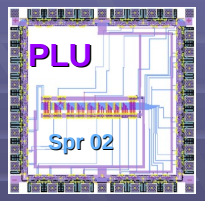
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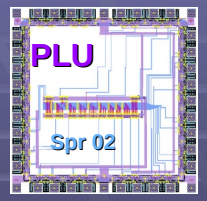
Genetic Algorithms



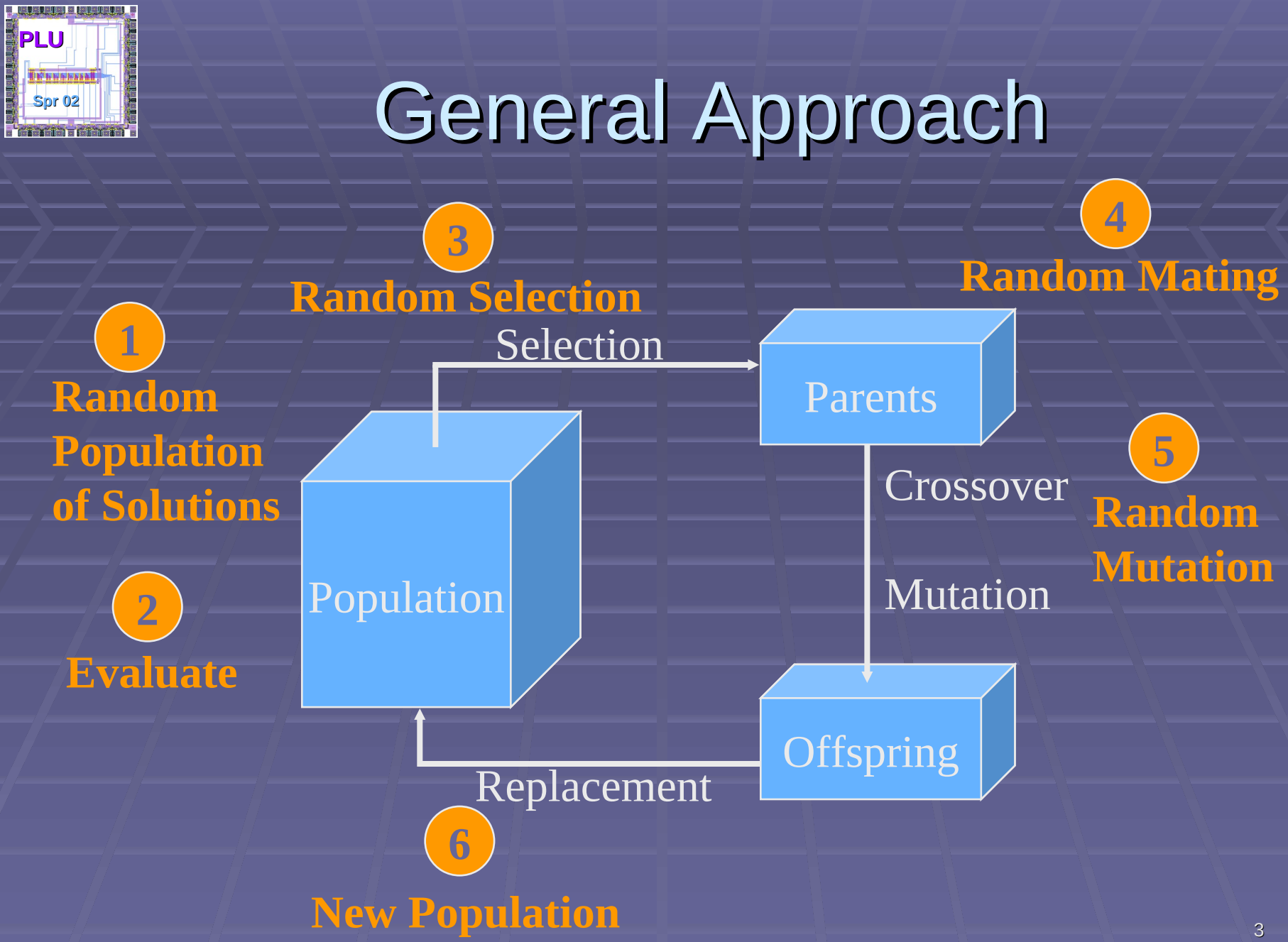
Definition

- Goldberg, 1989: “Genetic Algorithms are search algorithms based on the mechanics of natural selection and natural genetics.”

