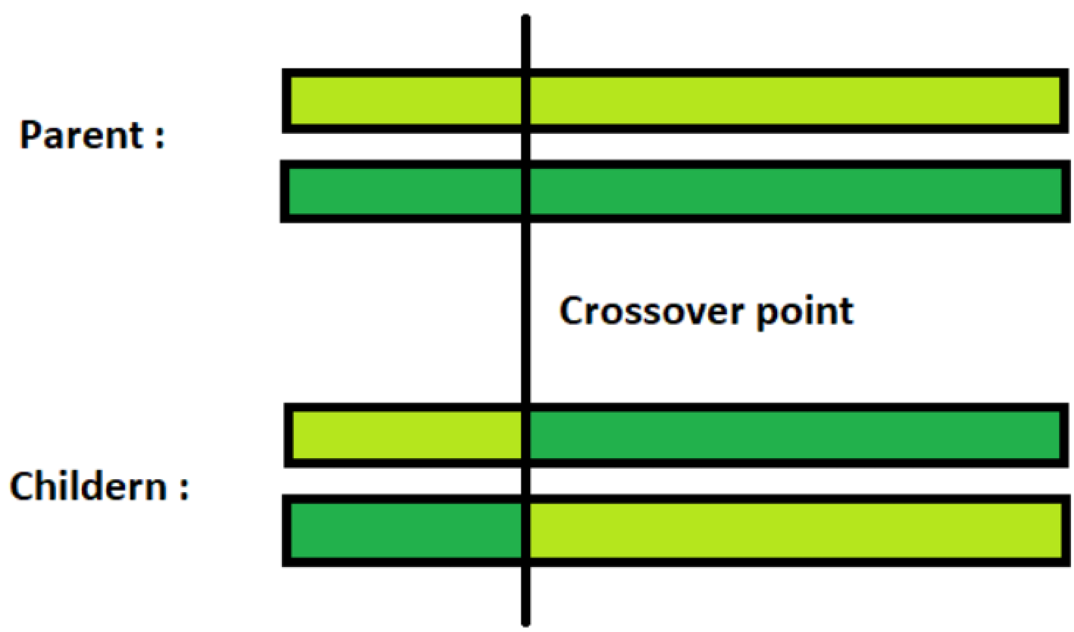
Genetic Algorithms - Crossover

Different types of crossover :

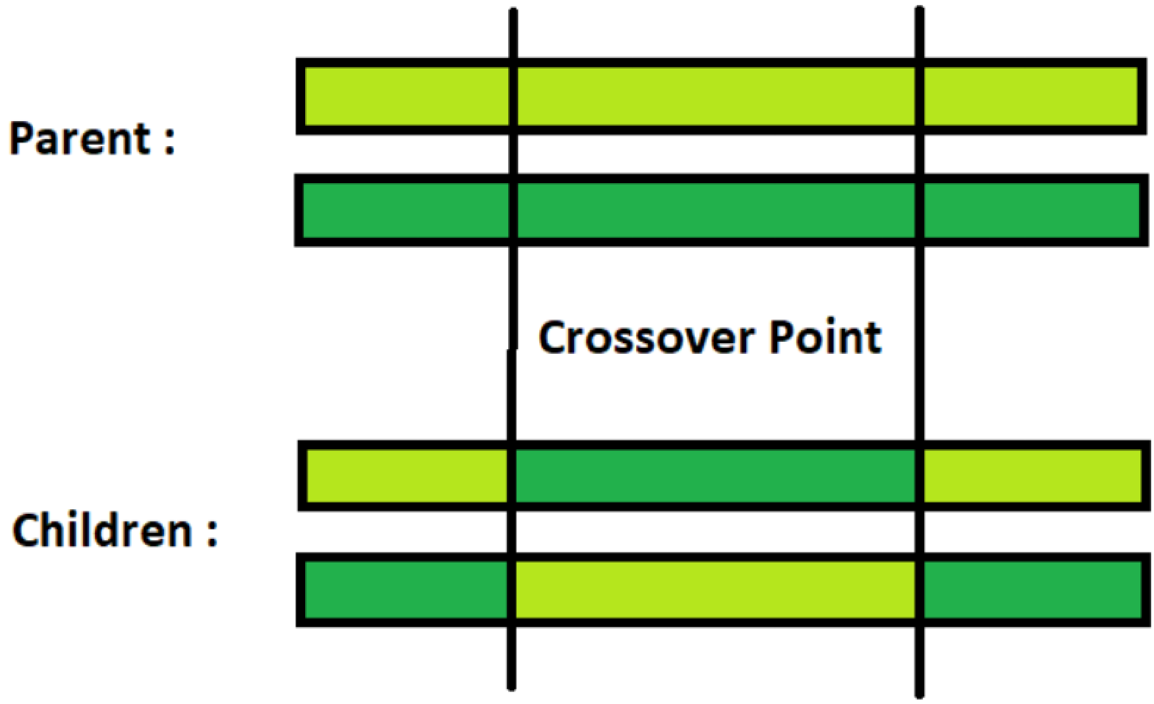
Single Point Crossover : A crossover point on the parent organism string is selected. All data beyond that point in the organism string is swapped between the two parent organisms. Strings are characterized by Positional Bias.



