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Introduction to Genetic Algorithms (GAs)

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Demonstration of Idea

Example:

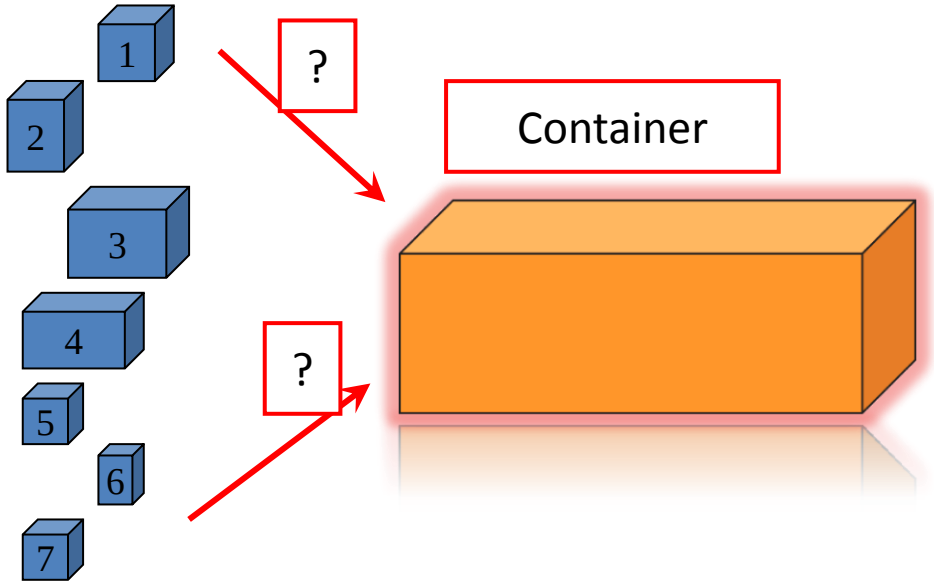
Allocation of Boxes into container

Objective: **Maximum Profit**

Constraints: Weight - 2100 lbs

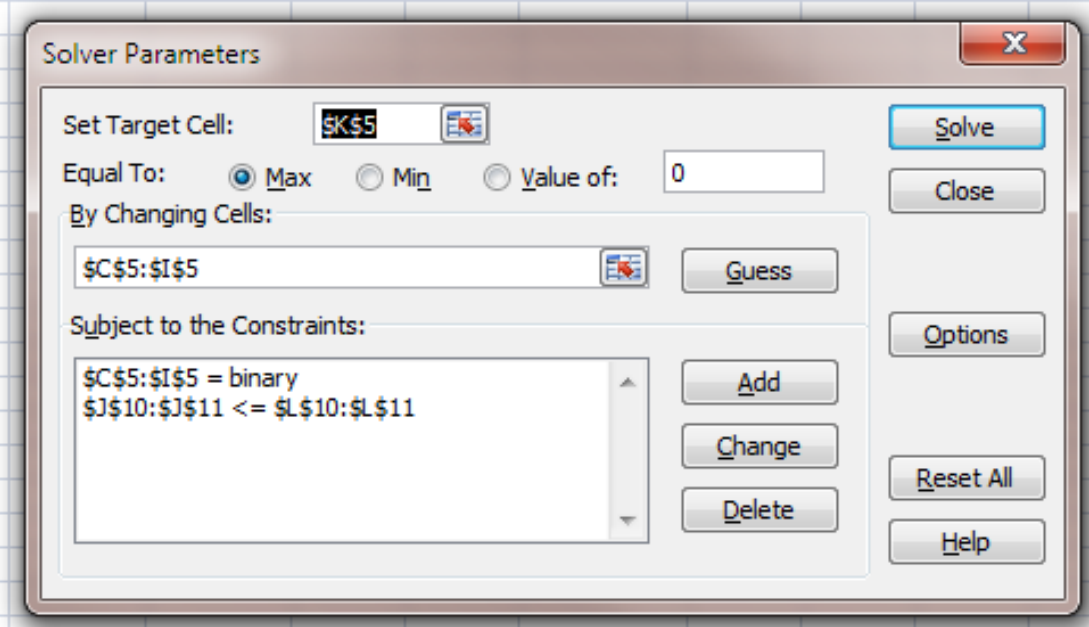
capacity - 12 m^3

Cargo	Volume (m^3)	Weight (lb)	Value ($1000)
1	3	400	3
2	4	500	6
3	6	200	4
4	5	600	9
5	2	250	4
6	1	300	2
7	2	350	5



