柔性网络配送能力分配分析

以新加坡最后一公里配送为例

第五组

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研究问题概述

Introduction to this problem

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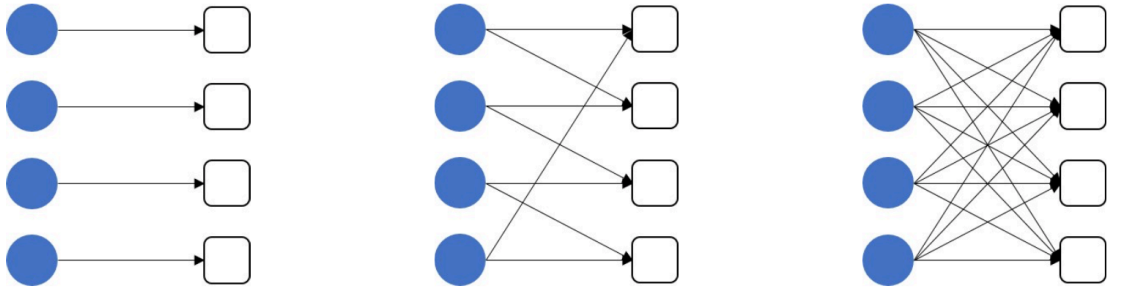
Figure 1 Flexibility configuration: Solid blue circles represent plant nodes and the squares represent product nodes. A link connecting a circle and square implies that the product can be produced by the plant. In a dedicated system, each product can only be produced at one plant and each plant can also only produce one product. In the partial flexibility system, each product can be produced at multiple sites and each plant can also produce different types of products. In the full-flexibility system, each product can be produced at any plant and each plant can produce all the products.



(a) Dedicated system (b) Partial-flexibility system (2-Chain) (c) Full-flexibility system

K-Chain Network

柔性供应网络即每个服务中心/工厂可以服务多个客户，K-Chain Network表示每个DC可以服务k个客户

每个客户对应独立同分布需求

该问题假设客户的需求来自独立同分布，以此为基础进行进一步的实验

需要实现更高的服务水平

如何在配送能力不变的情况下实现，面对相同的需求，实现更高的服务水平

典型案例：京东配送工厂安排问题，盒马快速配送系统

研究问题概述

Introduction to this problem

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Algorithm 2 Optimal Capacity Configuration for Problem (P1)

* *Input:* $\boldsymbol{\lambda}^1 = \mathbf{0}$ *and* $\boldsymbol{S}^0 = \mathbf{0}$.

1. For $k = 1, 2, \ldots,$ do the following:
   - Compute the capacity profile $\bar{\boldsymbol{S}}^k$ and the expected capacity allocation quantity $\boldsymbol{D}^k$ using the online gradient descent algorithm (Algorithm 3 in Appendix C);
   - Update the dual multiplier $\boldsymbol{\lambda}^{k+1}$ based on (16).
2. Terminate the above process when $\max_{i \in \mathcal{I}} \{|\lambda_i^{k+1} - \lambda_i^k|\} \leq \epsilon$, where $\epsilon > 0$ is a predetermined tolerance threshold. We choose $\epsilon = 0.01$ in our numerical studies. Then the capacity profile $\bar{\boldsymbol{S}}^k$ is the desired capacity profile for Problem (P1).

如何通过算法获得最优配置

Table 1 **Comparison of optimal capacity profiles in the k-chain and full-flexibility networks.**

	Total Capacity Level					Capacity Gap (%)			
N	$k=1$	$k=2$	$k=3$	$k=4$	Full Flex.	$k=1$	$k=2$	$k=3$	$k=4$
4	57.58	47.02	47.02	47.02	47.02	22.47	0.00	0.00	0.00
8	114.70	88.35	88.27	88.27	88.27	29.94	0.09	0.00	0.00
12	172.40	130.33	129.63	129.63	129.57	33.05	0.59	0.05	0.05
16	228.93	173.54	171.24	171.24	171.16	33.75	1.39	0.05	0.05
20	286.16	215.64	211.35	211.32	211.20	35.49	2.10	0.07	0.06

