Traveling Repairman Problem (TRP)

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Outlines

- Background
- Problem Statement
- Algorithms
- Future Work

Background-1

- **Repair steps**

After disaster occurs, some components are out of work, then some repairmen should be assigned to repair them. Because of limitation of equipment, materials, human resources and so on, the repair process is not a one-step process, it needs several steps.

- **Traveling way**

The way to failure position is depending on the condition of road. Taking Wenchuan earthquake for instance, the ways of the repairmen to the failure location are foot, car or helicopter.

Backgound-2

- **Damage of disaster in recovery process.**

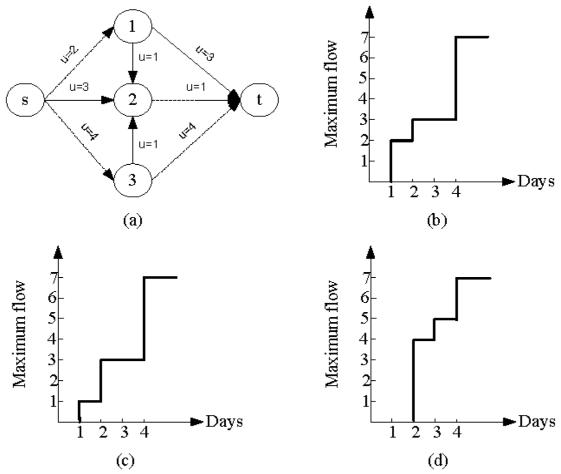

Fig. 1. An example of network disruption and recovery

The damage here is the number of failed lightpaths multiply their lasting time.

- **Drawbacks**

Ignore the traveling time of repairman.

Hence, we need to figure out a repair path for the repairman, considering both the repair time and traveling time.

Our objective is minimizing the total damage of the whole recovery process.

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Pre-conditions

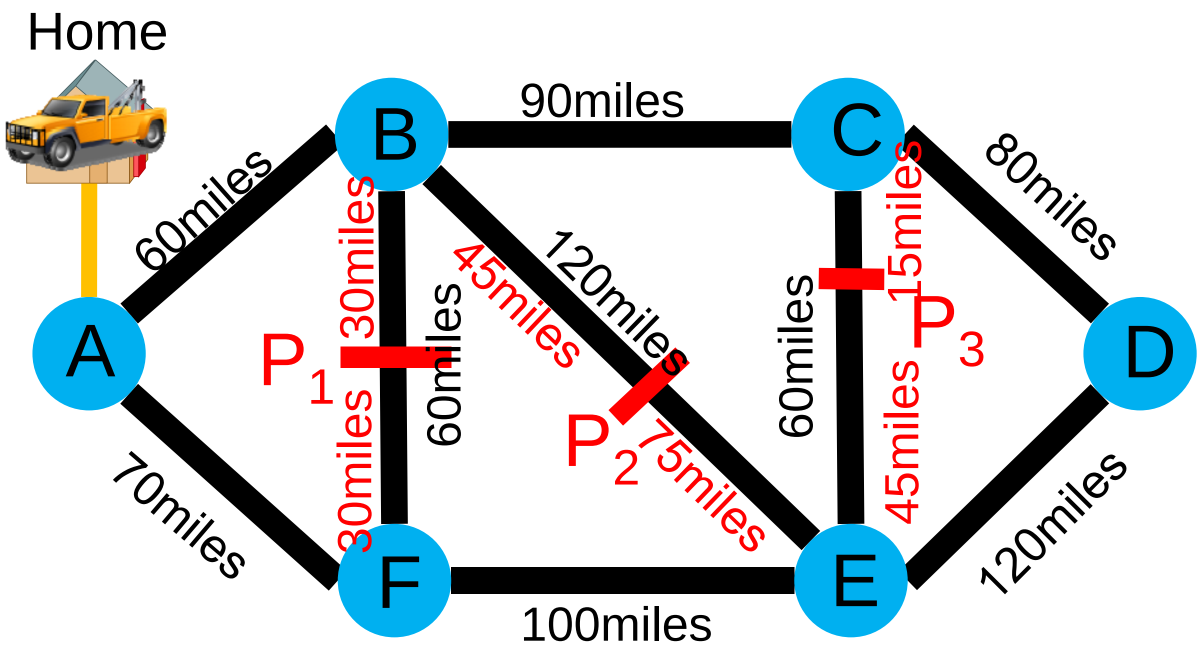
- Only one repairman in the problem, and he repairs one failure in each step.
- The location of failure:

  (1) Repairman knows the exactly position of failure in the networks.

  (2) Repairman does not know the exactly position of failure in the networks. (Maybe my work in the future)
- The repairman is traveling by car, and his speed is constant.
- The road network is the same with the communication network.
- The repairman needs a fixed time to repair each failure.

