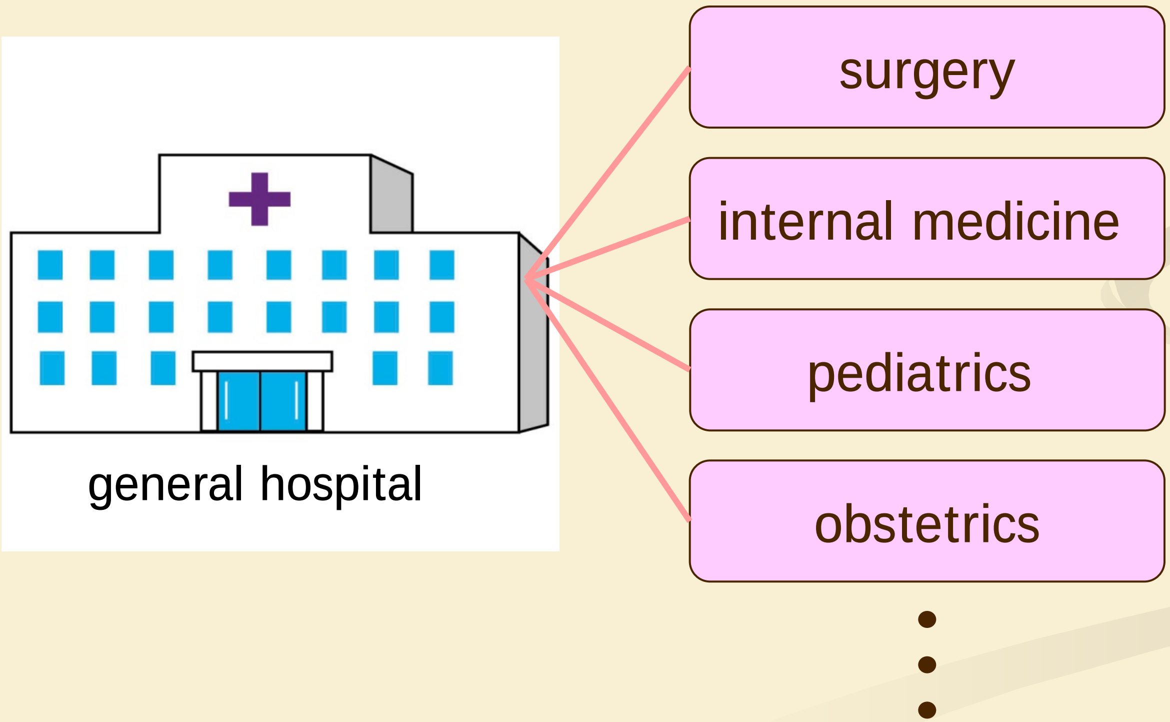
Effective Genetic Operators of Cooperative Genetic Algorithm for Nurse Scheduling



◆About Fifteen to Thirty nurses are working in each section.