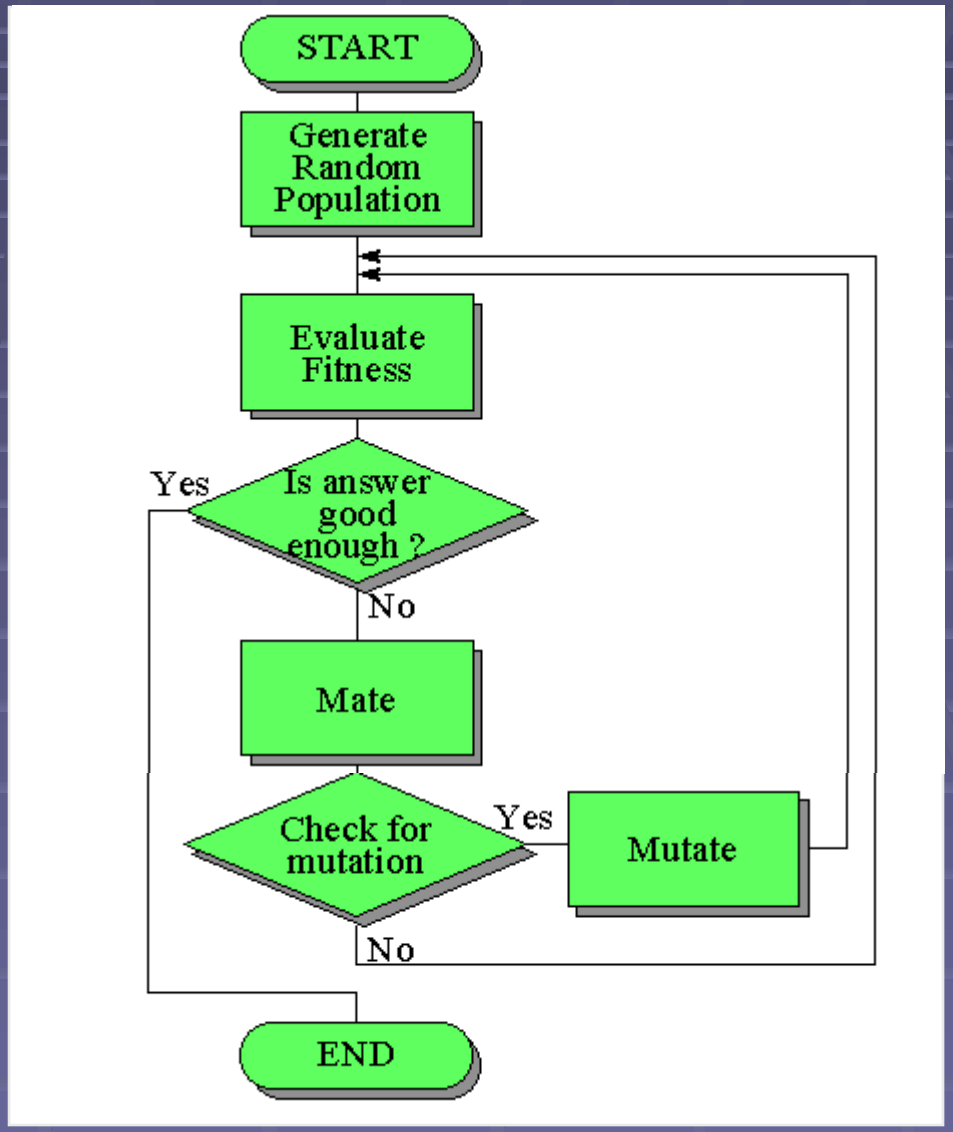
- A genetic algorithms is a directed random search procedure

A genetic algorithm borrows ideas from biology to search a solution space for a target value.

