Presentation Outline:

1) Introducing the 4-Queen problem

2) **Activity**: Solving 4-Queen problem using artifacts

3) Solution of 4-Queen problem in Backtracking approach

4) Demerits of Backtracking approach

5) Introducing 8-Queen problem

6) Discussion on Genetic Algorithm

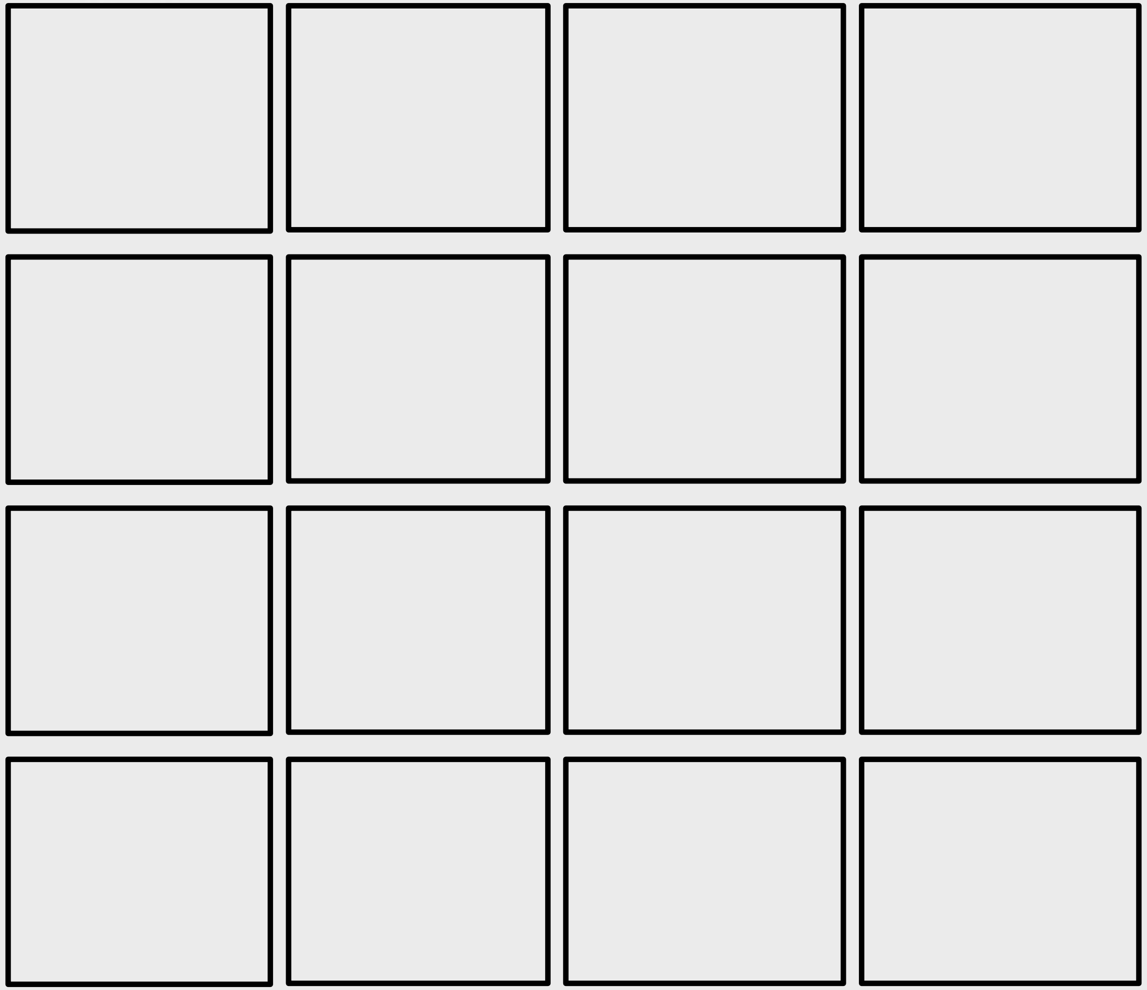
7) Solution of 8-Queen problem using GA

8) Conclusion

The 4-Queen Problem

Once upon a time, there was a great king in India. However, it was a matter of shame that he had 4 Queens. The Queens were so arrogant and they didn't even want see one another. Therefore, the King built a castle of 4 x 4 rooms. However, he couldn't find way the to place the 4 Queens in 4 separate rooms, so that they couldn't see each others.

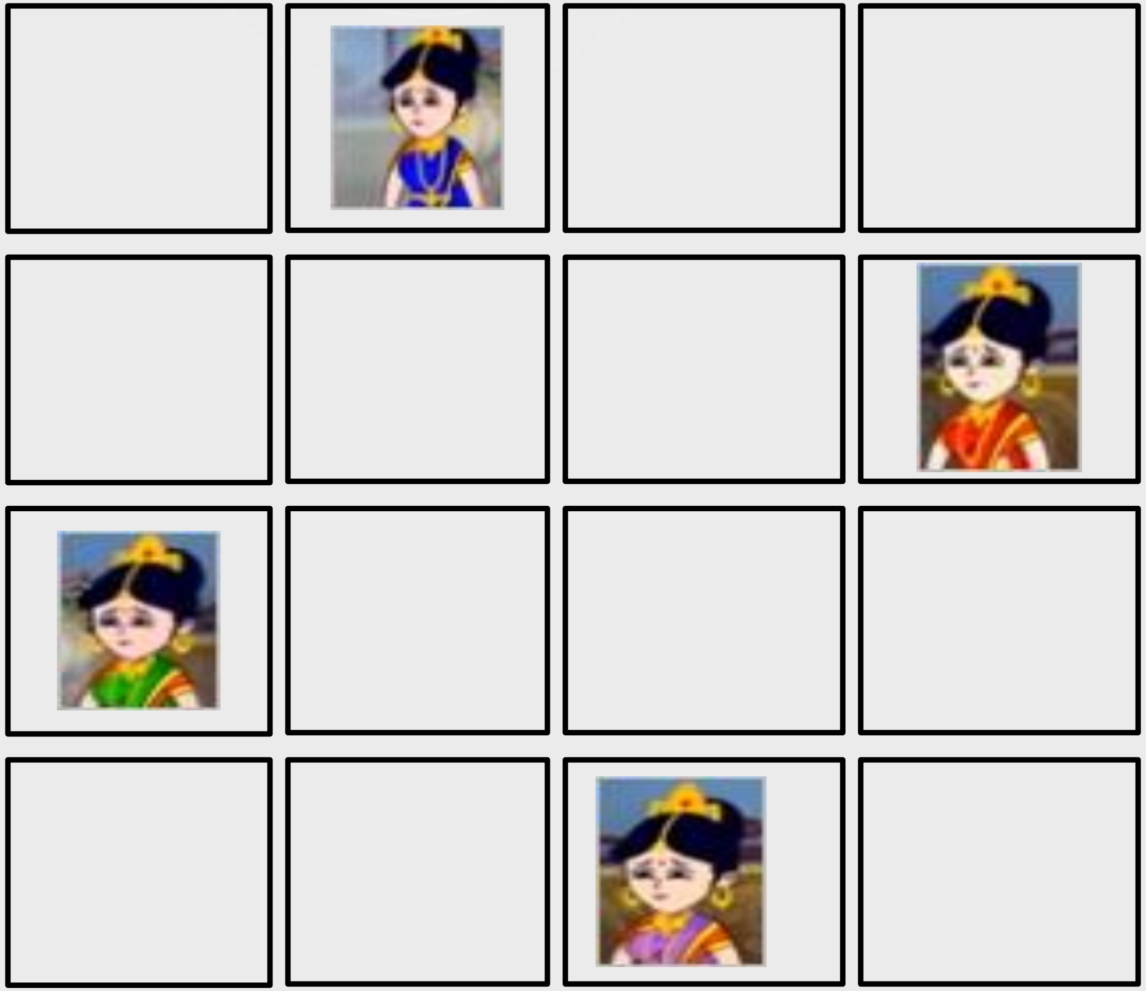
Would, you please help the King to place the Queens? Avoid placing two Queens in a same row, same column and even same diagonal rooms.



