Statistical Physics Approaches for Traffic Characterization of NoC Platforms

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Networks-on-chip (NoCs) have been proposed as a viable solution to solving the communication problem in multicore systems. In this new setup, mapping multiple applications on available computational resources leads to interaction and contention for various network resources. Consequently, taking into account the traffic characteristics becomes of crucial importance for performance analysis and optimization of the communication infrastructure, as well as proper resource management (see Figure 1). Traditional approaches to network performance analysis assume that the network operates at low injection rates and the network is in a congestion-free (free-flow) state (see Figure 2). Moreover, it is usually assumed that packet arrival rates are exponentially distributed and so the blocking probabilities at various buffers in the network can be easily calculated. However, as shown in Figure 2, while increasing the values of packet injection rate, the network exhibits a phase transition from a free flow state to a completely jammed state. This phase transition requires a non-equilibrium type of analysis of the traffic which, unlike queueing-based approaches, can account for non-stationary and long-term memory effects that are crucial for multicore platform design.

To overcome these limitations, we propose a statistical physics inspired approach to capture the traffic dynamics in multicore systems. This is of fundamental significance for re-thinking the very basis of multicore systems design and it also opens up new research directions into multicore optimization which require accurate models to account for time-dependent and space-dependent traffic behavior.

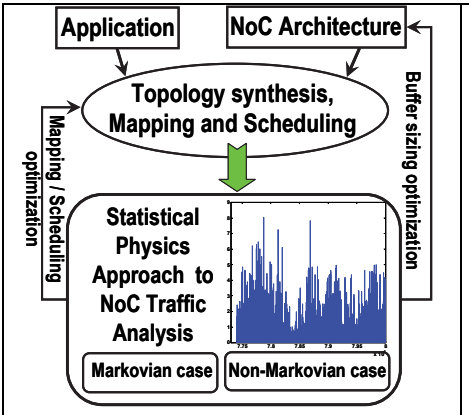

Fig. 1: Implications of the statistical physics inspired approach to NoC traffic characterization and analysis.

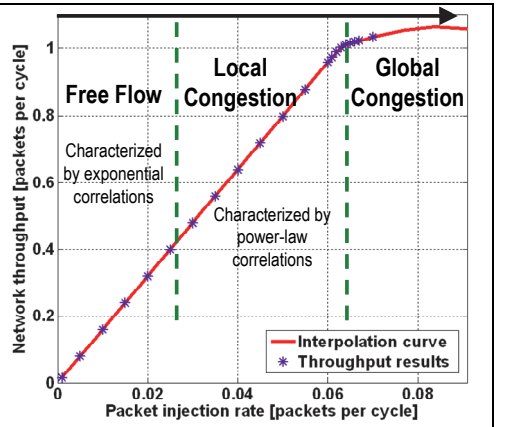

Fig 2: Phase transition for a 4x4 mesh NoC under XY wormhole routing and uniform packet injection.