General Approach



GA Flow Chart

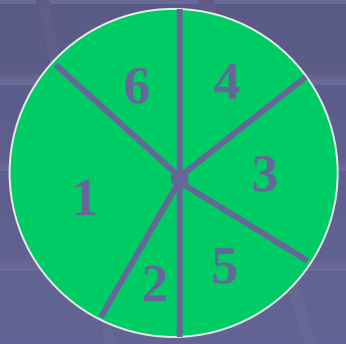


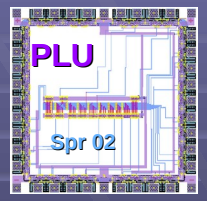
Parent Selection

- The process in which individual strings in the population are selected to contribute to the next generation is called **parent selection**
  - based on fitness
  - strings with a high fitness have a higher probability of contributing one or more offspring to the next generation

- Biased Roulette Wheel Selection

When you spin the wheel, items 1 and 5 have the greatest chance of coming up while item 2 has the smallest





Example

- Given the following population of chromosomes, select two parents:

Chromosome	Fitness	% fitness	cf
(1 0 1 0 0 1)	23	0.28	0.28
(1 1 1 0 0 1)	12	0.15	0.43
(0 1 1 0 1 1)	25	0.30	0.73
(0 1 0 1 1 0)	5	0.06	0.79
(0 1 1 0 1 0)	17	0.21	1.00
Total Fitness	82		

Find the total fitness of the population

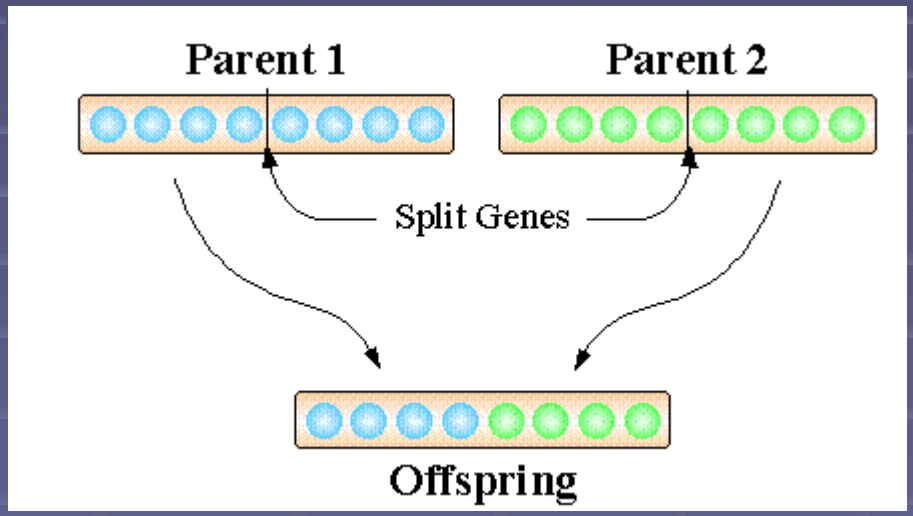
Find the %fitness of each element

Find the cumulative fitness

Now, throw a random number between 0 and 1, if it is in the range 0 to 0.28 select element 1, between 0.28 and 0.43 select element 2, . . .

