Chapter 3

Keys for Administration of Reconfigurable NoC: Self-Adaptive Network Interface Case Study

Rachid Dafali
European University of Brittany, France

Jean-Philippe Diguet
CNRS, Lab-STICC (UMR 3192), France

ABSTRACT

This chapter presents an analysis of current needs in the domain of Reconfigurable Network on chip. We first detail our motivations for NoC reconfiguration, which is followed by a description of our model for Reconfigurable Network on chip in relation with the usual OSI network layers. Then, we propose a study of outstanding research issues of current work and open issues organized into three topics: dynamic reconfiguration administration, network infrastructure reconfiguration and network protocol reconfiguration. To finish, we present our strategy for reconfiguration and introduce a self-adaptive Network Interface architecture as a part of the configuration manager.

INTRODUCTION

The design of recent Systems-on-Chip (SoC) for a large scope of applications, such as telecom and multi-media domains, and in various platform types ranging from dedicated platforms to fully programmable platforms, is mainly constrained by communications. Networks-on-Chip (NoC) have recently emerged as a promising concept to support communication on SoCs providing a solution to connect different IP-cores through an effective, modular, and scalable communication network.

In recent years, the introduction of hard and soft processor cores into reconfigurable circuits, exploiting the flexibility of FPGA, has changed the job and horizon of designers by providing them with complete Reconfigurable System-on-Chip (RSoC). Key industry issues such as design productivity and embedded system reliability have turned RSoC into viable solutions for embedded systems design. However, we observe that recurrent drawbacks are usually stressed by industrial partners regarding
academic innovative NoCs and their associated CAD tools. The first one is the final cost in terms of area (thus, static power), which remains the number one concern in embedded systems. For example, the priority that has driven the Arteris industrial solution is the optimization of the NoC area according to market constraints. This means that strong efforts may be made to reduce features that have the most impact, such as memory.

The second usual criticism is the inadequacy of current tools and methodologies with real applications. The main drawback is the lack of flexibility to support dynamic systems, where communication features greatly change at runtime. This aspect is obvious, for instance, when architectures with multiple general purpose processors are considered. In such cases, the number of processes communicating over the network usually cannot be predicted.

Actually, in such a context, current NoC CAD approaches, based on path and time-slot allocations (e.g. Evain & Diguet, 2007; Radulescu et al., 2004) or on simulations (e.g. Arteris 2005), can lead to extra cost, since worst-cases must be considered to support communication demand fluctuations including peaks. Thus, a new NoC design methodology, which provides adaptivity of infrastructure resources and of network protocols, emerges as an alternative solution to face current constraints. It appears that learning-based methods relying on observations are necessary to adapt the NoC to application needs mainly in terms of bandwidth.

In this chapter, we explore the different dimensions of NoC reconfigurations. Then, we propose a methodology that we first apply to Network Interfaces (NI) according to our NoC model and CAD tool. It is organized as follows; part 1 provides the NoC model we consider for exploring the reconfiguration space and classifies current work. In part 2, we give an overview of our configuration strategy and present a new model of self-adaptive NI illustrated with results that clearly show how optimizations can be obtained. Finally we conclude.

**MODELING OF RECONFIGURABLE NETWORK-ON-CHIP (RNOC)**

The development of embedded systems is based on hardware and software resources that are physically separated, but cooperate to achieve various tasks. The architecture is, therefore, composed of a set of components collaborating to execute application(s). At run-time, communication requirements can change according to data dependency, to application needs, to user choices in terms of concurrent application choices, to architecture hazards (cache coherency, for instance) and to network access conditions (data-rate, protocols, standards). It can also depend on architecture reconfiguration itself to implement or remove given functional blocks. Moreover, it is increasingly needed to be able to change the system architecture to add new services, which were not defined or known at design time.

To cope with these changes caused by ‘natural’ consequences of the system evolution, the designer must include a control mechanism that transforms and adapts HW/SW environmental parameters to the new process and execution conditions, while avoiding or minimizing system downtime or interruption. This mechanism is called Dynamic Reconfiguration (DR).

In this section, we present the dynamic reconfiguration model and define the layered abstraction-based view. The model is derived from standard network abstraction OSI (Open Systems Interconnection) models and is adapted to RNoC.

**Dynamic Reconfiguration Model**

The approach of the DR model proposed by Kramer & Magee (1985; 1990) is organized around three stages:
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