Excel Solver

Objective										
MAX	Profit									
Variable	x1	x2	x3	x4	x5	x6	x7		Results	
	0	1	0	1	0	1	1	=	22	
Coefficient	3	6	4	9	4	2	5			
Subject to										
	x1	x2	x3	x4	x5	x6	x7	Summation		
	3	4	6	5	2	1	2	12	<=	12
	400	500	200	600	250	300	350	1750	<=	2100



Demonstration of Idea

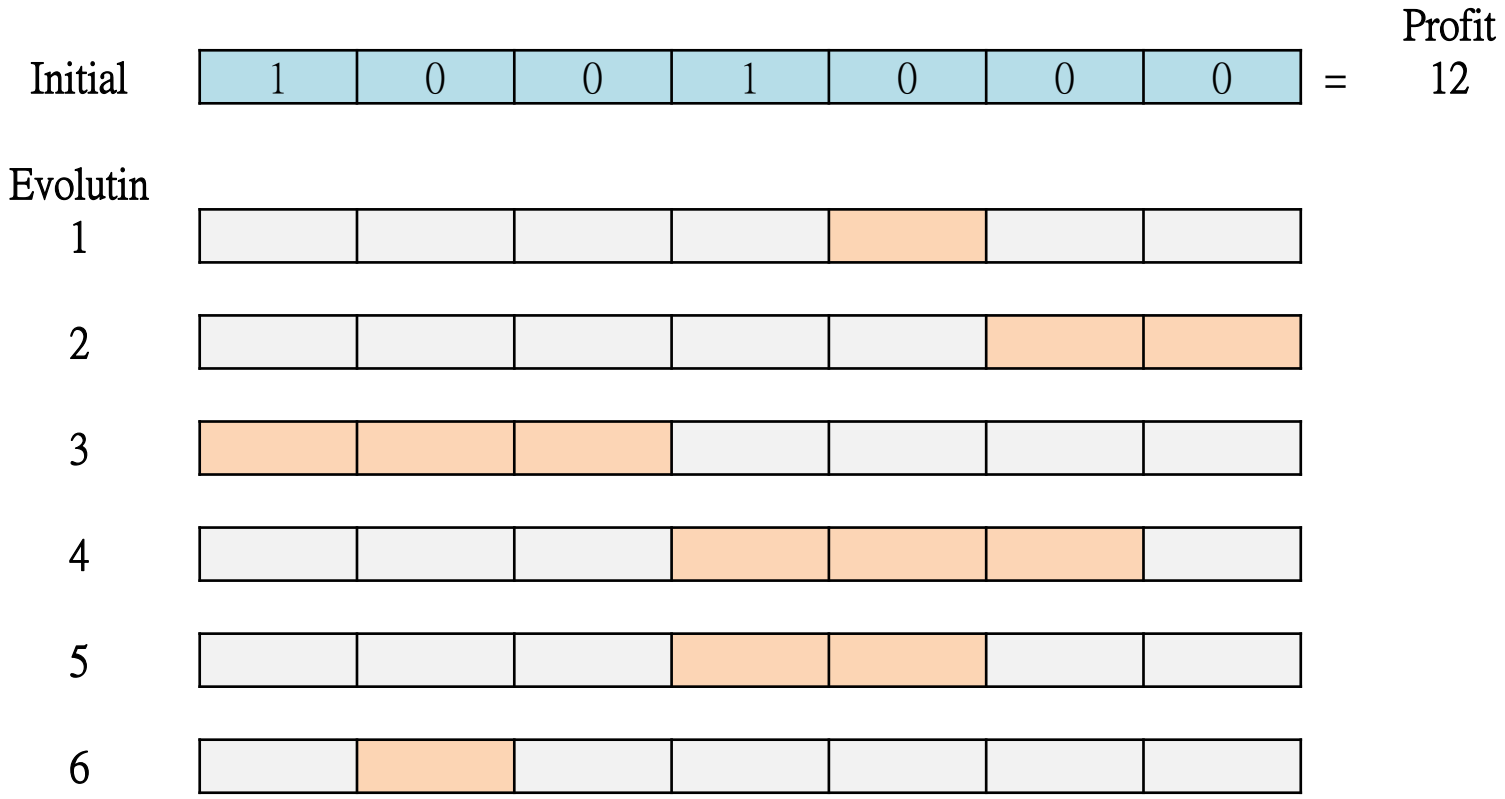
Genetic Evolution
Example: 1 Gene

									Profit
Initial	1	0	0	1	0	0	0	=	12
Evolutin 1	1	0	0	1	1	0	0	=	16
2	1	0	0	1	1	0	1	=	21
3	0	0	0	1	1	0	1	=	18
4	0	0	0	1	1	1	1	=	20
5	0	0	0	1	0	1	1	=	16
6	0	1	0	1	0	1	1	=	22

Demonstration of Idea

Genetic Evolution

Example: More genes (certain part)



Design Factors

(I) Design Chromosome

(II) Fitness Value

(III) Evolution Process

- *Mating Pool*
- *Crossover*
- *Mutation*

(IV) Stopping Condition

Introduction

GAs was proposed by Holland in 1975

Idea of GAs

- To mimic a biological evolutionary process.