K - Chain Network情况比较

可以通过算法模型检验最佳配置

该问题假设客户的需求来自独立同分布，以此为基础进行进一步的实验

2-Chain与全柔性模型效果基本一致

基于优化算法的重复仿真中，2-Chain与全柔性服务水平类似

最后一公里问题

Last mile problem

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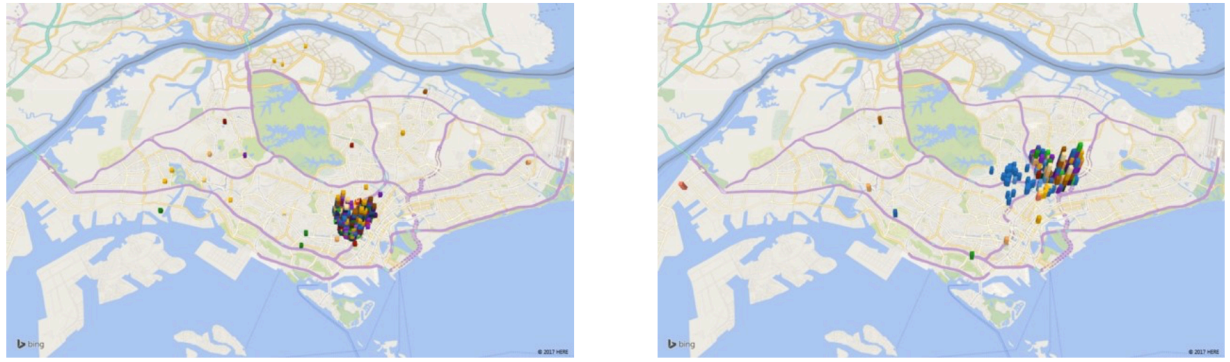
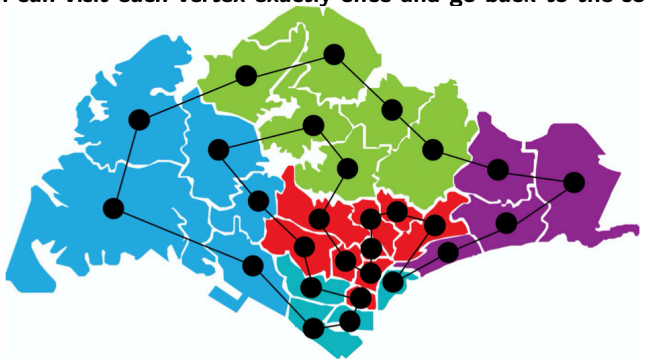
Figure 3 Parcel delivery activities of two delivery workers over 46 periods: Each period is identified by a unique color and the colored bars represent the delivery destinations. In each period, the worker mainly focuses on a specific zone.



(a) Worker A (b) Worker B

Figure 4 Hamiltonian cycle: Each black vertex represents a zone. Accorded by the geographic information, adjacent vertices are linked by a line and each vertex is exactly linked by two lines. Starting from any vertex, the delivery man can visit each vertex exactly once and go back to the source vertex.



