Extensibility of TSN

MILP Formulation

- Indices, constant parameters, and variables

  i : index of a flow

  j : index of a path

  k : index of a link

  B_{ijk} : [0,1] link k is in path j of flow i

  U_i : utilization of flow i

  x_{ij} : [0,1] flow i's path j is used

  y_k : remaining capacity of link j

- Constraints

  $\sum_j x_{ij} = 1$ for all i

  $1 - \sum_i \sum_j x_{ij} B_{ijk} U_i = y_k$ for all k

  $y_k \geq 0$ for all k

  $y_k \geq z$ for all k

- Objective

  z : minimum of remaining capacity

Input & Output Format

Input

The first line is N (number of flows)

The second line is M (number of links)

Each of the following N lines is U_i (utilization of each flow)

Each of the following N lines is P_i (number of paths of each flow)

Each of the follwing P_i * M matrix contains B_{ijk} (link k is in path j of flow i)

Output

Each of the $4N$ lines is the direction of the path used by each flow (0: clockwise; 1: counterclockwise; -1: no path). The first $2N$ lines are the solutions of MILP, and the following $2N$ lines are the solutions of All Shortest Path.

Test Results Before Modification
(Stop adding flows when one addition fails)

Non-uniform

- N=100, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	967	96.7%
MILP < All Shortest Path	16	1.6%
MILP = All Shortest Path	17	1.7%

- N=1000, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	1000	100%
MILP < All Shortest Path	0	0%
MILP = All Shortest Path	0	0%

Uniform

- N=100, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	662	66.2%
MILP < All Shortest Path	185	18.5%
MILP = All Shortest Path	153	15.3%

- N=1000, M=19

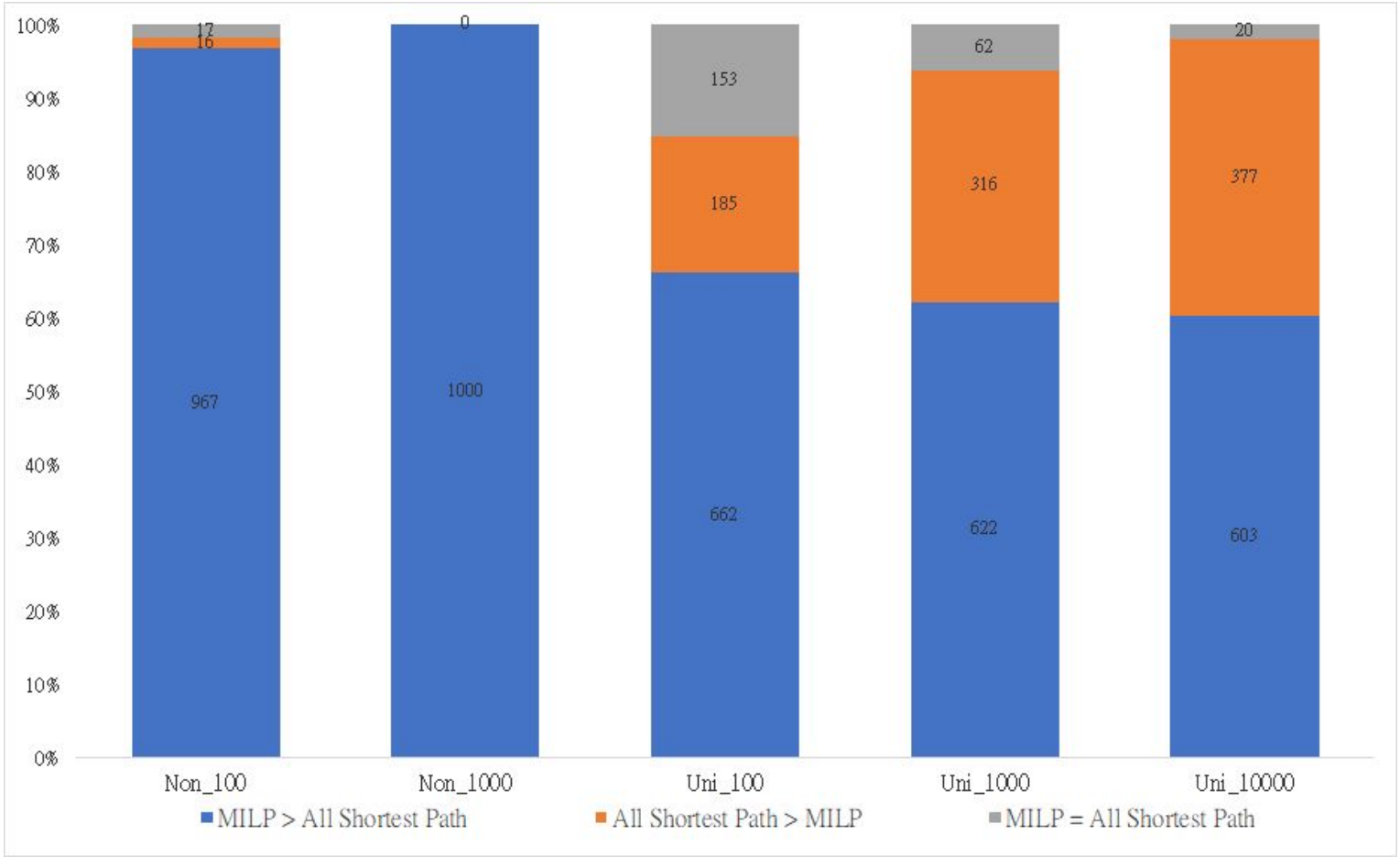
Result	Number of cases	Percentage
MILP > All Shortest Path	622	62.2%
MILP < All Shortest Path	316	31.6%
MILP = All Shortest Path	62	0.62%

