CAUSALITY OF 0-JUNCTIONS IN ENERGY BASED MODELING

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Abstract

The paper considers flow activities at determination of computational causality 0-junction bond graph physical system model. At first, it says about responsibility question, then about the algorithm for causality determination. Particularly this work considers the case 0-junction with one input and two output of energetic flow. here are included the flow activities for effort and flow causality of the input bond.

Keywords: *bond graph model, 0-junction, causality*

1. INTRODUCTION

A model always represents only some a real system abstraction, depending on the intended usage. From control point of view, energetic aspect of system description, based on bond graph method is useful [1-4]. Creation of the simulation model is structured by the few abstraction levels which create hierarchy in the sense that the degree of details increases from physical component level to the mathematical level. At the last step, in order to have quantitative system analyses, it is necessary to define mathematical relations which describes physical mechanisms from previous phase. These relations are denoted as constitutive relations.
I general, the mathematical abstraction process can be divided into two steps [2]:

- Definition of constitutive relations
- Mathematical causalities determination

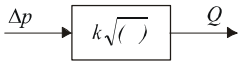
Should be noticed, that constitutive relations are given in declarative way, not as assign statements. This intensify flexibility and possibility of repeat use of the model. [5, 6]. In the next step, depending of the context model application, we have to definition causality.

2. CAUSALITY

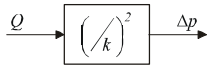
Causality plays an important role in any aspect of model based reasoning about physical system. In prediction or simulation, causality controls the propagation of information. In explanation of behavior it is used to describe the propagation of effects, etc. It has two sides: mathematical and physical. From mathematical point of view it refers order of computations, from physical point of view it refers to an interpretation of this ordering in physical terms.
The main concept of the notion of causality is the concept of computational causality. For example, if we consider the flow through the resistance with turbulent regime which can be described by:

$$Q := k\sqrt{\Delta p} \tag{1}$$

Mathematical abstraction of resistance given in the equation form (1) presents its essence and doesn't depend from application. It only claims that the relation between flow and pressure drop must to be satisfied in any moment. It doesn't say anything about what happens: the flow determines the pressure drop or the pressure drop determines the flow. But, in implementation phase to this relation the computational direction must to be define. Here two cases are possible (Fig.1)

$Q := k\sqrt{\Delta p} \quad \Leftrightarrow$ 

(a)

$\Delta p := (Q/k)^2 \quad \Leftrightarrow$ 

(b)

Fig. 1 Two computational directions of turbulent resistance constitutive relation

In order to make explicit computational direction, assignment statement (:=) instead equality relation (=) is used. In the first case *(a)* the pressure drop (Δp) is used as input (independent) variable by which output (dependent) variable Q is calculated. In second case (b) we use second form of constitutive relation with the exchanged role of variables Δp and Q.

The question is how for one functional block (FB) to define calculation order? In fact, the first question is who is responsible for calculation direction determination? From previous it can be seen that causality is defined in relation on variables with FB has communication with output world. It is independent from the FB constitutive relation. It means that we can't say nothing about causality of FB but in the context of the output world in which it is. In other words, causality is global system property of all system, but not of the system parts. Therefore the question is how to make the model library because we don't know in advance the

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