Comparison of Test Pattern Decompression Techniques

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Abstract

Test pattern decompression techniques are bounded with the algorithm of test pattern ordering and test data flow controlling. Some of the methods could have more sophisticated sorting algorithm, some of the methods may be supported by fault simulation and some can work without any information about the quality of previously generated test patterns. The differences between the decompression techniques cause that the efficiency of the automata is not comparable and the published results do not give us any idea of the best choice of decompressing automaton. We have performed experiments, in which we have studied the degradation of random input stimuli by the decompression automata (DA) used by different authors. We have found that a medium percentage of the (n,r) exhaustive test set created on the DA outputs after stimulating the DA inputs with a given number of random pattern is correlated with the DA efficiency. This statement has been verified by experiments with ISCAS circuits.

1. Experimental Arrangement

The decompression automaton (DA) converts test seeds, which are stored in a memory, into test patterns. We have used an average percentage of the (n,r) exhaustive sets as a measure of the decompression efficiency. The parameter n equals to the total number of the CUT inputs and r equals to the maximum CUT cone size. The DA is fed with regularly distributed random bits in regular instants. The experiments indicate whether any part of test vectors is difficult to be obtained from the DA. In order to keep the comparability between different types of automata we have compared a percentage of exhaustive test sets in the time instants in which the total number of "consumed" random input bits is the same for every automaton. We have performed the following experiments:

Comparison of the percentage of created (n,r) exhaustive test set depending on the number of clock cycles performed between feeding a new input random bit into the automaton. The number of automaton stages is fixed.

Comparison of the percentage of created (n,r) exhaustive test set depending on the automaton dimensions. The number of clock cycles performed between feeding a new input random bit is fixed.

Comparison of the relative part of (n,r) exhaustive test set, which was obtained by the DA for different values of r.

Evaluation of the number of detected faults for ISCAS circuits.

The experimental results do not provide any information about the number of bits, which have to be stored in a memory in real decompression schemes, because they are based on random DA inputs and not on the compressed test patterns.

2. Experimental results

The mathematical model was fed with a decompressing automaton output sequence. At the beginning the automaton was set to a randomly chosen state. A given number of clock cycles was performed and a new input bit was loaded to the first automaton flip-flop. This sequence was repeated until a given number of input bits was consumed for the sequence modification. We checked the percentage of (n,r) exhaustive test set on the model inputs in logarithmically distributed instants.

We can see that the highest percentages of (n,r) exhaustive is obtained for the cellular automaton with primitive polynomial and then for the MP LFSR. In the case of the Johnson counter, there are gaps in the percentage for the numbers of clock cycles between feeding a new bit, which are equal to any multiple of the Johnson counter length. Some of the experimental results are plotted in the Figure.

We have found that if we choose the parameter r, which represents the maximum cone size of the tested circuits substantially smaller than the automaton dimension, the results are representative and similar for different experiments. In other words: the relative DA effectiveness can be verified by one representative experiment, variations of the parameter r in the above mentioned range does not impact the final decompression effectiveness.

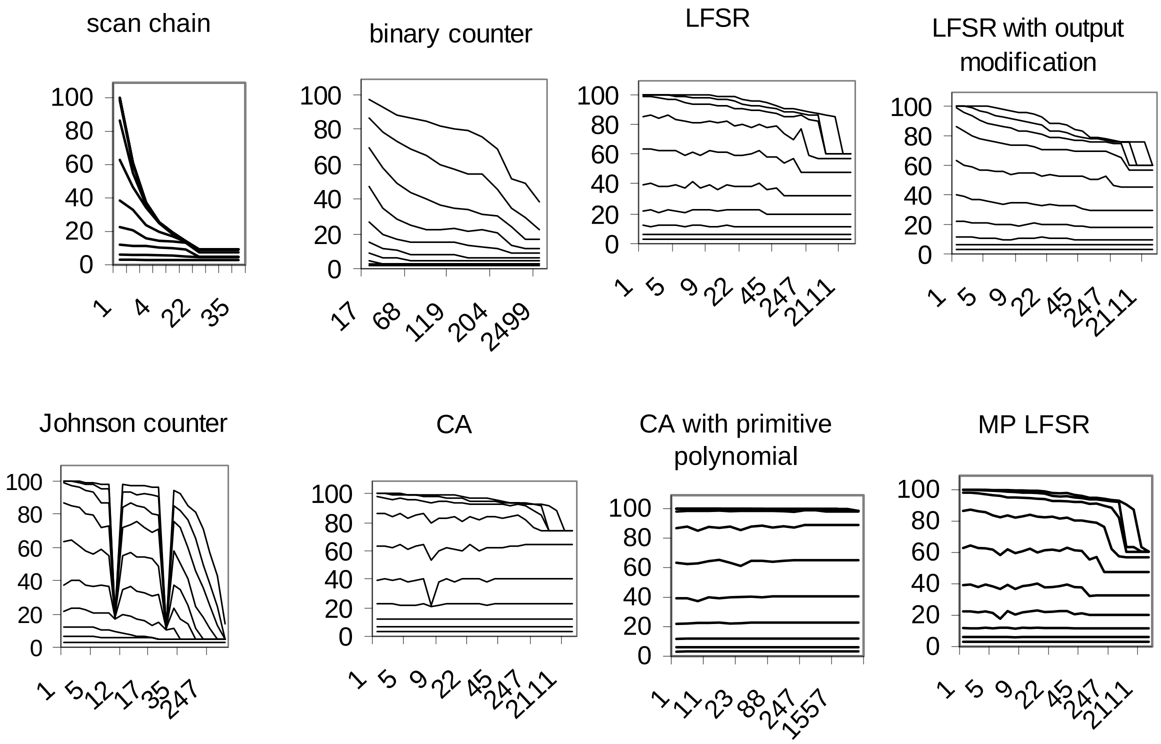

Figure: Medium percentage of an (17,8) exhaustive test set for different automata. The exhaustive test set percentage is checked after performing 16 (the lowest curve), 32, 64, 128, 256, 512, 1024, 2048 and 4196 (the highest curve) clock cycles. The number of clock cycles performed after each new input bit feeding is a parameter on the x-axis of the graph.

We have performed several series of experiments with the ISCAS circuits. The experiments were done similarly to the above described experiments with the only difference of using a percentage of detected faults instead of the medium percentage of (n,r) exhaustive test set. These results are correlated with the results of experiments with mathematical model.

Conclusions

We have verified that checking the relative percentage of the (n,r) exhaustive test sets obtained from DAs, which are excited with regularly distributed random bits gives us a general idea of the decompression quality of DAs.

We can estimate the necessary DA length according to the experimental results and we can choose the maximum number of autonomously generated test patterns for which the degradation of the pattern quality is still not critical. The high correlation between fault coverage obtained on the CUT and the percentage of created (n,r) exhaustive test set gives us a possibility to choose appropriate DA without detailed knowledge of the CUT structure. The experiments have proved that a scan chain has the same pattern decompression effectiveness as other more complicated automata in case of using a new input bit every clock cycle. As it is the simplest DA solution it can be advantageously used. The second simplest solution is the Johnson counter. The experiments have shown that for a limited number of clock cycles between feeding a new input bit it could be used for decompression also very effectively. For maximum memory savings (maximum numbers of autonomously performed cycles) we have to use more complicated hardware structures of DA in order to avoid the pattern quality degradation. The experiments have shown that cellular automata with primitive polynomials are very suitable for this purpose.

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