Online Supplement of the Paper "Heterogeneous Risk Management Using a Multi-agent Framework for Supply Chain Disruption Response"

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# 1 Algorithms

**Algorithm 1** Random coloring algorithm (Yu et al., 2022)

Network $G = (N, E)$, color coding $\phi$, iteration budget maxIter, number of solutions to early stop nSol, evaluated solution set $S$, dual optimal solution $\pi$.
Initialization $T = \emptyset$ as candidate solution set, $k = 0$
**while** $k <$ maxIter or $|T| <$ nSol **do**
  Generate a random coloring function $\phi_k : N \to \{1, \ldots, Q\}$
  Initialize $\Lambda_{\text{depot}} \leftarrow \{0 \ldots, 0\}$
  **for** $i \in N$ **do**
    $\Lambda_i \leftarrow \emptyset$
  **end for**
  $B = \{\text{depot}\}$
  **while** $B \neq \emptyset$ **do**
    Sample $i \in B$
    **if** $i =$ depot **then**
      Add corresponding routes from $\Lambda_{\text{depot}}$ with negative cost to $T$
    **else**
      **for** $j : (i, j) \in E$ **do**
        **for** $\lambda_i = (R_i, C_i) \in \Lambda_i$, with $R_i = (n_i, N_i^1, \ldots, N_i^Q)$ **do**
          **if** $N_i^{\phi(j)} = 0$ **then**
            Extend $\lambda_i$ to obtain $\lambda_j$
            **if** $\lambda_j \notin S$ **then**
              **if** $\lambda_j$ is not dominated by any path in $\Lambda_j$ **then**
                Add $\lambda_j$ to $\Lambda_j$ and $B = B \cup \{j\}$
                Remove any path in $\Lambda_j$ that is dominated by $\lambda_j$
              **end if**
            **end if**
          **end if**
        **end for**
      **end for**
    **end if**
    Remove $i$ from $B$
  **end while**
  Add routes with negative cost to $T$
  $k = k + 1$
**end while**
Return $T$

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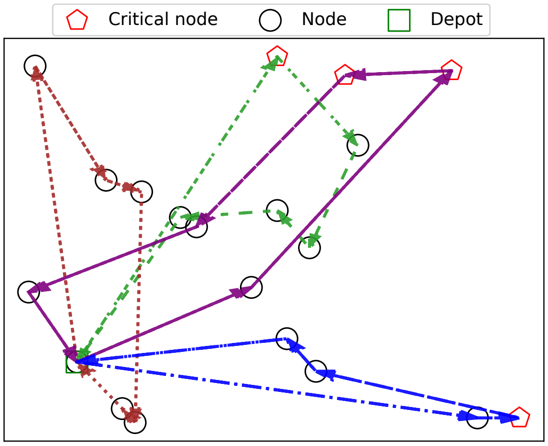
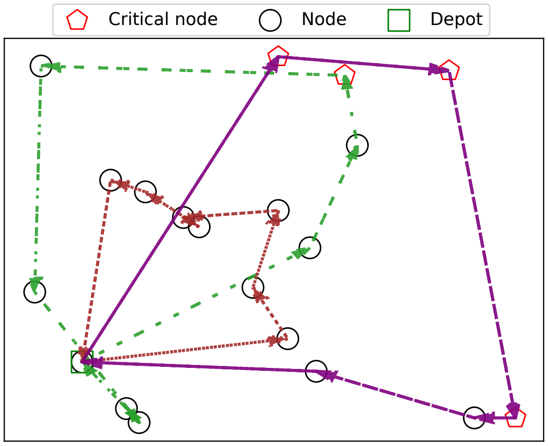
## 2 Additional computational results

