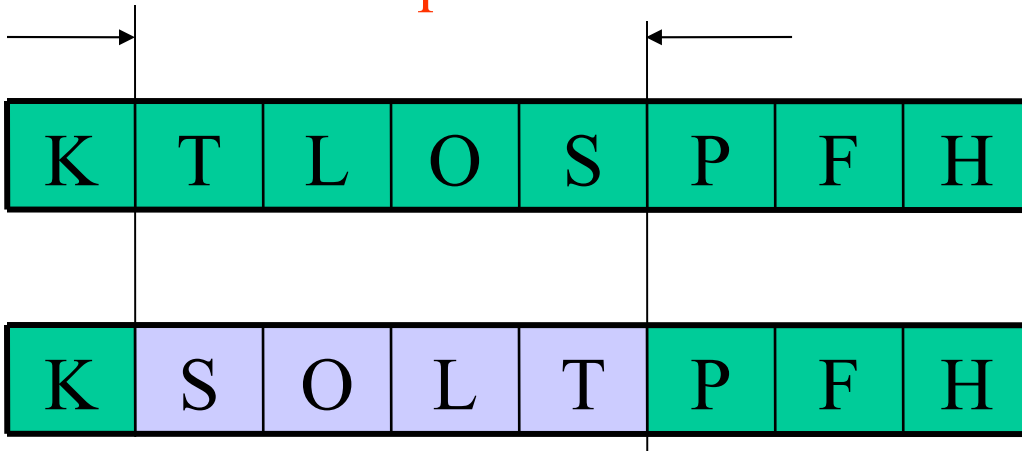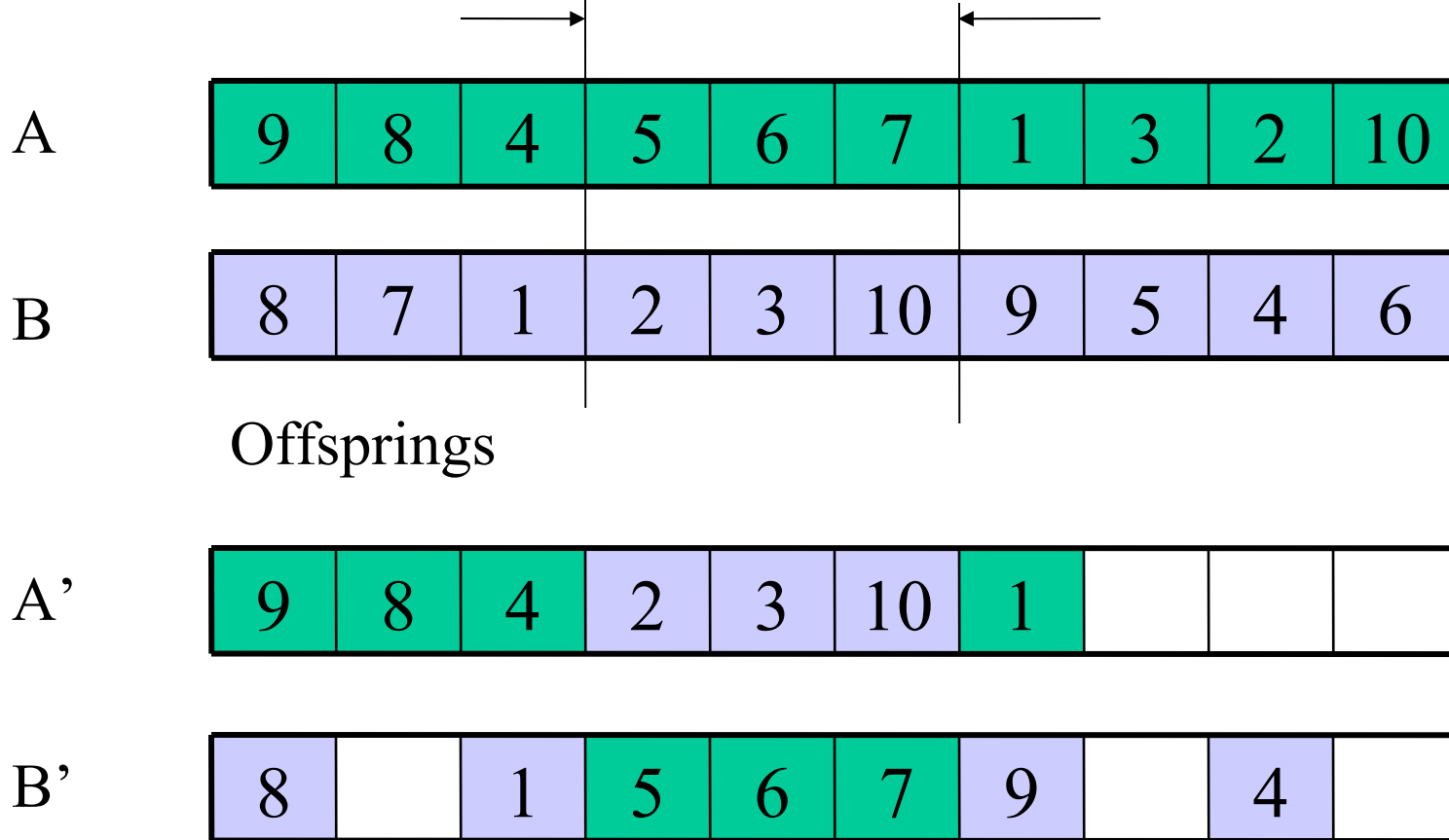# Permutational operators