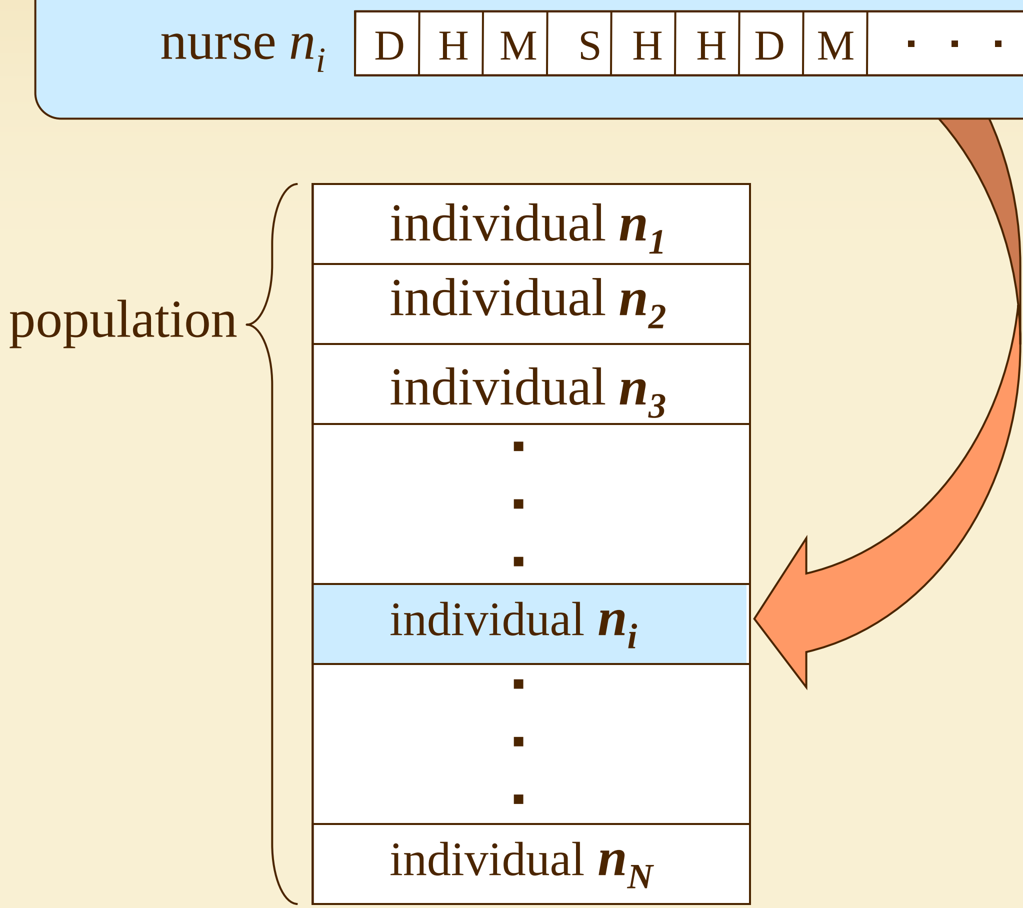
◆A clinical director of the section must arrange their shift schedule every month.

◆He/she needs one or two weeks for the nurse scheduling.

Computer Software for the Nurse Scheduling

2. Nurse Scheduling by Cooperative GA (CGA)

One month schedule of a nurse n_i is coded by consisting of task symbols.



In the CGA, the individual is coded as an one-month schedule of each nurse.

The population totally consists of one-month schedules of the whole section.

The population denotes the whole nurse schedule of the current month.

The population, or the nurse schedule, is optimized by applying a <u>crossover operator</u> in the conventional way.

3. Performing the Nurse Schedule

We have summarized many requirements about the nurse schedule into twelve penalty functions for performing the population set, the nurse schedule.

* Duty load of each nurse : $F_{1i} = \sum_{j=2}^{D-1} p_{ij}$

* Fairness of holidays and night time duties of each nurse :

$$F_{2i} = \left| N_i^{\mathrm{hom}} - N_{\mathrm{hom}} \right| \qquad F_{3i} = \max\left(N_i^{sem} - N_{sem}, 0\right) + \max\left(N_i^{mid} - N_{smid}, 0\right)$$

* Intensiveness of night time duty assignment of each nurse :

$$F_{4i} := F_{4i} + \max\left(N_{night/6} - 3, 0\right)$$

* Violation of prohibition of the training at the next day of night duty : F_{5i}

* Consecutive duty days without holidays :

$$F_{6i} := F_{6i} + \max\left(N_{cons} - 5, 0\right)$$

∗ Total nursing levels of the day time, the semi night and the mid night duties at a duty day:

$$F_{7j} = \max\left\{ L_j^{day} - \sum_i L(n_i), 0 \right\}, n_i \in M_j^{day} \qquad F_{8j} = \max\left\{ L_j^{sem} - \sum_i L(n_i), 0 \right\}, n_i \in M_j^{sem}$$

$$F_{9j} = \max\left\{ L_j^{mid} - \sum_i L(n_i), 0 \right\}, n_i \in M_j^{mid}$$

