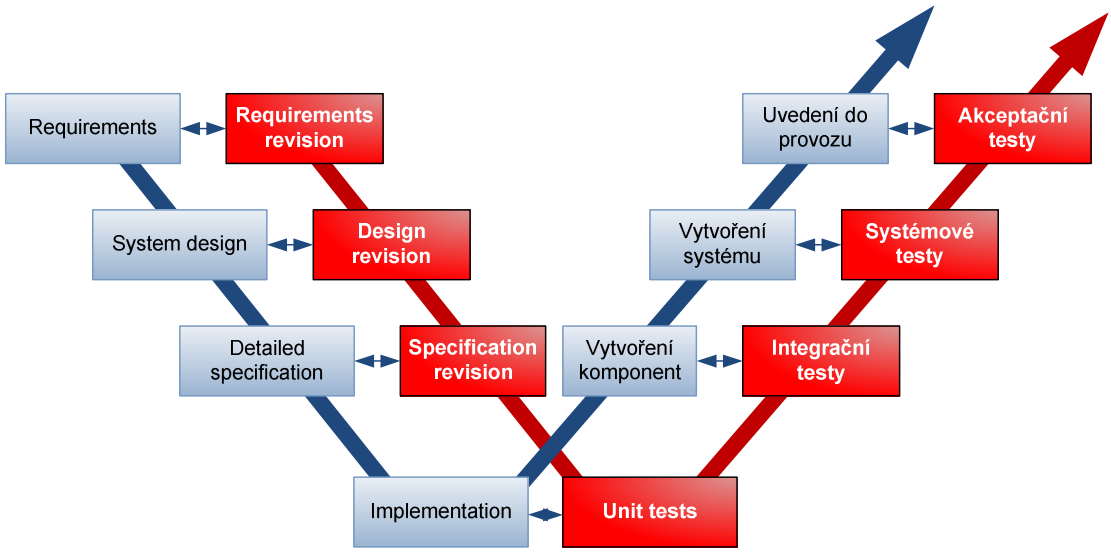

Fig. 1: Development W-model

There is examined if the requirements are satisfied or developed product matches its own specification. In case of the W-model there exist more model interpretations like in V-model.

DELTA-W MODEL

The Delta-W model was developed as an extension of the W-model about explicit description of the hardware and software development phases. The Delta-W model can be presented like a fourth pyramids built abreast. Situation is showed in fig. 1. The model was named after Greek letter Delta that seems like pyramid.

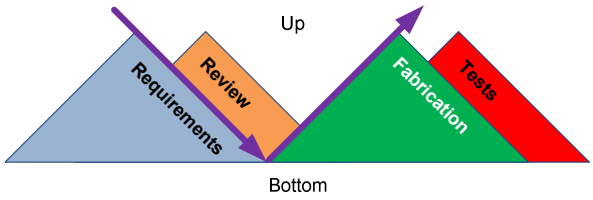

Fig. 2: Scheme of the Delta-W model

The model describes two fundamental groups of the activities during device development: Requirements and structure specification and requirements realization. There are two groups of test and revision shadowing two groups of main activities mentioned above. The activities sequence during development is in "Up-Bottom-Up" order in Delta-W model similarly like in W-model case. We proceed from the most common level down to the most concrete level of the design activity. In opposite, during the fabrication we proceed from the most concrete level up to the most common level. It means we make elementary parts at first and then we complete them into the final device. The system requirements and specifications diagram is showed in fig 2.

At first, on the hierarchically highest level, the user (costumer) defines requirements on system. Next, the development engineers define, still in cooperation with users, hardware and software requirements.