Solution of the 4-Queen Problem Using Backtracking Approach

Therefore , the king called Professor of an University to solve the 4-Queen problem. And Professor solved the 4-Queen problem in backtracking approach.

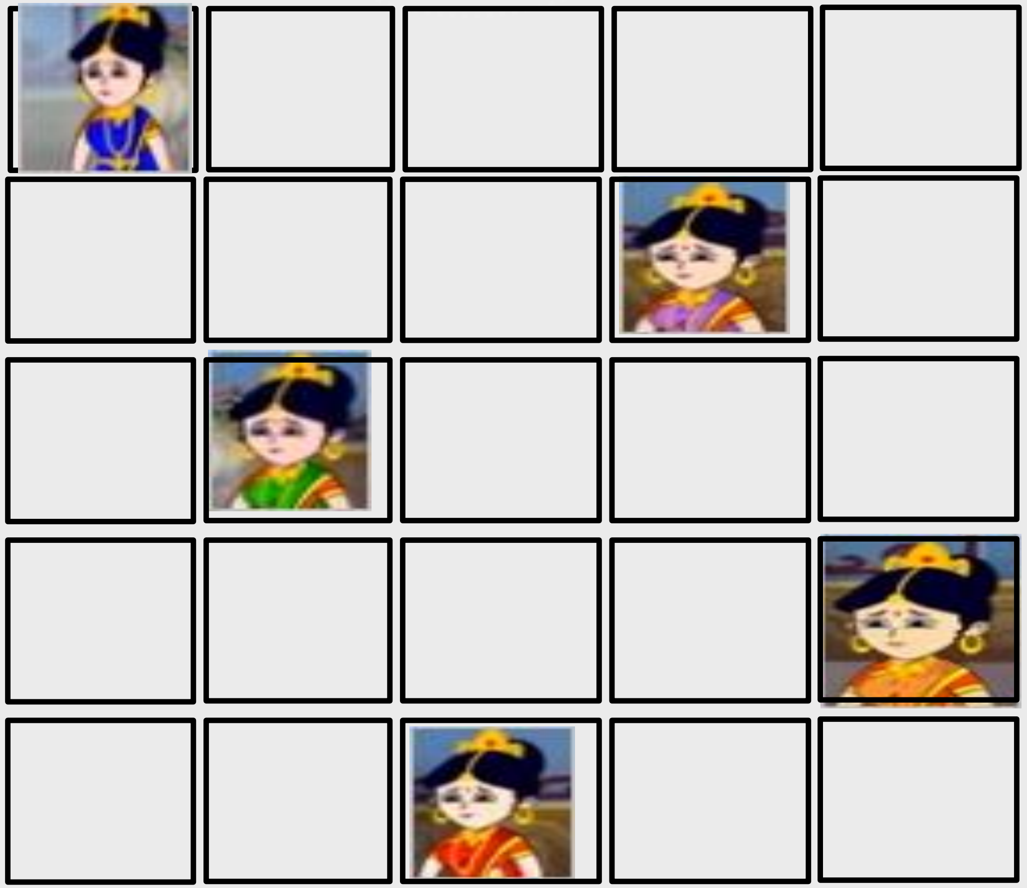
Complexity: NQueens : O(N!)



The 5-Queen Problem

One month later, Professor received a call from the great King to solve his 5-Queen problem. Professor, solved the 5-Queen problem in backtracking approach.