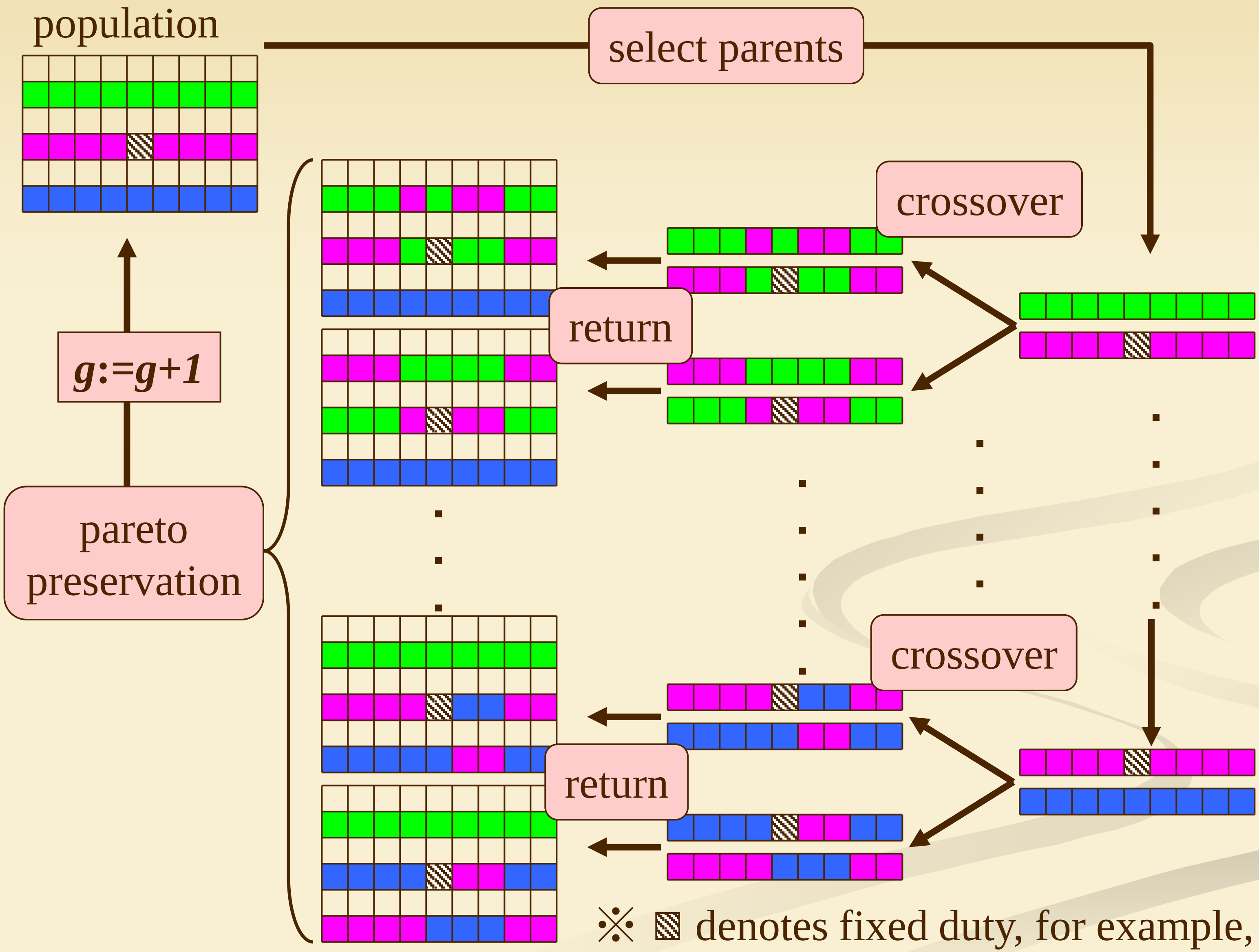
∗ Bad affinity combination of nurses assigned to the mid night duty at a duty day : F_{10j}

∗ Assignment of two or more new faces to the night duty at a duty day :

$$F_{11j} := F_{11j} + \begin{cases} 0 & , N_{j,new}^{mid} < 2, \\ \sum_{i=0}^{N_{j,new}^{mid}-2} \left(N_{j,new}^{mid} - i \right) & , N_{j,new}^{mid} \geq 2, \end{cases}$$