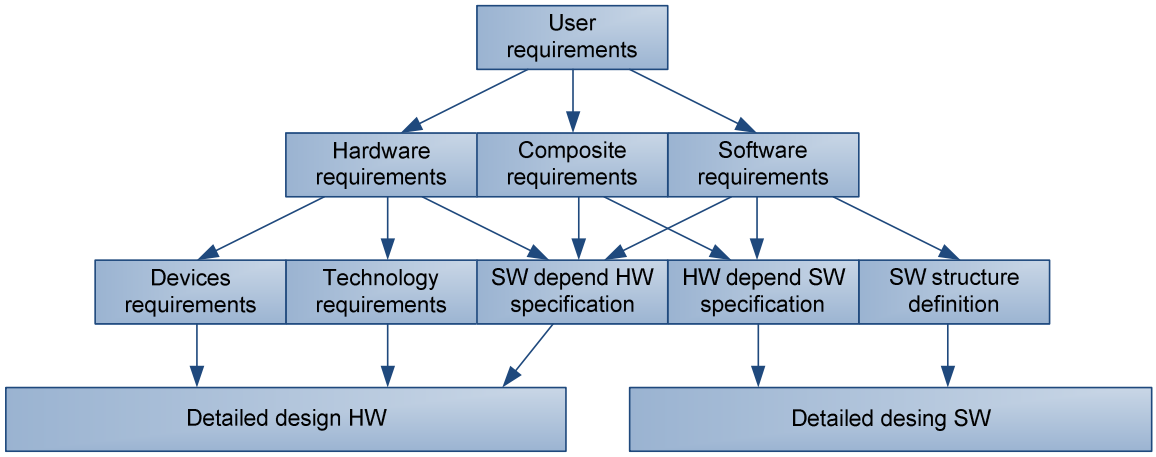

Fig. 3: Requirements definition in Delta-W model

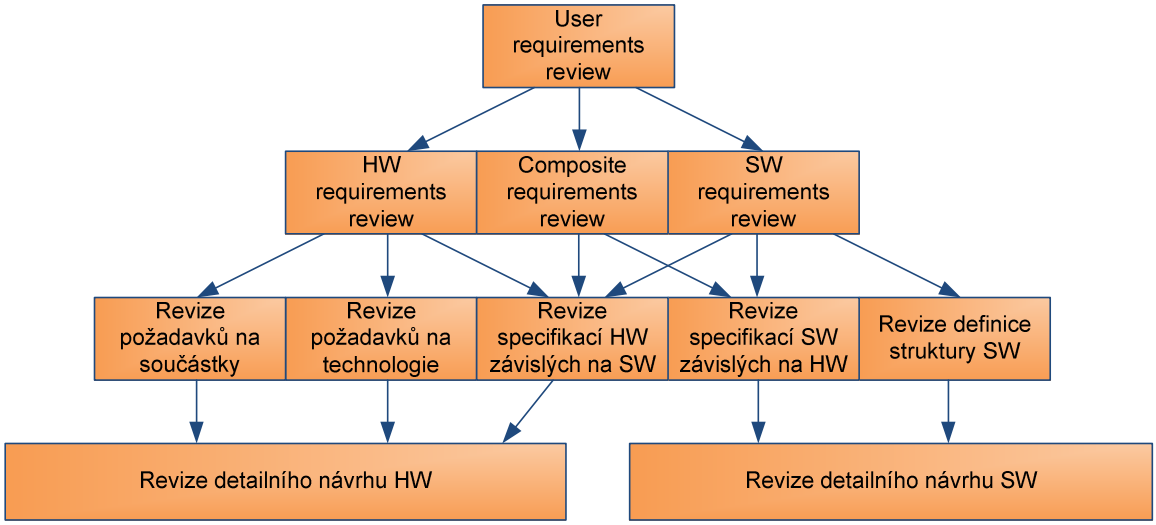

Fig. 4: Requirements revision

As mentioned above, in case of embedded systems the definitions of the hardware and software meet together. Due to the model describes definition of the composite requirements. On basis of the engineers' requirements on system the component requirements and program structure are defined as well. The intersection of the hardware and software leads to hardware requirements specification for easier software development and requirements software specification for easier hardware realization.

