

(a)

**Algorithm 1:** Minimum-update successive shortest path**Input:** Graph  $G(V, E, C)$ **Output:** Min-cost flow  $f$  $G \leftarrow \text{ClipDummyEdge}(G)$  $f \leftarrow 0$  $G_r^{(0)} \leftarrow G$  $T_{\mathcal{SP}}^{(0)}, \pi^{(0)}, d^{(0)} \leftarrow \text{DAG-SP}(G_r^{(0)})$  $k = 0, U^{(0)} = \emptyset$ **while**  $\sum_{i=0}^k \text{Cost}(\pi^{(k)}, G_r^{(k)}) < 0$  **do**     $f \leftarrow \text{AugmentFlow}(f, \pi^{(k)}, G_r^{(k)})$ 

// get node set that needs update

 $U^{(k+1)} \leftarrow \text{IdentifyNode4Update}(\pi^{(k)}, T_{\mathcal{SP}}^{(k)})$      $U^{(k+1)} \leftarrow U^{(k+1)} \cup U^{(k)}$      $\Pi = \text{FindMultiPath}(T_{\mathcal{SP}}^{(k)}, U^{(k+1)})$     **if**  $\neg \text{empty}(\Pi)$  **then**

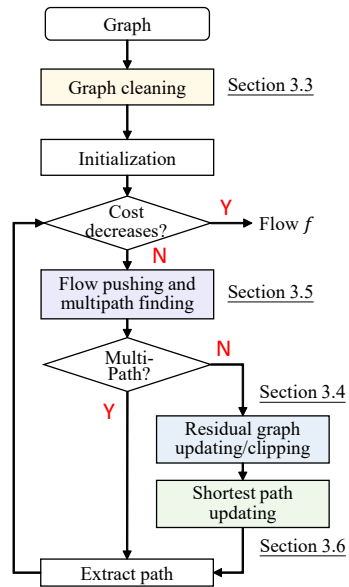
// no update needed

 $T_{\mathcal{SP}}^{(k+1)} \leftarrow T_{\mathcal{SP}}^{(k)}$          $G_r^{(k+1)} \leftarrow G_r^{(k)}$          $d^{(k+1)} \leftarrow d^{(k)}$          $k \leftarrow k + 1$     **else**         $G_r^{(k)} \leftarrow \text{ConvertEdgeCost}(G_r^{(k)}, d^{(k)})$          $G_r^{(k+1)} \leftarrow \text{ResidualGraph}(G_r^{(k)}, \pi^{(k)}, \Pi)$          $k \leftarrow k + 1$          $G_r^{(k)} \leftarrow \text{ClipPermanentEdge}(G_r^{(k)})$ 

// update shortest path tree

 $T_{\mathcal{SP}}^{(k)}, d^{(k)} \leftarrow \text{DijkstraWithBatchProc}(G_r^{(k)}, U^{(k)}, T_{\mathcal{SP}}^{(k-1)})$          $U^{(k)} \leftarrow \emptyset$     **end**     $\pi^{(k)} \leftarrow \text{ExtractPath}(T_{\mathcal{SP}}^{(k)}, \Pi)$ **end**

(b)



(c)