Table 1: Computational time and optimality gap of methods on described instances

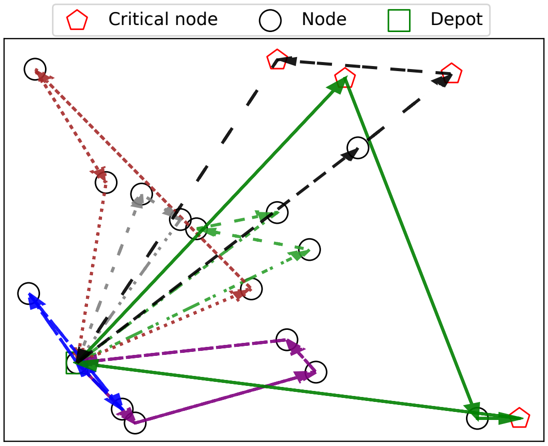
| Instance | $\frac{\lvert K\rvert}{\lvert N\rvert}$ | $\frac{Q\lvert K\rvert}{\lvert N\rvert}$ | Gurobi | | Greedy | | Scenario decomposition | |
|---|---|---|---|---|---|---|---|---|
| | | | Time (s) | Gap (%) | Time (s) | Gap (%) | Time (s) | Gap (%) |
| G-10-30 | 0.15 | 1.0 | 8.2 | - | 0.5 | 37.5 | 16.1 | 0.10 |
| | 0.15 | 1.5 | 9.3 | - | 1.0 | 27.8 | 19.3 | 0.12 |
| | 0.25 | 1.0 | 9.9 | - | 2.2 | 43.6 | 15.9 | 0.15 |
| | 0.25 | 1.5 | 10.9 | - | 2.7 | 49.3 | 19.5 | 0.14 |
| | 0.35 | 1.0 | 12.2 | - | 4.6 | 51.2 | 16.5 | 0.09 |
| | 0.35 | 1.5 | 11.8 | - | 5.1 | 49.7 | 20.3 | 0.12 |
| G-20-75 | 0.15 | 1.0 | 520.3 | - | 1.4 | 51.0 | 153.5 | 0.06 |
| | 0.15 | 1.5 | 600.4 | - | 1.6 | 48.9 | 291.3 | 0.17 |
| | 0.25 | 1.0 | 650.2 | - | 1.8 | 35.7 | 164.3 | 0.23 |
| | 0.25 | 1.5 | 710.5 | - | 2.3 | 39.9 | 313.6 | 0.19 |
| | 0.35 | 1.0 | 720.9 | - | 2.1 | 37.8 | 174.8 | 0.08 |
| | 0.35 | 1.5 | 740.7 | - | 2.5 | 44.8 | 319.1 | 0.13 |
| IEEE-33-136 | 0.15 | 1.0 | 1200.0 | - | 15.5 | 23.9 | 395.8 | 0.19 |
| | 0.15 | 1.5 | 1240.2 | - | 17.9 | 33.6 | 450.2 | 0.04 |
| | 0.25 | 1.0 | 1313.8 | - | 20.2 | 23.0 | 402.1 | 0.06 |
| | 0.25 | 1.5 | 1277.9 | - | 23.4 | 33.5 | 449.1 | 0.18 |
| | 0.35 | 1.0 | 1335.0 | - | 26.4 | 40.3 | 401.9 | 0.12 |
| | 0.35 | 1.5 | 1360.9 | - | 28.4 | 38.6 | 455.3 | 0.21 |
| IEEE-123-556 | 0.15 | 1.0 | 6013.9 | - | 353.7 | 110.5 | 1212.4 | 2.50 |
| | 0.15 | 1.5 | 7031.5 | - | 360.3 | 95.2 | 1406.2 | 1.75 |
| | 0.25 | 1.0 | 6309.1 | - | 340.2 | 220.3 | 1220.3 | 2.10 |
| | 0.25 | 1.5 | 7207.5 | - | 390.5 | 170.5 | 1404.1 | 1.90 |
| | 0.35 | 1.0 | 7453.2 | - | 440.2 | 210.5 | 1230.0 | 3.02 |
| | 0.35 | 1.5 | 8204.6 | - | 494.7 | 190.2 | 1430.5 | 2.50 |



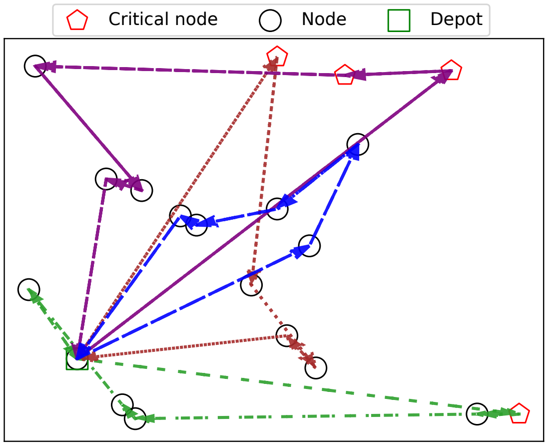

(a) $|K| = 4, Q = 5$




(b) $|K| = 4, Q = 7$




(c) $|K| = 7, Q = 3$




(d) $|K| = 7, Q = 5$

Figure 1: Optimal routes for 20% of critical nodes

# References

Yu, M., Nagarajan, V., and Shen, S. (2022). Improving column generation for vehicle routing problems via random coloring and parallelization. *INFORMS Journal on Computing*, 34(2):953–973.