

SVEUČILIŠTE U ZAGREBU
FAKULTET ELEKTROTEHNIKE I RAČUNARSTVA

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DIPLOMSKI RAD

METODE ZA RJEŠAVANJE PROBLEMA NARUČIVANJA VOŽNJI



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GENETSKI ALGORITMI

JEDINKA ILI KROMOSOM

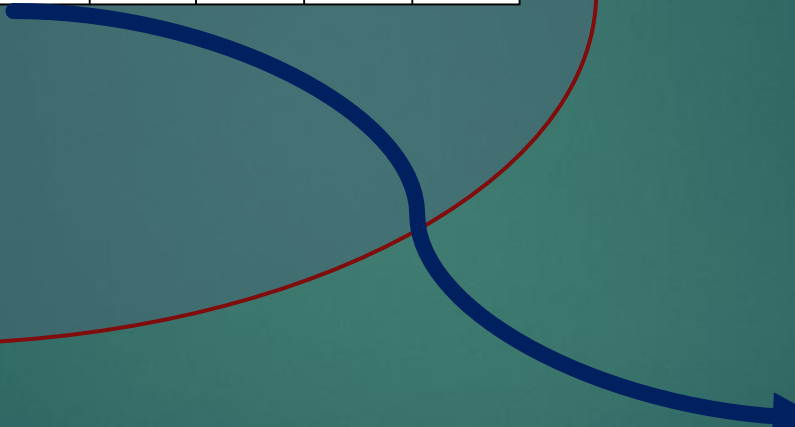
1	1	1	1	0	0	1	0	0	1	0
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FUNCKIJA DOBROTE

4



1	1	1	1	0	0	1	0	0	1	0
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$\mathbb{R}, \mathbb{R}^2, \mathbb{R}^3 \dots$

A close-up photograph of a colony of ants on a light-colored, textured leaf. The ants are dark brown and are moving along the edge of the leaf. The background is a bright, out-of-focus yellow-green. The image is partially obscured by a dark teal overlay on the right side of the page.

POPULACIJA

KRIŽANJE (CROSSOVER)



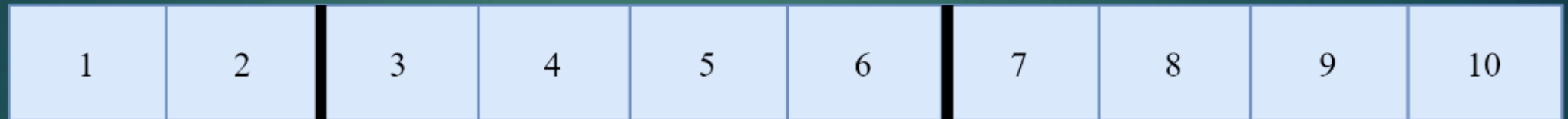
KRIŽANJE DJELOMIČNIM PRESLIKAVANJEM (PARTIALLY MAPPED CROSSOVER)

