Week	Content	CO	Activity and Assessments	Percentage
19/08	• Introduction to Genetic Algorithms • GA Implementation	CO-1	Refreshing and Discussion	-
26/08	• Cycle of Basic GA • Holland's schema theorem.	CO-1	Quiz-1	2
02/09	Encoding in Genetic Algorithm	CO-3	Quiz-2	2
09/09	Selection	CO-2	Quiz-3	2
16/09	Crossover Part 1	CO-2	Quiz-4	2
23/09	Crossover Part 2	CO-2	Quiz-5	2
30/09	Proposal Presentation (Problem Formulation)	CO-3	Presentation and Discussion	10+2,5
../10	UTS		Holland's schema and What is GA GA Encoding GA Operators	5 5 5

Week	Content	CO	Activity and Assessments	Percentage
21/10	• Mutation • Genetic Algorithm Parameters	CO-2	HW-1	2.5
28/10	Hybrid Genetic Algorithm	CO-5	HW-2	2.5
04/11	Progress Report	CO-4	Presentation and Discussion	10 + 2.5
11/11	Applications of Genetic Algorithms	CO-5	HW	5
18/11	Final Project Report	CO-4	Presentation	10
25/11	Trend research on Genetic Algorithm	CO-6	Presentation of Lit Review	5
02/12	Paper Report	CO-5	Draft paper	10
…/12	UAS	CO-2 CO-4 CO-6	GA Operator and Parameters GA Design Trend GA	5 5 5

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Genetic Algorithm: Selection

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How to solve problem using GA ?

- Generate Population ..done
- Encoding → Chromosome…done
- Define Fitness Function …done
- Define GA Operator
  - **Selection**
  - **Cross Over**
  - Mutation

Selection

- During each successive generation, a proportion of the existing population is selected to breed a new generation.

- Individual solutions are selected through a *fitness-based* process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected.

- There some of Methods that can be used :
  - Fitness Proportionate Selection (FPS)
    - *Roulette wheel*
    - **Baker's SUS** (*Stochastic Universal Sampling*)
  - Rank-Based Selection
    - Linear Ranking
    - Non-linear ranking
  - Tournament Selection

FPS: Roulette Wheel

- The simplest selection scheme is roulette-wheel selection, also called stochastic sampling with replacement.

- This is a stochastic algorithm and involves the following technique:
  - The individuals are mapped to contiguous segments of a line, such that each individual's segment is equal in size to its fitness.
  - A random number is generated and the individual whose segment spans the random number is selected.
  - The process is repeated until the desired number of individuals is obtained (called mating population).

- This technique is analogous to a roulette wheel with each slice proportional in size to the fitness.

Algorithm of Roulette Wheel Selection

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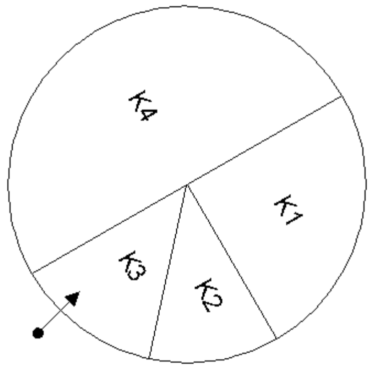
```
Set j=1, S=0, {N=population size, mpool = mating pool size}
While j<=N
Begin
        Compute P_j
        Compute S = S+ P_j
        Calculate CumP_j = CumP_{j-1} + P_j
End

Set l=1, j=1, i=nogen
While l <= mpool
Begin
        Generate random number r from interval (0,S)
        Set j=1
        While j<=N
        Begin
                If r ≤ CumP_j,
                Begin
                        Select the individual j ,
                        break
                end
        end
        l=l+1
End
```

FPS: Roulette Wheel

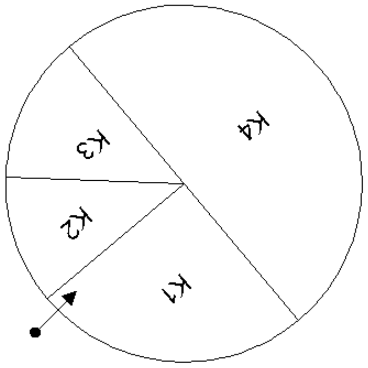
$$P_i = \frac{fitness(i)}{\sum_{j=1}^{n} fitness(j)}$$

kromosom	
K1	2/8 = ¼ = 0,25
K2	1/8 = 0,125
K3	1/8 = 0,125
K4	4/8 = 0,5
Total	1

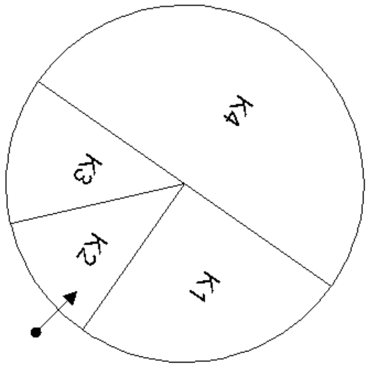
Kromosom	*Fitness*
K1	2
K2	1
K3	1
K4	4
Jumlah	8