Process of Traveling Repairman Problem

Without Considering the Requests



- T_{T1}: 1.5 hours (from *A* to P_1)
- T_{R1}: 2 hours (repair P_1)
- T_{T2}: 1.25 hours (from P_1 to P_2)
- T_{R2}: 2 hours (repair P_2)
- T_{T3}: 2 hours (from P_2 to P_3)
- T_{R3}: 2 hours (repair P_3)
- **Total time:** $T=T_{T1}+T_{R1}+T_{T1}+T_{R1}+T_{T1}+T_{R1}=$ 10.75 hours

- **Output:** The path of repairman from the beginning node *A* and traveling all the failures.

TRP with Virtual Network Requests

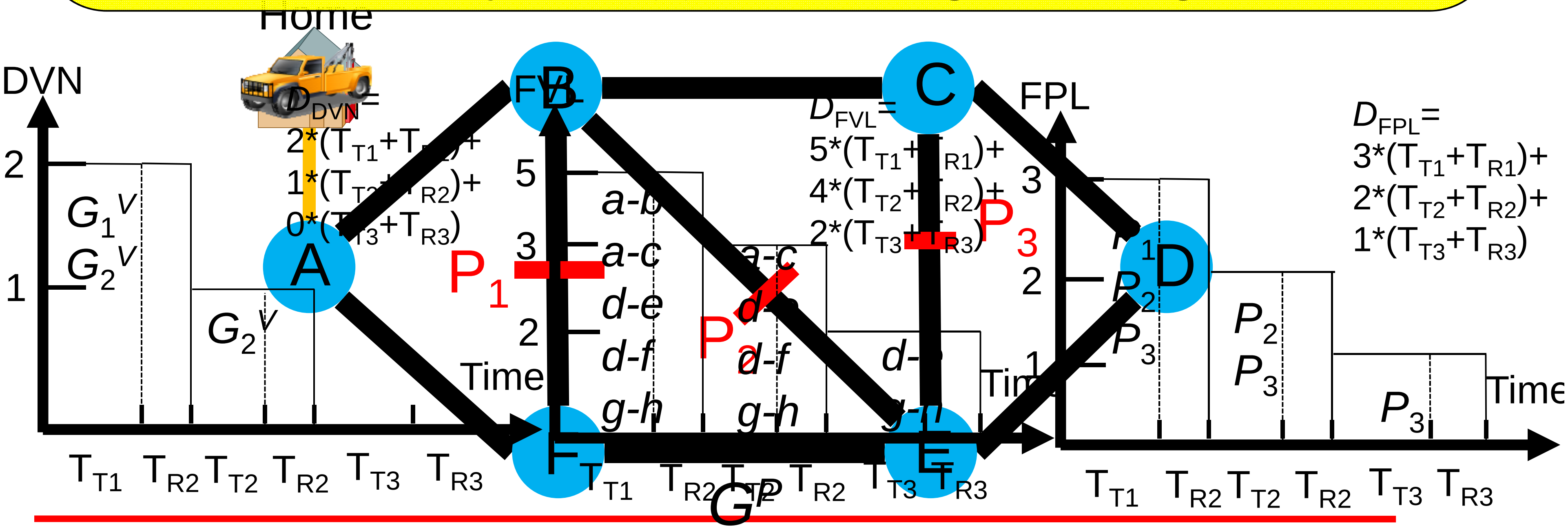
Output: The path of repairman from the beginning node *A* and traveling all the failures.

Objectives:

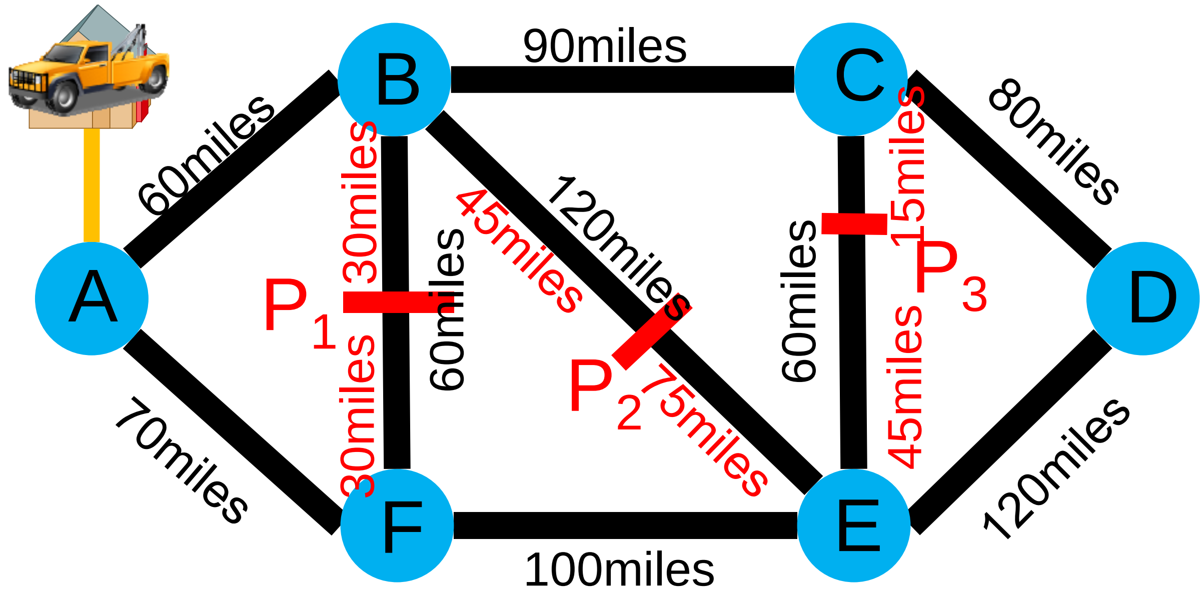
(1) Minimizing the damage of DVN;

