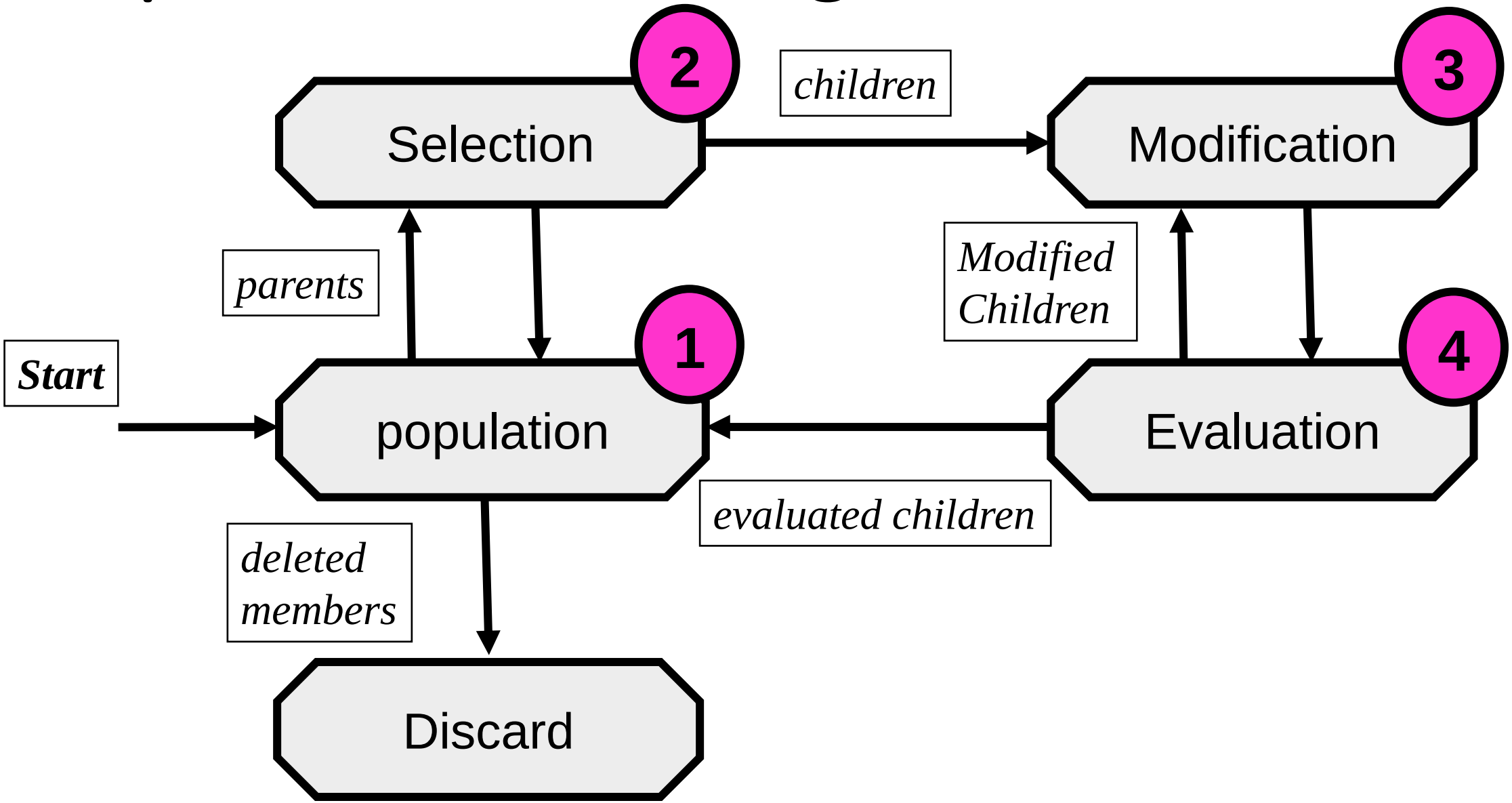
Genetic Algorithms (GA)

Genetic Algorithm

- Genetic Algorithm is inspired form biological evolution
- Developed by John Holland, University of Michigan (1970's)
  - To understand the adaptive processes of natural systems
  - To design artificial systems software that retains the robustness of natural systems
- Provide efficient, effective techniques for optimization and machine learning applications
- Widely-used today in business, scientific and engineering circles