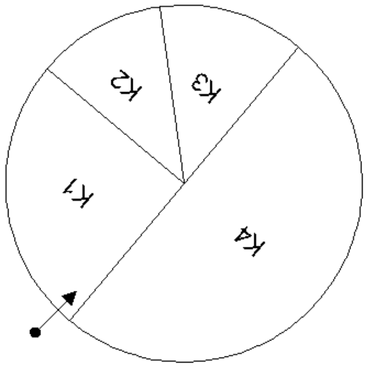
Putaran ke-1



Putaran ke-2



Putaran ke-3



Putaran ke-4

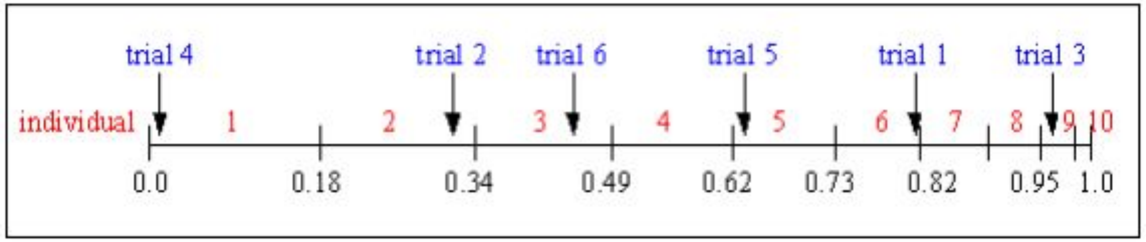
Example (FPS: RW)

Table shows the selection probability for 11 individuals. Individual 1 is the most fit individual and occupies the largest interval, whereas individual 10 as the second least fit individual has the smallest interval on the line. Individual 11, the least fit interval, has a fitness value of 0 and get no chance for reproduction

Number of individual	1	2	3	4	5	6	7	8	9	10	11
fitness value	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2	0.0
selection probability	0.18	0.16	0.15	0.13	0.11	0.09	0.07	0.06	0.03	0.02	0.0

sample of 6 random numbers:

```
0.81, 0.32, 0.96, 0.01, 0.65, 0.42.
```



After selection the mating population consists of the individuals:

```
1, 2, 3, 5, 6, 9.
```

The roulette-wheel selection algorithm provides a zero bias but does not guarantee minimum spread.

FPS: Baker's SUS (Stochastic Universal Sampling)

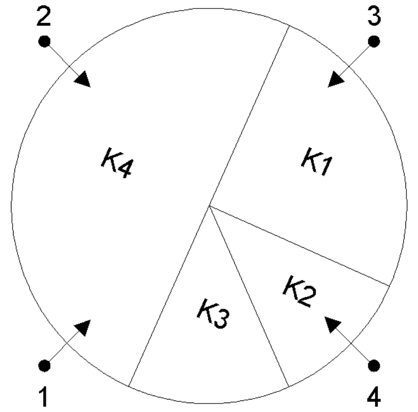
- Stochastic universal sampling[Bak87] provides zero bias and minimum spread.

- The individuals are mapped to contiguous segments of a line, such that each individual's segment is equal in size to its fitness exactly as in roulette-wheel selection.

- Here equally spaced pointers are placed over the line as many as there are individuals to be selected.

- Consider *NPointer* the number of individuals to be selected, then the distance between the pointers are 1/*NPointer* and the position of the first pointer is given by a randomly generated number in the range [0, 1/*NPointer*].

Kromosom	*Fitness*
K1	2
K2	1
K3	1
K4	4
Jumlah	8



[Bak87] *Baker, J. E.*: Reducing Bias and Inefficiency in the Selection Algorithm. In [ICGA2], pp. 14-21, 1987.