Two main Parts:

- Chromosome Design
- Genetic Operators Design

Design Chromosome

Encoding of chromosome

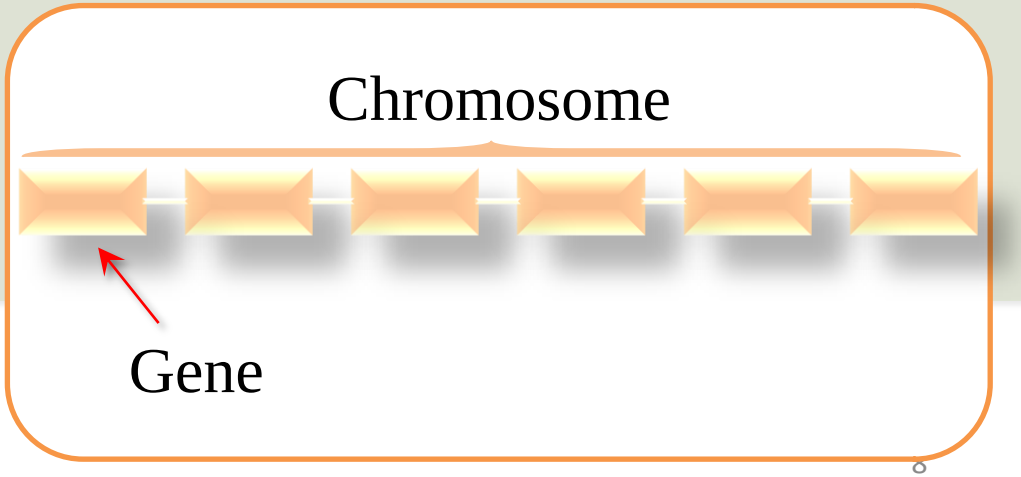
- The first step in GAs is to design and encode a chromosome.

Chromosome function

- Represents a feasible solution of the problem.
- Consists of a number of Genes
- The length of a chromosome depends on the problem and the designer of the GAs.

Gene

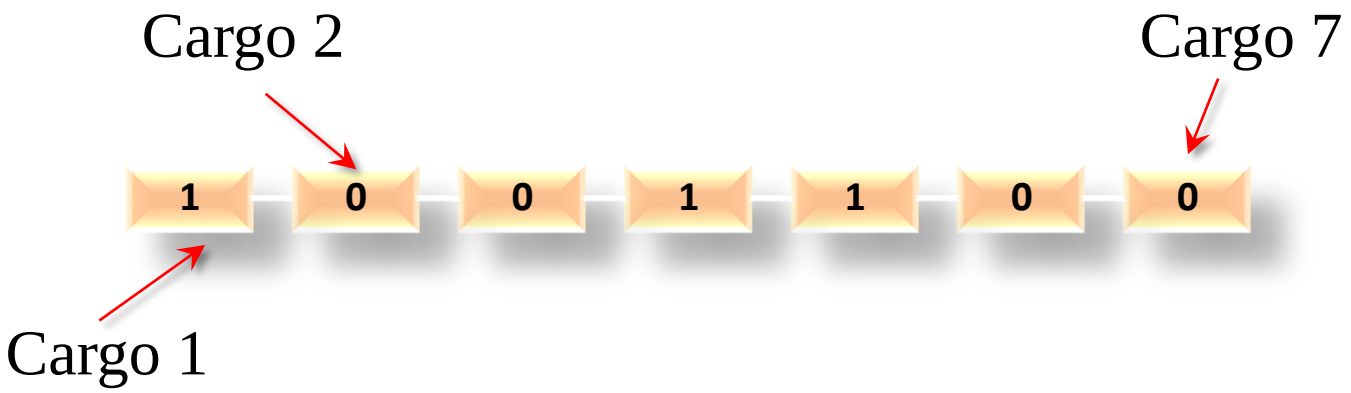
- Binary integer: 0 or 1.
- Real number.



Design Chromosome

Allocation Example

- Each gene represents 1 cargo.
- The chromosome consists of 7 genes
- If the cargo is in, then represents by 1 otherwise 0.