- Designed for permutational structure
- Every gene has specific signification
- Every gene has to be once in the chromosome
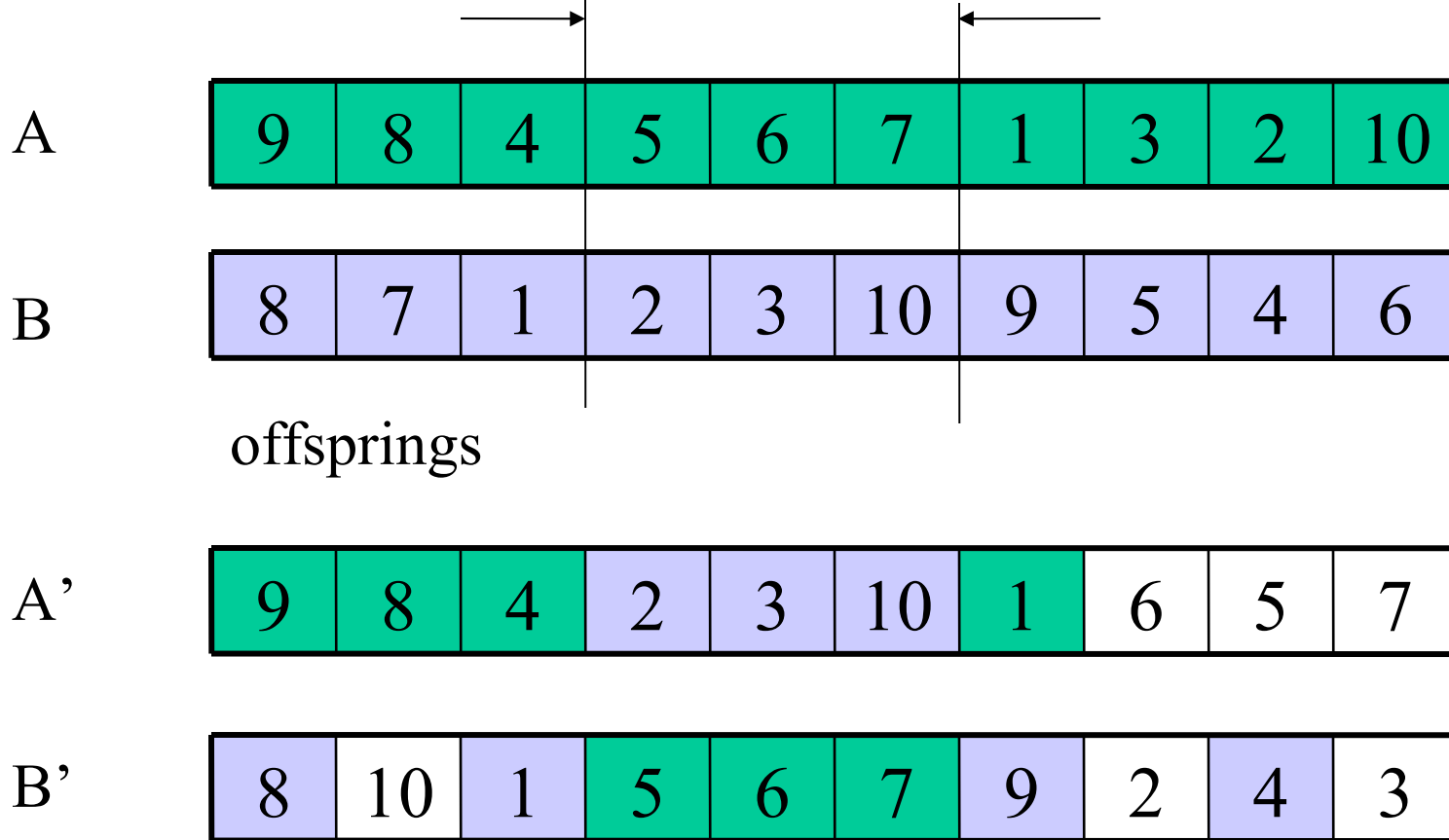- The permutational structure remains after the application of the genetic operators