7

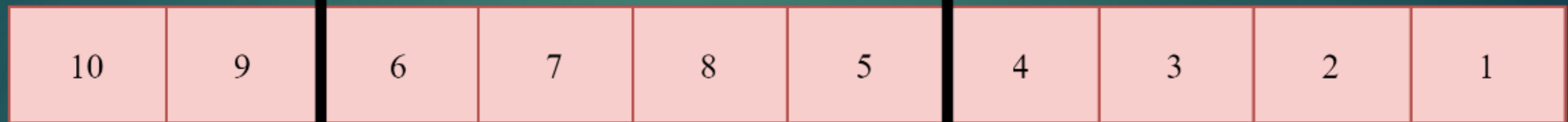
A

B

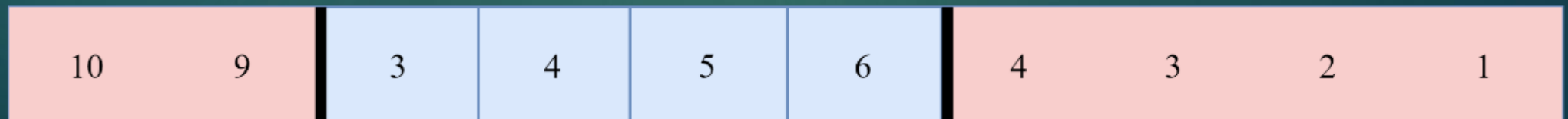
Roditelj 1



Roditelj 2

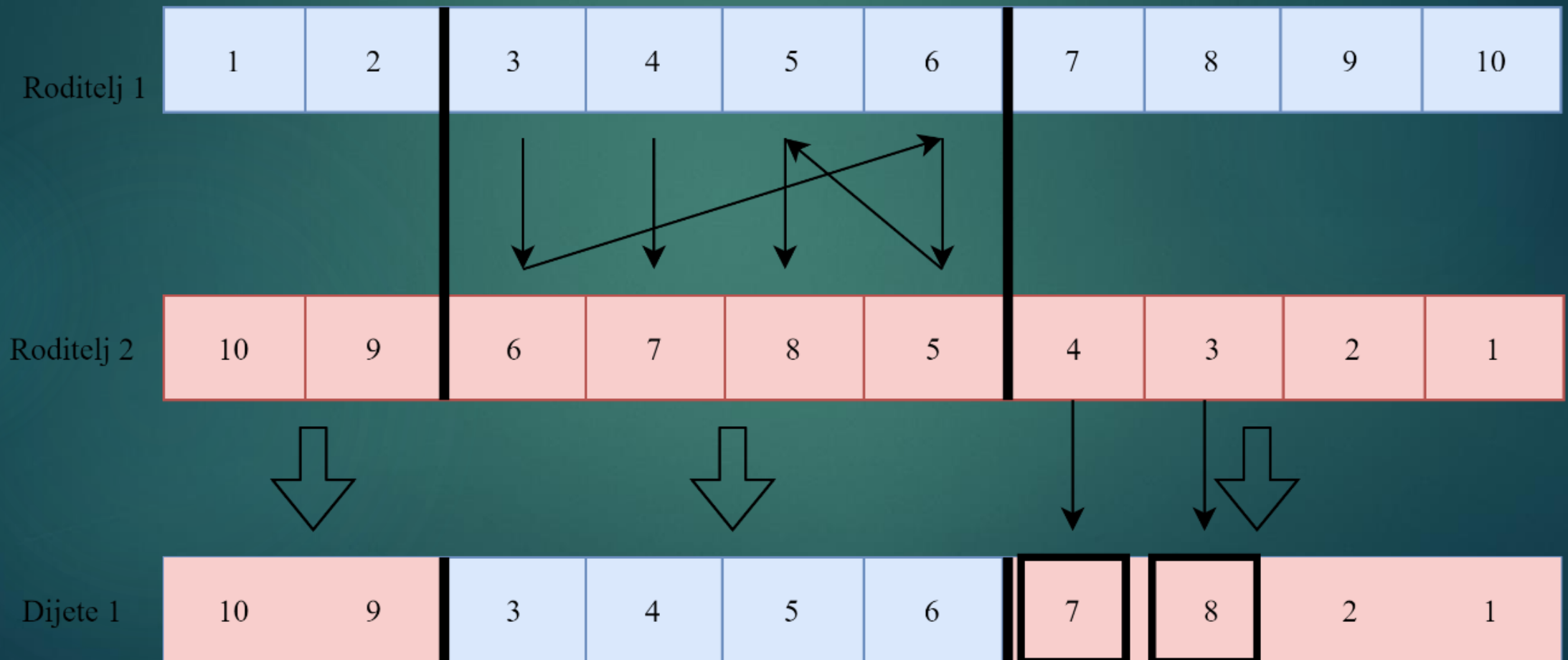


Dijete 1



KRIŽANJE DJELOMIČNIM PRESLIKAVANJEM (PARTIALLY MAPPED CROSSOVER)

