Empty-Backhaul Management

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Truck Transportation

- The most popular mean of freight transportation
  - Door-to-door delivery

- Empty-backhaul problem (empty load on the way back)
  - 46% of all trips in Thailand
  - Wasting unnecessary energy
  - Making air pollution
Empty-Backhaul Problem

- **Cause:** lacks of planning and collaboration
  - Not enough service requests to match trucks
- **Solution:** Thai truck alliance project
  - **Purpose:** Share service requests and trucks among members
  - **Collaborations:**
    - 120 trucks from 10 companies (12,480 trips per year)
      - Empty-backhaul (5741 trips per year / 2.3 M km. per year / 0.66 M Liter per year)
    - 2 truck cooperative
    - Suranaree University of Technology : IT / Comp Eng. / Transportation Eng.
Empty-Backhaul Management Model

Before matching (requests & empty trucks)

1. **Shipper A**
   - Service Request
   - Linehaul Truck
   - Carrier 1
     - Empty-Backhaul Truck

2. **Shipper B**
   - Service Request
   - Backhaul Truck
   - Carrier 2
     - Empty-Linehaul Truck

3. **Shipper C**
   - Service Request
   - Carrier 3

4. **Shipper D**
   - Service Request

Matching Empty Trucks with Service Requests

Empty Trucks

Service Requests

Cooperative
Empty-Backhaul Management Model

After matching (requests & empty trucks)
Truck & Request Matching Algorithm

- Date
- Type
- Volume
- Source & Destination
  - Exact match
  - Similarity match
    - Don't create more empty trucks
    - Select the most cost-effective route
Don't create more empty truck

- Original route = 900 km.
- New route = 130 + 120 = 250 km.
New route < Original route [Accepted]

- Original route = 900 km.
- New route = 600 + 500 = 1100 km.
New route > Original route [Rejected]
Select the most cost-effective route

- Cost effective value
  - Distance with requests / (1+distance w/o requests)
  - More value, more priority
Matching Possibility

2 requests / 1 truck
- Set 1 → \( P = \emptyset \).
- Set 2 → \( P = \{(R1,T1)\} \).
- Set 3 → \( P = \{(R2,T1)\} \).
- Set 4 → \( P = \{(R1, T1) (R2, T1)\} \).
  - \{(R1, T1) (R2, T1)\}
  - \{(R2, T1) (R1, T1)\}

2 requests / 2 trucks
- Set 1 → \( P = \emptyset \).
- Set 2 → \( P = \{(R1,T1)\} \).
- Set 3 → \( P = \{(R1,T2)\} \).
- Set 4 → \( P = \{(R2,T1)\} \).
- Set 5 → \( P = \{(R2, T2)\} \).
- Set 6 → \( P = \{(R1, T1)(R2, T1)\} \).
  - \{(R1, T1)(R2, T1)\}
  - \{(R2, T1)(T1, T1)\}
- Set 7 → \( P = \{(R1, T1)(R2, T2)\} \).
- Set 8 → \( P = \{(R1, T2)(R2, T1)\} \).
- Set 9 → \( P = \{(R1, T2)(R2, T2)\} \).
  - \{(R1, T2)(R2, T2)\}
  - \{(R2, T2)(T1, T2)\}
Matching Possibility

- Requests = 2: $1T^0 + 2T^1 + 1T^2$
- Requests = 3: $1T^0 + 3T^1 + 3T^2 + 1T^3$
- Requests = 4: $1T^0 + 4T^1 + 6T^2 + 4T^3 + 1T^4$
- ...

- Very expensive calculation!! = $O(T^R)$
  - Plus permutation for multiple requests in a truck
Implementation

- Empty Trucks
- Service Requests
  - Storing/Requesting Empty Truck Description
  - Storing/Requesting Service Request Description
  - Matching Empty Trucks with Service Requests
    - Matching Empty Trucks with Service Requests
      - Matching Empty Trucks with Service Requests
        - Merging and Sorting Routes
          - Ranked Routes
            - Selecting & Explaining a Designate Route

Shipper

Carrier
Experimental Environments

- **Hardware**
  - CPU Intel Core-i5 3.1 GHz, 4GB of RAM

- **Software**
  - PHP + MySQL, C + MPI (OpenMPI)

- **Data**
  - 6 months : 648 trucks, 674 requests
Execution Time

![Graph showing execution time](graph.png)
% Reduction of Empty Trucks

![Graph showing % Reduction of Empty Trucks](image)
% Reduction of Service Requests

![Graph showing % Reduction of Service Requests with months January to June. The graph compares Exact Match and Similarity Match.]
% Reduction of Empty Backhaul Distance

% Reduction of Empty Backhaul Distance

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<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
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<td>Similarity Match</td>
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Conclusion & Future Work

- Empty-Backhaul Management
  - HPC meet Logistics

- Future Work
  - Partial Load
    - Trucks can carry more than one request at a time
  - More collaboration
    - Plan to collaborate with 80 truck companies
THANK YOU