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Generalized Net Model of the Microcontroller Operation

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Abstract: Generalized nets are advanced approach in modelling of parallel processes in complex systems with many different components. They are used in various fields such us computer science, physics, medicine, economics, transport etc. In this article, we introduce a reduced generalized net model of the operation of the main part of each embedded system – the microcontroller operation.
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1 Introduction

Since the first introduction (1982) of the Generalized nets theory, many generalized net models, in various fields of the science and technologies are developed – data bases, data mining, artificial intelligence etc. In [4] are described generalized net models of knowledge based systems. This approach is used also in modelling of telemedicine, based on body temperature sensors [1], mobile communication usage in information security improvement [6], operation of a flexible manufacturing systems [7], network security serving processes [8]. Generalized nets, along with intuitionistic fuzzy sets are used in modelling the behaviour and control of mobile robots in unknown environment [5].

Our intention is to use the generalized nets in modeling of the processes in electronic circuits, in particular, in digital circuits. The microcontroller is a complex electronic device, based mainly on digital circuits, and is a main component in the widespread nowadays embedded systems. In this article we represent a simplified generalized net model of the microcontroller operation.

2 Microcontroller operation

In Fig. 1 is shown a simplified flowchart of the microcontroller operation. The operation includes two types of processes: software and hardware initiated. Pointing to the Fig. 1.1, the software initiated processes are the initialization and the main loop (including interrupt service routines). They are implemented, based on the written program instructions. The hardware processes (reset, interrupt and peripheral services) are implemented by the additional circuits (subsystems, modules), simultaneously with the main program flow.

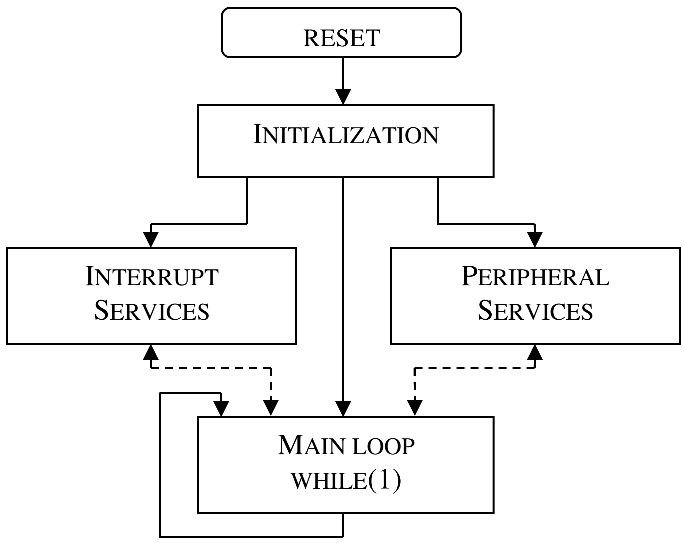

Figure 1. Simplified flowchart of the microcontroller operation

3 Generalized Net Model

In Figure 2 is shown a generalized net (GN) model, based on the simplified flowchart from Fig. 1.

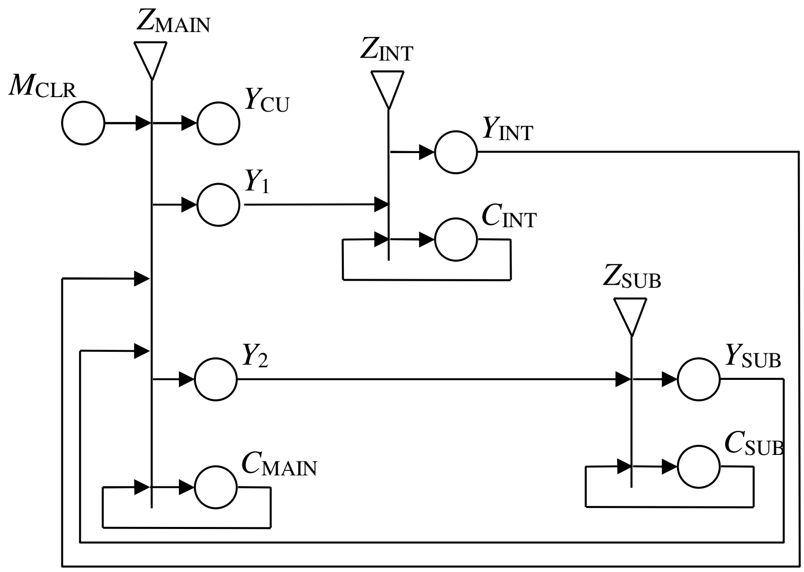

Figure 2. Generalized net model of the microcontroller operation

The GN model is represented by the following set of transitions:

$$A = \{Z_{\mathrm{MAIN}}, Z_{\mathrm{INT}}, Z_{\mathrm{SUB}}\}.$$

Initially, the following tokens are present in the net:

- token α, in place M_{CLR} with characteristic "*RESET signal*";
- token β, in place C_{MAIN}, with characteristic "Initial register values";

The transition Z_{MAIN} is presented by the following expression:

$$Z_{\mathrm{MAIN}} = \langle \{M_{\mathrm{CLR}}, Y_{\mathrm{SUB}}, Y_{\mathrm{INT}}, C_{\mathrm{MAIN}}\}, \{Y_{\mathrm{CU}}, Y_1, Y_2, C_{\mathrm{MAIN}}\}, R_{\mathrm{MAIN}}, \wedge(M_{\mathrm{CLR}}, Y_{\mathrm{SUB}}, Y_{\mathrm{INT}}, C_{\mathrm{MAIN}})\rangle.$$

The matrix R_{MAIN} has the following form:

$$R_{MAIN} = \begin{array}{c|cccc} & Y_{CU} & Y_1 & Y_2 & C_{MAIN} \\ \hline M_{CLR} & false & false & false & true \\ Y_{SUB} & false & false & false & true \\ Y_{INT} & false & false & false & true \\ C_{MAIN} & W_{CYCU} & W_{CY1} & W_{CY2} & true \end{array},$$

where:

- W_{CYCU} = "There are new user values";
- W_{CY1} = "There are new configuration values for the interrupt subsystem";
- W_{CY2} = "There are new configuration values for the peripheral subsystems ".

The tokens from places M_{CLR}, Y_{SUB} and Y_{INT} merge in place C_{MAIN}, and do not change their characteristics.

The token from place C_{MAIN} splits in three tokens, which enter places Y_{CU}, Y_1 and Y_2, where the token that enters place Y_{CU}, obtains characteristic *"Current user variable values"*; the token that enters place Y_1 obtains characteristic *"Interrupt subsystem configuration values"*, and the token that enters place Y_2 obtains characteristic *"Peripheral subsystems configuration values"*.

The transition Z_{INT} is presented by the following expression:

$$Z_{INT} = \langle \{Y_1, C_{INT}\}, \{Y_{INT}, C_{INT}\}, R_{INT}, \wedge(Y_1, C_{INT})\rangle.$$

The matrix R_{INT} has the following form:

$$R_{INT} = \begin{array}{c|cc} & Y_{INT} & C_{INT} \\ \hline Y_1 & false & true \\ C_{INT} & W_{CY} & true \end{array},$$

where W_{CY} = "There's an interrupt event".

The token from place Y_1 enters place C_{INT} and does not change its characteristic.

The token from place C_{INT} enters place Y_{INT}, where obtains characteristic *"Interrupt flag"*.

The transition Z_{SUB} is presented by the following expression:

$$Z_{SUB} = \langle \{Y_2, C_{SUB}\}, \{Y_{SUB}, C_{SUB}\}, R_{SUB}, \wedge(Y_2, C_{SUB})\rangle.$$

The matrix R_{SUB} has the following form:

$$R_{\mathrm{SUB}} = \begin{array}{c|cc} & Y_{\mathrm{SUB}} & C_{\mathrm{SUB}} \\ \hline Y_2 & false & true \\ C_{\mathrm{SUB}} & W_{\mathrm{CY}} & true \end{array},$$

where W_{CY} = "There are changes of the peripheral subsystem register values".

The token from place Y_2 enters place C_{SUB} and does not change its characteristic.

The token from place C_{SUB} enters place Y_{SUB}, where obtains characteristic *"Peripheral subsystems register values"*.

4 Conclusion

The presented generalized net model describes the basic operations of the sample microcontroller. It can be used as a basis in generalized net modeling of more complex microcontroller based systems.

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