Solution of the 5-Queen Problem Using Backtracking Approach



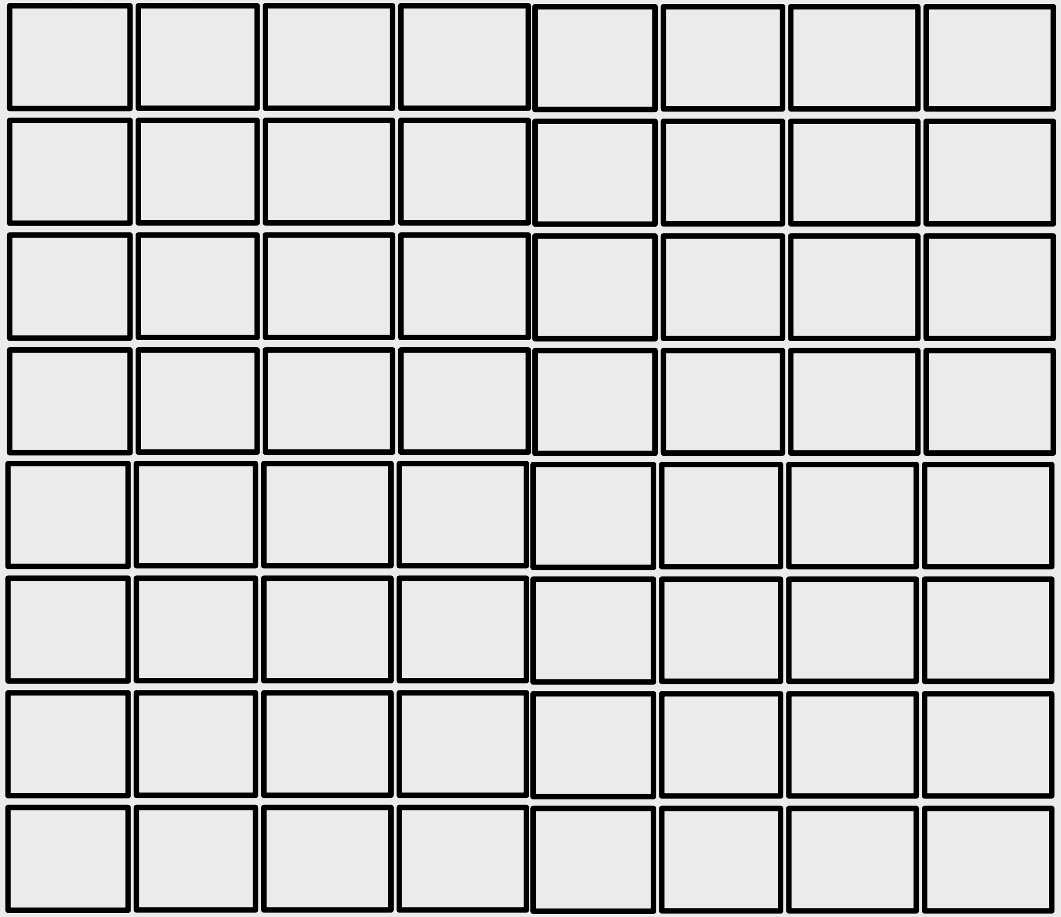
6-Queen Problem

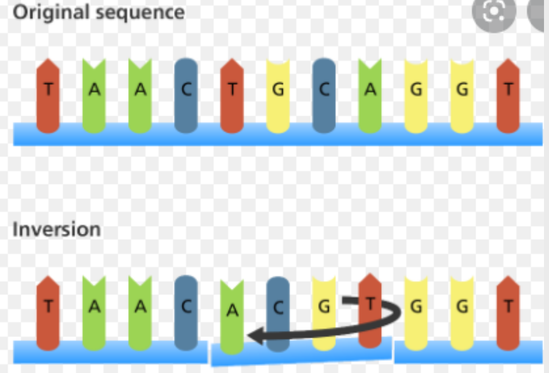
Fortunately, one month later, the King requested the professor to solve 6-Queen problem. The professor thought that the King may request him to solve 16-Queen problem within next 10 months.

Backtracking approach will not be efficient to solve the 8 or 16-Queen problems.

Therefore, professor invented Genetic Algorithm to solve the n-Queen problem.

8-Queen Problem



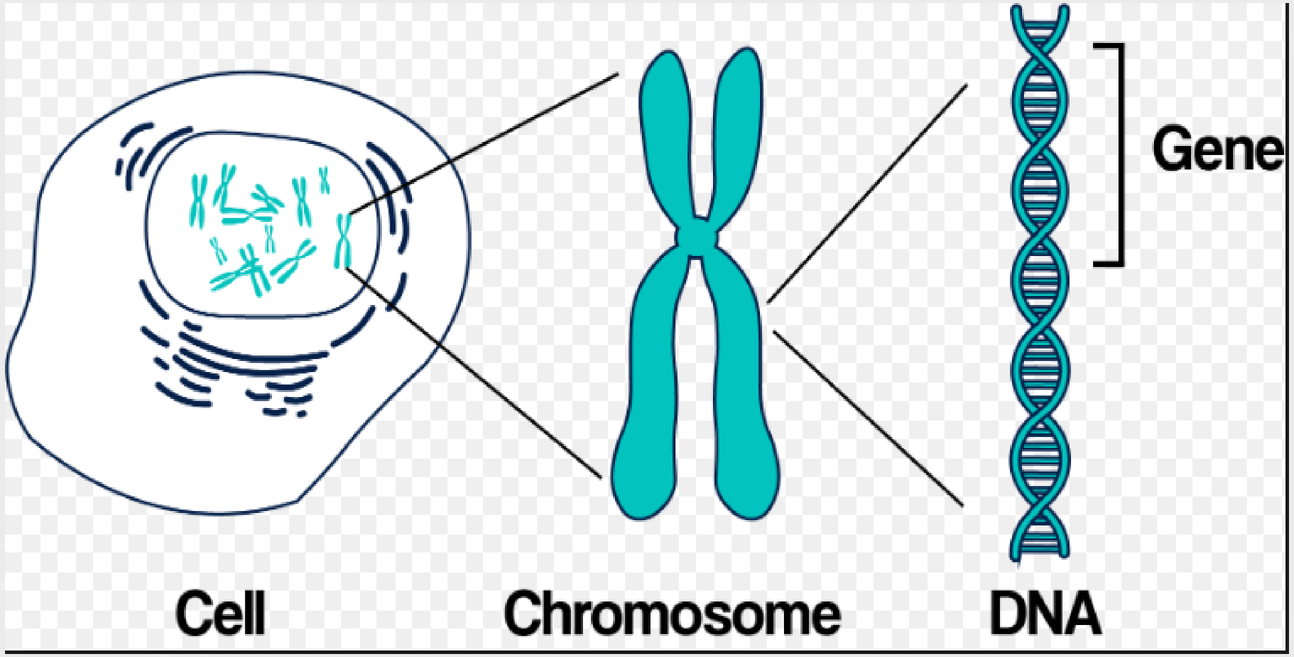


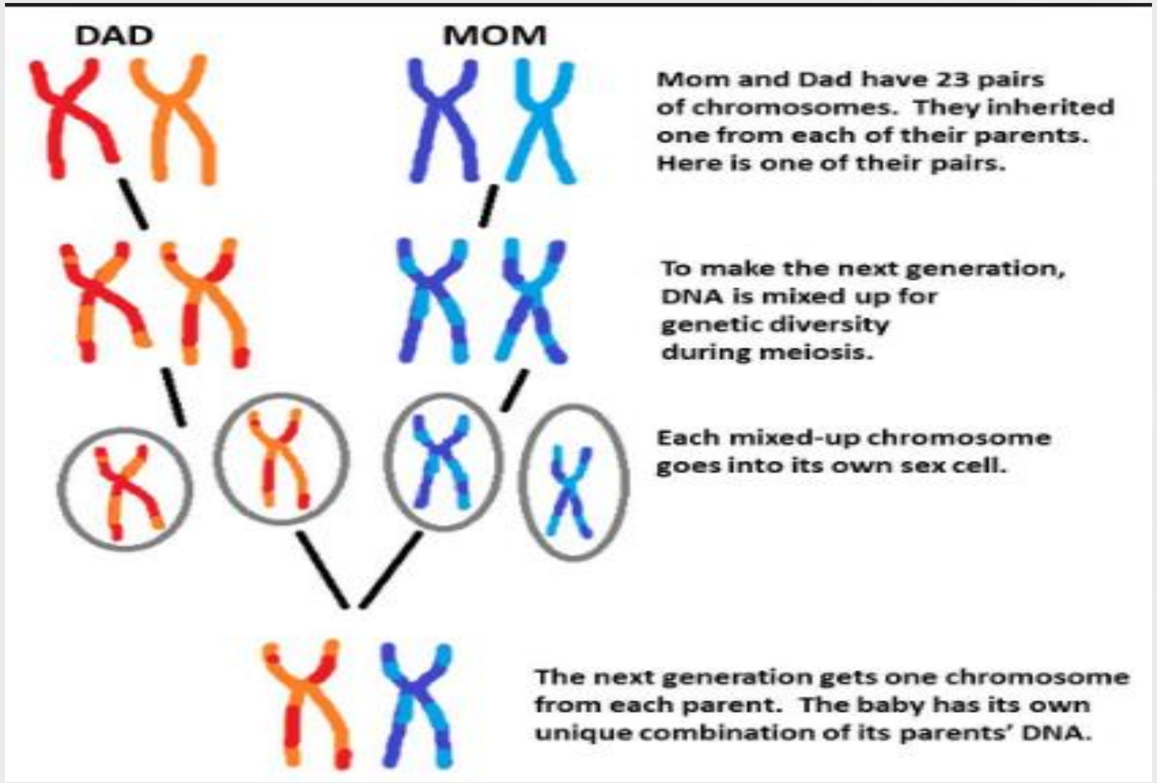
John Holland introduced **Genetic Algorithm (GA)**

Genetic Algorithm

Darwin's theory of evolution

The **genetic algorithm** is a method for solving both constrained and unconstrained optimization problems that is based on natural selection, the process that drives biological evolution.