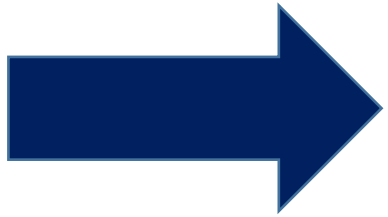
Steps of a Genetic Algorithm



The Problem

0	0	0
0	0	0
0	0	0

Start State



1	1	1
1	1	1
1	1	1

Goal State

Chromosome Representation

0	0	0	0	0	0	0	0	0

Fitness Function: The number of 1s in the chromosome.

Fitness(start) = 0

Fitness(goal) = 9

1. Initial Population

	Chromosomes in Population	Chromosomes Fitness
P1	0 0 0 0 0 0 0 0 0	Fitness(P1) = 0
P2	0 1 0 0 0 1 0 0 0	Fitness(P2) = 2
P3	0 0 0 0 0 0 0 1 0	Fitness(P3) = 1
P4	1 0 0 1 0 0 0 0 1	Fitness(P4) = 3

2. Selection

- Selection is random and is based on the fitness value:

$$Selection\_Prob_i = \frac{Fitness\ (P_i)}{\sum_{i=1}^{p\_size} Fitness\ (P_i)}$$

Selection_Prob(P1) = 0

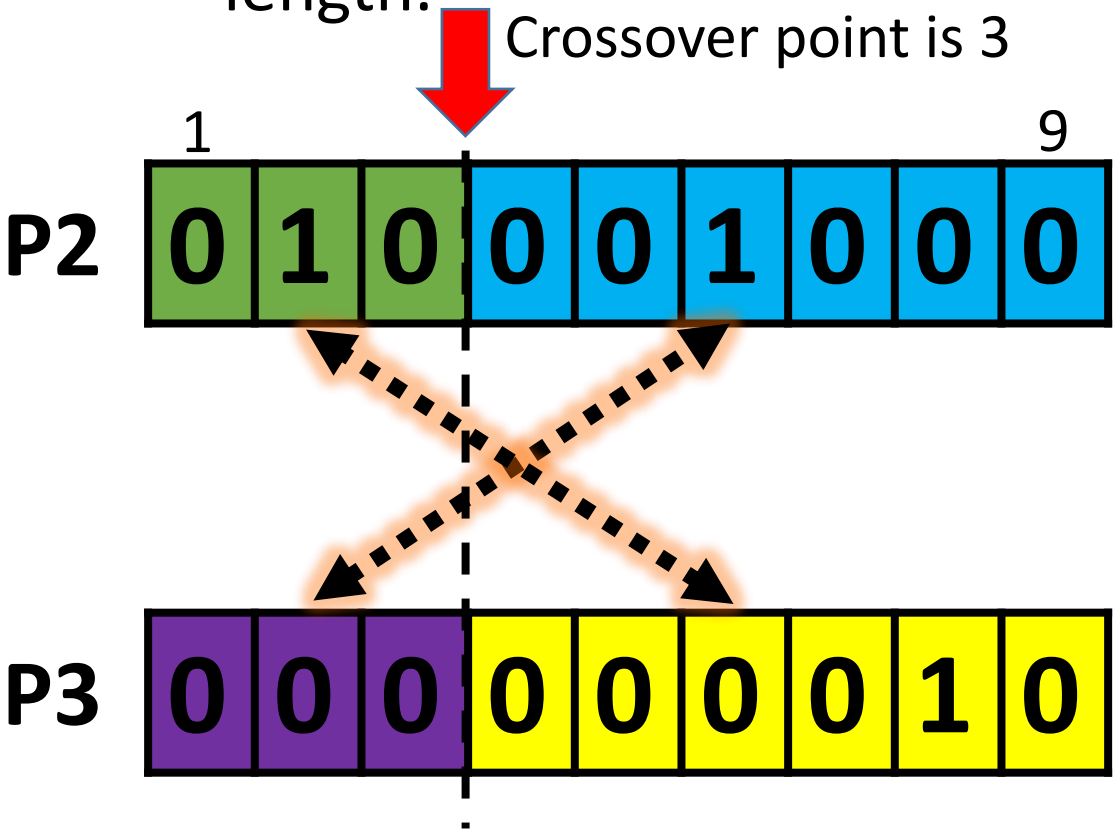
Selection_Prob(P2) = 2/6

Selection_Prob(P3) = 1/6

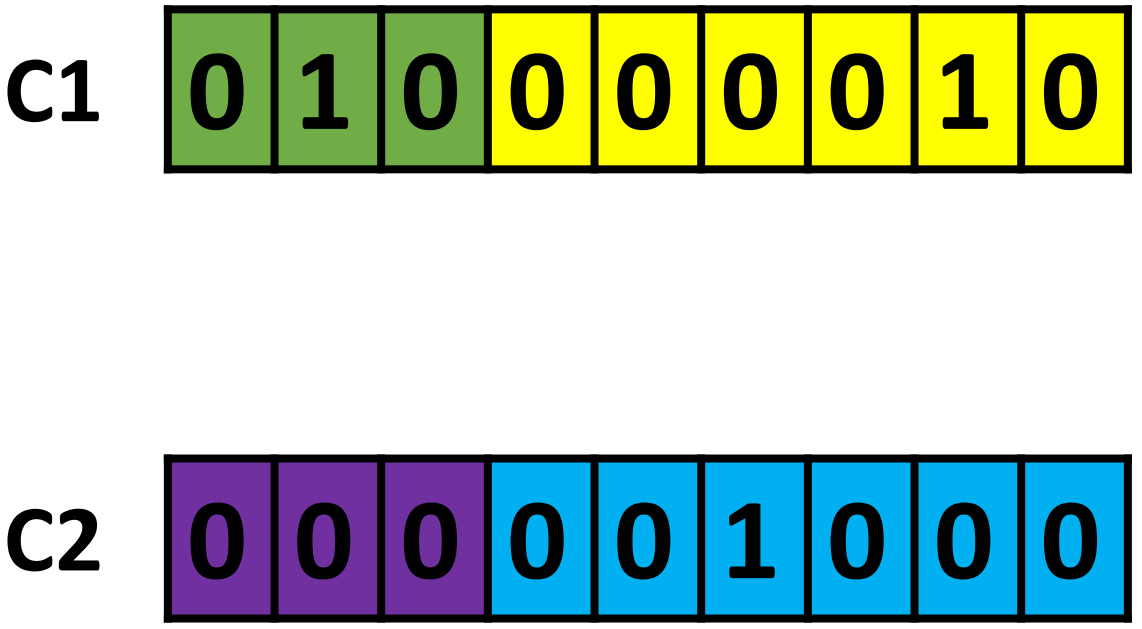
Selection_Prob(P4) = 3/6

3. Modification [Crossover]

- **Single point crossover:** Generate a random number in the chromosome length.



