Entropy Modeling of Information in Finite State Machines Networks

Elena Fomina

Driven by remarkable theorems of Claude E. Shannon, which motivate entropy as the measure of information content, we have been examining the entropy measures for search of an approximate or indirect method of evaluation information and information dependences in Finite State Machines. Our goal is to originate a quantitative theory of decomposition for FSMs based on the structural decomposition theory by J. Hartmanis and R. E. Stearns. Mathematical foundations of pair algebra supply the algebraic formalism necessary to study problems about information in FSMs when they operate.

We wish to consider information of partition contents in a special sense; it is a measure of the freedom of choice with which a partition is selected from the set of all possible partitions. The greater information in partitions, the lower its information randomness, and hence the smaller its entropy. Assuming notion of partition on finite set as an algebraic equivalent of information, a quantitative measure of information dependence is defined as a channel on this finite set. Shannon's entropy becomes an important measure for evaluating structures and patterns in channels. The lower the entropy (uncertainty) the more structure is already given in the relation.

Entropy criteria for selecting the set of partitions for decomposition of FSMs allow evaluating partitions sets, to build the informational model of the FSM network under design, and to estimate the network implementation complexity. Amount of information that flows through the FSMs network can be also estimated by entropy or statistical technique, which propagates information statistics at the primary input through the network and monitors the distribution of information. In this way, we have possibility to evaluate the informational flows in each terminal and component of FSMs network and thus create an entropy model for it.

The idea of using entropy is based on informational measures can be applied to other phases of logic synthesis. Partitions that are incomparable under the least upper bound and the largest lower bounds in classic lattice usually do have different entropy values, so they become comparable. This property of lattice functions opens perfect new possibilities for decomposition and coding methods. Practically confirmed high correlation proves that partition entropy is a good indicator of implementation complexity. Previously presented implementation-independent approach for low power partitioning synthesis attempts to minimize the average number of signal transitions at the sequential circuit nodes through dynamic power management. A lower power FSM synthesis framework can integrate the proposed techniques because of the fact that decomposition yields attractive power reduction in the final implementations.

As it is stated in many sources, probabilistic behavior of FSMs has been investigated using concepts from the Markov chain theory. The construction of a Markov chain requires two basic ingredients, namely a transition matrix and an initial distribution. We assume that the state lines of the FSM are modeled as Markov chain characterized by the stochastic matrix where elements are conditional probabilities of the FSM transitions. These probabilities, along with the steady state probability vector can be found using standard techniques for probabilistic analysis of FSMs. This paper advocates entropy modeling of information of FSMs networks. We describe a range of aspects of using entropy criteria as measure of information flows. The main objective of the current work is to give a scalable entropy approach to evaluation. By "scalable", we mean that information in all parts of FSMs network can be estimated and analyzed separately and can then be composed, estimated and analyzed completely.