Mom and Dad have 23 pairs of chromosomes. They inherited one from each of their parents. Here is one of their pairs.

To make the next generation, DNA is mixed up for genetic diversity during meiosis.

Each mixed-up chromosome goes into its own sex cell.

The next generation gets one chromosome from each parent. The baby has its own unique combination of its parents' DNA.

Genetic Algorithms

Successor States are Generated Combining Two Parent S

Introduced in the 1970s by John Holland at University of Michigan

- begin with *k* randomly generated states (population)
- each state (individual) is a string over some alphabet (chromosome)
- fitness function (bigger number is better)
- crossover
- mutate (evolve?)

John Holland introduced **Genetic Algorithm** (**GA**)

Darwin’s theory of evolution

GA: PROCEDURE

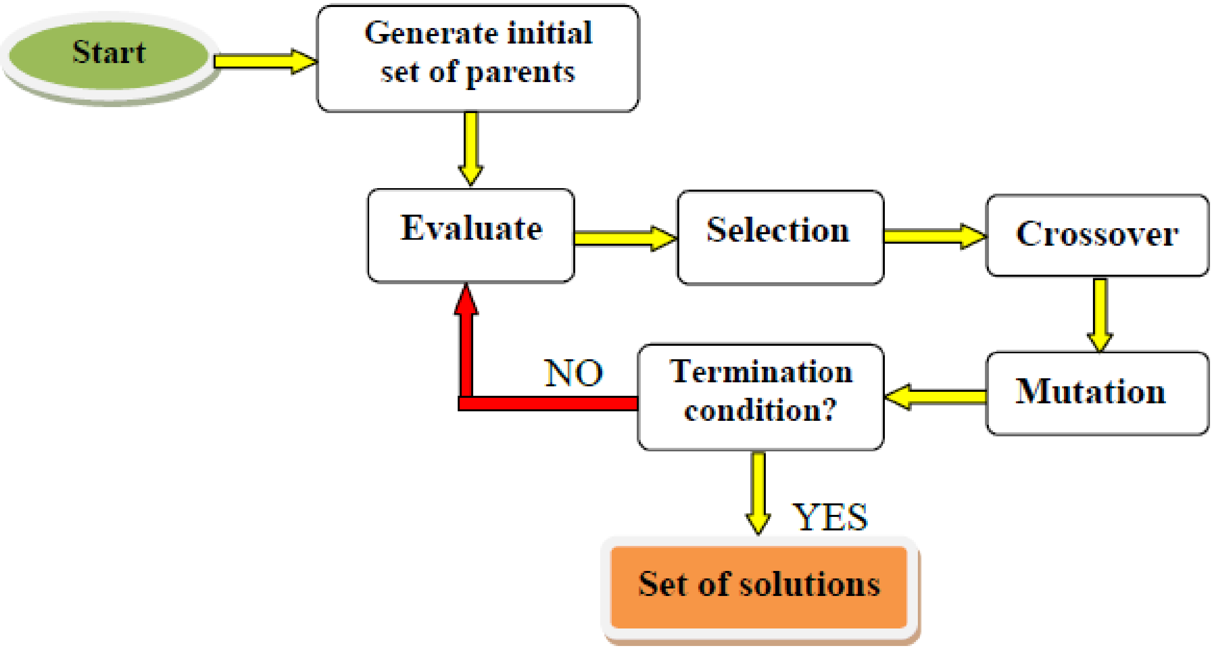


Fig.1 Process of genetic algorithm

Pseudo-code of GA:

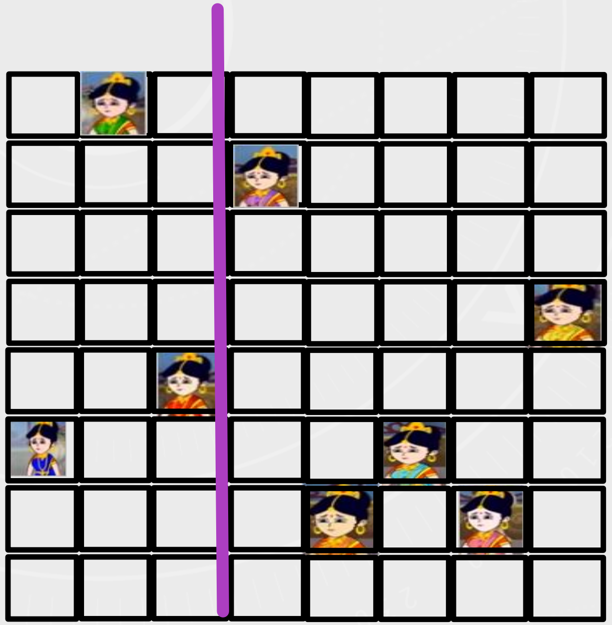
```
START
    Generate the initial population
    Compute fitness
    REPEAT
            Selection
            Crossover
            Mutation
            Compute fitness
    UNTIL population has converged

STOP
```

Formulation of Genetic Algorithm

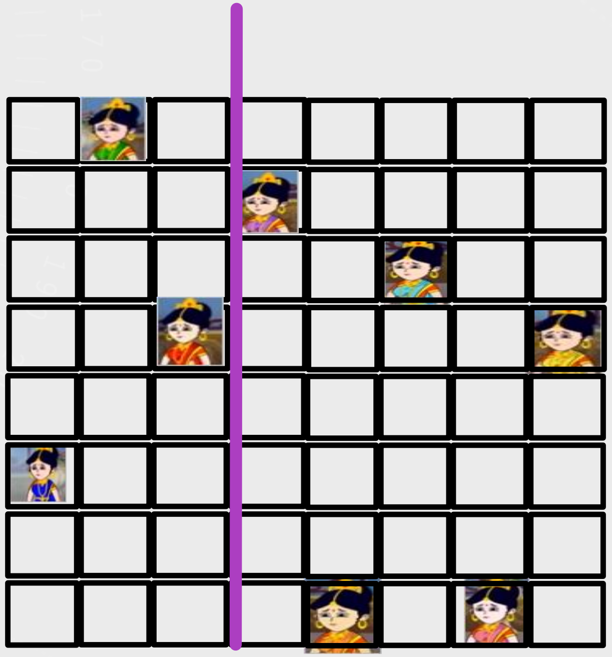
John Holland introduced **Genetic Algorithm (GA)**

