MODEL OF DYNAMIC INTEGRATED INVENTORY AND DISTRIBUTION PROBLEM FOR GASOLINE SUPPLY CHAINS

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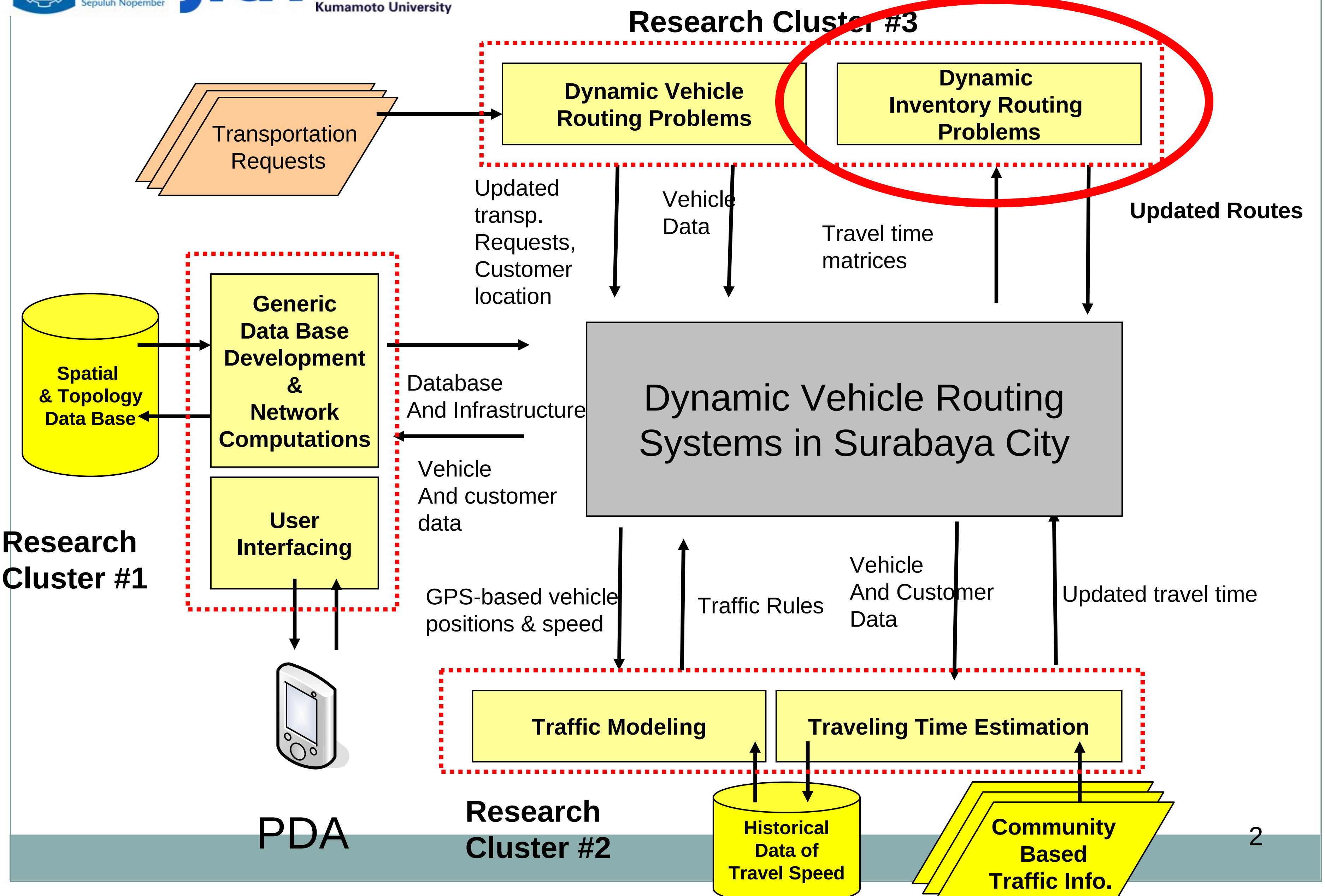
Collaboration Research



Background

Modern economy markets tend to become increasingly open and competitive

Companies now need to focus on timeliness to ensure not only their competitiveness, but also their survival.

Efficient, just-in-time, distribution systems where goods are delivered at the right place, in the right quantity and exactly when needed

Strategic Alliances

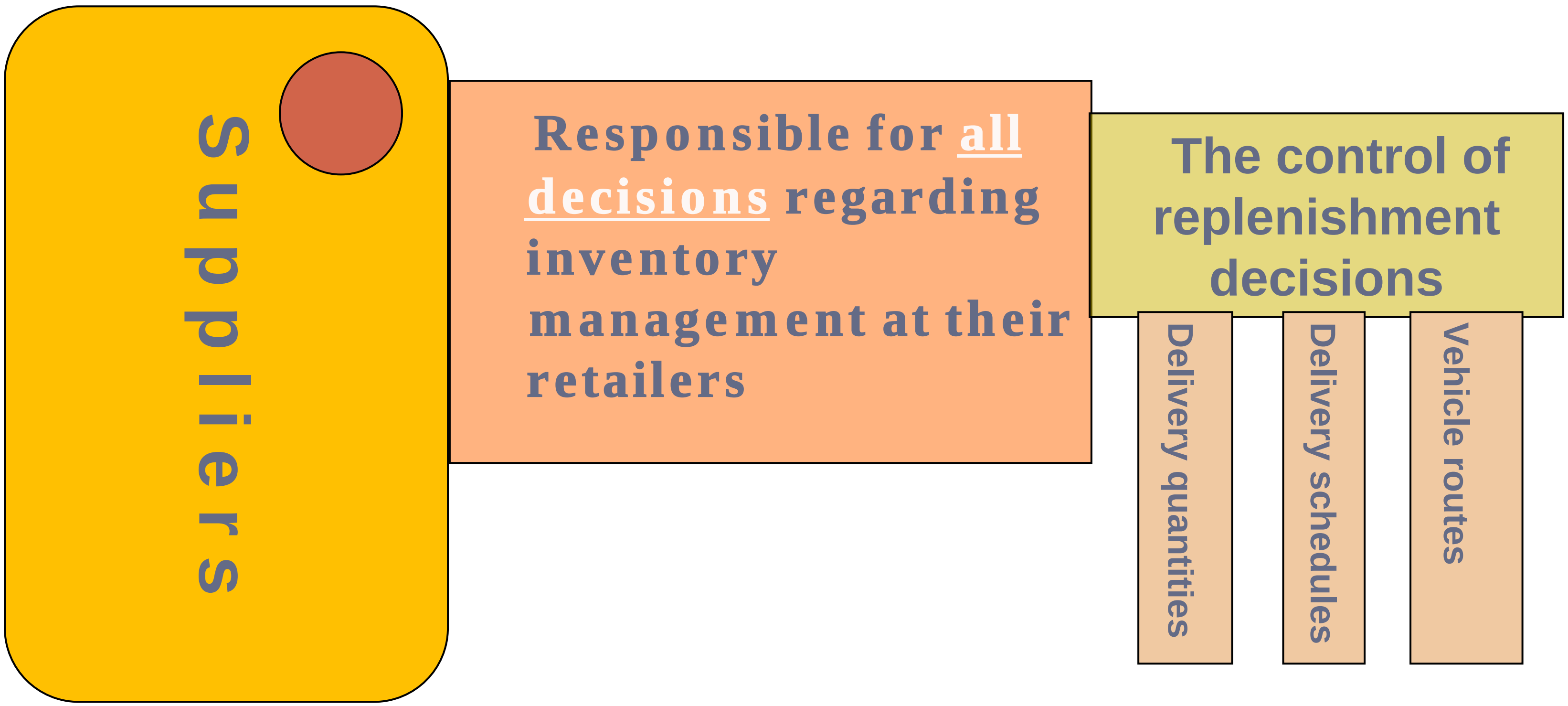
The objective of supply chains is to minimize system wide costs and increase efficiency while satisfying service level requirements