任务分配问题

$$\max \sum_{j,i} w_i(\boldsymbol{X}, \boldsymbol{S}) D_{j,i}$$

$$\text{s.t.} \sum_{j} D_{j,i} \leq X_i, \forall i$$

$$\sum_{i} D_{j,i} \leq S_j, \forall j$$

$$D_{j,i} \geq 0, \forall i, j$$

$$\text{Min} \sum_{i=0}^{n} Capacity\ of\ DC_i$$

实验目标

比较在相同配送能力下，不同配送网络能够达到的服务水平

供应网络配置

Supply chain

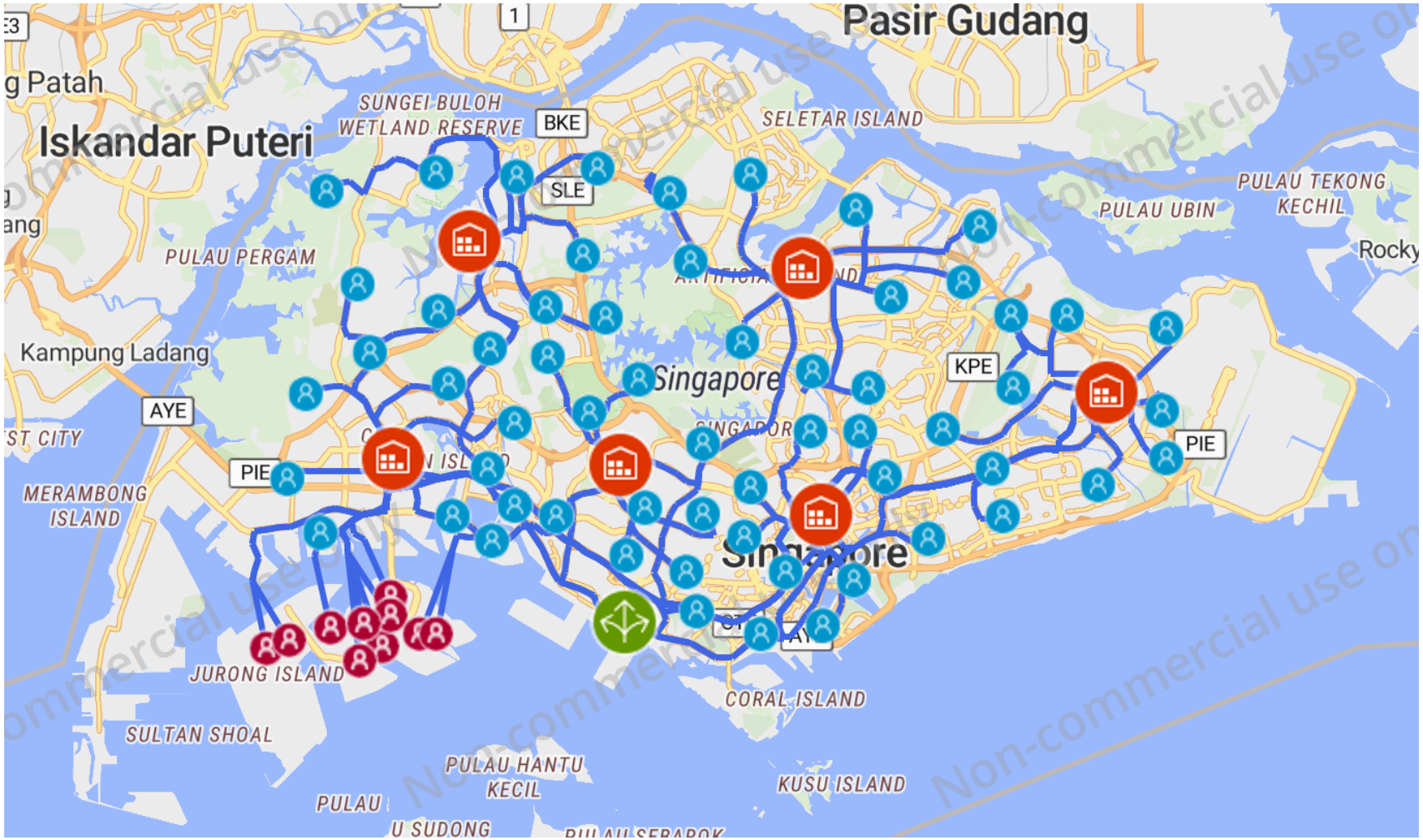
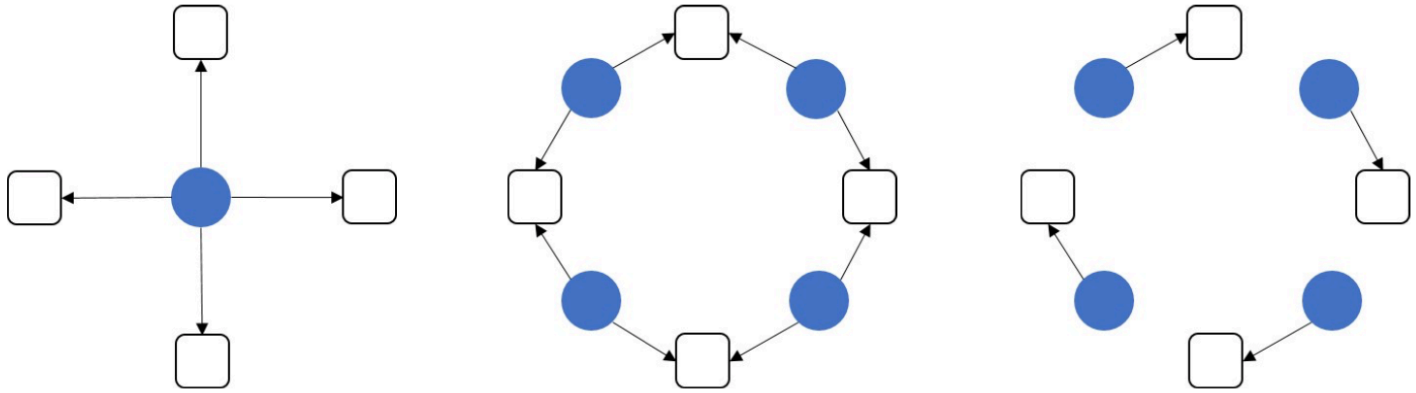


Figure 5 Zonal assignment mechanisms: The blue circle represents the delivery personnel and the square represents the zonal vertex. A link connecting the circle and square implies that the delivery worker is responsible for the parcel delivery in the zone.