An example of the hardware design for easier software design should be matrix keyboard connected directly to whole microcontroller's port without any signal switches.

At opposite, an example of the software design for easer hardware design should be minimizing device dimensions. It leans on minimizing signal traces at the expense of connecting signals to micro-controller switched and reducing microcontroller speed.

Hierarchic structure of the requirements is shadowed by revision structure that describes review specification for each of development stages. Requirements revision structure is shown in Fig. 4. If we compare Delta-W model with W-model, described two structures are tally with W-model left wing. We specified software and hardware requirements separately at first, e.g. at the second hierarchic level.

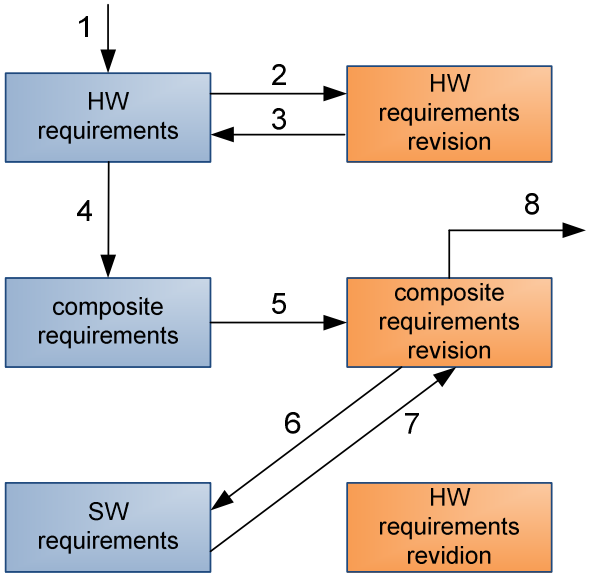

Fig. 5: Requirements specification scenario

Group of the composite requirements are established during the process. Hypothetic scenario of the composite requirements definition is described in fig. 5. At first, the requirement is defined like a "hardware requirement" (1). The requirement is revised (2) and result is returned back (3). Revision result is finding out that hardware can be simplified by software modification. Due to the requirement is reordered into composite requirements group (4). The collision control (6) with software requirements should follow behind this stage (5). In case, the requirement is approved (7) it continuous to next development level (8). The presented scenario ends at this moment. Nevertheless, if the composite requirement collides with software requirements, it has to be moved back into hardware requirement group.

It should make process to circuit, mechanical and software design after complete definition of system requirements and then manufacturing and/or programming. It is hierarchically showed in Fig. 7. Products of each defined stages are already testing during manufacturing. It corresponds to right wing in comparison with W-model. The tests structure is shown in Fig 8.

Possible scenario of the hardware design and testing is shown in Fig. 6. The simulation (2) and real check (3) of the designed circuitry is done after circuit specification. After testing (4) the circuit design is reworked to take into account parasitic and other effects (5). Next, the additional simulations are run (6). The physical circuit design (e.g. printed circuit boards) (8) is processed based upon simulation results. When the design is successfully simulated (9) it is possible to move up to component manufacturing (10) and its next testing (11).