One of SC initiatives is to build *strategic alliances* within supply chain players.

Retailer-Suppliers Partnerships (RSP)

- Quick Response (QR)
- Continuous Replenishment (CR)
- Vendor Managed Inventory (VMI)

VMI : definition



VMI : the needs of integrated decisions

Under VMI system, the supplier can :

- decide which retailers should be replenished at which times, and with how much product.
- coordinate the deliveries to the retailers

→

An operational-level decision tool to assist the coordination of inventory management and distribution decision

↓

Integrated Inventory and Distribution Decisions

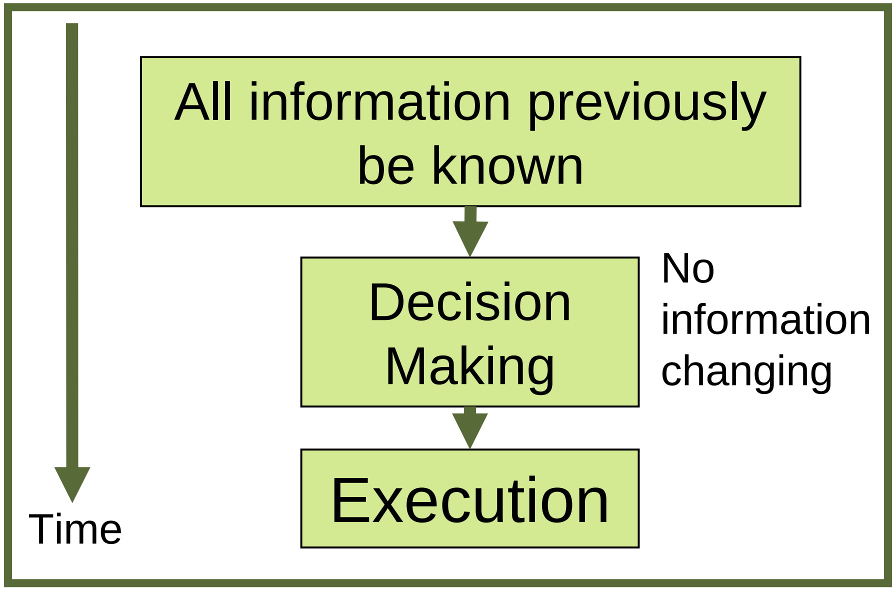
Gasoline Supply Chains

Existing Vs Proposed System

Existing	Proposed
• The retailer (“gasoline stations”) orders fuels from the supplier/depot (“Pertamina”) • The supplier collects orders from many stations and then solves the routing problem over the stations who ordered. • The current system may produce an “unfair” allocation of gasoline (a limited supply !) among the stations, since the supplier have no information about the inventory level of each station.	• The supplier takes both inventory decisions and routing decisions. • The supplier is responsible to decide when and how much of replenishment and ensure that there would be no stockouts. • The replenishment based on the realtime inventory level of stations.

Problem Background

Static IIDP

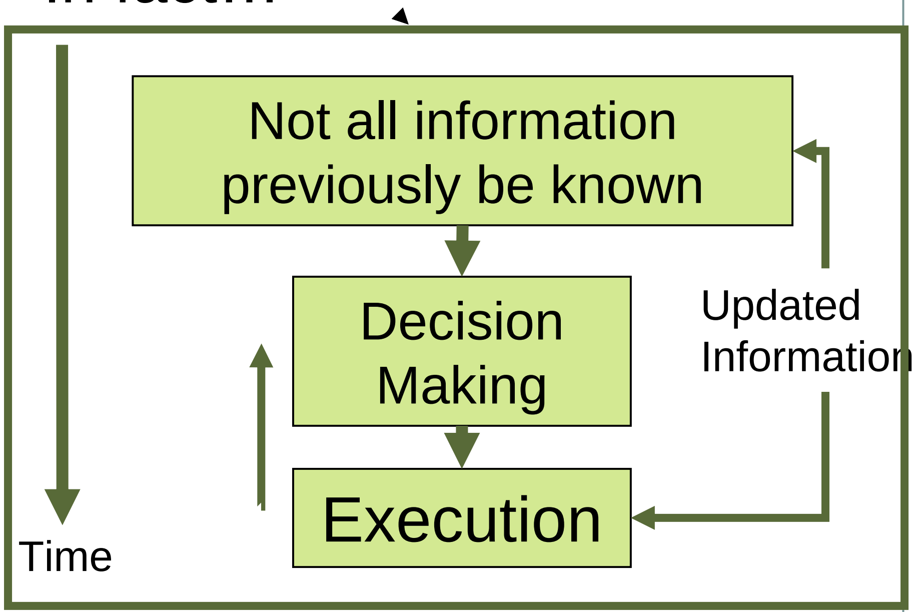


-Federgruen dan Zipkin (1984) → one period

-Abdelmaguid and Dessouky (2004, 2006) → multiperiod

-Campbell et.al (1998)

In fact…



- Not commonly discussed

Model Formulation for Static IIDP

Based on models of Abdelmaguid (2004) and Campbell (1998)