INVERSION operator

A

| K | T | L | O | S | P | F | H |

A'

| K | S | O | L | T | P | F | H |

PMX-Partially Mixed Crossover

A	9	8	4	5	6	7	1	3	2	10

B	8	7	1	2	3	10	9	5	4	6

Offsprings

A'	9	8	4	2	3	10	1			

B'	8		1	5	6	7	9		4	

3

PMX-Partially Mixed Crossover

A: 9 8 4 5 6 7 1 3 2 10

B: 8 7 1 2 3 10 9 5 4 6

offsprings

A': 9 8 4 2 3 10 1 6 5 7

B': 8 10 1 5 6 7 9 2 4 3

4

OX - Order Crossover

A	9	8	4	5	6	7	1	3	2	10

B	8	7	1	2	3	10	9	5	4	6

offsprings

A'	9	8	4	5	6	7	1			

B'	8		1	2	3	10	9		4	

OX - Order Crossover

A | 9 | 8 | 4 | 5 | 6 | 7 | 1 | 3 | 2 | 10 |

B | 8 | 7 | 1 | 2 | 3 | 10 | 9 | 5 | 4 | 6 |

offsprings

A' | 5 | 6 | 7 | 2 | 3 | 10 | 1 | 9 | 8 | 4 |

B' | 2 | 3 | 10 | 5 | 6 | 7 | 9 | 4 | 8 | 1 |

CX - Cycle Crossover

A

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

B
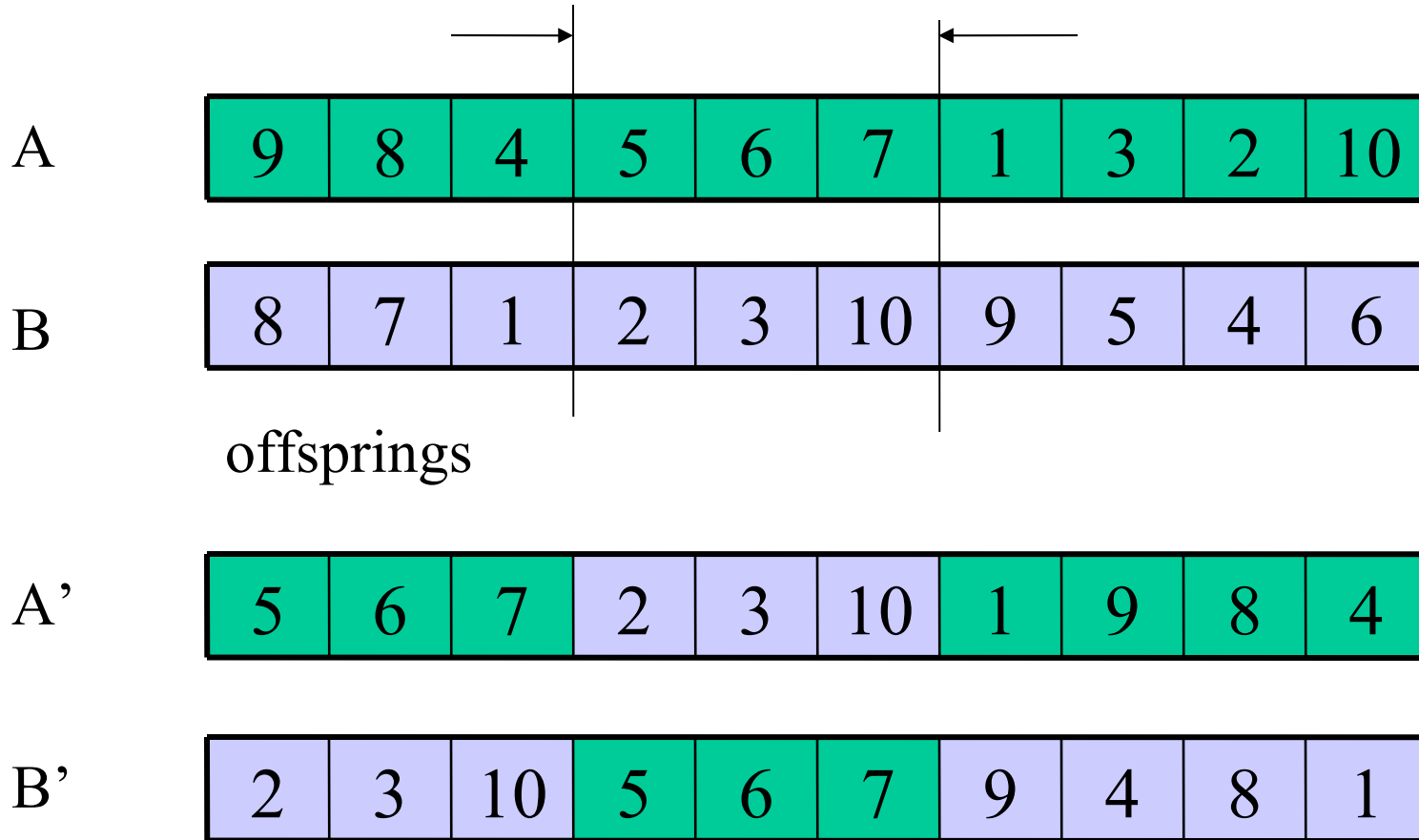
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

offsprings

A'

| 9 | | | | | | | | | |

B'

| 1 | | | | | | | | | |

CX - Cycle Crossover

A

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

B

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

offsprings

A'

| 9 | | | 1 | | 4 | | | 6 | |

B'