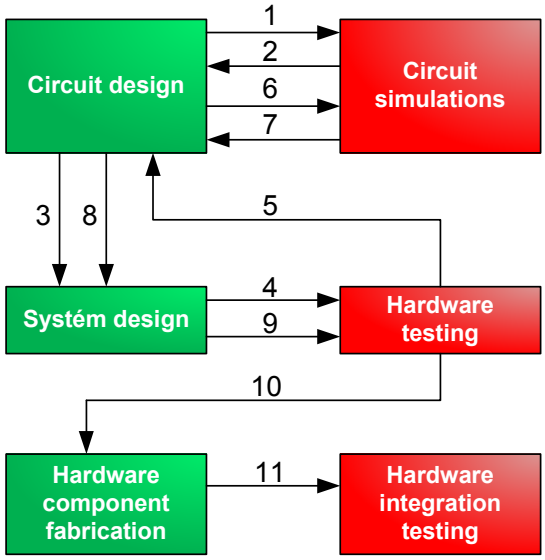

Fig. 6: Low-level hardware manufacturing and testing scenario

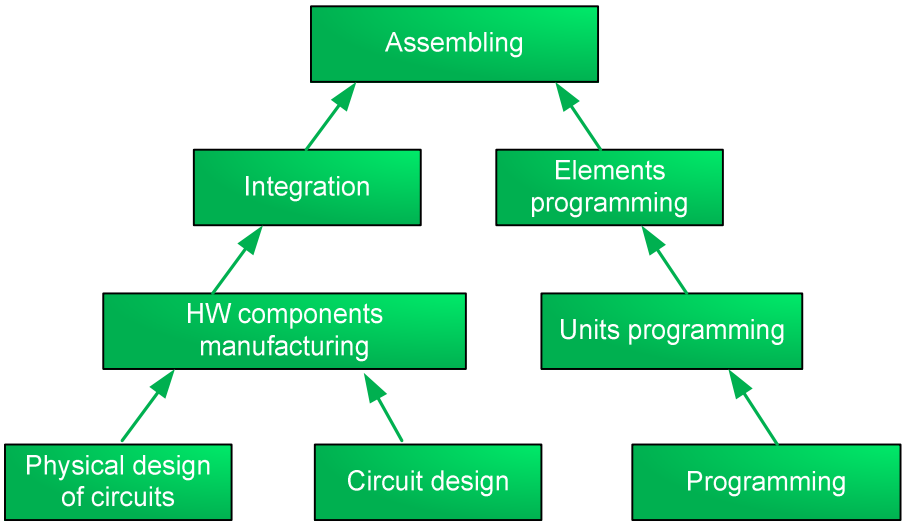

Fig. 7: Fabrication process in Delta-W model

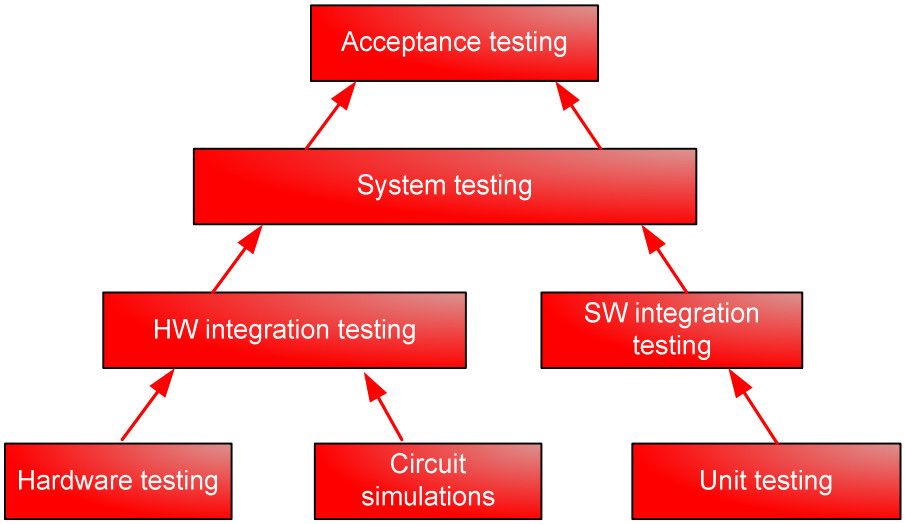

Fig. 8: Tests on the fabrication state

CONCLUSION

Embedded systems are electronic devices with integrated processor where processor provides device correct function. Even if, the embedded systems can be separated into hardware and software part, new issues are arising in case of embedded systems. The article describes extension of development W-model. The extension describes specifications of activities for embedded system development. Proposed model was named as Delta-W model after Greek letter Delta that seems like model structures.

ACKNOWLEDGMENTS

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