Darwin's theory of evolution



3 8 4 7 2 3 2 5

Fitness=28-7=21



3 8 5 7 1 6 1 5

Fitness=28-4=24

Fitness function: number of non-attacking pairs of queens

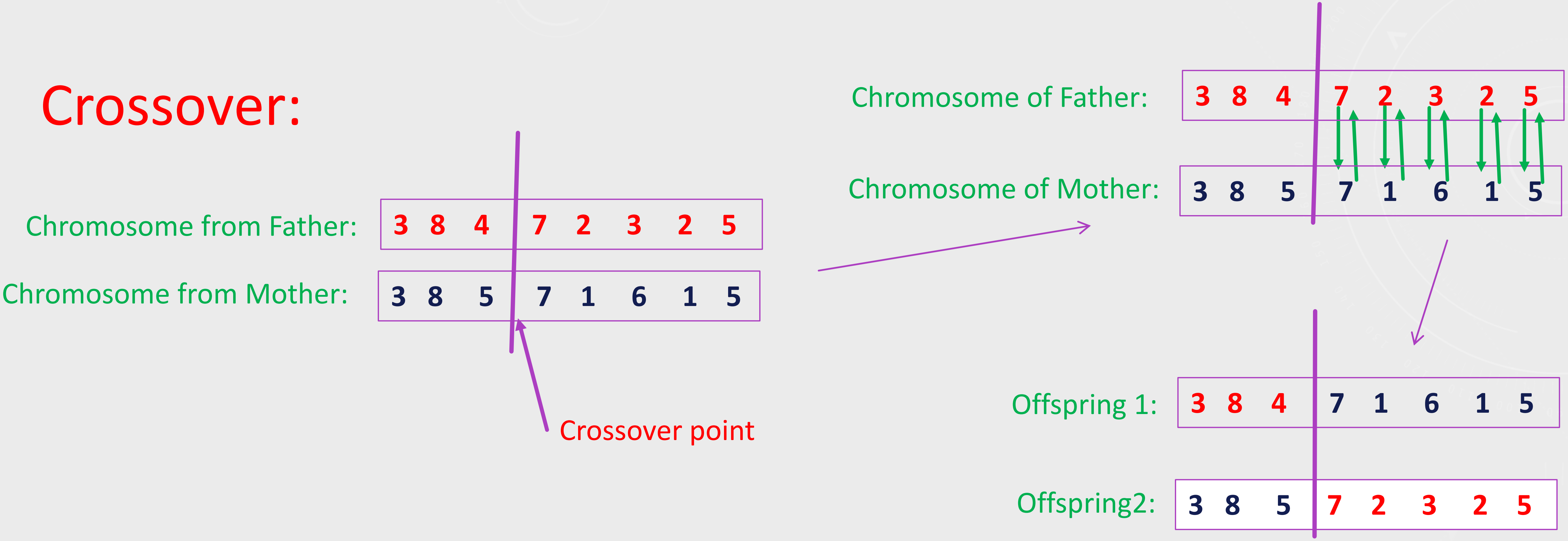
Maximum number of attacking pairs: 8 × 7/2 = 28

[Q1 Q2]
[Q1 Q3]
[Q1 Q4]
[Q1 Q5]
[Q1 Q6]
[Q1 Q7]
[Q1 Q8]
………
[Q8 Q7]

Chromosome of Father: 3 8 4 7 2 3 2 5

Chromosome of Mother: 3 8 5 7 1 6 1 5

Crossover:



Chromosome from Father: 3 8 4 7 2 3 2 5

Chromosome from Mother: 3 8 5 7 1 6 1 5

Crossover point

Chromosome of Father: 3 8 4 7 2 3 2 5

Chromosome of Mother: 3 8 5 7 1 6 1 5

Offspring 1: 3 8 4 7 1 6 1 5

Offspring2: 3 8 5 7 2 3 2 5

3 8 4 7 2 3 2 5

3 8 5 7 1 6 1 5

2 4 4 1 5 1 2 4

3 2 5 4 3 2 1 3

Mutation:

Before Mutation:

Offspring 1: 3 8 4 7 1 6 1 5

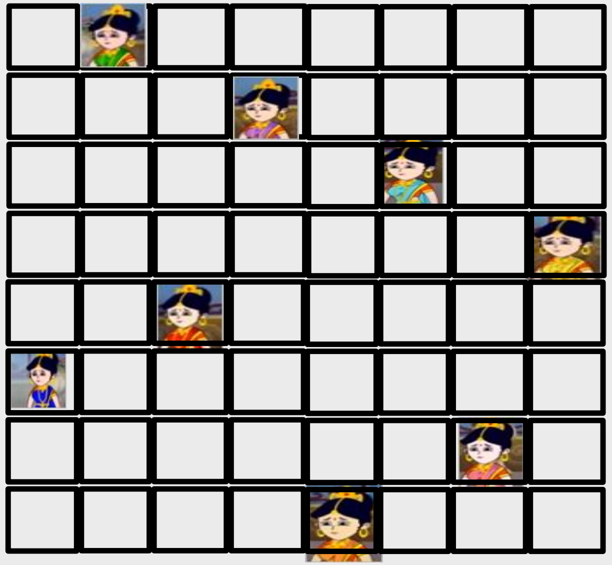
Offspring2: 3 8 5 7 2 3 2 5

After Mutation:

Offspring 1: 3 8 4 7 1 6 2 5

Offspring2: 3 8 6 7 2 3 2 5

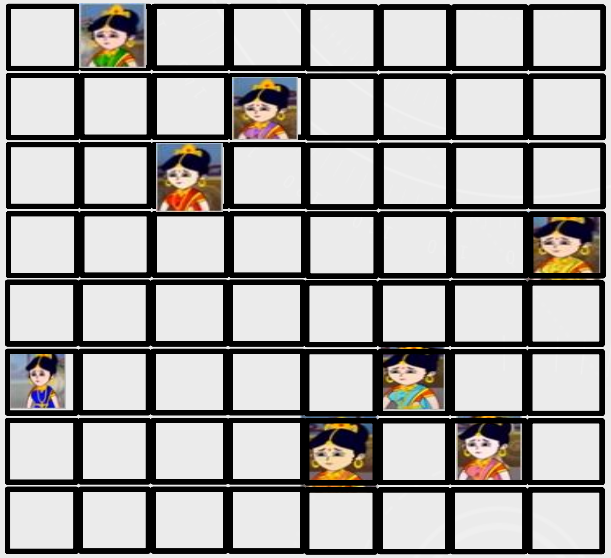
Offspring 1:



3 8 4 7 1 6 2 5

Fitness=28-0=28

Offspring2:

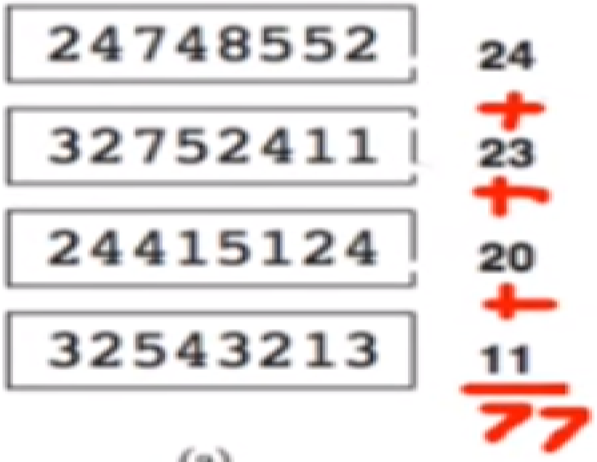


3 8 6 7 2 3 2 5

Fitness=28-7=21

Genetic Algorithms
Example

Represent states and compute fitness function.