8

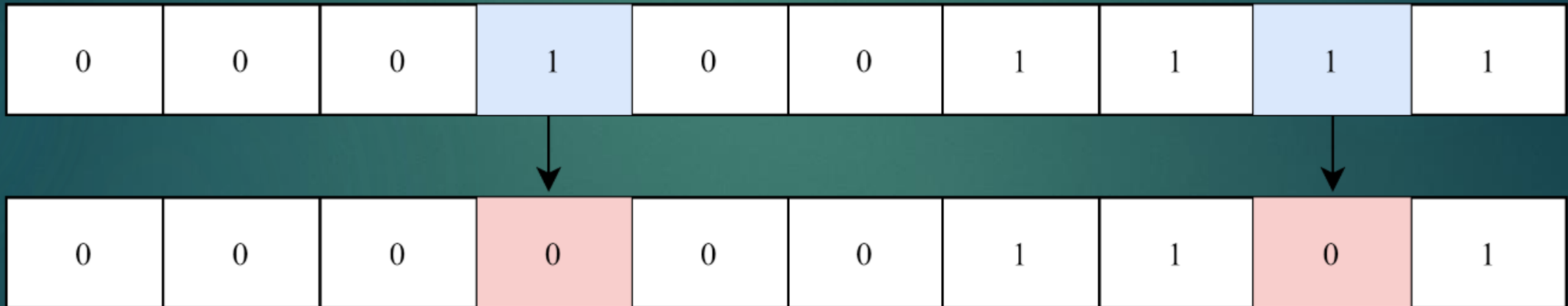


A photograph of three white daisy flowers with bright yellow centers, growing on a bed of grey gravel. The flowers are in various stages of bloom, and their green stems and leaves are visible. The image is partially obscured by a dark teal overlay on the right side of the slide.

MUTACIJA

MUTACIJA PROMJENE JEDNOG BITA ONE-BIT FLIP MUTATION

$p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$ $p = 0.1$



SELEKCIJA



TURNIRSKA SELEKCIJA



KRITERIJ ZAUSTAVLJANJA

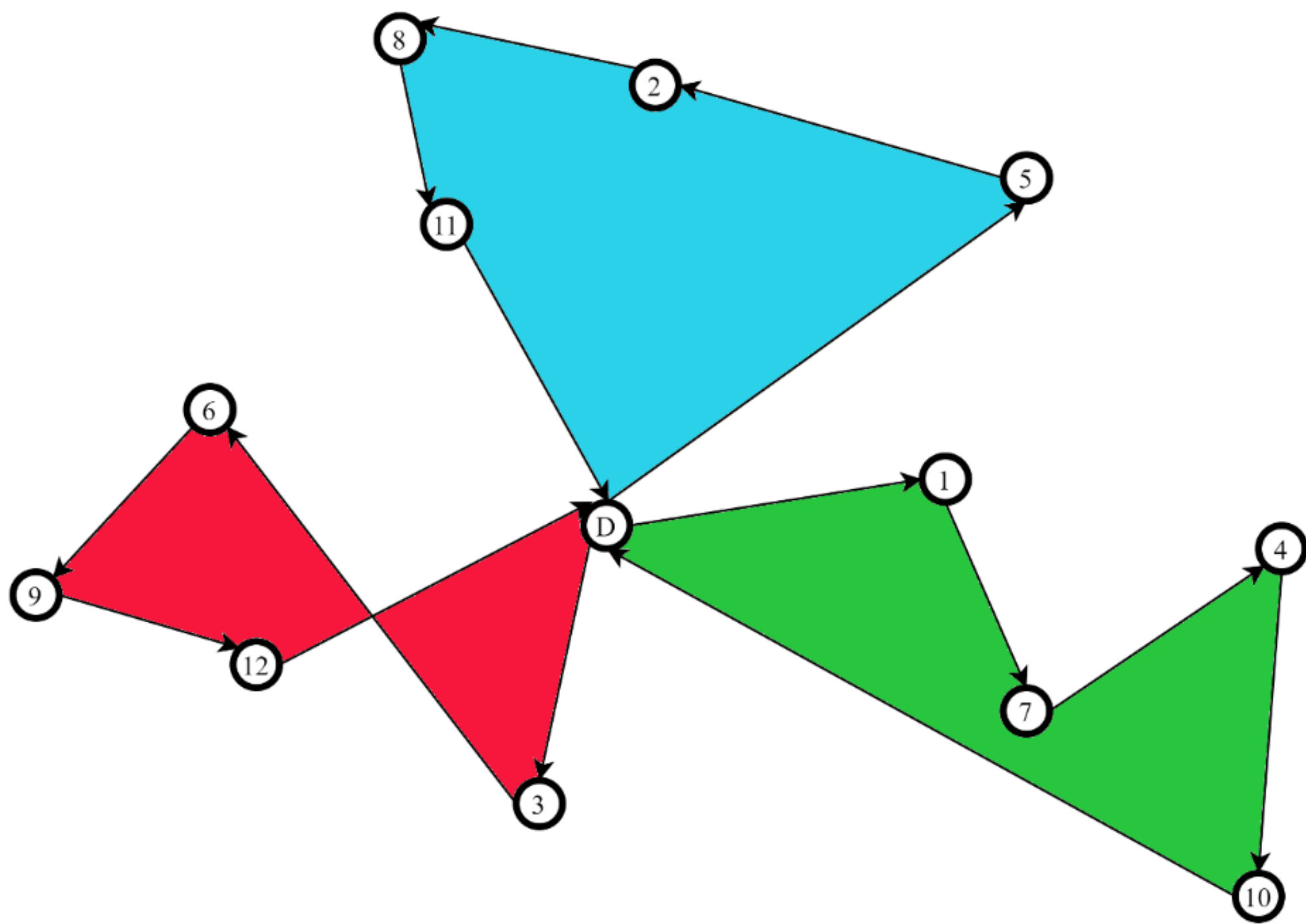
Genetski_algoritam

```
{  
  
    t = 0  
  
    generiraj početnu populaciju potencijalnih rješenja      P(0)  
  
    Sve dok nije zadovoljen kriterij zaustavljanja  
    {  
        t = t + 1;  
  
        selektiraj P'(t) iz P(t-1);  
  
        križaj jedinke iz P'(t) i djecu spremi u P(t);  
  
        mutiraj jedinke iz P(t);  
    }  
  
    ispiši rješenje;  
}
```