- Mathematical Model:

Min $$\sum_{v=1}^{V} f_t x_{ojv} + \sum_{i=0}^{N} \sum_{\substack{j=0 \\ j \neq i}}^{N} \sum_{v=1}^{V} c_{ij} x_{ijv}$$

Minimization of Transportation Costs (Fixed and Variable)

Subject to:

$$\sum_{\substack{j=0 \\ j \neq i}}^{N} x_{ijv} \leq 1$$ *i* = 0, ..., *N; v = 1, ...,V*(1)

$$\sum_{\substack{k=0 \\ k \neq i}}^{N} x_{ikv} - \sum_{\substack{l=0 \\ l \neq i}}^{N} x_{liv} = 0$$ *i* = 0, ..., *N*; *v* = 1, ...,*V*(2)

Route synchronization (1)–(2)

$$y_{ijv} - q_v x_{ijv} \leq 0$$ *i* = 0, ..., *N*; *j* = 0, ..., *N*; *i* ≠ *j*;*v* = 1, ...,*V*(3)

Vehicle Capacity

$$\sum_{\substack{k=0 \\ k \neq i}}^{N} y_{ikv} - \sum_{\substack{l=0 \\ l \neq i}}^{N} y_{liv} \leq 0$$ *i* = 1, ..., *N*; *v* = 1, ...,*V*(4)

Subtour elimination

$$L_i + \sum_{v=1}^{V} \left(\sum_{\substack{l=0 \\ l \neq i}}^{N} y_{liv} - \sum_{\substack{k=0 \\ k \neq i}}^{N} y_{ikv} \right) \leq D_i$$ *i* = 0, ..., *N; v* = 1, ...,*V*(5)

Lower bound constraint

$$D_i \leq \sum_{v=1}^{V} \left(\sum_{\substack{l=0 \\ l \neq i}}^{N} y_{liv} - \sum_{\substack{k=0 \\ k \neq i}}^{N} y_{ikv} \right) + U_i$$ *i* = 0, ..., *N; v* = 1, ...,*V*(6)

Upper bound constraint

$$y_{ijv} \geq 0$$ *i* = 0, ..., *N; j* = 0, ..., *N; i* ≠ *j;v* = 1, ...,*V*(7)

$$x_{ijv} = 0$$ *i* = 0, ..., *N; j* = 0, ..., *N; i* ≠ *j; v* = 1, ...,*V*(8)

Non negativity constraint (7)–(8)

Binary variable

Heuristic : Static IIDP

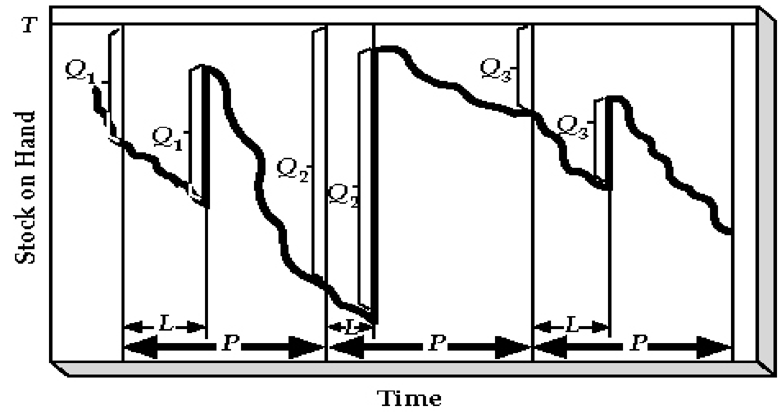
Start

1. Determine retailer that have to be delivered
Chose retailer that has Ii ≤ Mi , sorted by *Di*
H = Set of retailer to be delivered

1. For i ∀ H, determine delivery quantities
Di = Ui - Ii

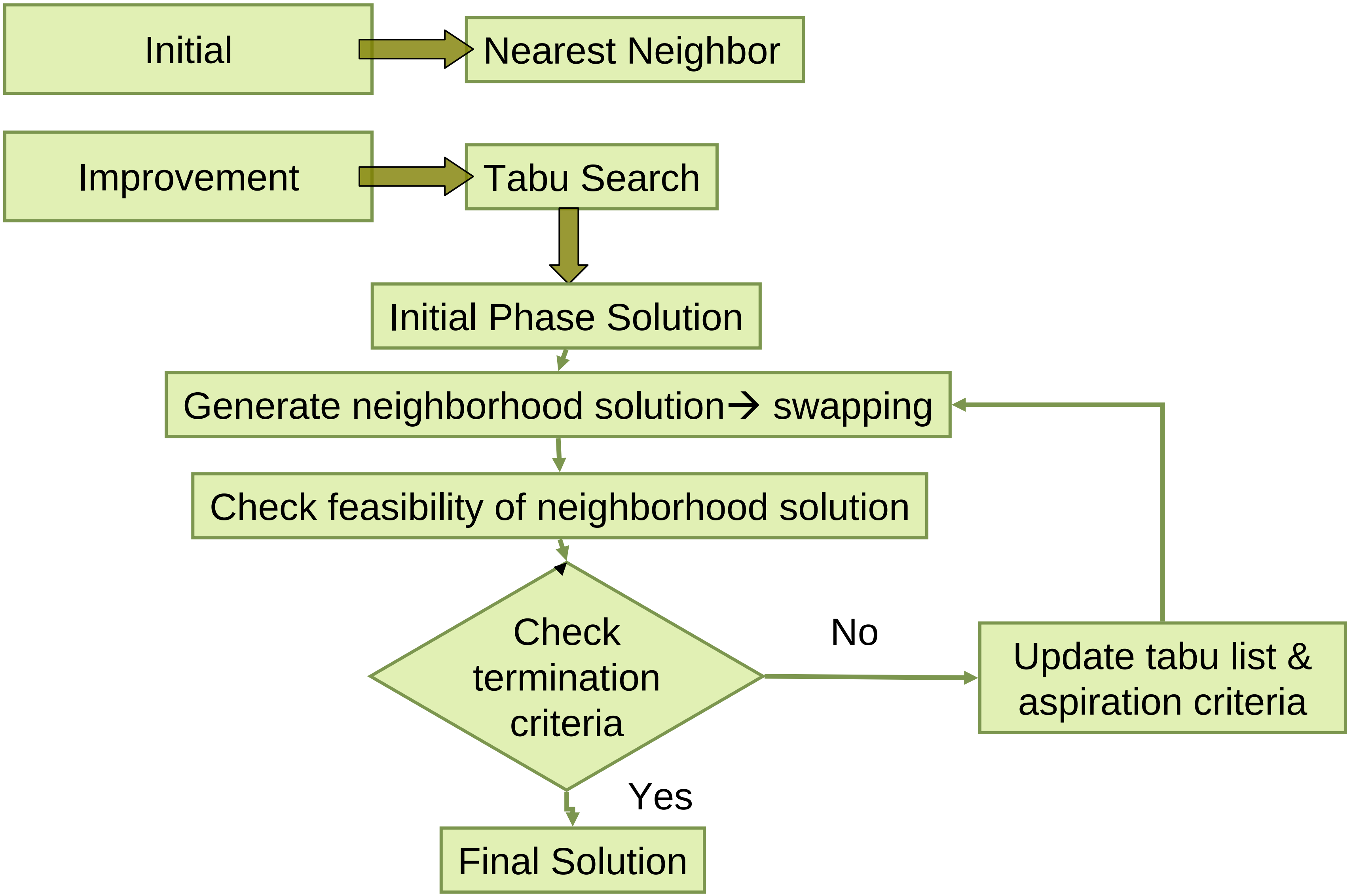
1. Generate vehicle routes to execute delivery
a. Initialization Phase → Nearest Neighbor
b. Improvement Phase → Tabu Search