24748552 24

+

32752411 23

+

24415124 20

+

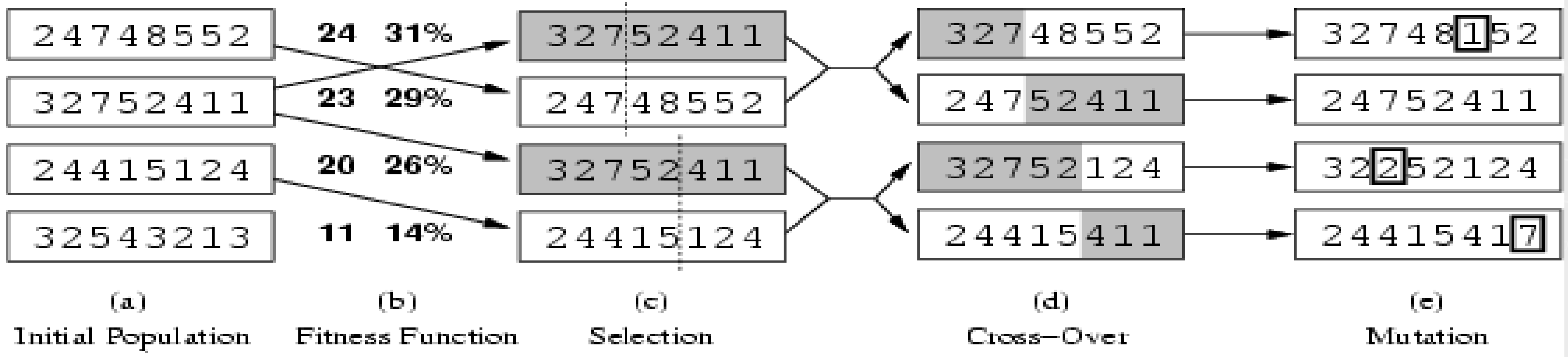
32543213 11

77

(a)

Initial Population

GENETIC ALGORITHMS

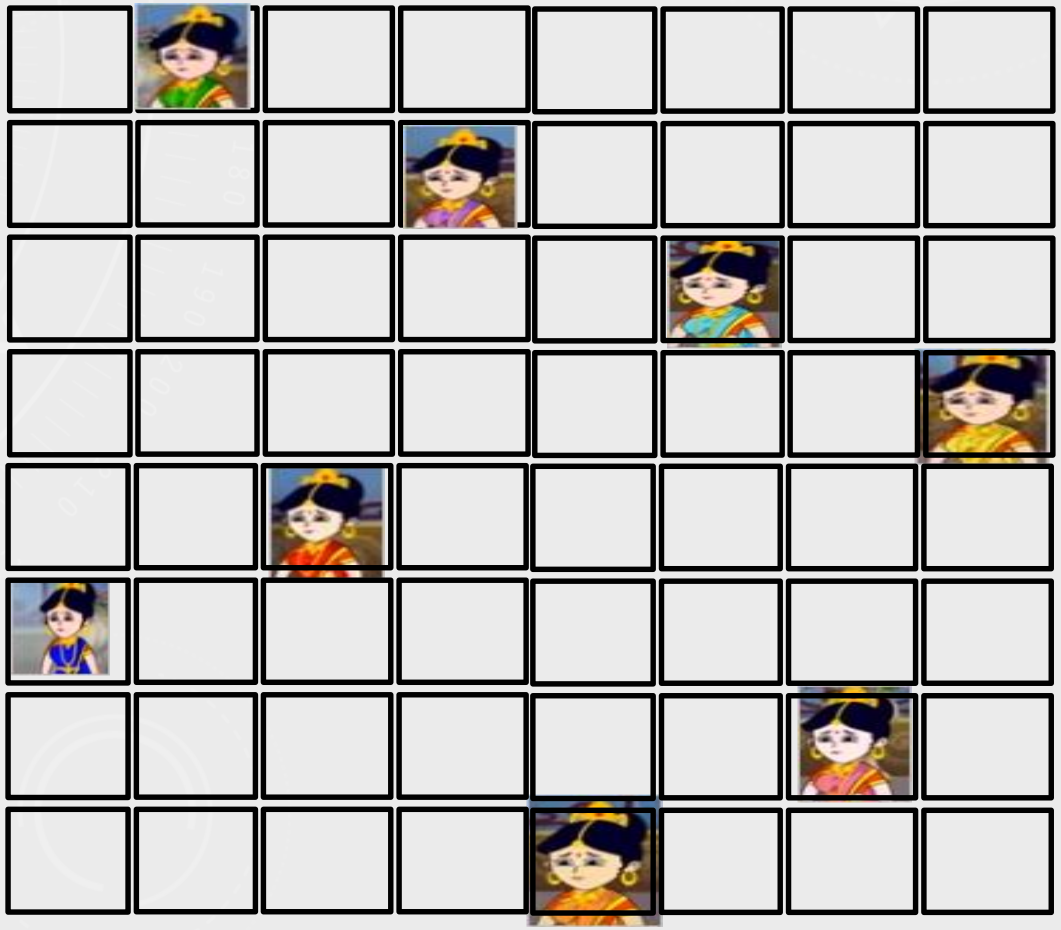


- Fitness function: number of non-attacking pairs of queens (min = 0, max = 8 × 7/2 = 28)
- 24/(24+23+20+11) = 31%
- 23/(24+23+20+11) = 29% etc