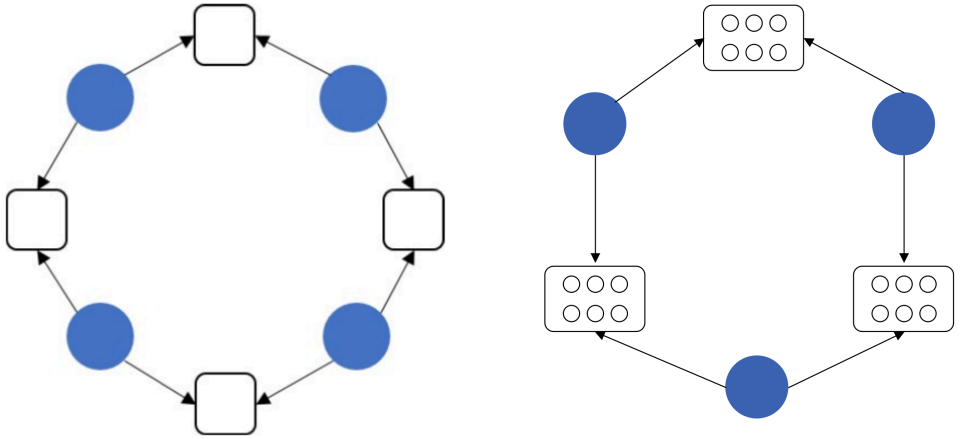
(a) Pooling mechanism (b) Long-chain mechanism (c) Dedicated mechanism

实验目标

比较在相同配送能力下，不同配送网络能够达到的服务水平

网络模型改进

Network model improvements



#	Name	Description	Customers	Sites	Suppliers
	Filter	Filter	Filter	Filter	Filter
9	Group 1		[Group1 Customer 1, G...	[]	[]
10	Group 2		[Group2 Customer 1, G...	[]	[]
11	Group 3		[Group3 Customer 1, G...	[]	[]
12	Group 4		[Group 4 Customer 1, ...	[]	[]
13	Group 5		[Group 5 Customer 1, ...	[]	[]
14	Group 6		[Group 6 Customer 1, ...	[]	[]
15	Inventory Controll...		[10 customers]	[]	[]

网络修改方案

考虑末端配送中心的网络修改，将每个需求拆分为多个末端配送中心

网络实现情况

每个配送中心对应一个分组，分组中有该区域内的全部的客户

柔性网络实现

Flexible network

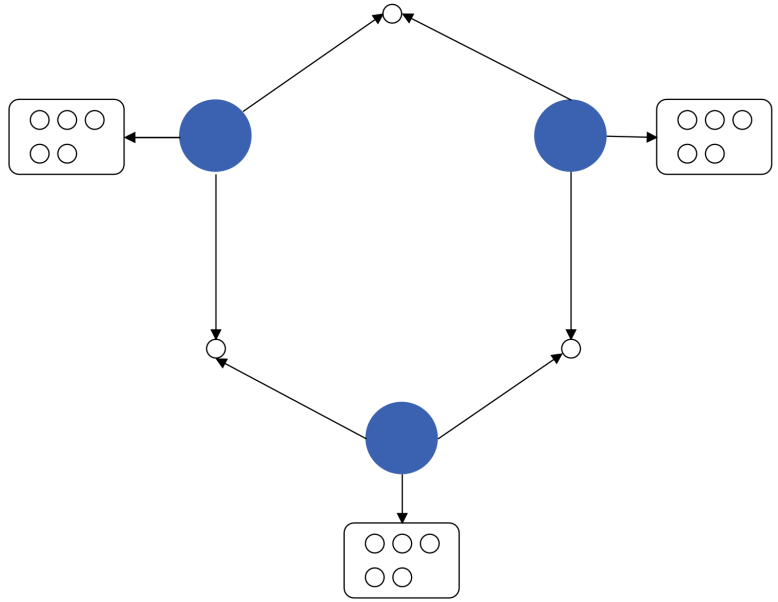
Service Level by Orders

	Statistics name	Source	Value	Unit
1	Service Level by Orders	DC 1	1	Ratio
2	Service Level by Orders	DC 2	1	Ratio
3	Service Level by Orders	DC 3	1	Ratio
4	Service Level by Orders	DC 4	1	Ratio
5	Service Level by Orders	DC 5	1	Ratio
6	Service Level by Orders	DC 6	1	Ratio