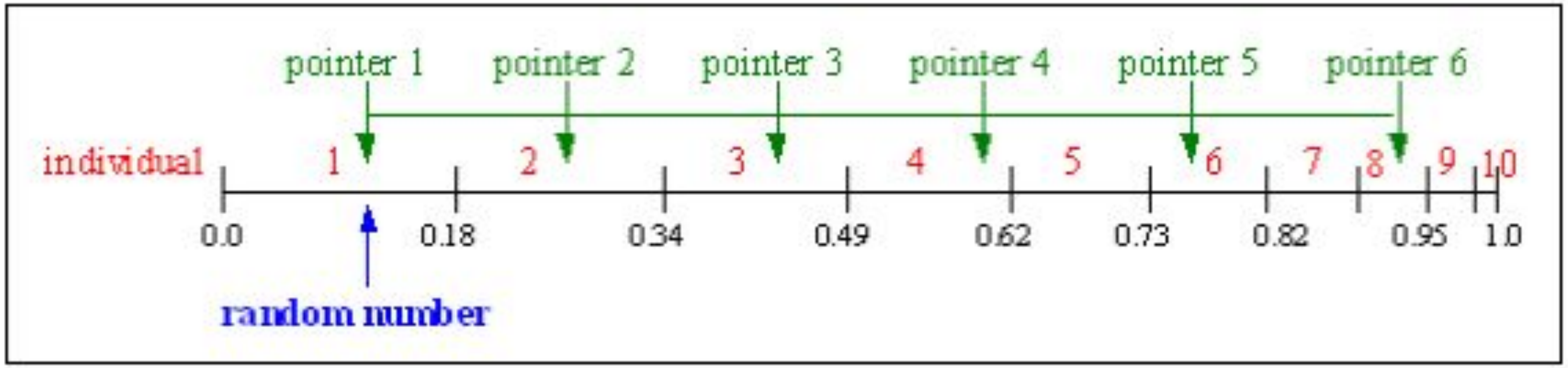
Example (FPS: B'SUS)

For 6 individuals to be selected, the distance between the pointers is 1/6=0.167. Figure shows the selection for the above example.

sample of 1 random number in the range [0, 0.167]:

```
0.1.
```

Fig. 3-4: Stochastic universal sampling



After selection the mating population consists of the individuals:

```
1, 2, 3, 4, 6, 8.
```

Tournament Selection

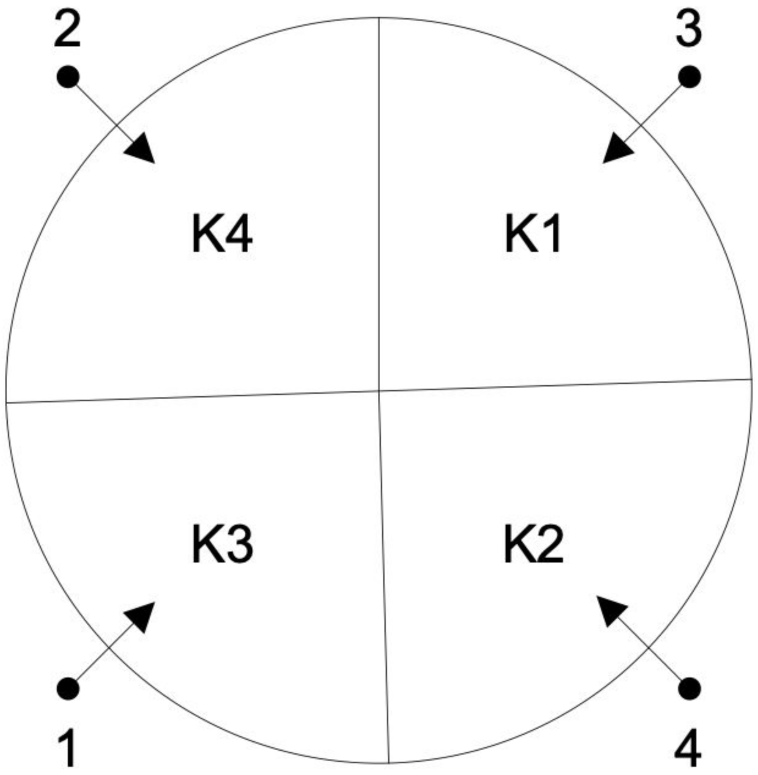
- In tournament selection, a number *Tour* of individuals is chosen randomly from the population and the best individual from this group is selected as parent.
- This process is repeated as often as individuals must be chosen.
- These selected parents produce uniform at random offspring.
- The parameter for tournament selection is the tournament size *Tour*.
- *Tour* takes values ranging from 2 to *Nind* (number of individuals in population).
- Relation between tournament size and selection intensity:

Tournament Size	1	2	3	5	10	30
Selection intensity	0	0.56	0.85	1.15	1.53	2.04

[GD91] *Goldberg, D. E. and Deb, K.*: A Comparative Analysis of Selection Schemes Used in Genetic Algorithms. In [FGA1], pp. 69-93, 1991
[BT95] *Blickle, T. and Thiele, L.*: A Comparison of Selection Schemes used in Genetic Algorithms (2. Edition). TIK Report No. 11, Computer Engineering and Communication Networks Lab (TIK), Swiss Federal Institute of Technology (ETH) Zürich, Switzerland, 1995.
http://www.tik.ee.ethz.ch/Publications/TIK-Reports/TIK-Report11abstract.html.