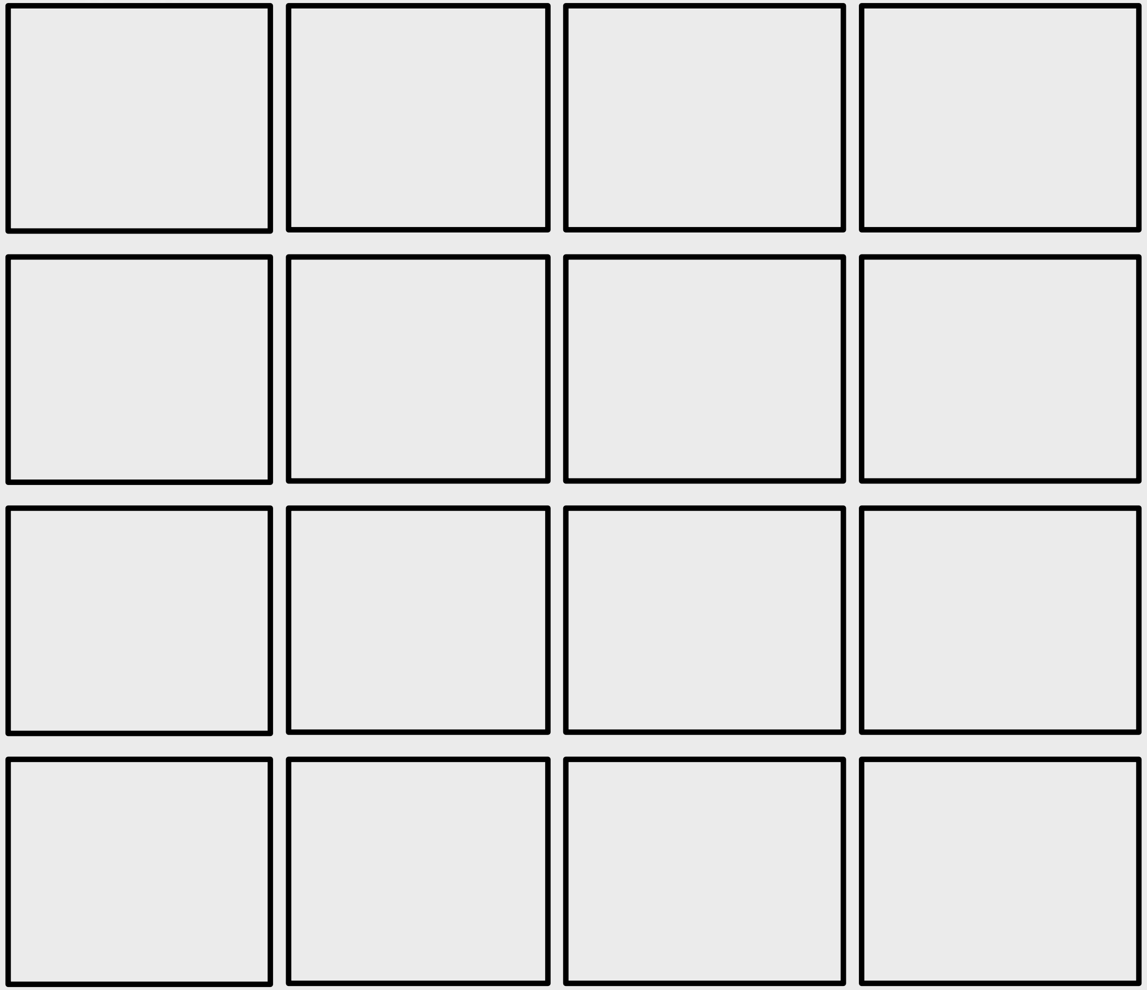
Solution of 8-Queen Problem using Genetic Algorithm

John Holland introduced **Genetic Algorithm** (**GA**)

Darwin's theory of evolution



The 4-Queen Problem



Fitness function: number of non-attacking pairs of queens

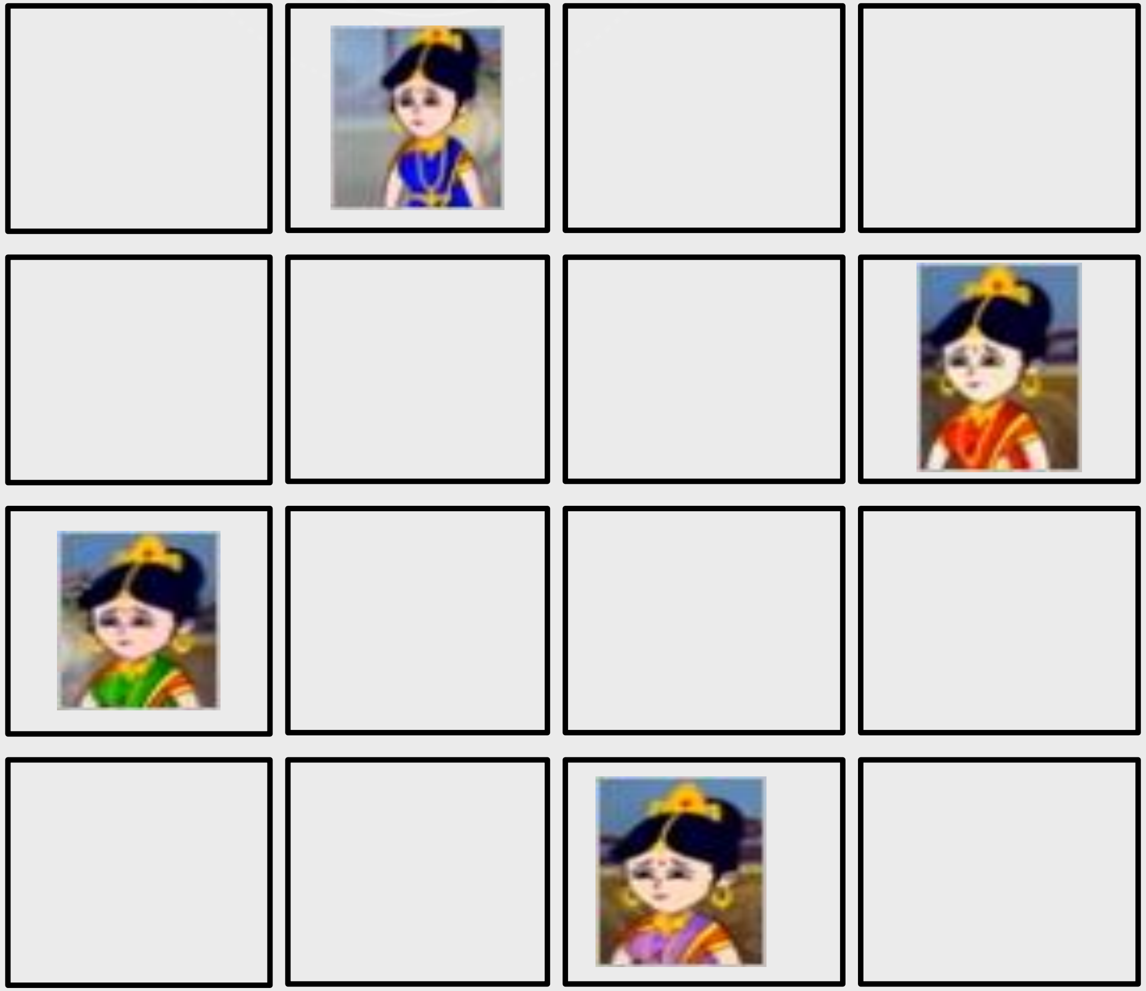
What is the Maximum fitness value: ????