A photograph of a busy city street, likely in New York City, featuring several yellow taxis. The taxis are parked or moving slowly in traffic. The buildings are tall and modern, with many windows. The sky is overcast. The image is used as a background for the text on the right.

PROBLEM NARUČIVANJA VOZILA

- ▶ Flota vozila
- ▶ 2n zahtjeva korisnika
- ▶ 1-n zahtjevi ukrcaja
- ▶ n-2n zahtjevi iskrcaja
- ▶ Sva vozila kreću s iste početne točke - depoa
- ▶ Vozila imaju ograničen kapacitet
- ▶ Korisnici mogu dijeliti vozilo
- ▶ Korisnike se ne vozi direktno
- ▶ Postoje vremenska ograničenja
- ▶ Sva vozila se vraćaju u depo



Instanca problema

Problem:

- ▶ Broj vozila
- ▶ Broj zahtjeva
- ▶ Maksimalno trajanje jedne rute
- ▶ Kapacitet vozila
- ▶ Maksimalno vrijeme vožnje jednog korisnika

Zahtjev:

- ▶ Koordinate
- ▶ Vrijeme posluživanja
- ▶ Zauzeće u vozilu
- ▶ Najranije vrijeme dolaska
- ▶ Najkasnije vrijeme dolaska

IMPLEMENTACIJA RJEŠENJA

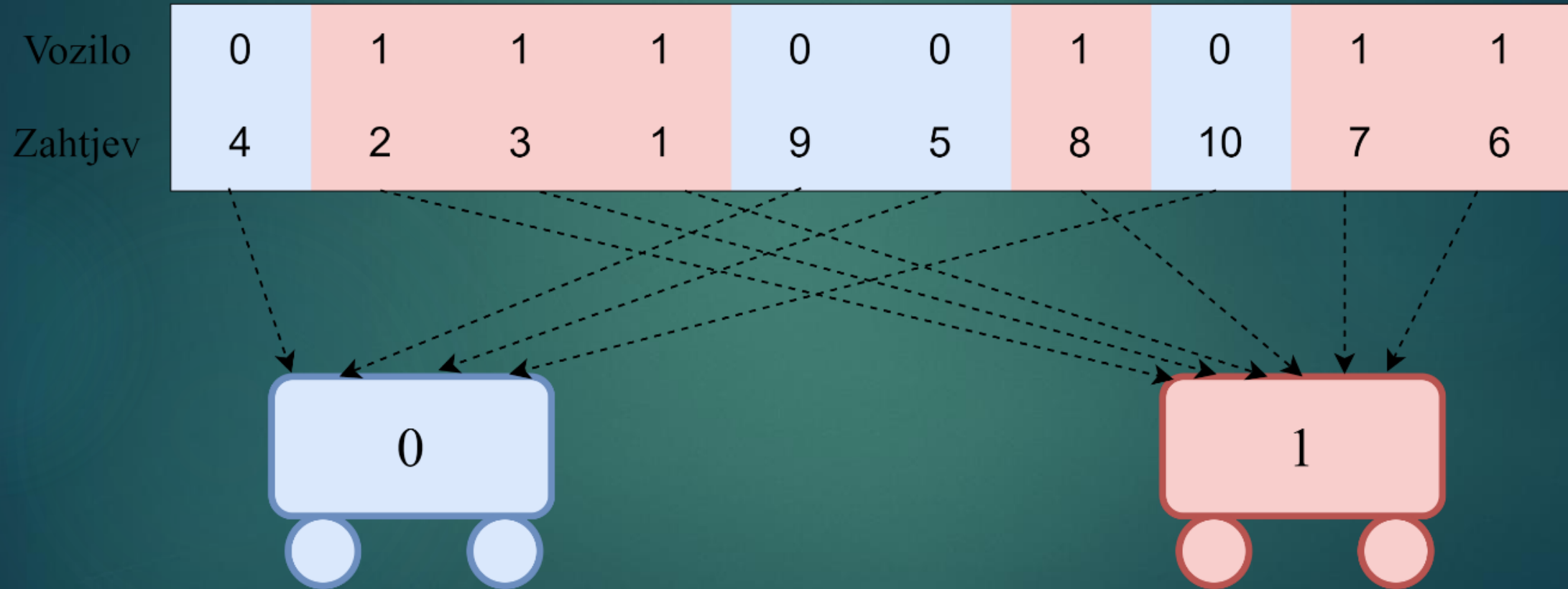
FUNKCIJA DOBROTE

20

- ▶ Ukupno trajanje ruta
- ▶ Vrijeme čekanja vozila
- ▶ Vrijeme vožnje korisnika
- ▶ Kašnjenje korisniku
- ▶ Kršenje ograničenja na maksimalno vrijeme vožnje korisnika
- ▶ Kršenje ograničenja na maksimalno vrijeme vožnje vozila