| 1 | | | 4 | | 6 | | | 9 | |
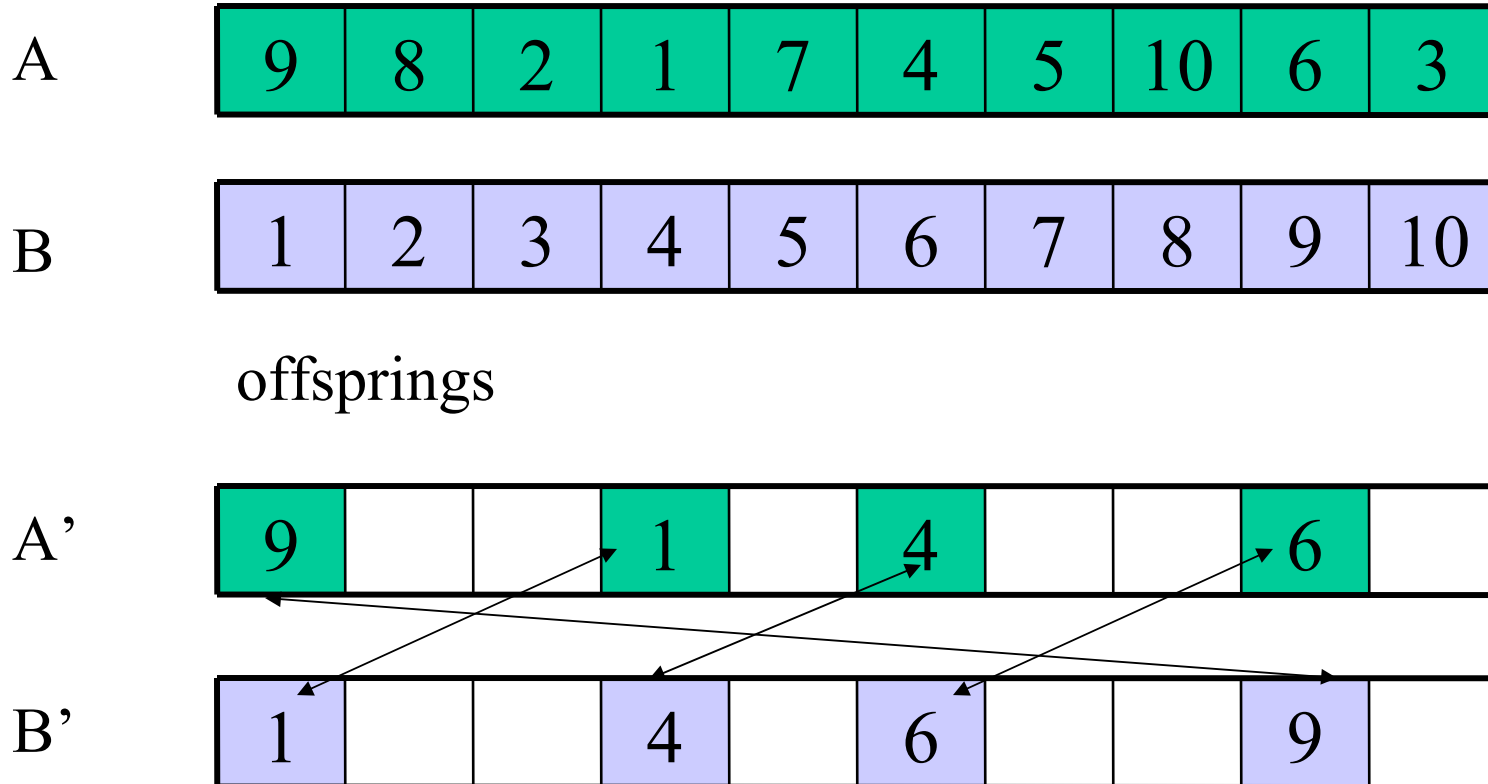
CX - Cycle Crossover

A	9	8	2	1	7	4	5	10	6	3

B	1	2	3	4	5	6	7	8	9	10

offsprings

A'	9	2	3	1	5	4	7	8	6	10

B'	1	8	2	4	7	6	5	10	9	3

Edge recombination operator

- Whitley D., Starkweather T, Fuquay D., Sheduling problems and traveling salesman: **the genetic edge recombination operator**. In: Proceedings of the third international conference on genetic algorithms (ICGA 89) Palo Alto, CA: Morgan Kaufmann; 1989. p. 133-40.

- Offsprings inherits the neighbourhood of the parents genes
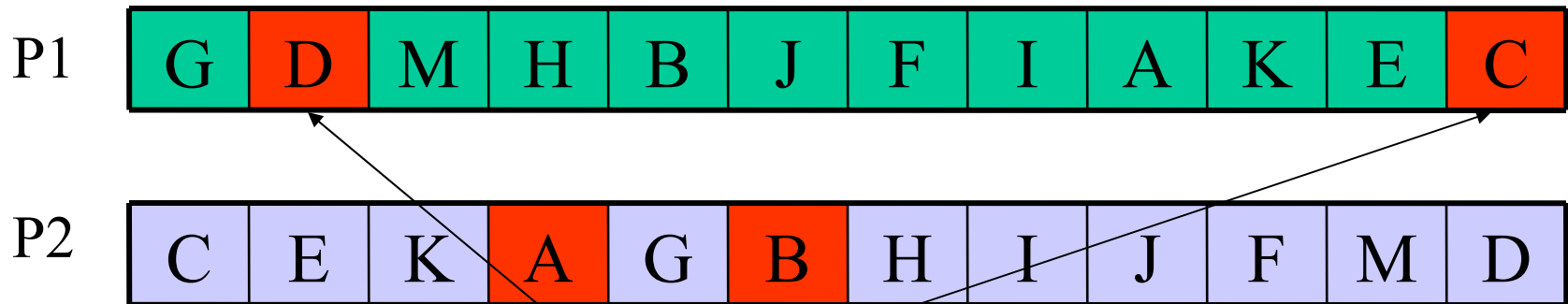
ERC – Edge Recombination Crossover