Crossover

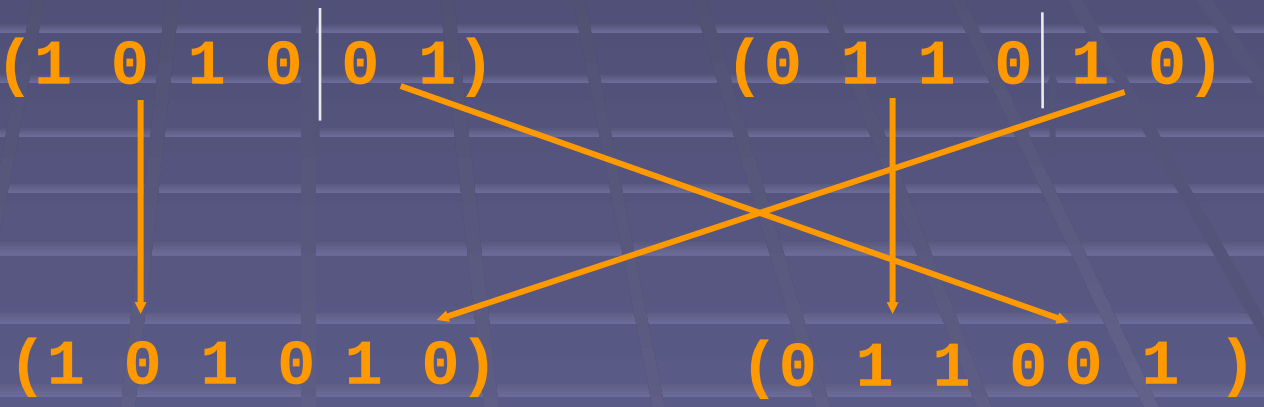
- Once two parents are selected, their chromosomes are mixed to create the children for the next generation



Called single point crossover

Example

- Assume the parents selected from the previous example are: (1 0 1 0 | 0 1) (0 1 1 0 | 1 0)



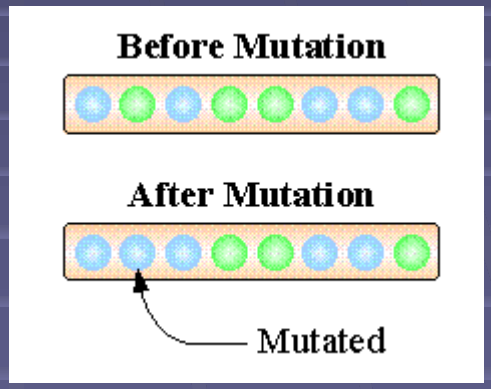
These are the two children which are now part of the next generation

Find a random crossover point

Swap the bits after the crossover point

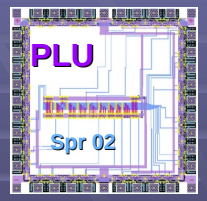
Mutation

- A bit in a child is changed (from 1 to 0 or from 0 to 1) at random



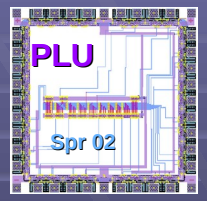
This is a small probability event

The effect is to prevent a premature convergence to a local minimum or maximum



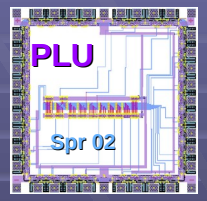
GA Performance

- Increasing diversity by genetic operators
  - mutation
  - Recombination
- Decreasing diversity by selection
  - of parents
  - of survivors



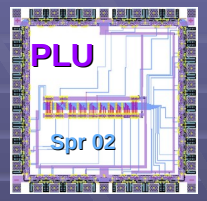
Effects of the Genetic Operators

- Using selection alone will tend to fill the population with copies of the best individual from the initial population
- Using selection and crossover will tend to cause the algorithm to converge on a good but sub-optimal solution
- Using mutation alone induces a random walk through the search space
- Using selection and mutation creates a parallel, noise-tolerant, hill climbing algorithm



