THE SCALABILITY AND FLEXIBILITY OF QUALITATIVE ARCHI BOND GRAPHS FOR BUILDING SIMULATIONS

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ABSTRACT

Qualitative Archi Bond Graphs (QABGs) are energy-based unified representations for buildings that can be used for building simulations at the early stage of designing. This paper presents an approach to their scalability and flexibility when applied to the simulation of the behaviour of buildings with complex spatial structures or building dynamics under time varying situations.

\textbf{Keywords:} Bond graphs, qualitative, representation, scalability

1. INTRODUCTION

Current representations for buildings mainly focus on their static aspects such as spatial arrangements and arrangements of different building energy systems. The majority of these representations are applicable only at the final stage of building design when most of the data is already known. Designers use different representations for different building subsystems including space-people systems and building energy systems.

Bond graphs (Thoma 1975; 1990; Gawthrop and Smith 1996; Karnopp et al. 2000) combining graphical representations and mathematical equations are an energy-based systematic representation. They provide a unified approach to the modelling and analysis of the dynamics of hybrid multi-domain systems. Qualitative reasoning does not reason about a system in terms of the precise values but rather reasons at a qualitative level. It can be employed to build a knowledge model to represent the relationship between system structure and behaviour (Williams 1991; Werthner 1994; Wang and Linkens 1996).

Based on bond graphs, Gero and Tsai (2004; 2005) developed bond graphs for multiple domains (MBGs) that have the capacity to integrate multiple domains using the concepts of energy transformation and transduction. They further specialised MBGs to the domain of architecture to develop Archi Bond Graphs (ABGs). ABGs are capable of representing and simulating static system structures and dynamic behaviours of different building subsystems. Drawing on qualitative physics and using discrete symbols to represent dynamic properties of a system, Tsai and Gero (2006a;