∗ Violation of a rule that one or more expert nurses at a duty day : F_{12j}

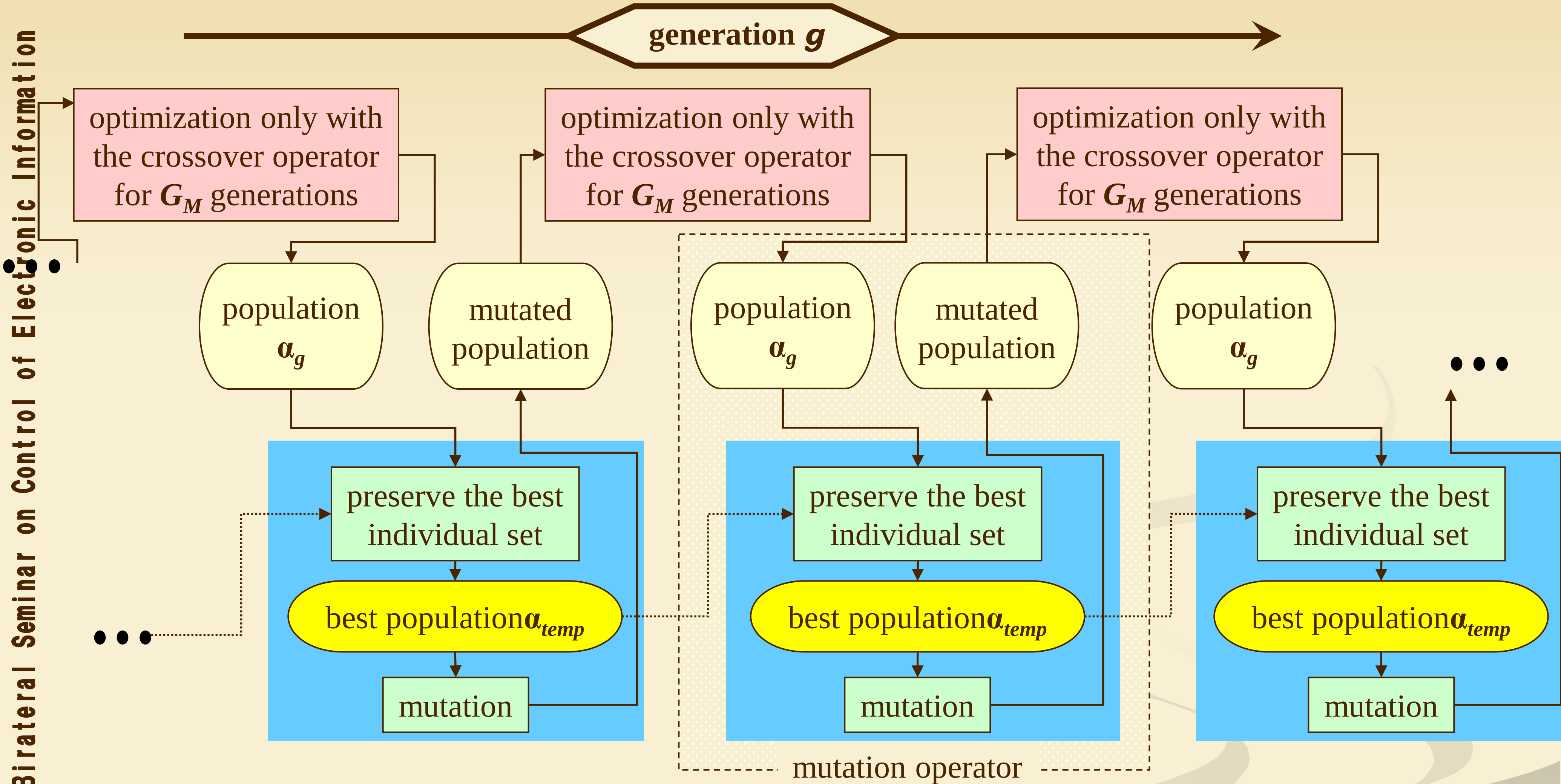
4. Basic Optimization Cycle by Crossover Operator



※ ▧ denotes fixed duty, for example, meeting, duty and requested holiday.