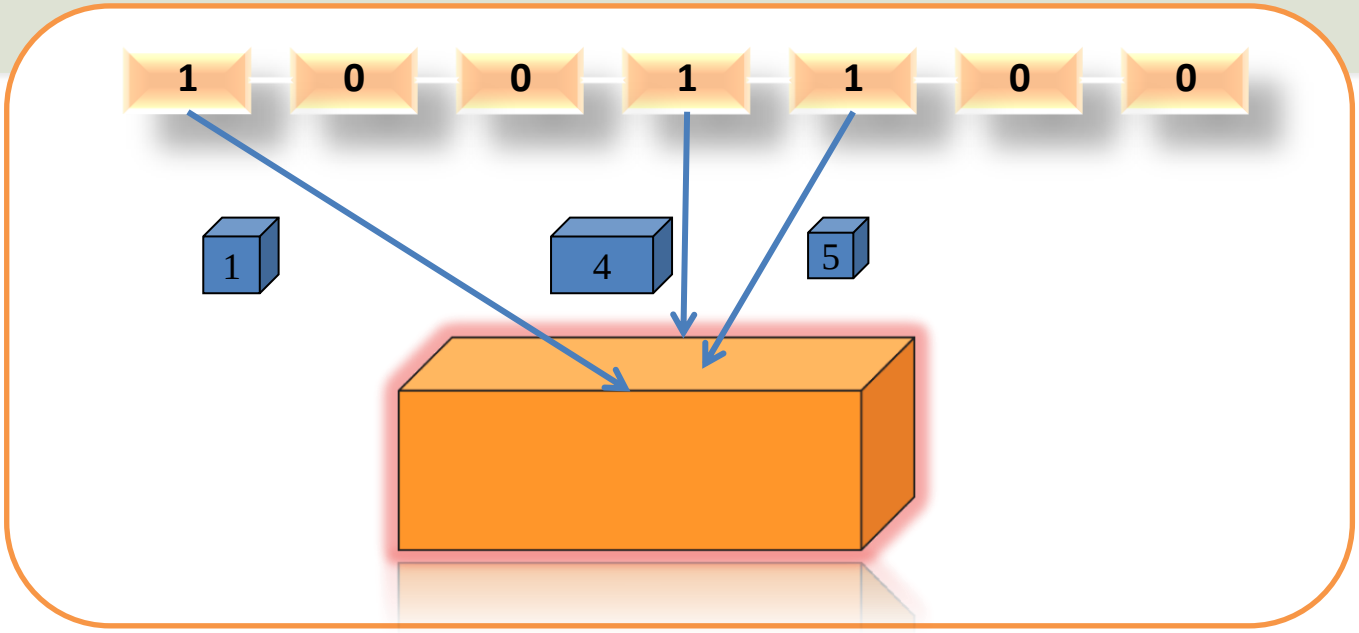
Design Chromosome

Decoding of Chromosome

- It means how to interrupt the chromosome.

-Explain how to convert the chromosome into a solution.

Allocation Example



Design Chromosome

Validation

- Check the chromosome validity.
- A chromosome is valid if it does not violate the constraints.

Allocation Example

Cargo	Volume (m^3)	Weight (lb)
1	3	400
2	4	500
3	6	200
4	5	600
5	2	250
6	1	300
7	2	350

Cargo	Volume	Weight
1	3	400
4	5	600
5	2	250
Total	10	1250

Constraints	12	2100

Valid

Question

Can we design the chromosome by using **Real Value**?

Design Chromosome

Encoding with Real Value

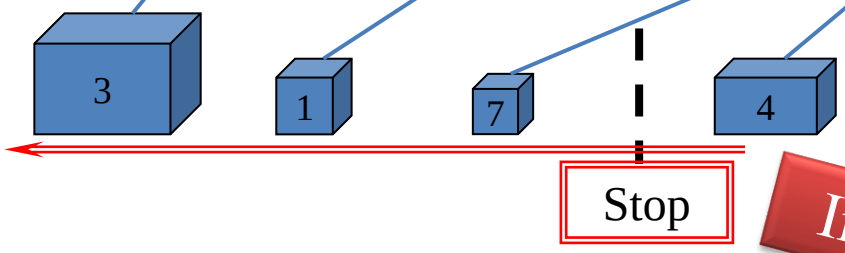
- Cargo's sequence to put in the container.
- Count until the constraints violated.