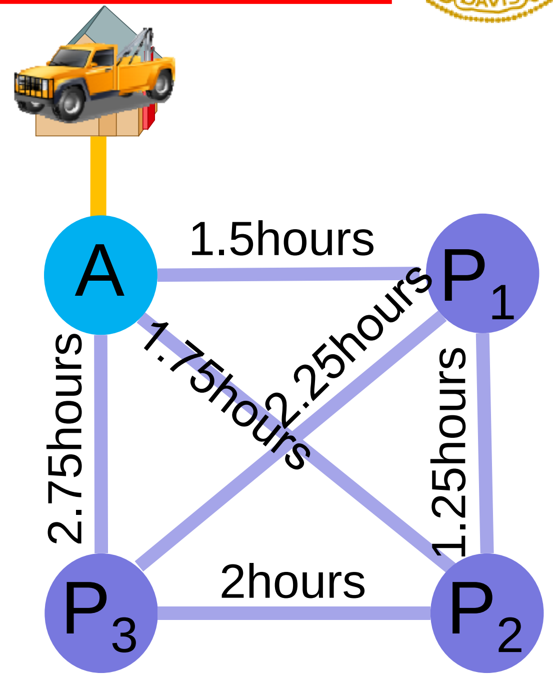
(2) Based on the objective (1), minimizing the damage of FVL;

(3) Based on the objective (2), minimizing the damage of FPL.



Auxiliary Graph of TRP





Output:
Find a path on auxiliary graph from n_B (the beginning node) and traveling all the auxiliary nodes.
Objectives:
Minimizing the damage.

Problem Statements

Given:

- $G^A(V^A,E^A)$: Auxiliary Graph, the weight of two nodes is the traveling time $t_{\mathrm{p1,p2}}$.
- n_B: The beginning node of repairman in G^A.
- M^{VA}: Mapping relationship of G^V and G^A.

Variables:

- k: 1..K, where K is the number of failure.
- n_k: the repaired node in step k, and $n_0=n_B$.
- N_k^{DVN}: the number of DVN after repaired at step k.
- N_k^{FVL}: the number of FVL after repaired at step k.
- N_k^{FPL}: the number of FPL after repaired at step k.

Damage of TRP

Take DVN for instance:

- In each step k={1..K}:

$$d_k^{DVN}=N_{k\text{-}1}^{\mathrm{DVN}}*(T_{\mathrm{n\_k,n\_k\text{-}1}}+T_R)$$

- Total damage

$$D^{DVN}=\sum_{(k=1..K)} d_k^{DVN}$$

Two factors of damage in each step *k*:

$N_{k\text{-}1}^{DVN}$: which is decided by node $n_{k\text{-}1}$, i.e., step k-1.

$T_{n\_k,n\_k\text{-}1}$: which is decided by both node n_k and $n_{k\text{-}1}$.

The relation of two factors?

Different with Traveling Salesman Problem:

(1) The objective is different.

(2) $N_{k\text{-}1}^{DVN}$ of each link is dynamically changed by the restored sequence of repairman.

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ILP Model (Finished)

- **Objective**

$$D=\alpha * D^{DVN}+\beta * D^{FVL}+\gamma * D^{FPL}$$

Here, $\alpha>\beta>\gamma$.

- **Constraints**

(1) Find the path from the beginning nodes and traveling all auxiliary nodes;

(2) Figure out the D^{DVN}

(3) Figure out the D^{FVL}

(4) Figure out the D^{FPL}

Heuristic Algorithms (Working Now)

- Heuristic Algorithm for Traveling Salesman Problem

(1) Tour construction procedures

(2) Tour improvement procedures

(3) Other composite algorithms

However, they are not fit for the Traveling Repairman Problem, because there are two factors of cost in each step of TRP. And the two factors are related.

Hence, we should find out the heuristic algorithm for the Traveling Repairman Problem.

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Future Work

1. Make clear the relationship of the two factors in Traveling Repairman Problem.
2. Investigate new heuristic algorithms for TRP.
3. Do the simulation of new heuristic algorithms.