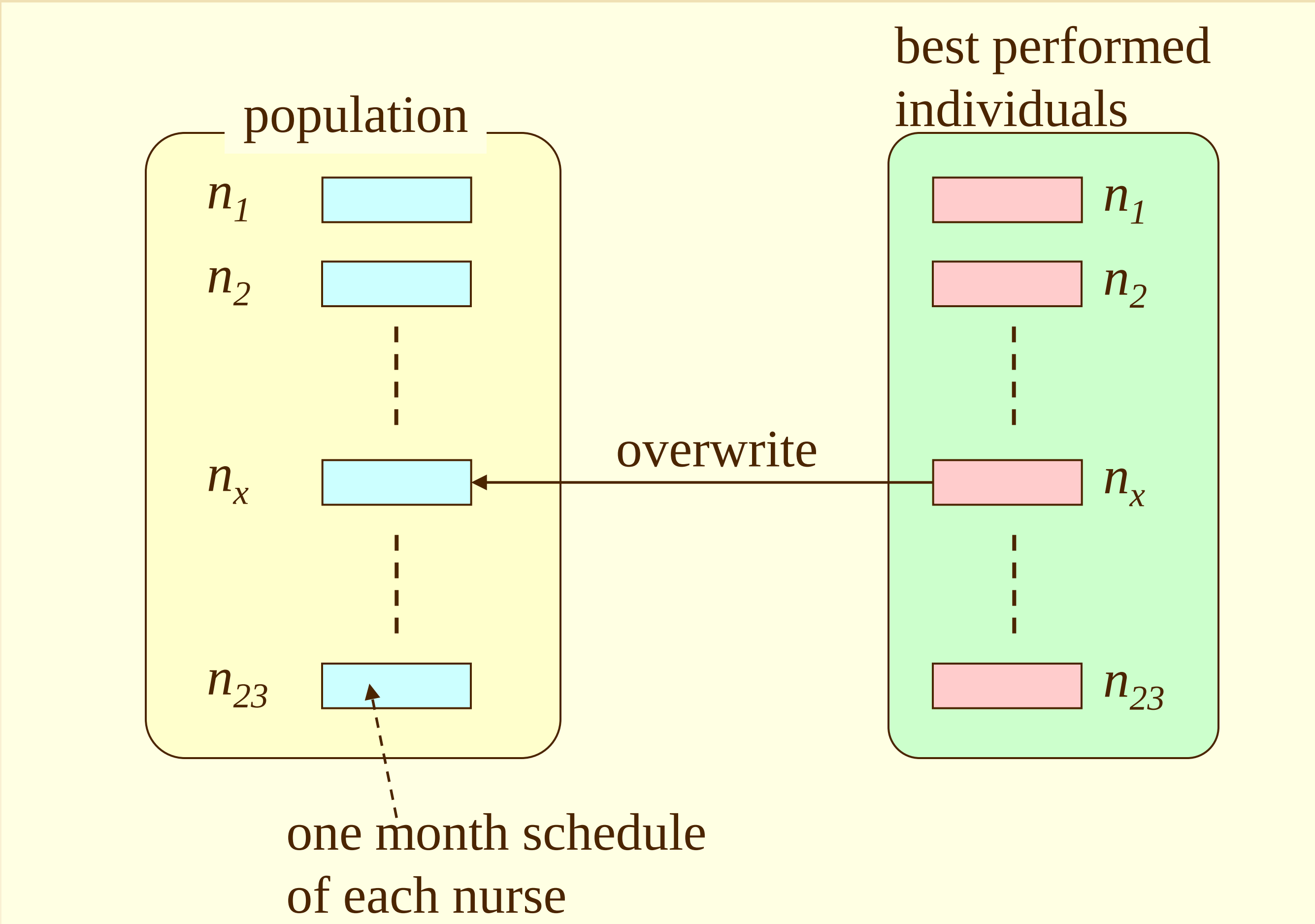
5. New Effective Operators

(1) Mutation Operator



- The mutation operator changes some parts of the population in the G_M generations interval without losing its consistency.
- The optimization before the mutation is carried out only by using the crossover operator for G_M generations.