End



Notes:
Ii = Inventory level at the time review
Mi = Minimum inventory level to be maintained
Ui = Maximum inventory level
Di = Product volume to be delivered

Static IIDP: Generating Vehicle Routes



Inventory Level

- Reorder Point

$$ROP_i = (D_i \times LT) + (Z \times St.Dev \times \sqrt{LT})$$

Dimana:
ROP_i = Reorder Point of station i
D_i = *Throughput* per hour of station i
LT = *lead time duration* (=4 hours)
Z = Z value of determined Service Level (*service level* 95%, Z= 1.645)

- Upper Bound of Inventory Point

$$U_i = (D_i \times T) + (Z \times StDev \times \sqrt{LT})$$

Dimana:
U_i = Upper Boind of Inventory Level of station i
D_i = *Throughput* per hour of station i
T = Review Period (=20 hours)
Z = Z value of determined Service Level(*service level* 95%, Z= 1.645)

Tabu List & Aspiration Criteria

Initial Solution
Route A: 0-1-2
Route B: 0-3-4
Cost:100

MOVE

Neighborhood Solution 1
Route A: 0-3-2
Route B: 0-1-4
Cost:90

Neighborhood Solution 2
Route A: 0-4-2
Route B: 0-3-1
Cost:85

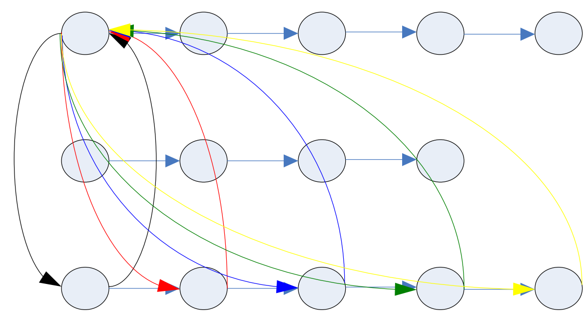
Neighborhood Solution 3
Route A: 0-1-3
Route B: 0-2-4
Cost:105

Neighborhood Solution 4
Route A: 0-1-4
Route B: 0-3-2
Cost:115

Iteration	Tabu Move
1	(4,RA,RB)&(1,RB,RA)
2	
…	
t+θ	

Tabu List

Tabu Length



Swapping

Static IIDP Static → Dynamic IIDP

Dynamic IIDP is a closed-loop system with retailer information updating as feedback (Inventory level in each retailer, position and the remain of capacity)

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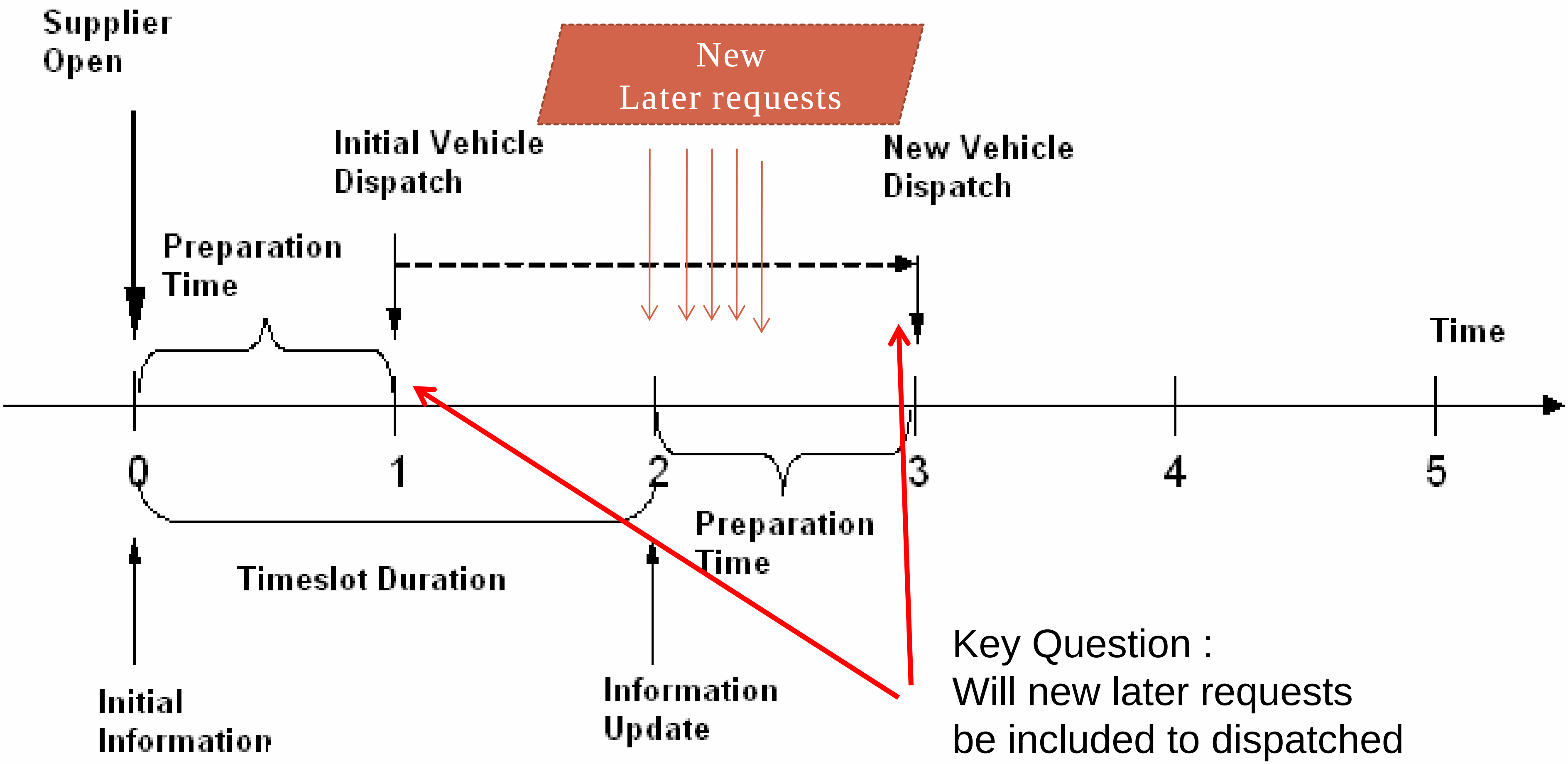
Dynamic IIDP can be viewed as repeated Static IIDP during the horizon planning