P1

G	D	M	H	B	J	F	I	A	K	E	C

P2

C	E	K	A	G	B	H	I	J	F	M	D
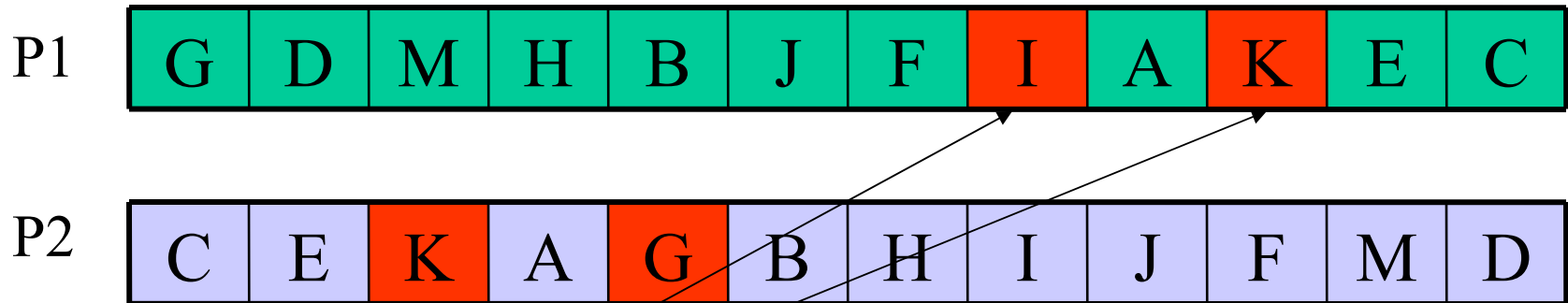
A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

List of edges

The edges, what are twice, are marked with -. Those will have priority in the next phases

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ERC – Edge Recombination Crossover

P1 | G | D | M | H | B | J | F | I | A | K | E | C |

P2 | C | E | K | A | G | B | H | I | J | F | M | D |

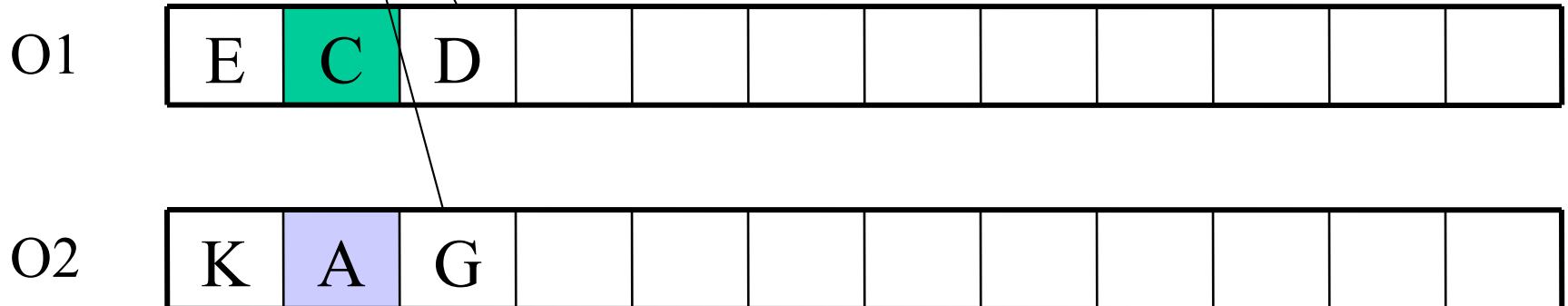| G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

List of edges

This approach is valid, when the matrix is simmetrical and the Salesman must go to the basis in the last step.