Cargo	Volume (m^3)	Weight (lb)
1	3	400
2	4	500
3	6	200
4	5	600
5	2	250
6	1	300
7	2	350

Cargo	3
Volume	6
Weight	200
Value	4

Cargo	3,1
Volume	9
Weight	600
Value	7

Cargo	3,1,7
Volume	11
Weight	950
Value	12



Cargo	3,1,7,4
Volume	16
Weight	1550
Value	21

Invalid

Design Chromosome

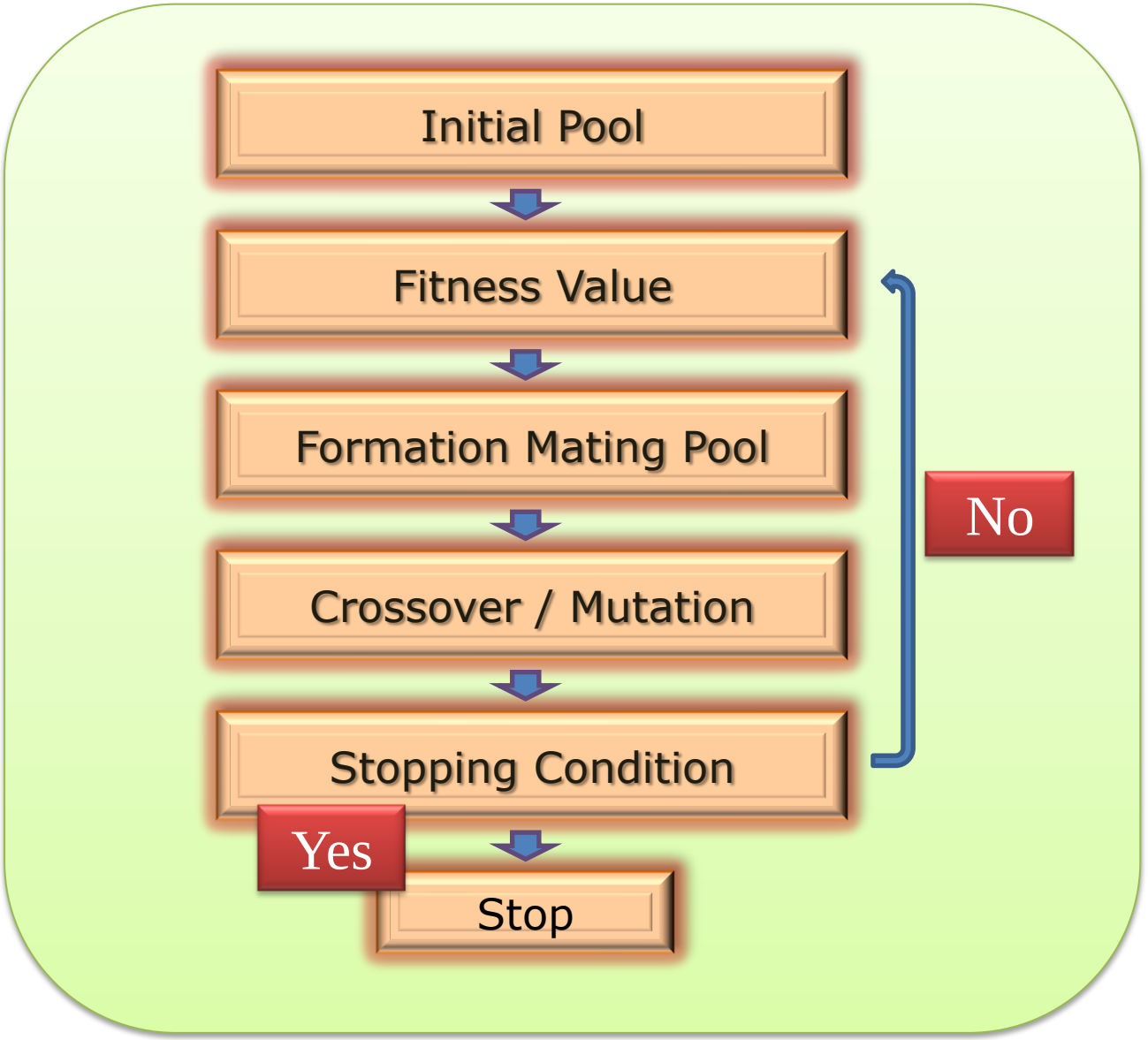
Summary : Encoding of Chromosome

Skills:

Real/Binary Value
Sequence/Position

Avoid: Lengthy chromosome

Outline: GA


Initial Pool
Fitness Value
Formation Mating Pool
Crossover / Mutation
Stopping Condition
No
Yes
Stop

Initial Pool

Formation of Initial Pool

- Evolution started based on the initial pool.
- A Pool of chromosomes

Ways of Forming:

- Totally Random.
- Rules

Allocation Example

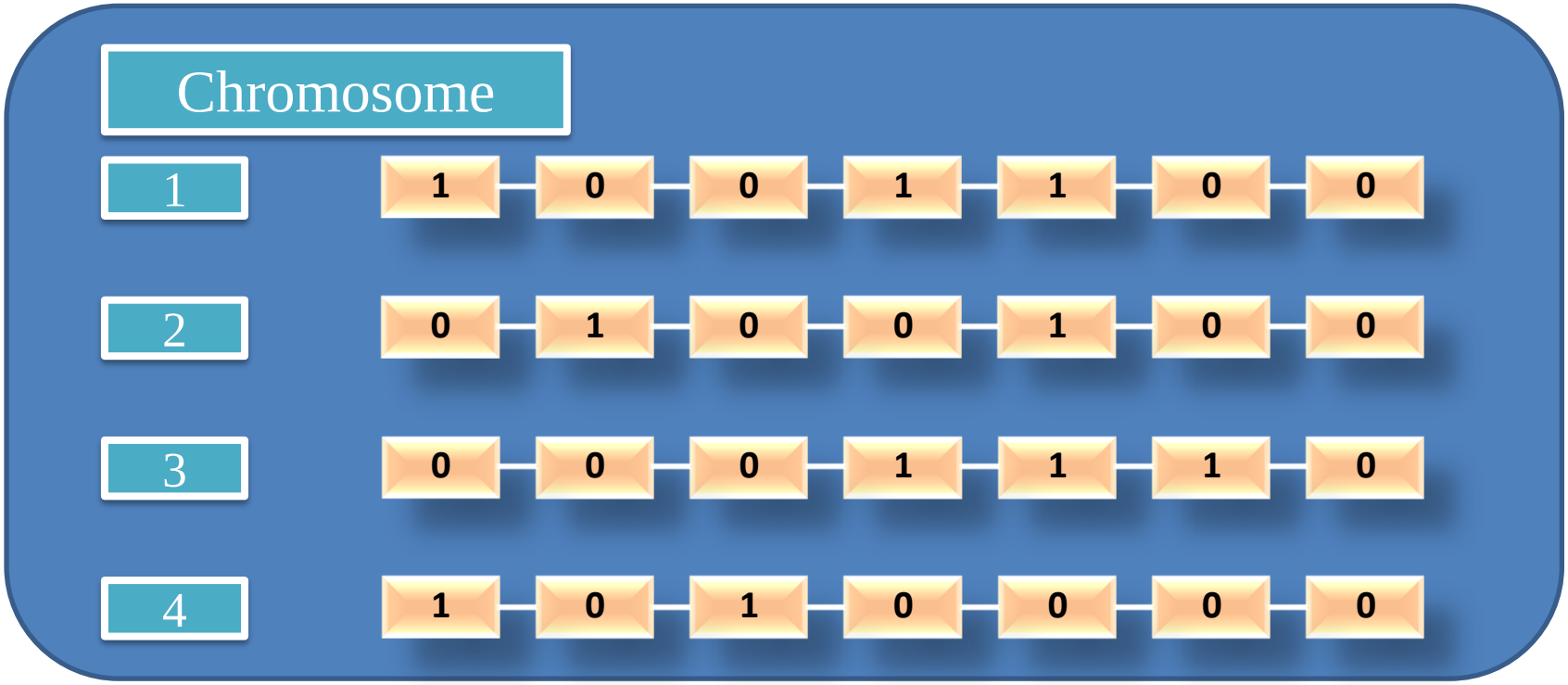
- Highest Profit
- Smallest Size
- Lightest Weight

Cargo	Volume (m^3)	Weight (lb)
1	3	400
2	4	500
3	6	200
4	5	600
5	2	250
6	1	300
7	2	350

