Increasing NoC Power Estimation Accuracy through a Rate-Based Model

Guilherme Guindani, Cezar Reinbrecht, Thiago R. da Rosa, Fernando Moraes
PUCRS, Av. Ipiranga 6681, P. 32, Porto Alegre, Brazil
{guilherme.guindani, fernando.moraes}@pucrs.br

This research work presents and compares two NoC power estimation models, one based on the volume of information transmitted in the network, and another based on the transmission rates of each router.

NoC power/energy ***volume-base estimation model*** is based in the volume of information transmitted through the network, and have been widely used as an option to commercial power estimation tools. These models are faster compared to commercial tools, since results are based in the application of mathematical equations. The volume-based models calculate how much will cost, in terms of power/energy, to transmit a packet from the origin router to the destination router, passing through *n* hops. This method gives a first order estimation, not considering effects due to the traffic propagating in the network fabric such as traffic congestion and burst transmissions. For energy consumption estimation model, this work uses the energy estimation model embedded in the CAFES framework [1], which estimates energy based on the Hu and Marculescu energy consumption model [2].

The ***rate-based power estimation model*** is an option to the volume-based models, and it is more precise than the volume-based models, since traffic effects change the transmission rates in each router. The power consumption of a router may be divided into three main components: buffers, control logic and crossbar. Buffers are responsible for the most significant part of power consumption in the router. The rate-based power model, introduced in [1], comprises two steps: calibration and application. The ***calibration*** step defines the parameters used in the model. This step starts synthesizing the router in the target technology. The synthesis generates a mapped RTL, and this new RTL description replaces the original router description. The new RTL NoC description is then simulated, applying different traffic scenarios. At the end of each simulation, a value change dump (VCD) file of the synthesized router is generated. Then, the power consumption of a complete router is annotated using a commercial power estimation tool. At the end of the calibration phase, a table with the power consumption for each injection rate is generated, for each element of the router. An equation is obtained for each table, applying a linear adjustment technique. This equation gives the power consumption as a function of the injection rate. This is a generic procedure, and it can be applied to networks with different features. In the second step, the ***application*** of the model, the NoC is simulated to obtain the reception rate of each buffer. The buffer reception rate is measured with a monitor inserted in each buffer of every router. This monitor counts the amount of flits received in a parameterizable sample window. For each buffer reception rate the associated power consumption is annotated, applying the power consumption equations generated in the calibration phase.

Experiments show that for traffic with up to a couple of flows, the volume-based power estimation error is kept below 10%. However, for traffics with three or more flows, the error increases, due to the packet collision effect. The error in the rate-based power estimation is kept below 10%, even with more packet flows injected in the network. The insertion of more packet flows modifies the buffers transmission rates in each router, this fact increase the power estimation precision given by the rate-based model. A second experiment, with all routers injecting traffic into the network, even with small rates (15% of the available rate), the rate-based power estimation model keeps an error below 10%, compared to the PrimePower estimation tool, while the volume-based power estimation model error surpasses the 50% in the same comparison.

The volume-based power estimation models can produce very fast results, but the NoC designer must have in mind that the network task mapping, and the increased NoC data flow, can produce large variations in the power estimative due to the packet collision/contention. For that purpose, the rate-based power estimation model allow a more precise power estimation, while performing the NoC power dissipation in a acceptable time.

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[2] Hu, J.; Marculescu, R. “Energy-aware mapping for tile-based NoC architectures under performance constraints”. In: ASP-DAC, 2003.
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