(2) Virus Operator

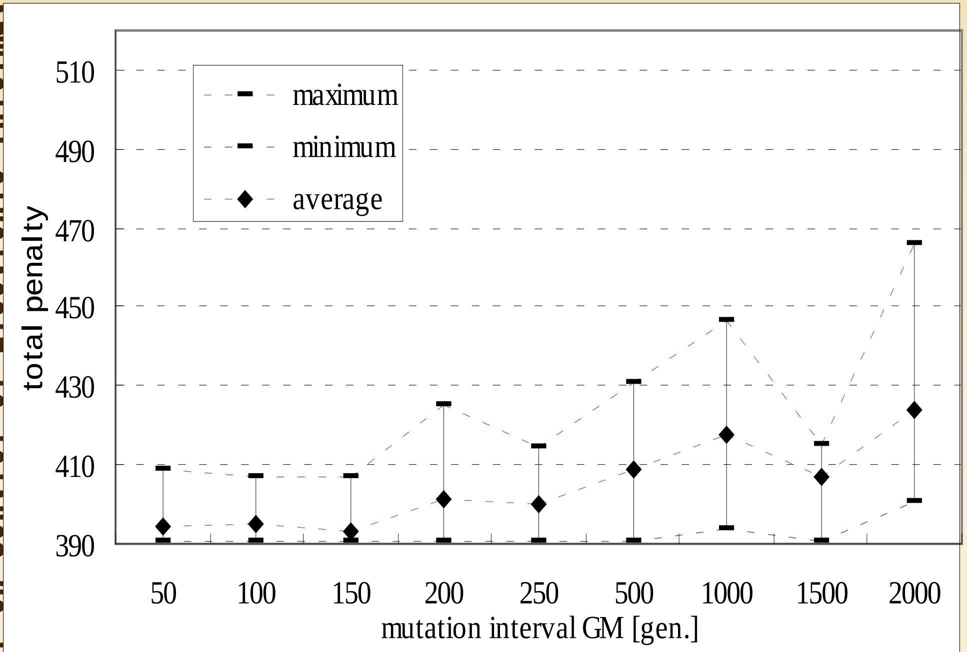


- After the pareto preservation, the best performed schedule of each nurse is preserved.

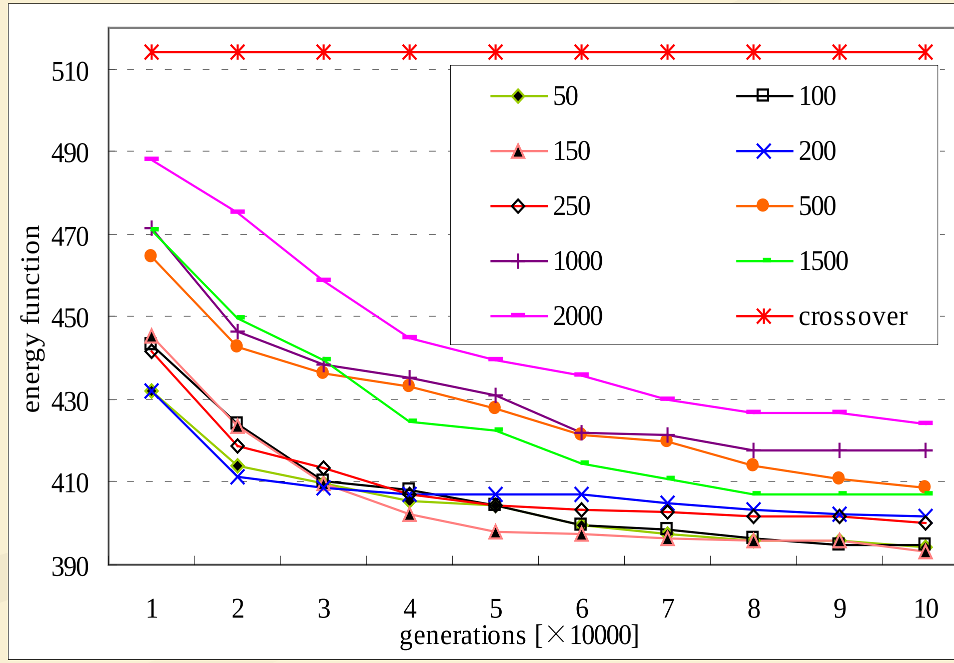
- When the mutation operator is execeuted G_v times, the virus operator is exectuted instead of the mutation operator.
- The virus operator overwrites the best performed individual onto an individual of the population.

