PiSDF: Parameterized & Interfaced Synchronous Dataflow for MPSoCs Runtime Reconfiguration

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***Abstract*—Dataflow models of computation are widely used for the specification, analysis, and optimization of Digital Signal Processing (DSP) applications. In this talk, we present the Parameterized and Interfaced Synchronous Dataflow (πSDF) model that addresses the important challenge of managing dynamics in DSP-oriented representations. In addition to capturing application parallelism, which is an intrinsic feature of dataflow models, πSDF enables the specification of hierarchical and reconfigurable applications. The Synchronous Parameterized and Interfaced Dataflow Embedded Runtime (SPIDER) is also presented to support the execution of πSDF specifications on heterogeneous Multiprocessor Systems-on-Chips (MPSoCs).**

I. Parameterized and Interfaced Synchronous Dataflow (πSDF)

A dataflow Model of Computation (MoC) models an application as a directed graph of computational entities, called actors, that exchange data packets, called data tokens, through a network of First-In First-Out queues (FIFOs) [1]. Synchronous Dataflow (SDF) [1] is the most commonly used dataflow MoC. Production and consumption token rates are fixed scalars in an SDF graph. A static analysis of an SDF graph ensures consistency and schedulability properties that imply deadlock-free execution and bounded FIFO memory needs.

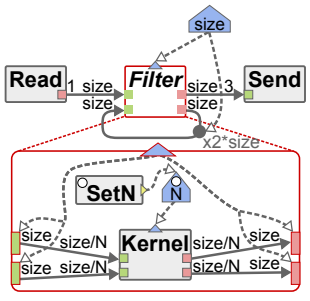

Fig. 1. Example of πSDF graph.

The πSDF MoC [2] is a generalization of the SDF MoC. In addition to the actors and FIFOs of the SDF semantics, the πSDF semantics contains a set of parameters and parameter dependencies that can be used to reconfigure the production and consumption token rates of actors. The πSDF semantics also includes a hierarchy mechanism that enables the composition of graphs by using a πSDF sub-graph as a specification of the internal behavior of an actor.

A πSDF specification of an image processing is presented in Figure 1. The top-level graph of this application contains three actors. The *Filter* actor is a hierarchical actor whose internal behavior is specified with a sub-graph. Parameters `size` and `N` influence the behavior of the application at compile time and at runtime respectively.

II. Synchronous Parameterized and Interfaced Dataflow Embedded Runtime (SPIDER)

The SPIDER runtime [3] is a Real-Time Operating System (RTOS) whose purpose is to map and schedule πSDF graphs on heterogeneous Multiprocessor Systems-on-Chips (MPSoCs). The SPIDER runtime exploits the parallelism and the predictability of πSDF specifications to minimize the latency of applications.

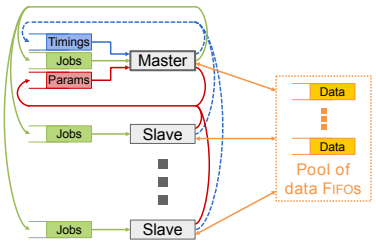

Fig. 2. Operating principle of the SPIDER runtime.

Figure 2 illustrates the operating principle of the SPIDER runtime. The purpose of the *Master* core is to make mapping and scheduling choices and send jobs to all processing elements, including itself, through FIFOs. On job completion, a core can send new parameter values and monitoring information back to the *master* core through the *Params* and *Timings* FIFOs respectively. A pool of data FIFOs can be accessed by *Master* and *Slave* cores to exchange data between jobs.

References

[1] E. Lee and D. Messerschmitt, "Synchronous data flow," *Proceedings of the IEEE*, vol. 75, no. 9, pp. 1235 – 1245, sept. 1987.

[2] K. Desnos, M. Pelcat, J.-F. Nezan, S. Bhattacharyya, and S. Aridhi, "PiMM: Parameterized and Interfaced Dataflow Meta-Model for MPSoCs Runtime Reconfiguration," in *SAMOS XIII*. IEEE, 2013.

[3] J. Heulot, M. Pelcat, K. Desnos, J. F. Nezan, and S. Aridhi, "SPIDER: A Synchronous Parameterized and Interfaced Dataflow-Based RTOS for Multicore DSPs," in *EDERC14*, 2014.