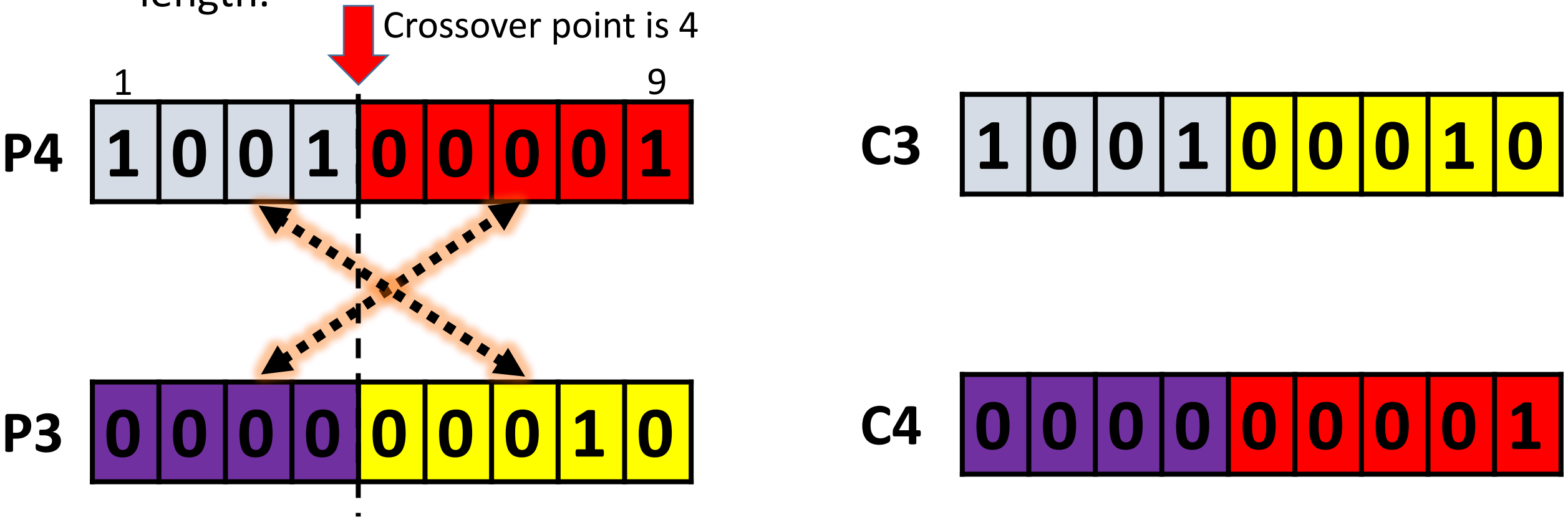
First two randomly selected parents



First two children from two parents

3. Modification [Crossover]

- **Single point crossover:** Generate a random number in the chromosome length.

