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Performance-driven assignment and mapping for reliable networks-on-chips

Key words: Network-on-chip (NoC), Mapping, Assignment, Reliability

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Introduction

- Network-on-chip (NoC) communication architectures present promising solutions for scalable communication requests in large system-on-chip (SoC) designs. Intellectual property (IP) core assignment and mapping are two key steps in NoC design, significantly affecting the quality of NoC systems. Both are complicated combinational optimal problems. So, it is necessary to apply intelligent algorithms

- Based on the characteristics of IP core assignment and mapping, improved multi-objective optimization intelligent algorithms PSOGA, PSOSA, and SS have been presented in this paper. The optimization goals of the proposed algorithms are to minimize power consumption,
- time, area, and load balance. In addition, an adaptive rerouting algorithm has been presented in order to improve the reliability of systems

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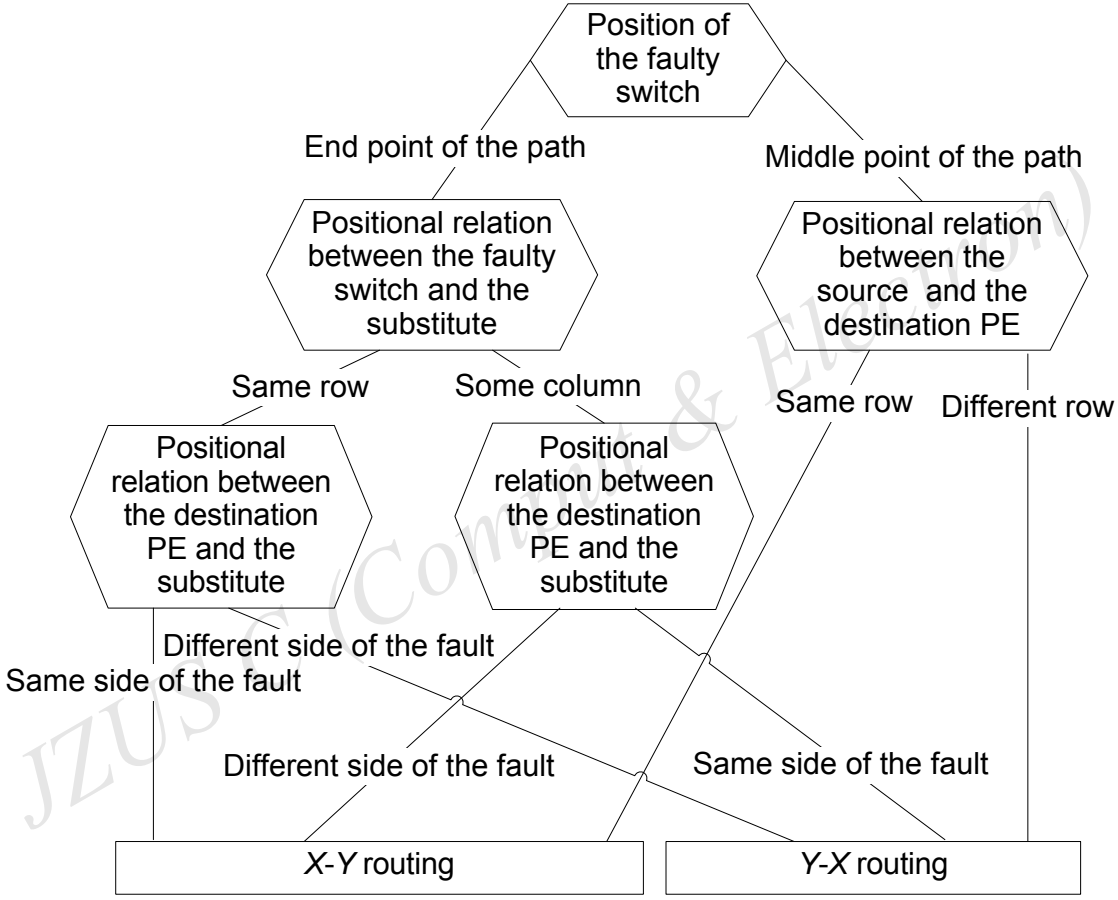
Design method (I)



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Decision tree of rerouting algorithm

Design method (II)

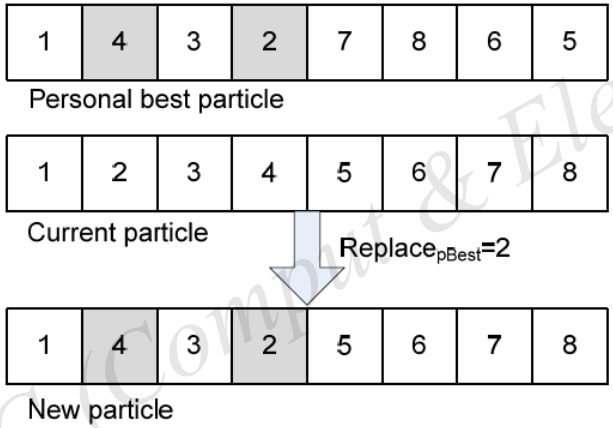
The main steps of PSOGA algorithm are as follows:

1. Generating and updating populations

   The updating formulas of particles are given by

$$V_{t+1} = \omega V_t \oplus c_1 rand_1 replace_{pBest} \oplus c_2 rand_2 replace_{gBest}$$

$$P_{t+1} = P_t \oplus V_{t+1}$$



Process of replacement

2. Diversifying updated populations

   In the assignment phase, the mutation value is selected only from the candidate IP core set of the corresponding subtask. In the mapping phase, the elements swap with other elements of the same particle

3. Calculating fitness

   Based on evaluation models, calculate the fitness of particles

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Design method (III)

PSOSA algorithm

```
1 Begin
2     Generate the initial particle swam;
3     Compute multi-objective evaluation indices for particles;
4     Select initial pBest and gBest;
5     Repeat
6     Update particles;
7     Repeat    //starting local searching by SA
8     Set the initial and final temperatures;
9     Repeat
10      Select a particle as current particle;
11      Repeat
12      Generate the particle's neighbors;
13      If (d1<0)+(d2<0)+…+(dN<0)≥N //di represents the difference of ith
        // evaluation index, N represents the number of evaluation indices
14          Accept the neighbor particle;
15      Else
16          If p<exp(−Δf/T)
17              Accept the neighbor particle;
18          End if
19      End if
20      Until (reaching the preset times of iterations)
21      Decrease the temperature;
22      Until (reaching the preset temperature)
23      Until (all particles finishing local searching)
24      Update local and global best particles;
25      Until (reaching the termination condition)
26 End
```

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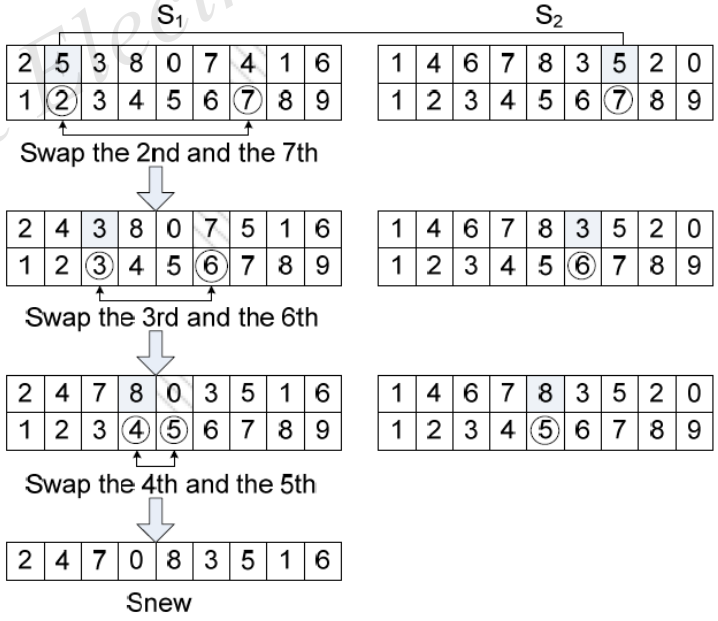
Design method (IV)

The main steps of multi-objective SS algorithm are as follows:

1. Individual generation method
   Each IP core assignment solution or mapping solution is represented by an individual
2. Reference set and subset generation method
   The reference set consists of high performance solutions and diverse solutions. 2-element subsets are adopted
3. Solution combination method



Process of crossover

4. Reference set update method
   The new solutions with high performance and long distance replace the old solutions at the lowest Pareto optimal rank