Initial Pool

Allocation Example

- Initial Pool Size: 4



Initial Pool

Pool Size

- Commonly around 10 to 100

Fitness Value

Fitness value

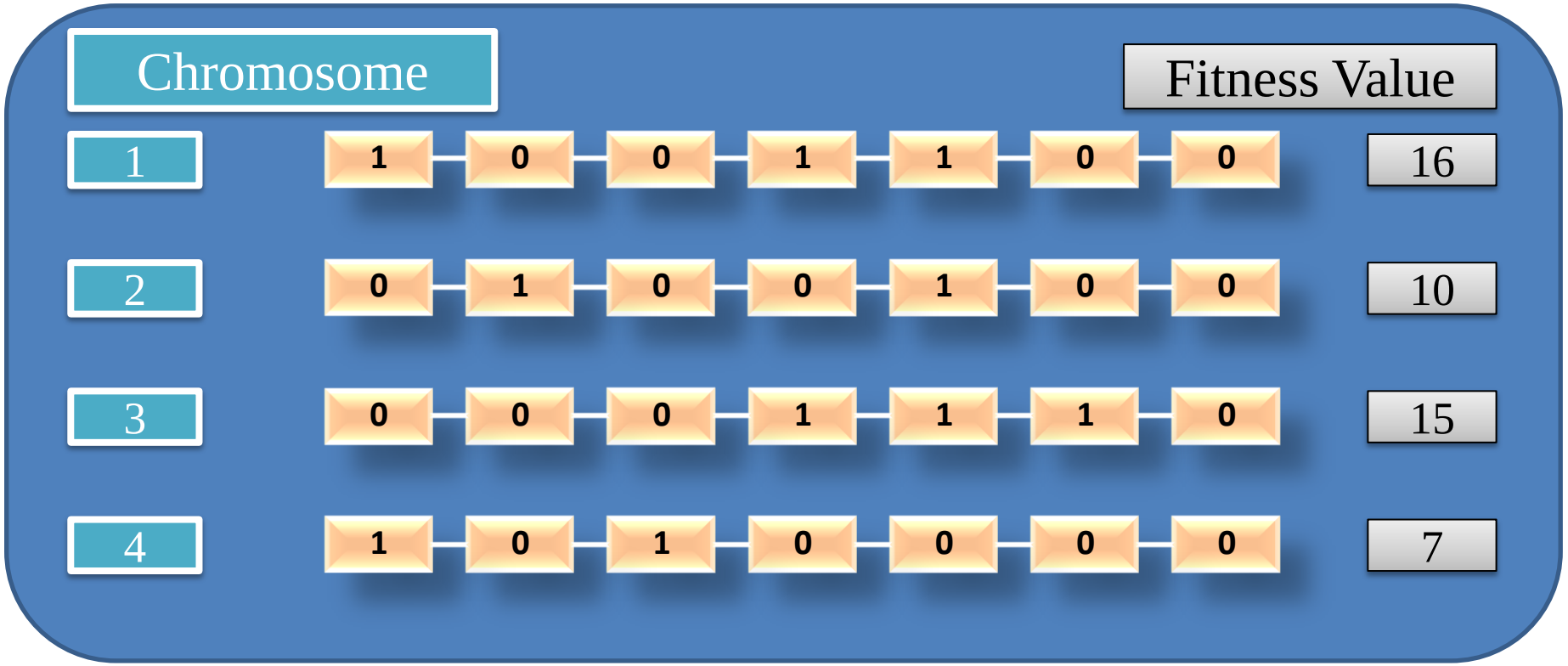
- Represents the strength/goodness of the chromosome.
- It means how good this solution is.
- A large fitness value, meaning a good chromosome

Allocation Example

Fitness Value = 3k + 9k + 4k = 16k

Cargo	Value ($1000)
1	3
2	6
3	4
4	9
5	4
6	2
7	5

Allocation Example



Forming Mating Pool

Purpose of Mating Pool

- Crossover and Mutation

Remark

- Number of chromosomes in Mating Pool = Number of chromosomes in Initial Pool.