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ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1

E	C										

O2

K	A										

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1 | E | C | D | | | | | | | | | | | |

O2 | K | A | G | | | | | | | | | | | |

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1	E	C	D	M									

O2	K	A	G	B									

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1

E	C	D	M	F											

O2

K	A	G	B	H											

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H
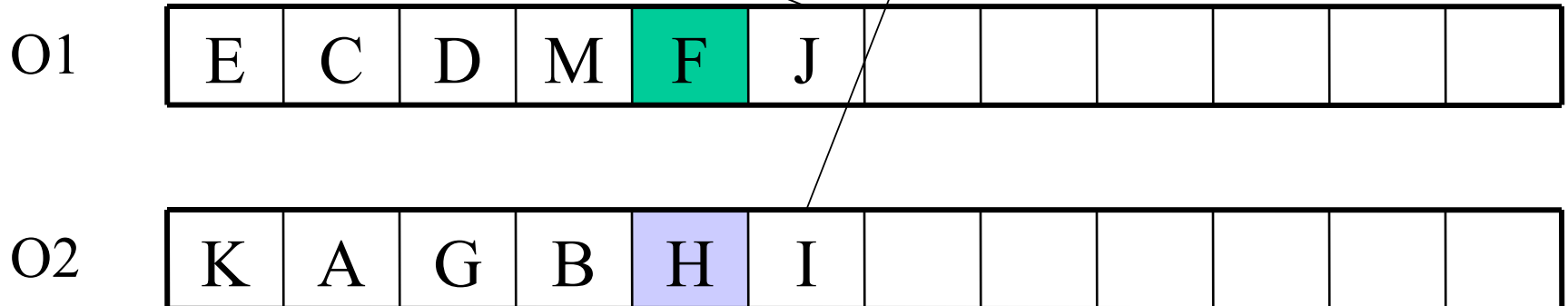
O1: E | C | D | M | F | J

O2: K | A | G | B | H | I

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1 | E | C | D | M | F | J | B | | | | | | | |

O2 | K | A | G | B | H | I | F | | | | | | | |
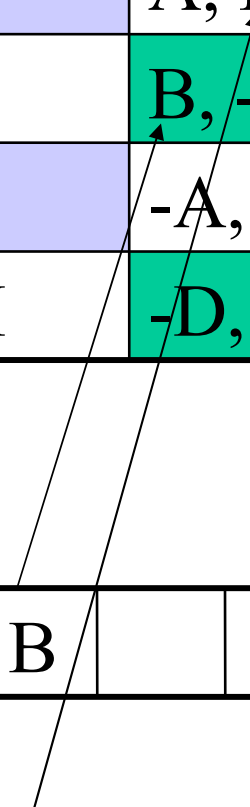
ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1 | E | C | D | M | F | J | B | H | | | | |

O2 | K | A | G | B | H | I | F | J | | | | |

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

J don't have a not used neighbor. Not used smallest letter is C.

O1 | E | C | D | M | F | J | B | H | I | | | |

O2 | K | A | G | B | H | I | F | J | C | | | |

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1 | E | C | D | M | F | J | B | H | I | A | | |

O2 | K | A | G | B | H | I | F | J | C | E | | |

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

E don't have a not used neighbor. Not used smallest letter is D.

O1

E	C	D	M	F	J	B	H	I	A	K	

O2

K	A	G	B	H	I	F	J	C	E	D	

ERC – Edge Recombination Crossover

A	G, I, -K
B	G, -H, J
C	D, -E, G
D	C, G, -M
E	-C, -K
F	I, -J, M

G	A, B, C, D
H	-B, I, M
I	A, F, H, J
J	B, -F, I
K	-A, -E
M	-D, F, H

O1 | E | C | D | M | F | J | B | H | I | A | K | G |

O2 | K | A | G | B | H | I | F | J | C | E | D | M |