Chromosome1	11011 | 00100110110
Chromosome2	11011 | 11000011110
Offspring1	11011 | 11000011110
Offspring2	11011 | 00100110110

Single Point Crossover

Two-Point Crossover : This is a specific case of a N-point Crossover technique. Two random points are chosen on the individual chromosomes (strings) and the genetic material is exchanged at these points.



Chromosome1	11011|00100|110110
Chromosome2	10101|11000|011110
Offspring1	11011|11000|110110
Offspring2	10101|00100|011110

Two Point Crossover

Uniform Crossover

In a uniform crossover, we don’t divide the chromosome into segments, rather we treat each gene separately. In this, we essentially flip a coin for each chromosome to decide whether or not it’ll be included in the off-spring. We can also bias the coin to one parent, to have more genetic material in the child from that parent.

AVERAGE CROSSOVER (AX)

Average Crossover is the value based crossover technique. It uses two parents to perform crossover and creates only one offspring [1]. Average Crossover creates one offspring from taking average of the two parents. It selects two parents as X and Y and generate the child Z as follows: each gene in a child is taken by averaging genes from both parents.

Parent 1: 5 3 3 2 3 9 7 6 5

Parent 2: 5 4 7 6 5 2 6 1 3

Offspring 1: 5 3 5 4 4 5 6 3 4

Uniform Crossover With Mask

Uniform crossover is quite different from the *N*-point crossover. Each gene in the offspring is created by copying the corresponding gene from one or the other parent chosen according to a random generated binary crossover mask of the same length as the chromosomes. Where there is a 1 in the crossover mask, the gene is copied from the first parent, and where there is a 0 in the mask the gene is copied from the second parent. A new crossover mask is randomly generated for each pair of parents. Offspring, therefore, contain a mixture of genes from each parent. The number of effective crossing point is not fixed, but will average $L/2$ (where L is the chromosome length).

In Figure 15-24, new children are produced using uniform crossover approach. It can be noticed that while producing child 1, when there is a 1 in the mask, the gene is copied from parent 1 else it is copied from parent 2. On producing child 2, when there is a 1 in the mask, the gene is copied from parent 2, and when there is a 0 in the mask, the gene is copied from the parent 1.

Parent 1	1 0 1 1 0 0 1 1
Parent 2	0 0 0 1 1 0 1 0
Mask	1 1 0 1 0 1 1 0
Child 1	1 0 0 1 1 0 1 0
Child 2	0 0 1 1 0 0 1 1

Three-Parent Crossover

In this crossover technique, three parents are randomly chosen. Each bit of the first parent is compared with the bit of the second parent. If both are the same, the bit is taken for the offspring, otherwise the bit from the third parent is taken for the offspring. This concept is illustrated in Figure 15-25.

Parent 1	1 1 0 1 0 0 0 1
Parent 2	0 1 1 0 1 0 0 1
Parent 3	0 1 1 0 1 1 0 0
Child	0 1 1 0 1 0 0 1

Figure 15-25 Three-parent crossover.

Ordered Crossover

Ordered two-point crossover is used when the problem is order based, for example in U-shaped assembly line balancing, etc. Given two parent chromosomes, two random crossover points are selected partitioning them into a left, middle and right portions. The ordered two-point crossover behaves in the following way: child 1 inherits its left and right section from parent 1, and its middle section is determined by the genes in the middle section of parent 1 in the order in which the values appear in parent 2. A similar process is applied to determine child 2. This is shown in Figure 15-27.

Parent 1: 4 2 | 1 3 | 6 5 Child 1: 4 2 | 3 1 | 6 5

Parent 2: 2 3 | 1 4 | 5 6 Child 2: 2 3 | 4 1 | 5 6

Figure 15-27 Ordered crossover.