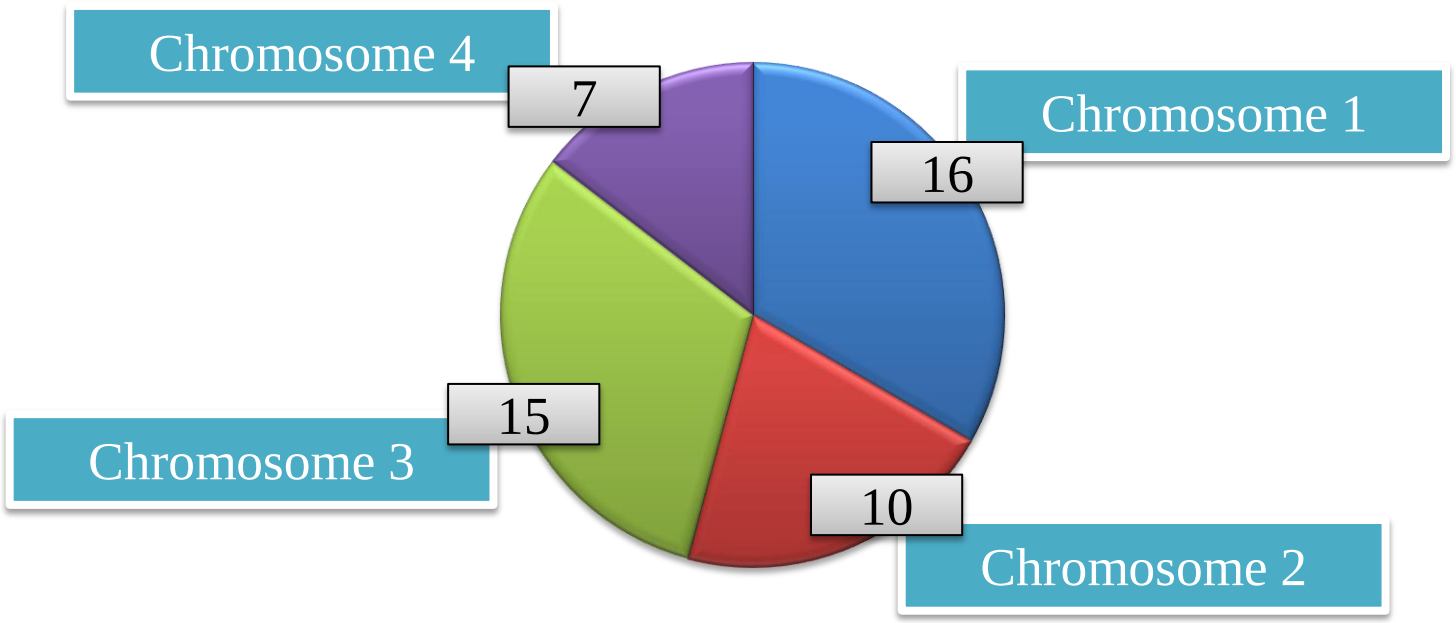
Forming Method

- Roulette Wheel Selection.

Forming Mating Pool

Roulette Wheel Selection

- Mimic the idea of survive of the best



Fitness Value

Allocation Example

Initial Pool

1	1	0	0	1	1	0	0	16
2	0	1	0	0	1	0	0	10
3	0	0	0	1	1	1	0	15
4	1	0	1	0	0	0	0	7

Mating Pool

1	1	0	0	1	1	0	0	16
2	0	0	0	1	1	1	0	15
3	1	0	1	0	0	0	0	7
4	0	0	0	1	1	1	0	15

Design Chromosome

Question: Design for Production Scheduling

- Chromosome
- Fitness Value

Problem

10 Jobs and 3 Machines

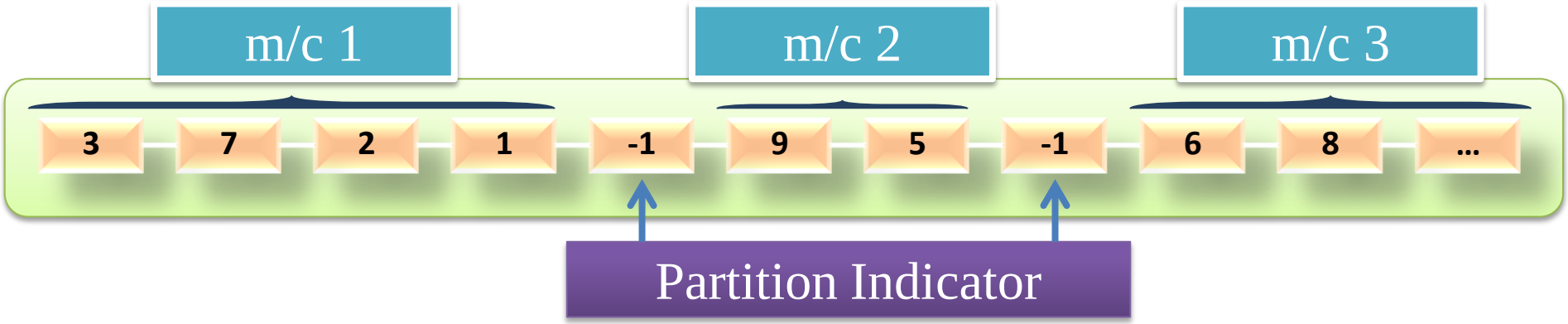
Minimize Makespan

Job	PT	Job	PT
1	12	6	5
2	15	7	12
3	16	8	17
4	11	9	21
5	17	10	15

Setup Time	1	2	3	4	5	6	7	8	9	10
1	-	12	4	2	5	6	4	12	5	3
2	5	-	3	6	7	3	2	4	6	4
3	3	1	-	1	3	4	6	7	8	8
4	7	4	2	-	12	3	3	1	3	5
5	12	3	6	3	-	12	3	3	12	6
6	4	1	8	3	4	-	6	7	2	8
7	6	9	5	3	2	1	-	9	4	3
8	12	4	7	3	9	4	10	-	2	6
9	1	2	7	4	9	3	12	15	-	4
10	9	6	2	6	8	11	3	8	6	-

Possible Answer

Chromosome Encoding



Fitness Value of Chromosome *i* = 1-1/makespan of *i*

Fitness Value

Skills

MIN		=1-f/max	=1-f/Sum
Chromo.		FV	FV
1	12	0.760	0.934
2	14	0.720	0.923
3	16	0.680	0.912
4	20	0.600	0.890
5	8	0.840	0.956
6	4	0.920	0.978
7	32	0.360	0.823
8	50	0.000	0.724
9	7	0.860	0.961
10	18	0.640	0.901