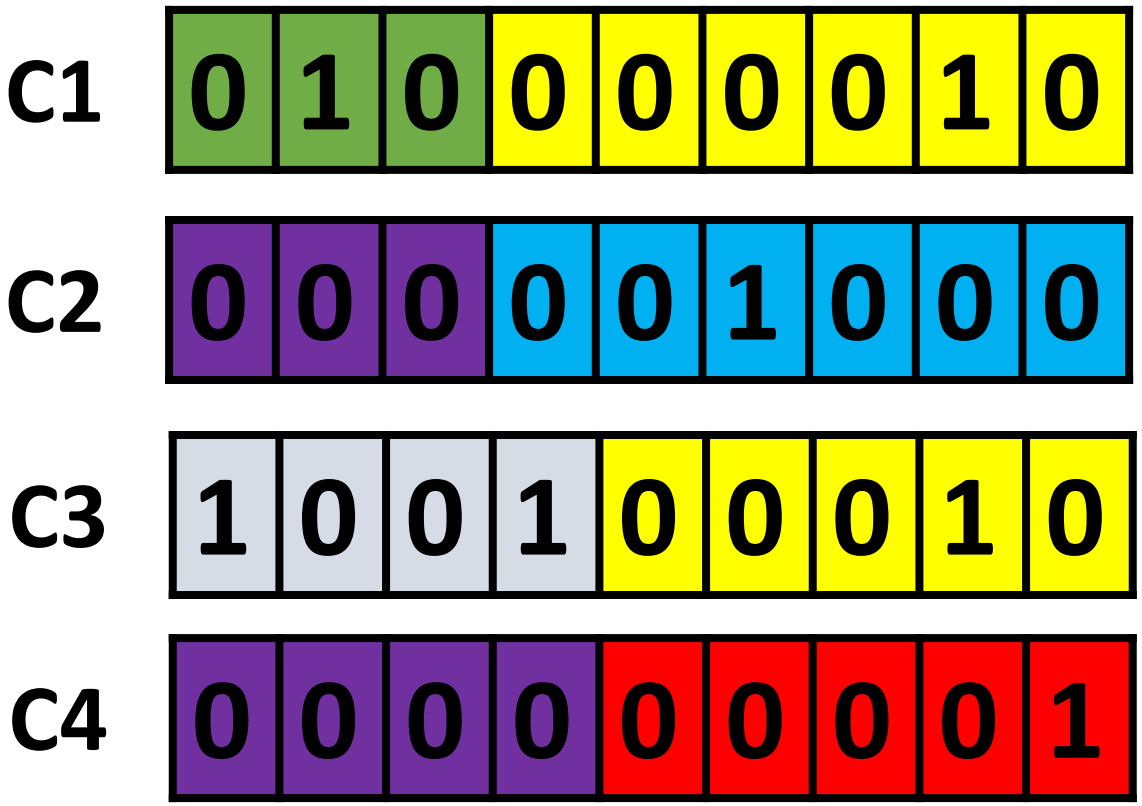


Another two randomly selected parents

Next two children from two parents

After CrossOver

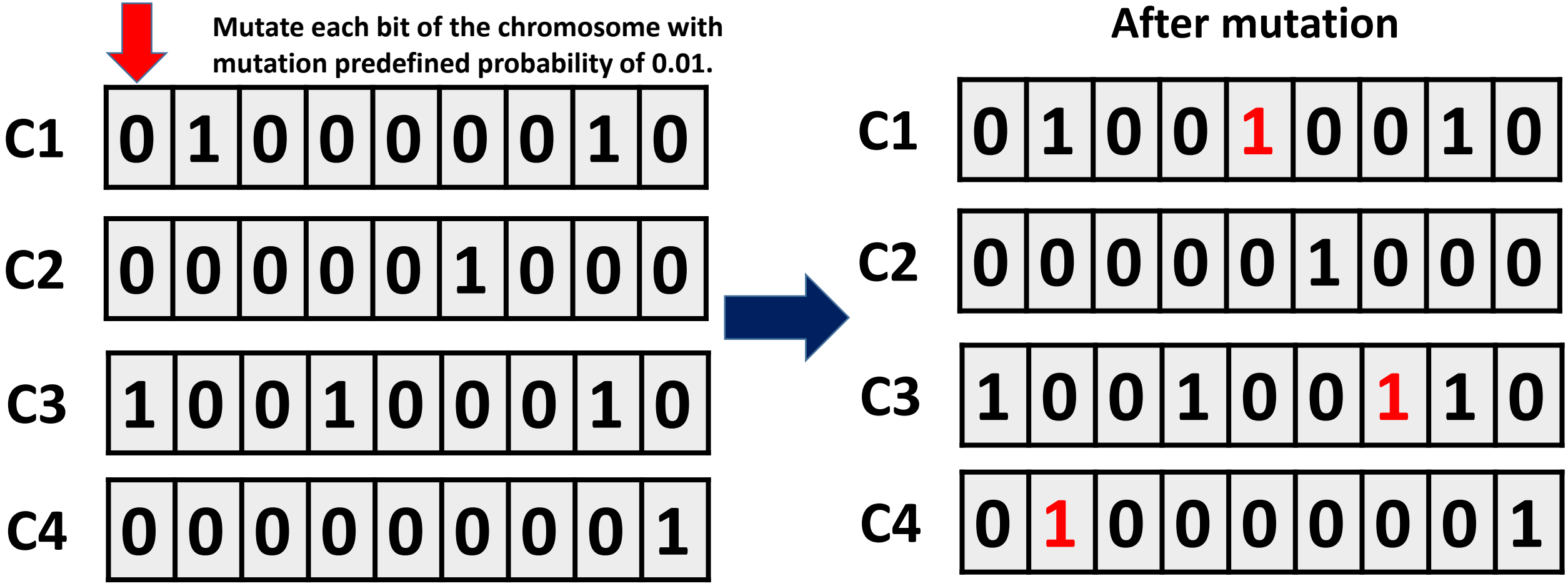
- After crossover operation is done we are left with the following children:



The next step is mutation….

3. Modification [Mutation]

- **Mutation** of chromosome is done using a predefined probablility. Usually it is a low number e.g., 0.01.



4. Evaluation

- The evaluator decodes a chromosome and assigns it a fitness measure
- Check the fitness of the states and apply goal test if goal state is available.
- If the goal state is not found or the termination condition is not met then the evaluated children are replaced with the existing population and Step 1-4 are repeated.

Applications of Genetic Algorithm

- **Feature Selection:** To select optimum number of features for a classifier.
- **Engineering Design:** To make design cycle process fast and economical using GAs.
- **Traffic and Shipment Routing (Travelling Salesman Problem):** efficiently adopted by many sales-based companies as it is time saving and economical.
- **Robotics:** Think of using GA to make robots that learn to behave like human.