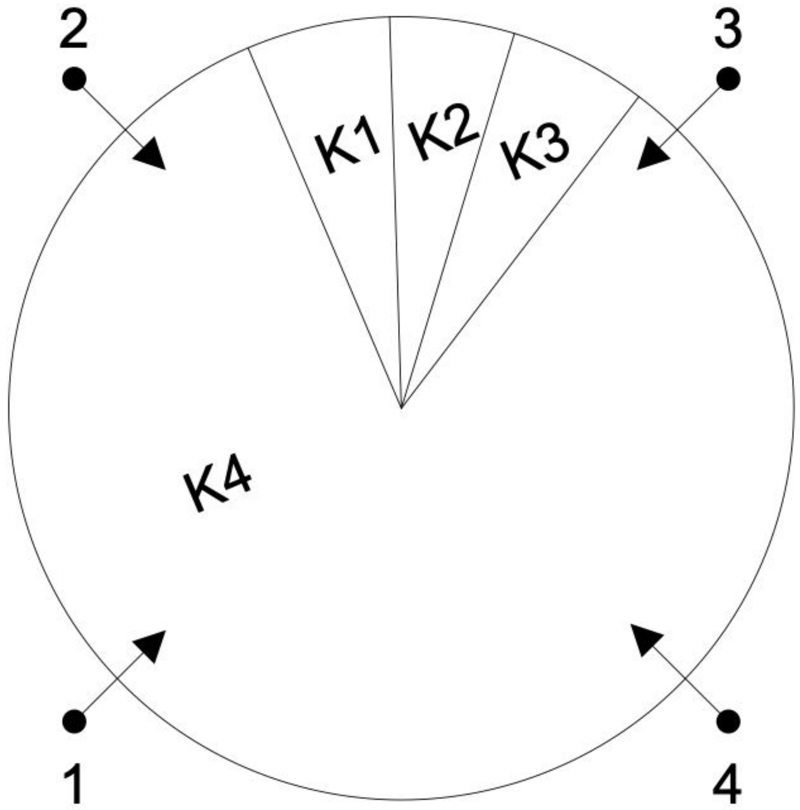
Disadvantages of **Baker's SUS**

Kromosom	*Fitness*
K1	1,98
K2	2,01
K3	1,99
K4	2,02
Jumlah	8



Disadvantages of **Baker's SUS**

Kromosom	*Fitness*
K1	1
K2	1
K3	1
K4	17
Jumlah	20



To Handle disadvantages of **Baker's SUS**

- *Linear Scaling*
- *Window Scaling*
- *Sigma Scaling*

Linear Scaling

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- Tujuannya menjaga agar perbedaan antar fitness tidak terlalu ekstrem, tapi tetap mempertahankan urutan ranking.
- Mengalikan fitness dengan faktor tertentu.

$$f'_i = af_i + b$$

- f_i = fitness value individual *i*
- *a* and *b* is selected so that $\overline{f'} = \overline{f}$
- $f'_{\max} = C_{mult} * \overline{f}$, in which C_{mult} is expectation value the best chromosome was selected as a parent
- C_{mult} = 1,2 … 2,0

Window Scaling

- Tujuannya memperjelas perbedaan nilai fitness semua kromosom yang mirip.
- Menggeser nilai fitness dengan mengurangi nilai fitness minimum dalam populasi.

$$f' = f - f_{\min} \text{ (pastikan } f' \geq 0)$$

Sigma Scaling

- *Menyesuaikan fitness berdasarkan rata-rata dan standar deviasi (σ) populasi.*
- *Individu dengan fitness di atas rata-rata akan tetap punya peluang lebih besar, tapi tidak berlebihan.*

$$f'_i = f_i + \left(\overline{f} - c * \sigma\right)$$

- *c* = small integers (usually equal to 2)
- Nilai fitness *f* diskalakan menggunakan rerata dan standar deviasi

Next…

- Crossover