Uniform (continued)

- N=10000, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	603	60.3%
MILP < All Shortest Path	377	37.7%
MILP = All Shortest Path	20	2%

Bar Chart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Uni_1000
Uni_10000
MILP > All Shortest Path
All Shortest Path > MILP
MILP = All Shortest Path

Test Results After Modification
(Continue adding flows even after one addition fails)

Non-uniform

- N=100, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	937	93.7%
MILP < All Shortest Path	42	4.2%
MILP = All Shortest Path	21	2.1%

- N=1000, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	933	93.3%
MILP < All Shortest Path	44	4.4%
MILP = All Shortest Path	23	2.3%

Uniform

- N=30, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	923	92.3%
MILP < All Shortest Path	54	5.4%
MILP = All Shortest Path	23	2.3%

- N=100, M=19

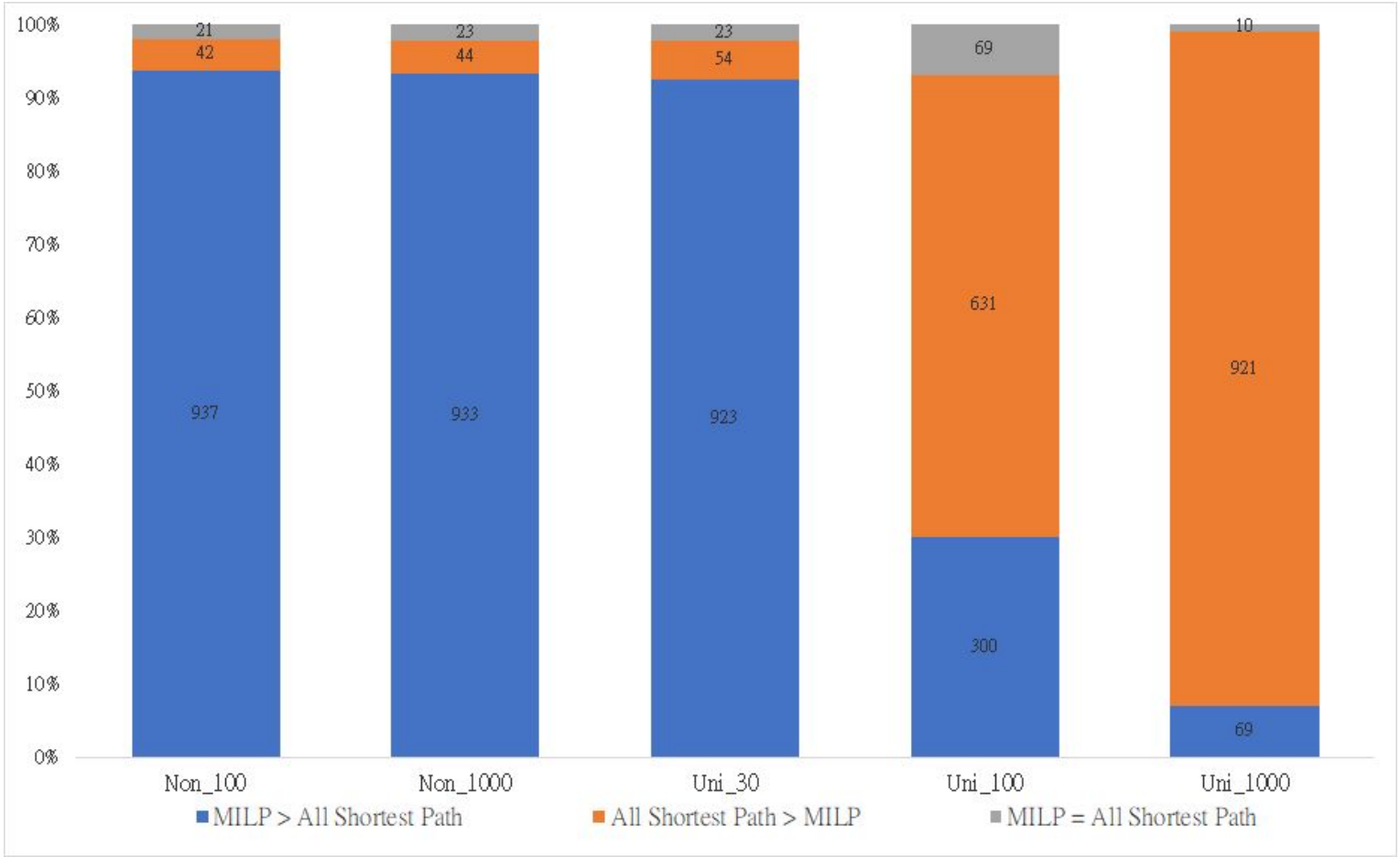
Result	Number of cases	Percentage
MILP > All Shortest Path	300	30%
MILP < All Shortest Path	631	63.1%
MILP = All Shortest Path	69	6.9%

Uniform (continued)

- N=1000, M=19

Result	Number of cases	Percentage
MILP > All Shortest Path	69	6.9%
MILP < All Shortest Path	921	92.1%
MILP = All Shortest Path	10	1%

Bar Chart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Uni_100
Uni_1000
MILP > All Shortest Path
All Shortest Path > MILP
MILP = All Shortest Path