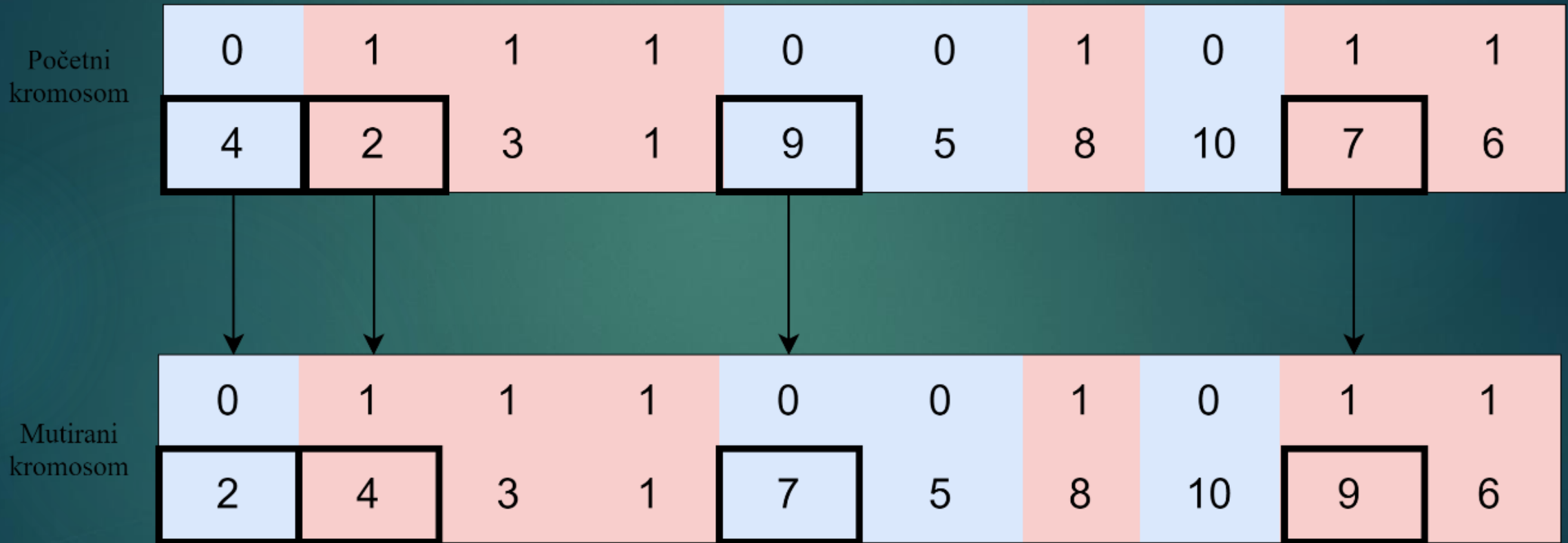
PRVI GENETSKI ALGORITAM

21

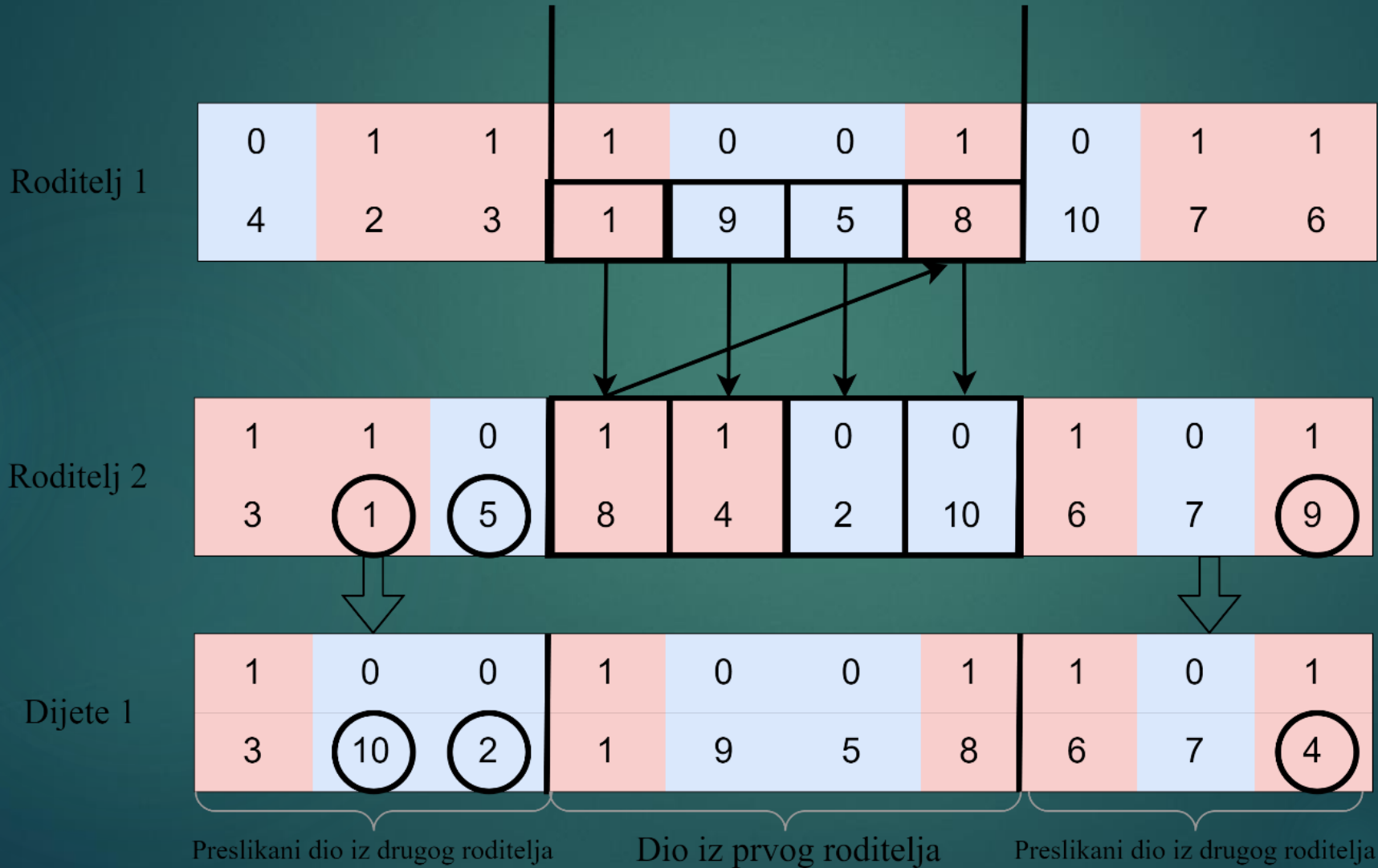


MUTACIJA ZAMJENE ZAHTJEVA

22



KRIŽANJE - PRILAGOĐENI PARTIALLY MAPPED CROSSOVER



ISPRAVLJANJE PRENAPUČENOSTI VOZILA

24

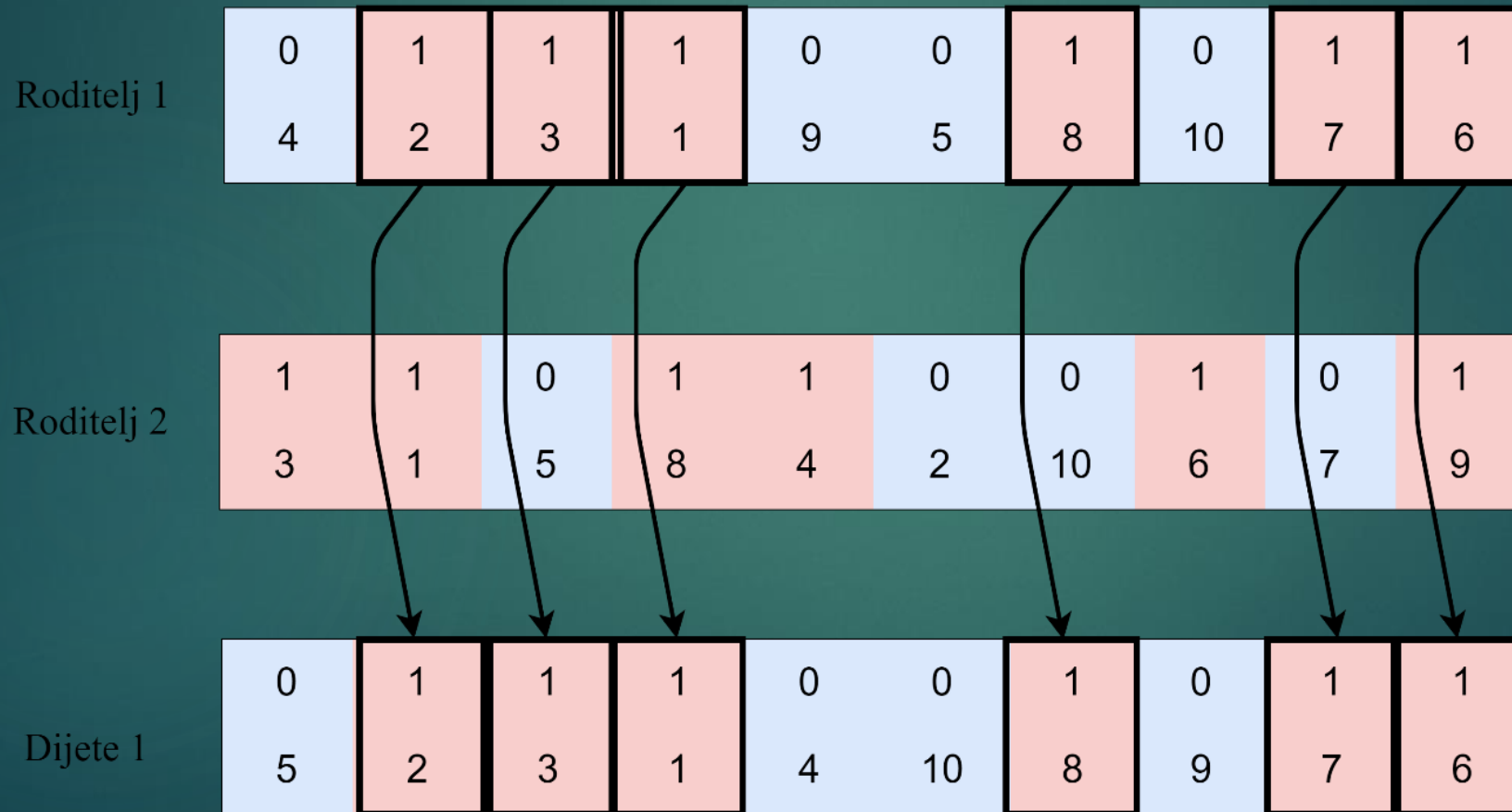
Kromosom

1	0	0	1	0	0	1	1	0	0
3	5	2	1	4	10	8	6	7	9

Popravljeni
kromosom

1	0	0	1	0	0	0	1	1	0
3	5	2	1	7	4	10	8	6	9

KRIŽANJE S DJELOMIČNIM PRESLIKAVANJEM VOZILA - PARTIALLY CAR MAPPED CROSSOVER



JEDNOSTAVNA HEURISTIKA

26

- ▶ Poredamo korisnike prema prioritetu
- ▶ Svakom korisniku dodjeljujemo vozilo po principu udaljenosti u vremenu i prostoru
- ▶ Što je vozilo bliže i vrijeme na satu mu je bliže vremenu zahtjeva, to je više na listi prioriteta za odabir baš tog automobila
- ▶ Ako je to vozilo puno, ukrcavamo korisnika u iduće s liste prioriteta