6. Results and Conclusion

We have considered on the mutation rate, G_M.

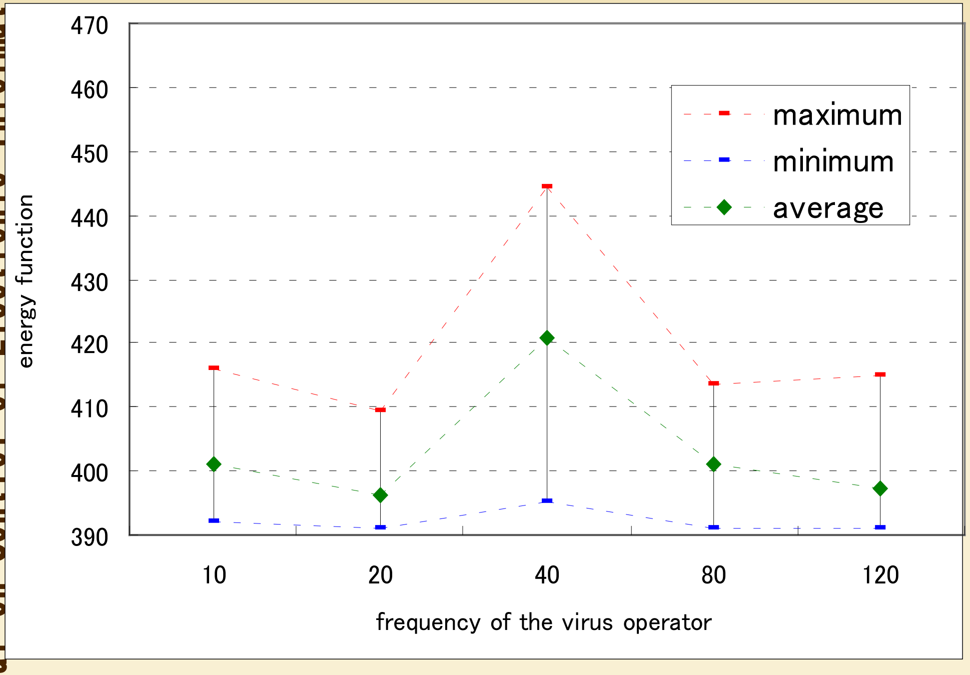


(a) Comparison of the mutation rate, G_M. This result shows that the mutation rate should be decided less than **150**.