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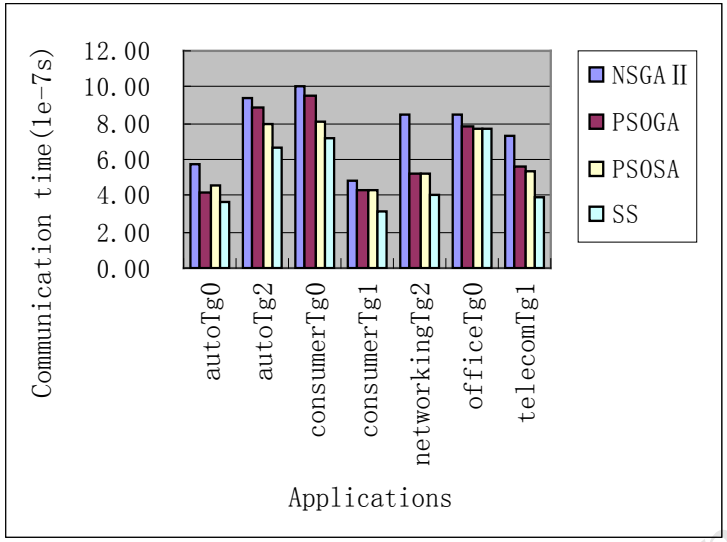
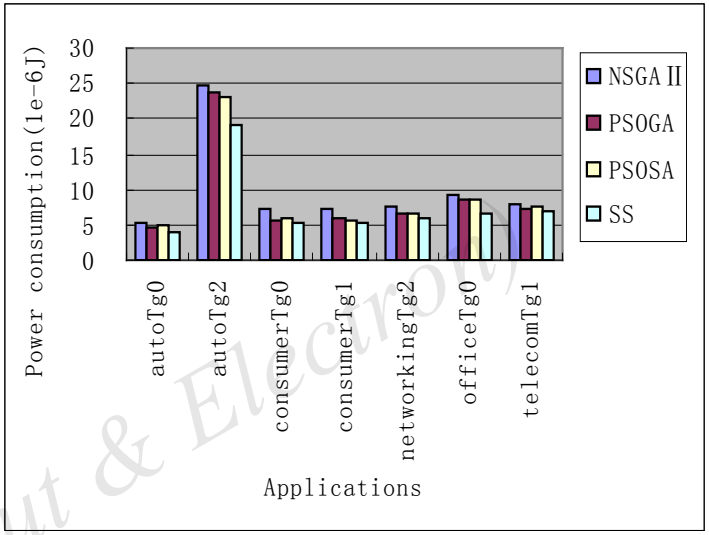
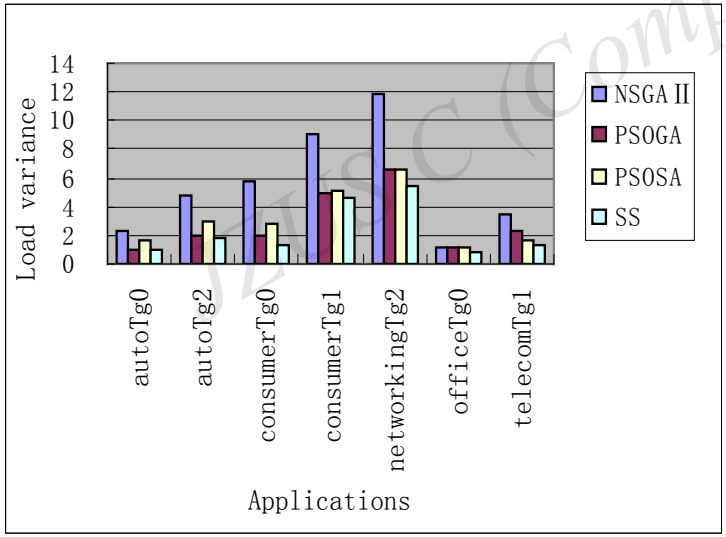
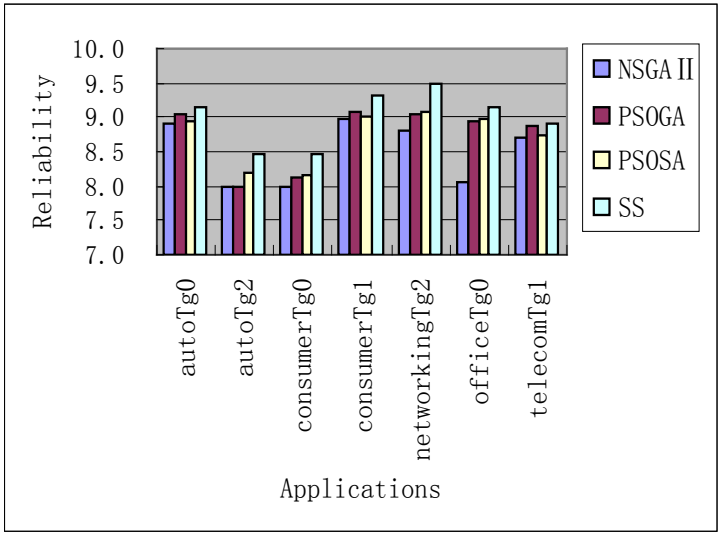
Simulation results









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Performance comparisons between mapping solutions obtained from different algorithms

Conclusions

- An adaptive fault-tolerant rerouting algorithm has been presented which can recover the communication and balance the load when switches fault
- The proposed algorithms PSOGA and PSOSA take advantages of particle swarm optimization, genetic algorithm, and simulated annealing algorithm. The multi-objective SS adopts effective searching methods which are still not emulated by other intelligent algorithms
- Compared with other traditional intelligent algorithms, the proposed algorithms in this paper have obtained higher performance and reliability assignment and mapping solutions

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