4-Queen Problem Using Backtracking vs GA Approach

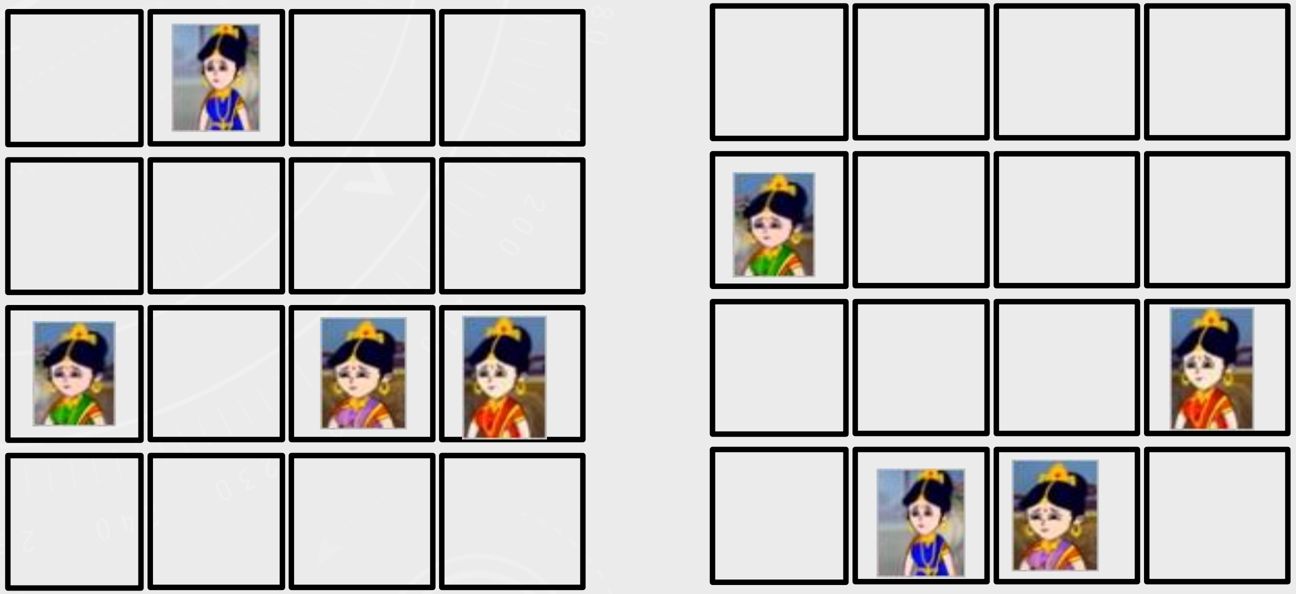
Therefore , the king called Professor John Holland of the University of Michigan to solve the 4-Queen problem. And solved the 4-Queen problem in backtracking approach.

Complexity: NQueens : O(N!)

Genetic Algorithms complexity is **O(g(nm + nm + n)) with g the number of generations, n the population size and m the size of the individuals**. Therefore the complexity is on the order of O(gnm))

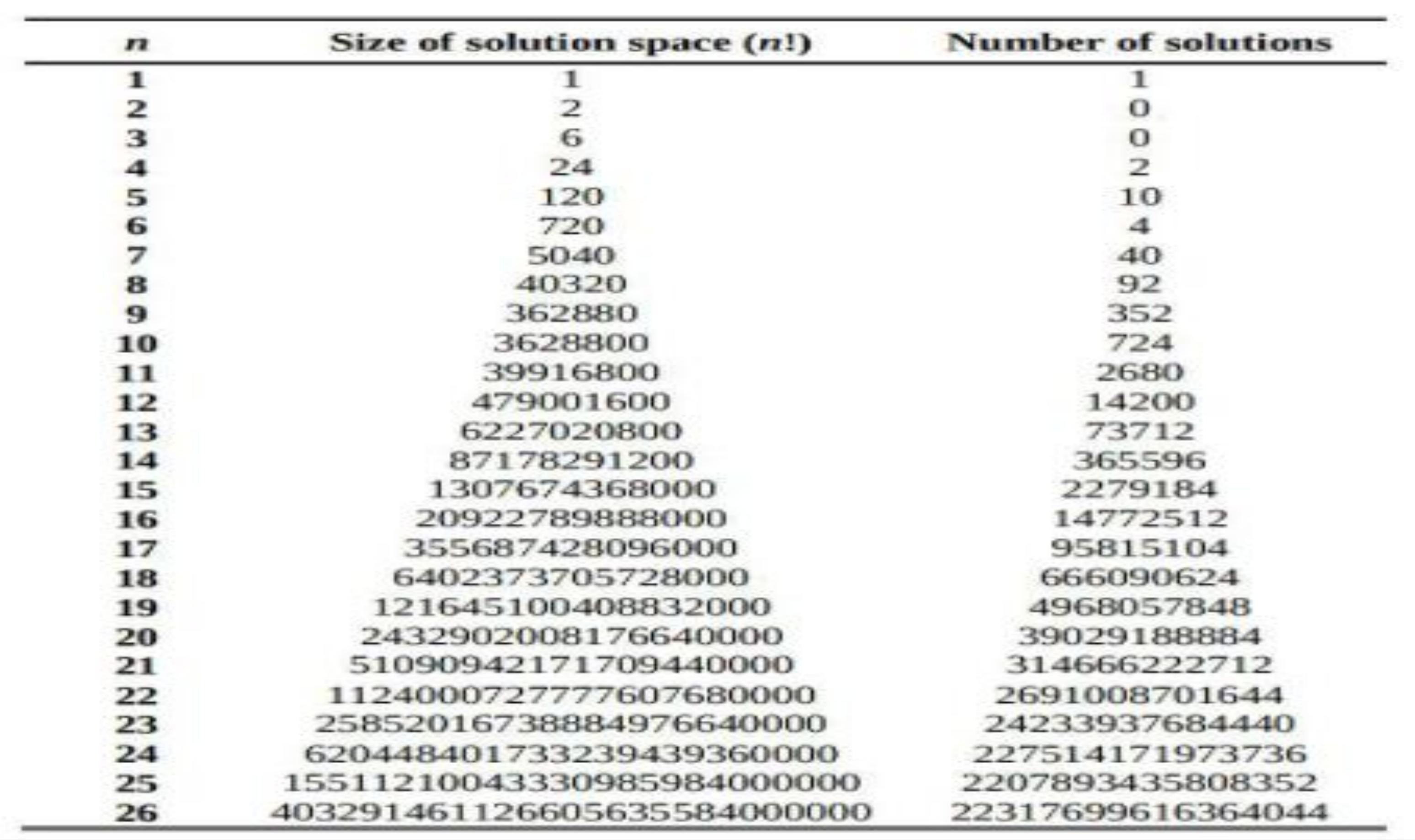


Try to Solve the 4-Queen Problem Using GA?



Initial Population

GA: ANALYSIS



n	Size of solution space (*n*!)	Number of solutions
1	1	1
2	2	0
3	6	0
4	24	2
5	120	10
6	720	4
7	5040	40
8	40320	92
9	362880	352
10	3628800	724
11	39916800	2680
12	479001600	14200
13	6227020800	73712
14	87178291200	365596
15	1307674368000	2279184
16	20922789888000	14772512
17	355687428096000	95815104
18	6402373705728000	666090624
19	121645100408832000	4968057848
20	2432902008176640000	39029188884
21	51090942171709440000	314666222712
22	1124000727777607680000	2691008701644
23	25852016738884976640000	24233937684440
24	620448401733239439360000	227514171973736
25	15511210043330985984000000	2207893435808352
26	403291461126605635584000000	22317699616364044