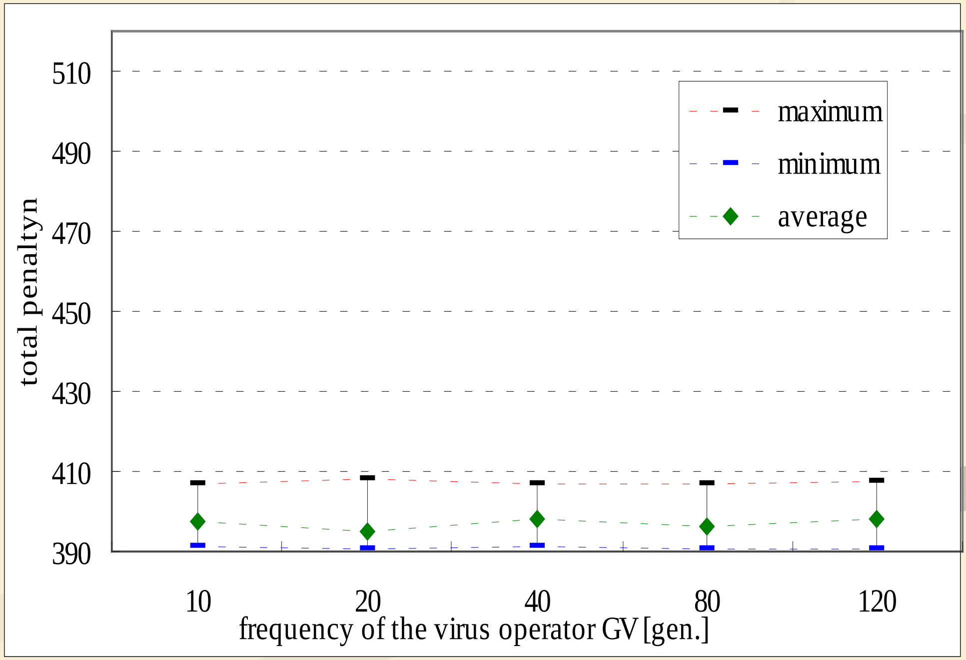


(b) Average of the penalty for **10** trials with several mutation intervals. This result shows that the mutation with the mutation rate, G_M, less than **200** effectively works.

We have considered on the penalty configuration of the virus operator.

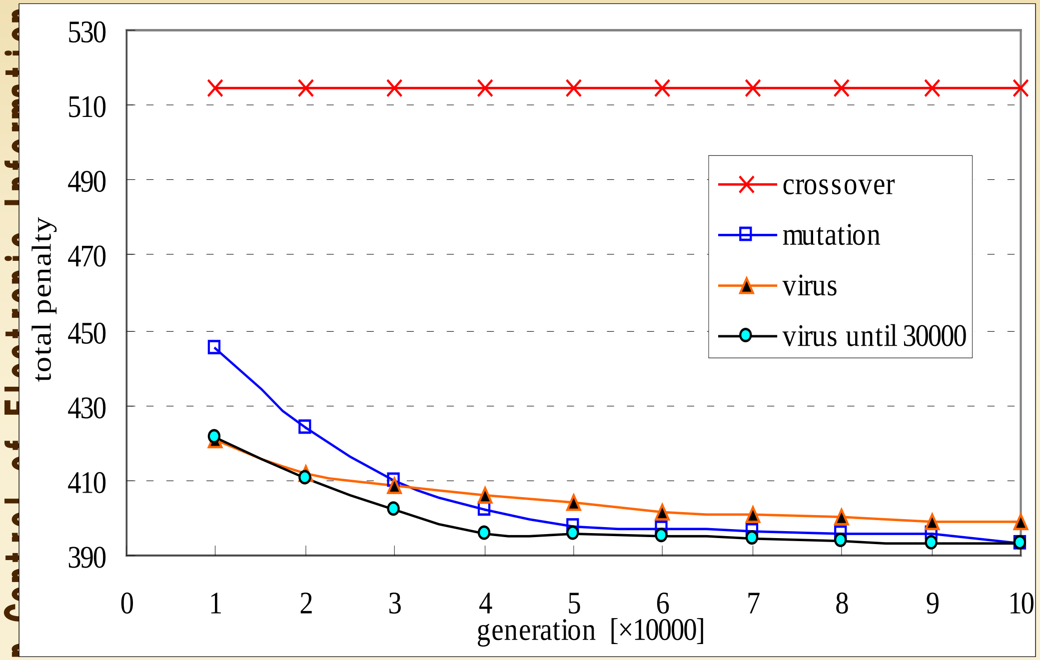


(c) In this case, penalty functions F_{1i}-F_{6i} are applied for the best individual selection. This approach does not stably good solution.



(d) We have tried to exclude the penalty function, F_{1i}, for the best individual selection. The penalty functions F_{2i}-F_{6i} are applied for the best individual selection. This modified approach stably good solution.

Finally, we have combined the new operators.



(e) Average of the penalty for **10** trials by using several techniques.

- The mutation operator slowly searches in the solution space and finally fined the best solution.
- The modified virus operator does not effectively searches after 30000 generations.
- The combined algorithm, shown by “virus until 30000”, gives the best performance.
- This result shows that the combined technique only requires 40000-50000 generations for the nurse scheduling.

Conclusion

- The nurse scheduling technique using CGA is proposed.
- The conventional CGA optimizes the schedule using only the crossover operator.
- Two new genetic operators, the mutation and the virus operators, are proposed to improve the optimization speed.
- We have considered on the mutation rate and the configuration of the penalty functions for the best individual selection.
- Finally, we have proposed the combined technique which quickly gives the best solution.