DRUGI GENETSKI ALGORITAM

27

4	1	6	2	7	3	5	9	10	8
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KREIRANJE POČETNE POPULACIJE

28

- ▶ Nasumično
- ▶ Heuristika

KONAČNI GA

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- ▶ Turnirska selekcija
- ▶ Zadržavanje najboljeg dijela populacije
- ▶ Križanje s djelomičnim preslikavanjem vozila
- ▶ Mutacija zamjene zahtjeva
- ▶ Ako je preko pola populacije ista jedinka, prisilno mutiramo sve “duplikate”

PARAMETRI I REZULTATI

30

- ▶ 1500 generacija
- ▶ Veličina turnira : 5
- ▶ Postotak najboljih jedinki prenesenih u sljedeću generaciju: 4%
- ▶ Veličina populacije: 200
- ▶ Vjerojatnost mutacije: 10%

REZULTATI



Problem	Prvi GA	Drugi GA	Heuristika
R1a	1849.6396	10194.904	13002
R2a	5280.8663	22699.24	27995
R3a	5788.616	31864.714	34988
R4a	9605.4583	43216.563	51087
R5a	11060.036	48469.692	64291

Problem	Route Duration		Vehicle Waiting Time		Ride Time		Best Avg. Late Time	Best Avg. Ride Time Violation
	Avg.	Best	Avg.	Best	Avg.	Best		
R1a	890	972	114	201	1138	694	0.48595683	0.07394674
R2a	1601	1975	164	491	2190	1969	0.72425273	1.59624029
R3a	2353.5	2386.7	117.25	92.546	3486.8	2957.6	0.344888407	0.918569627
R4a	3251.9	3598.5	269.71	547.53	4635.1	4494.5	0.529672435	1.204654246
R5a	3812.8	3958.1	193.02	316.91	5885.1	4789.7	0.97634376	1.323063408
R6a	4690.7	4773	279.24	322.58	7228.2	7133.2	0.924522088	2.578248611
R7a	1273	1353.7	133.13	161.56	1571	1295.4	1.49871474	0.194605793
R8a	2270.6	2254.3	45.818	14.286	3348.6	2802.5	0.888685602	2.861205659
R9a	3225.4	3304.5	64.377	117.84	5834.6	5947.4	4.718814796	2.516191584
R10a	4422.3	4517.9	96.778	102.31	8099.3	7795.5	5.185603279	4.264299874
R1b	788	765.54	31.309	3.5452	984.11	666.82	0.482367647	0.055866058
R2b	1498.9	1422	54.698	5.5902	2107.7	1733.1	0.420772778	1.322663886
R3b	2306.4	2282	68.717	34.193	3369.6	2554.8	0.338342375	0.41843259
R4b	3001	2940.9	75.223	37.503	4352.6	3635.5	0.197928391	0.817551003
R5b	3749	3981.2	135.48	242.11	5618.1	5129.8	0.584174884	1.3365416
R6b	4492	4456	148.8	138.85	6653.4	6170.7	1.125918783	1.013345061
R7b	1150.3	1119.8	19.2	9.7416	1570.7	1357.6	0.538261459	1.122871983
R8b	2328.6	2355	99.637	88.487	3504.5	2658.1	0.960419878	2.17390812
R9b	3287.1	3336.7	45.28	89.962	5961.7	5414.9	1.87709699	2.982317569
R10b	4388.3	4442	65.622	70.394	7734.1	7084.3	3.618267801	1.998619899
Total *	35659	36637	1249	1882	57264	51711	21.08272015	20.52453758

ZAKLJUČAK