Time Frame of Dynamic Planning



Key Question :
Will new later requests be included to dispatched vehicles or to the next Scheduled vehicles

Dynamic Mechanism

Information update

- The supplier updates the information based on timeslot given before. This information are inventory level, remaining capacity and position of vehicle that already dispatched.

New request handling

- After updates the information, the supplier recognizes new retailers that need to be delivered. Then it determines delivery quantities and delivery routes for these retailers.
- Suppose that old vehicle routes can not be inserted for the new request, so the supplier must generates new vehicle routes for the new retailers. This route generation conducted using nearest neighbor algorithm.

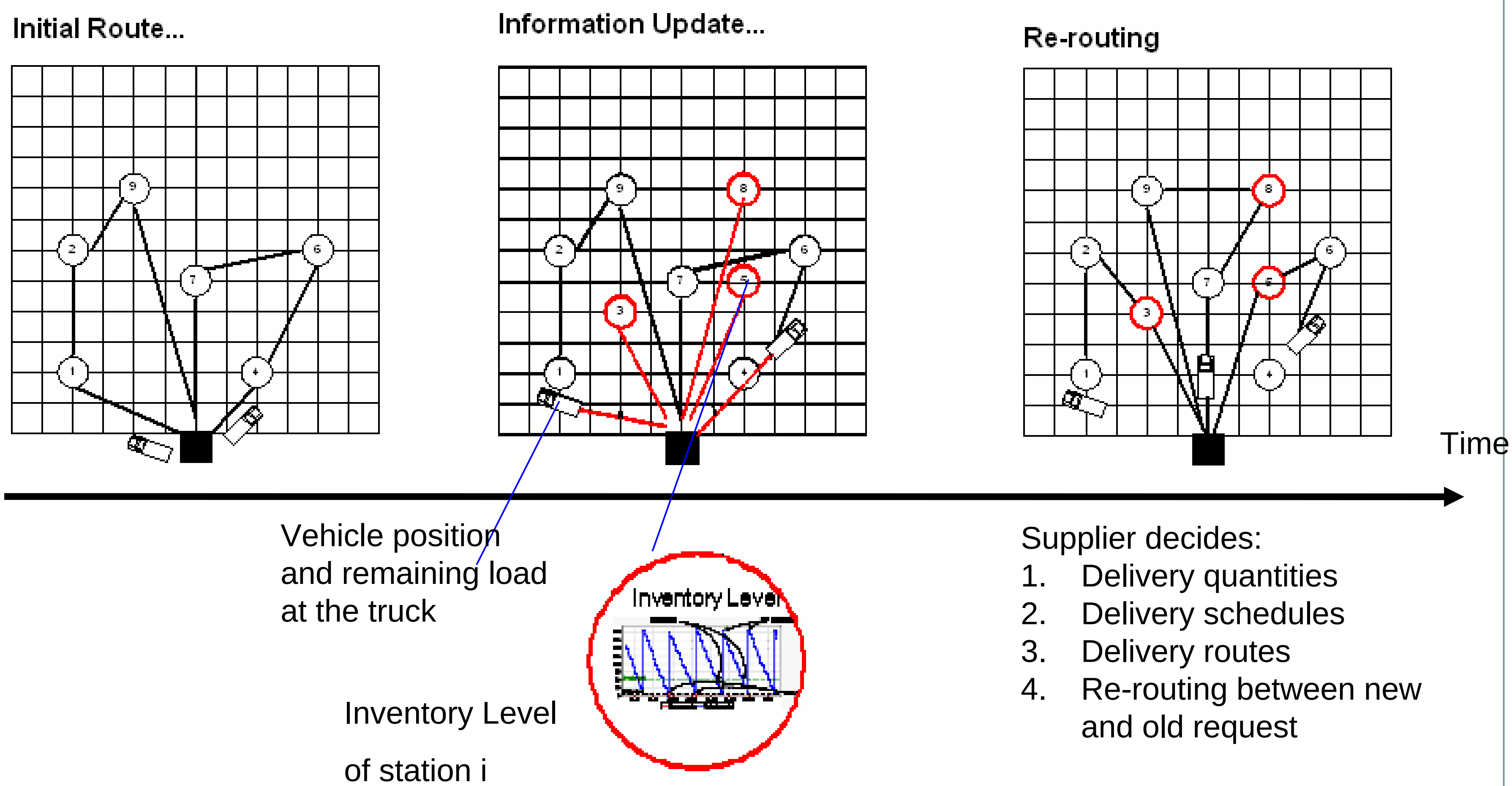
Synchronization between new and old routes

- Whenever it occurred new request and new routes have been constructed, synchronization can be made to minimize distribution cost while guarantee the service level for the retailer.
- We use tabu search algorithm.