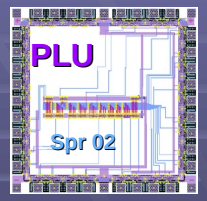
The Algorithm

- randomly initialize population(t)
- determine fitness of population(t)
- repeat
  - select parents from population(t)
  - perform crossover on parents creating population(t+1)
  - perform mutation on population(t+1)
  - determine fitness of population(t+1)
- until best individual is good enough



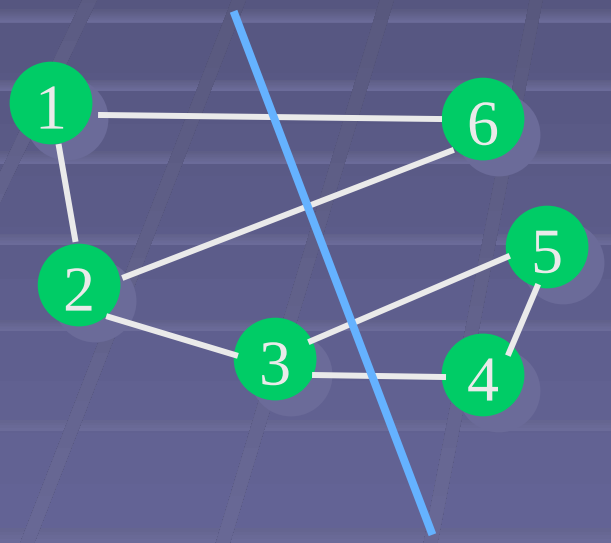
GA Applications

- GA's can be applied to several parts of the physical design problem
  - Partitioning
  - Placement
  - Other . . .
- Scope of the Partitioning problem
  - A standard layout benchmark suite has circuits ranging from 13,000 to 200,000 nodes.
  - The number of links range from 50,000 to 800,000



Representation

- A graph partition is represented by a binary string



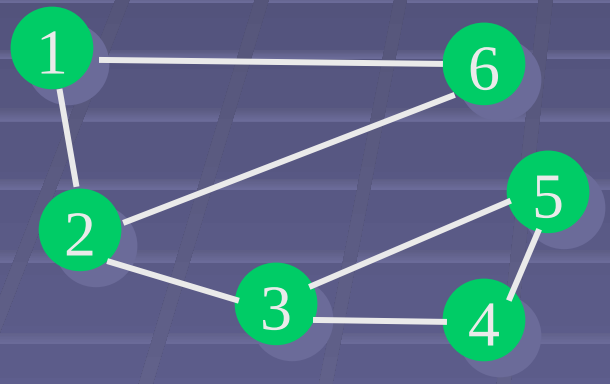
Each node is represented by a bit

The 0 nodes are in one segment, the 1 nodes are in the other segment

(0 0 0 1 1 1)

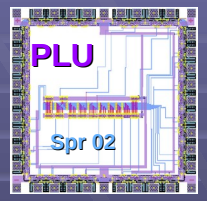
Population

- A random population of binary strings is produced



The fitness is the number of links

(0 0 0 1 1 1)	4
(1 0 0 1 0 1)	4
(1 0 1 1 0 0)	5
(1 0 0 1 1 0)	4



Crossover

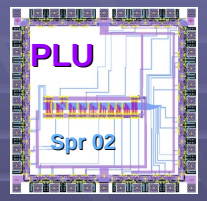
- Parents are randomly selected (with a bias to the better fit elements)
- The parents are combined to create two children (single point crossover)

(0 | 1 0 1 0 1)

(1 | 0 0 1 0 1)

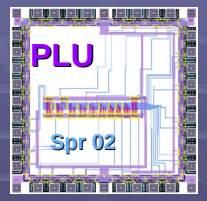
(1 1 0 1 0 1)

(0 0 0 1 0 1)



Mutation

- For a small number of the new population elements perform a mutation operation
  - Randomly select two nodes and swap their positions



Thank you