Dynamic IIDP Model Description

Static Condition

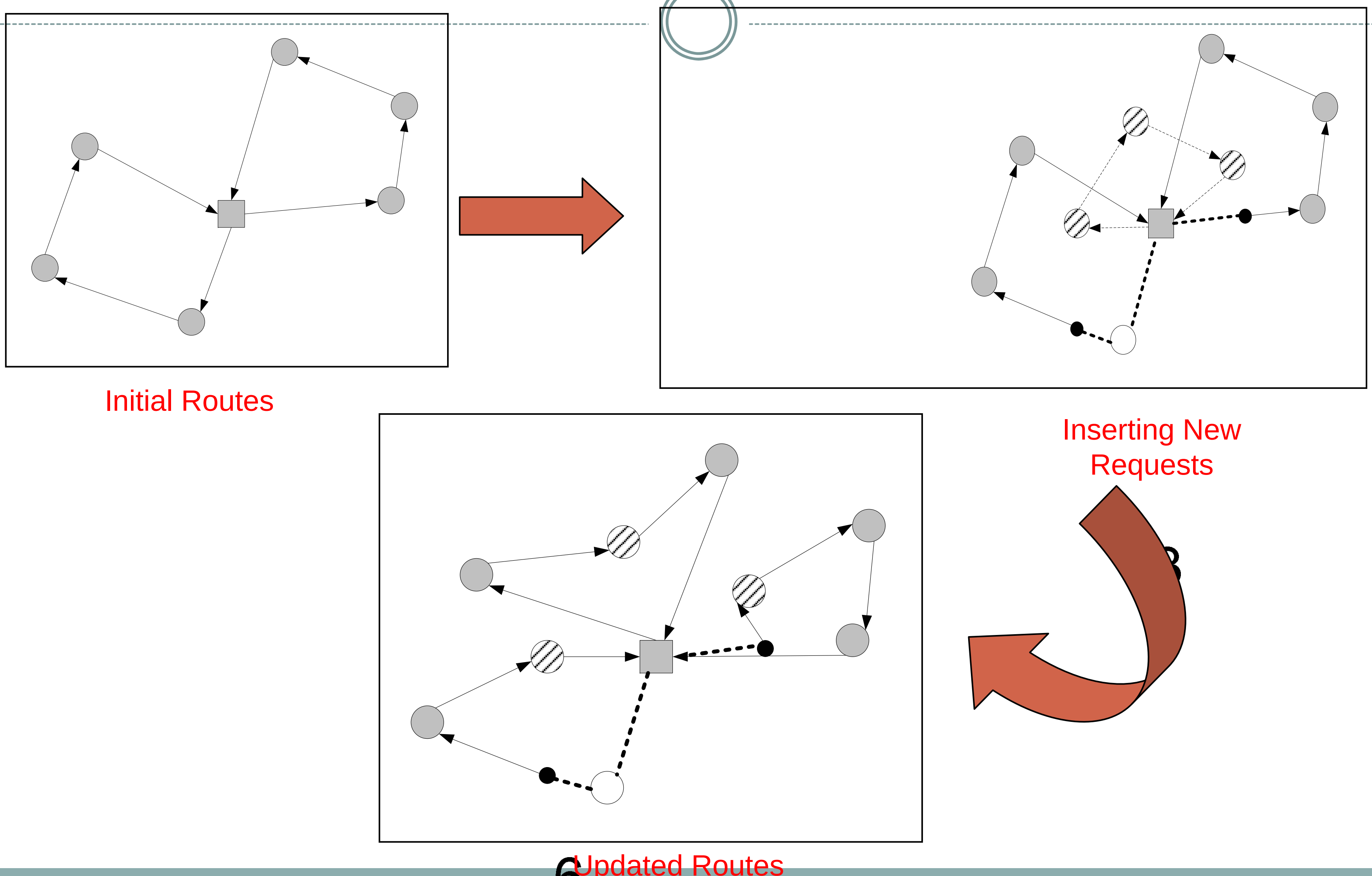
Dynamic Condition



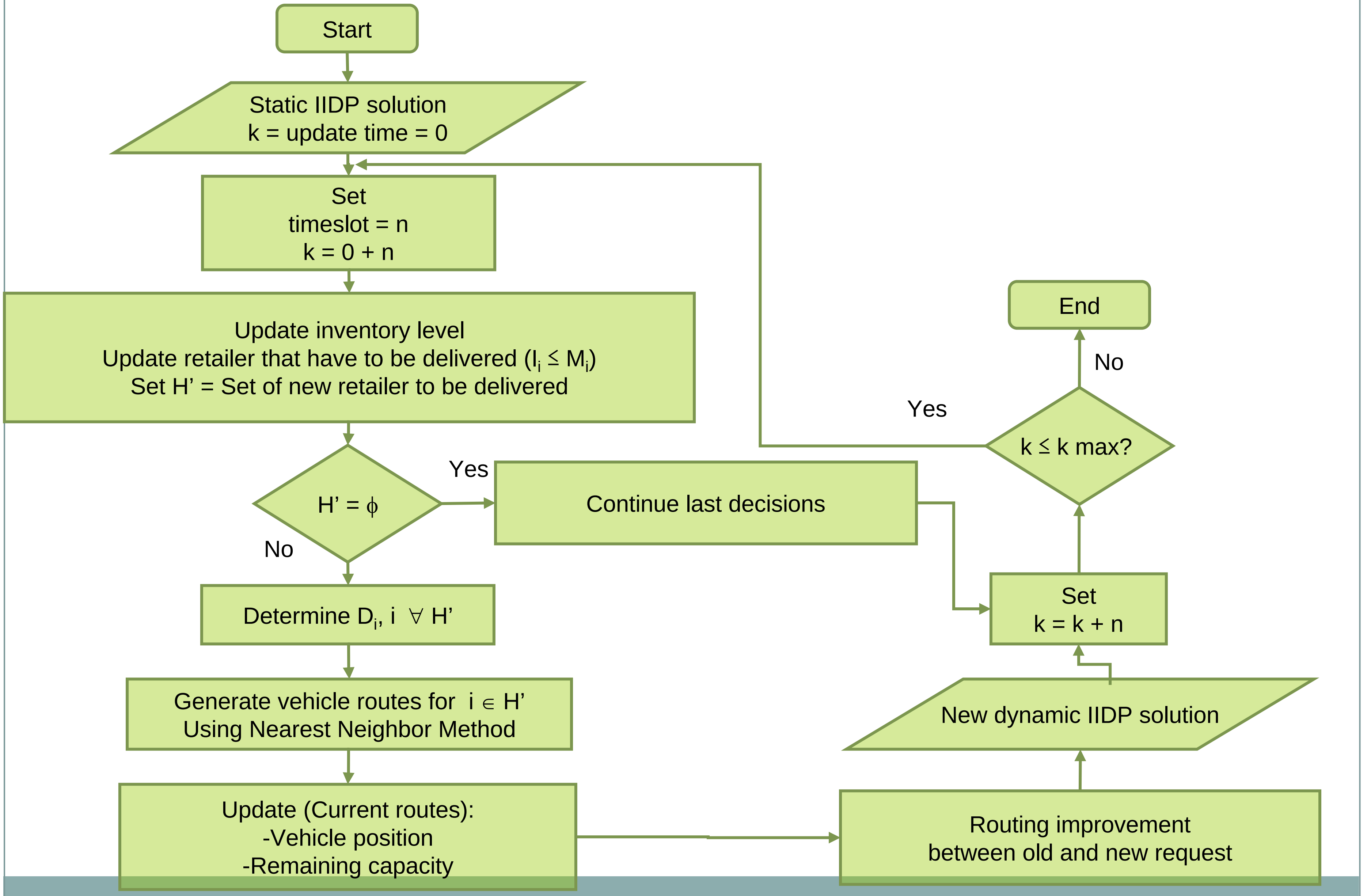
Supplier decides:

1. Delivery quantities
2. Delivery schedules
3. Delivery routes
4. Re-routing between new and old request

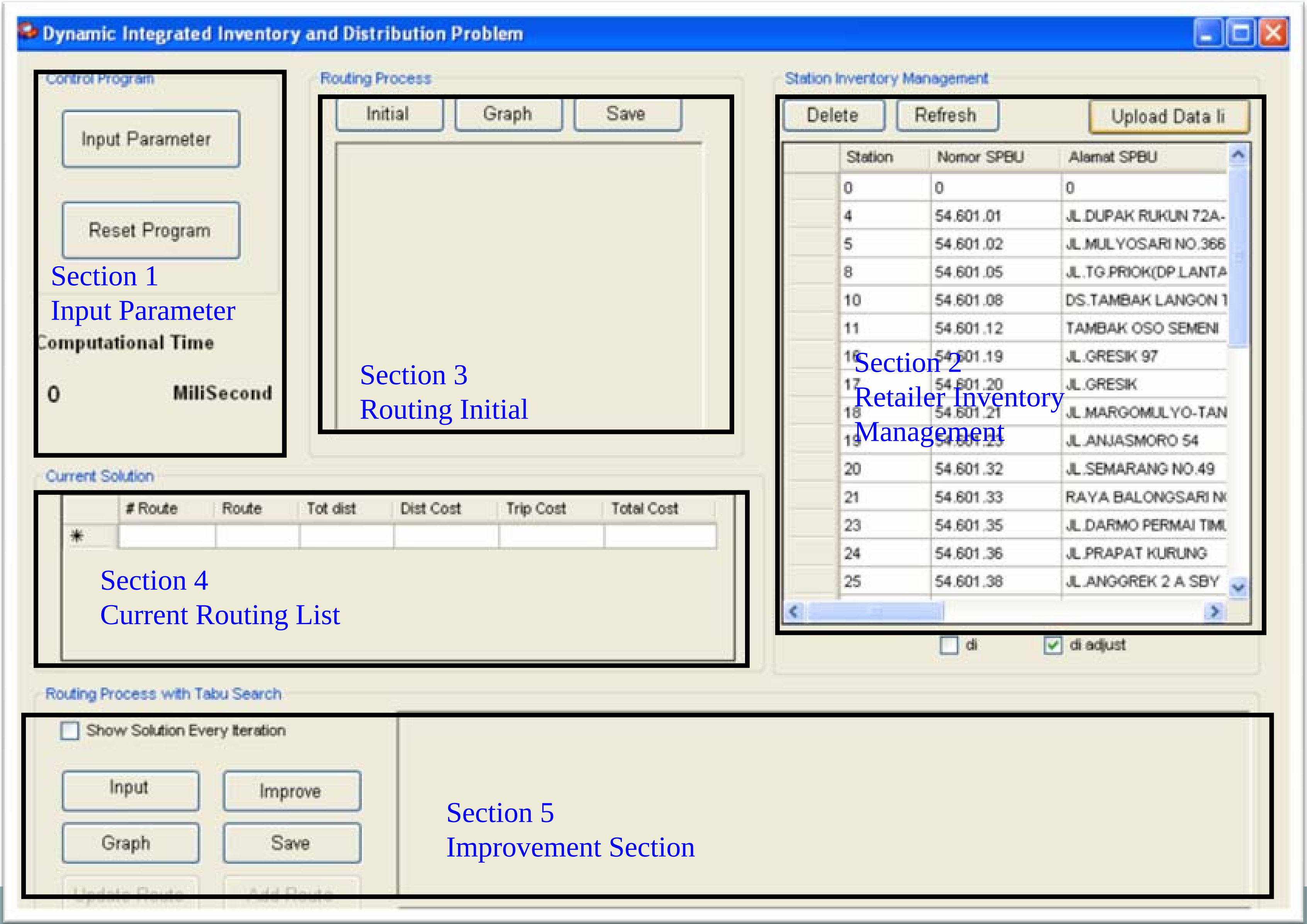
Updated Routes



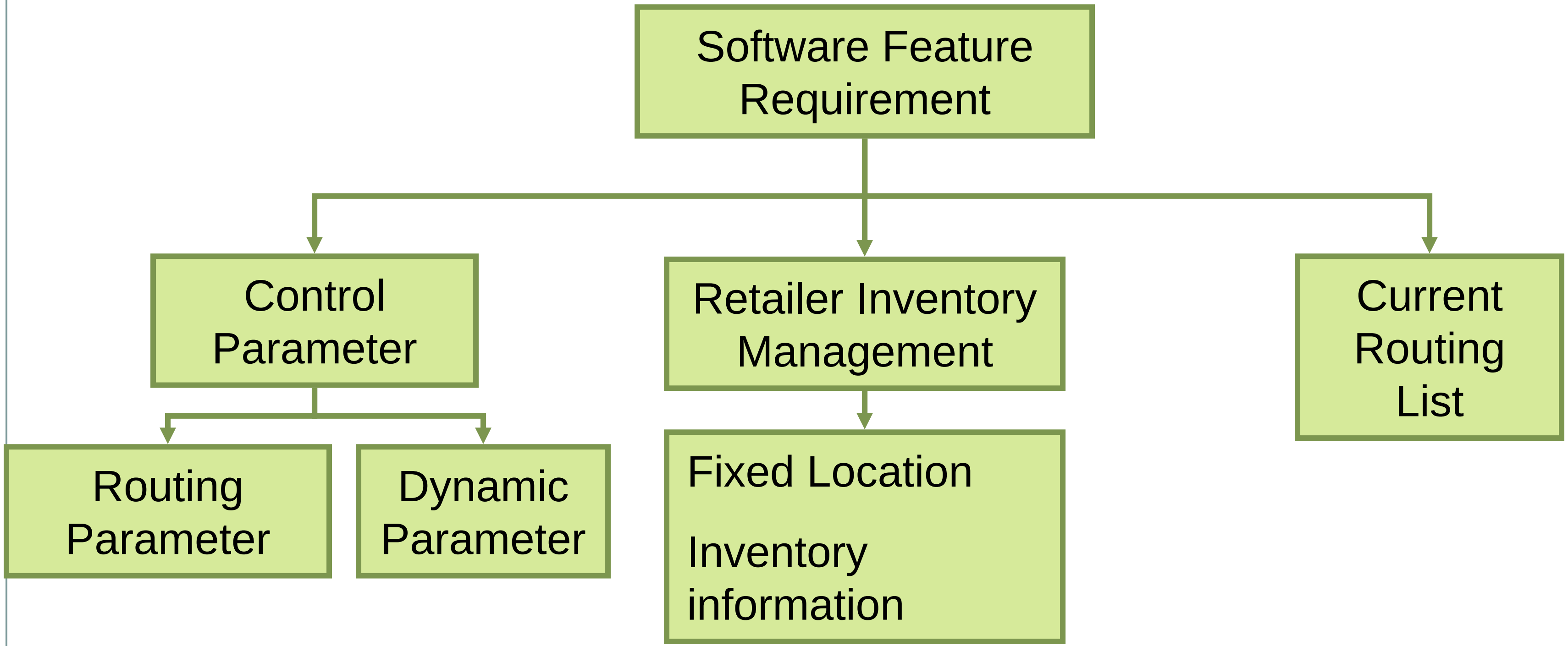
Dynamic IIDP: Flowchart

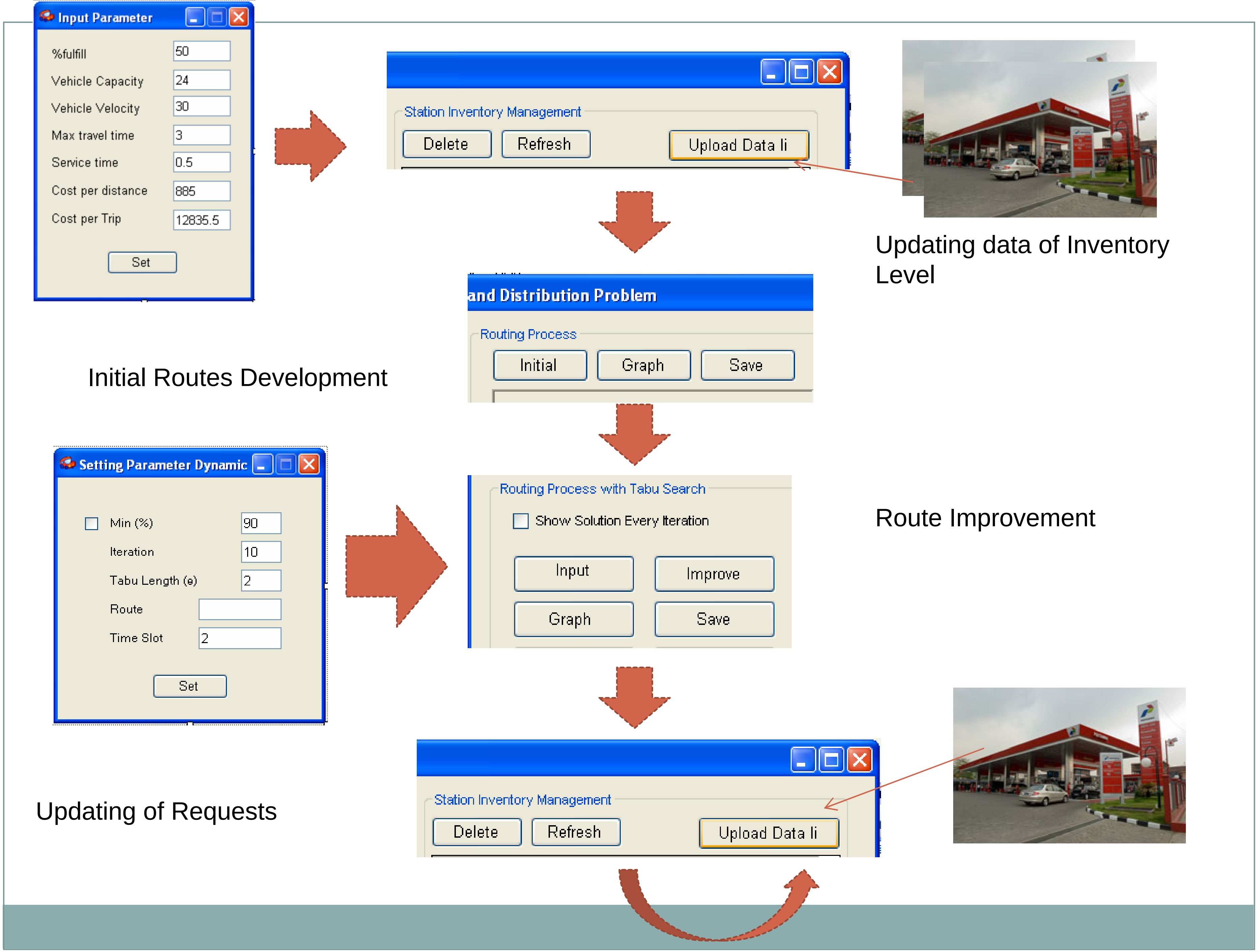


Prototye of Software



Software Features





Input Parameter
%fulfill
50
Vehicle Capacity
24
Vehicle Velocity
30
Max travel time
3
Service time
0.5
Cost per distance
885
Cost per Trip
12835.5
Set
Station Inventory Management
Delete
Refresh
Upload Data li
Updating data of Inventory Level
and Distribution Problem
Routing Process
Initial
Graph
Save
Initial Routes Development
Setting Parameter Dynamic
Min (%)
90
Iteration
10
Tabu Length (ø)
2
Route
Time Slot
2
Set
Routing Process with Tabu Search
Show Solution Every Iteration
Input
Improve
Graph
Save
Route Improvement
Station Inventory Management
Delete
Refresh
Upload Data li
Updating of Requests

Conclusion

- We have developed a model and a heuristic algorithm for solving *Dynamic Integrated Inventory and Distribution Problem* (Dynamic IIDP) for A Gasoline Supply Chain
- The model is based on Vendor Managed Inventory Scheme where the supplier is responsible to the retailers' inventory.