仅服务八个用户时可以实现100%服务水平

#	Name	Description	Customers
	Filter	Filter	Filter
3	Final Group 1		[Final 1 Customer 2, Final 1 Customer 1]
4	Final Group 2		[Final 2 Customer 2, Final 2 Customer 1]
5	Final Group 3		[Final 3 Customer 2, Final 3 Customer 1]
6	Final Group 4		[Final 4 Customer 2, Final 4 Customer 1]
7	Final Group 5		[Final 5 Customer 2, Final 5 Customer 1]
8	Final Group 6		[Final 6 Customer 2, Final 6 Customer 1]

提取出两个小组作为Final Group单独分配



柔性网络分配

从每个小组中提出1/2个客户，在服务完目标用户后，再独立单独选择库存最多的客户

柔性网络实现

Flexible network

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3	[Final Group]	(All products)	Most Inventory (..	No parameters	[DCs]	(All periods)	Include
4	[Group 1]	(All products)	Closest (Fixed So..	No parameters	DC 1	(All periods)	Include
5	[Group 2]	(All products)	Closest (Fixed So..	No parameters	DC 2	(All periods)	Include
6	[Group 3]	(All products)	Closest (Fixed So..	No parameters	DC 3	(All periods)	Include
7	[Group 4]	(All products)	Closest (Fixed So..	No parameters	DC 4	(All periods)	Include
8	[Group 5]	(All products)	Closest (Fixed So..	No parameters	DC 5	(All periods)	Include
9	[Group 6]	(All products)	Closest (Fixed So..	No parameters	DC 6	(All periods)	Include
10	[Inventory Contr..	(All products)	Most Inventory (..	No parameters	[DCs]	(All periods)	Include

Pooling Mechanism

从每个小组中提出1/2个客户，在服务完目标用户后，再独立单独选择库存最多的客户

柔性网络实现

Flexible network

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3	[Final Group 1]	(All products)	Most Inventory (..	No parameters	DC 2, DC 1, DC 6	(All periods)	Include
4	[Final Group 2]	(All products)	Most Inventory (..	No parameters	DC 2, DC 3, DC 1	(All periods)	Include
5	[Final Group 3]	(All products)	Most Inventory (..	No parameters	DC 2, DC 3, DC 4	(All periods)	Include
6	[Final Group 4]	(All products)	Most Inventory (..	No parameters	DC 3, DC 5, DC 4	(All periods)	Include
7	[Final Group 5]	(All products)	Most Inventory (..	No parameters	DC 5, DC 6, DC 4	(All periods)	Include
8	[Final Group 6]	(All products)	Most Inventory (..	No parameters	DC 5, DC 1, DC 6	(All periods)	Include
9	[Group 1]	(All products)	Closest (Fixed So..	No parameters	DC 1	(All periods)	Include
10	[Group 2]	(All products)	Closest (Fixed So..	No parameters	DC 2	(All periods)	Include
11	[Group 3]	(All products)	Closest (Fixed So..	No parameters	DC 3	(All periods)	Include
12	[Group 4]	(All products)	Closest (Fixed So..	No parameters	DC 4	(All periods)	Include
13	[Group 5]	(All products)	Closest (Fixed So..	No parameters	DC 5	(All periods)	Include
14	[Group 6]	(All products)	Closest (Fixed So..	No parameters	DC 6	(All periods)	Include

激活 Windows

Long Chain Mechamism

从每个小组中提出1/2个客户，在服务完目标用户后，再独立单独选择库存最多的客户

柔性网络实现

Flexible network

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3	[Final Group 1]	(All products)	Most Inventory (..	No parameters	DC 1	(All periods)	Include
4	[Final Group 2]	(All products)	Most Inventory (..	No parameters	DC 2	(All periods)	Include
5	[Final Group 3]	(All products)	Most Inventory (..	No parameters	DC 3	(All periods)	Include
6	[Final Group 4]	(All products)	Most Inventory (..	No parameters	DC 4	(All periods)	Include
7	[Final Group 5]	(All products)	Most Inventory (..	No parameters	DC 5	(All periods)	Include
8	[Final Group 6]	(All products)	Most Inventory (..	No parameters	DC 6	(All periods)	Include
9	[Group 1]	(All products)	Closest (Fixed So..	No parameters	DC 1	(All periods)	Include
10	[Group 2]	(All products)	Closest (Fixed So..	No parameters	DC 2	(All periods)	Include
11	[Group 3]	(All products)	Closest (Fixed So..	No parameters	DC 3	(All periods)	Include
12	[Group 4]	(All products)	Closest (Fixed So..	No parameters	DC 4	(All periods)	Include
13	[Group 5]	(All products)	Closest (Fixed So..	No parameters	DC 5	(All periods)	Include
14	[Group 6]	(All products)	Closest (Fixed So..	No parameters	DC 6	(All periods)	Include

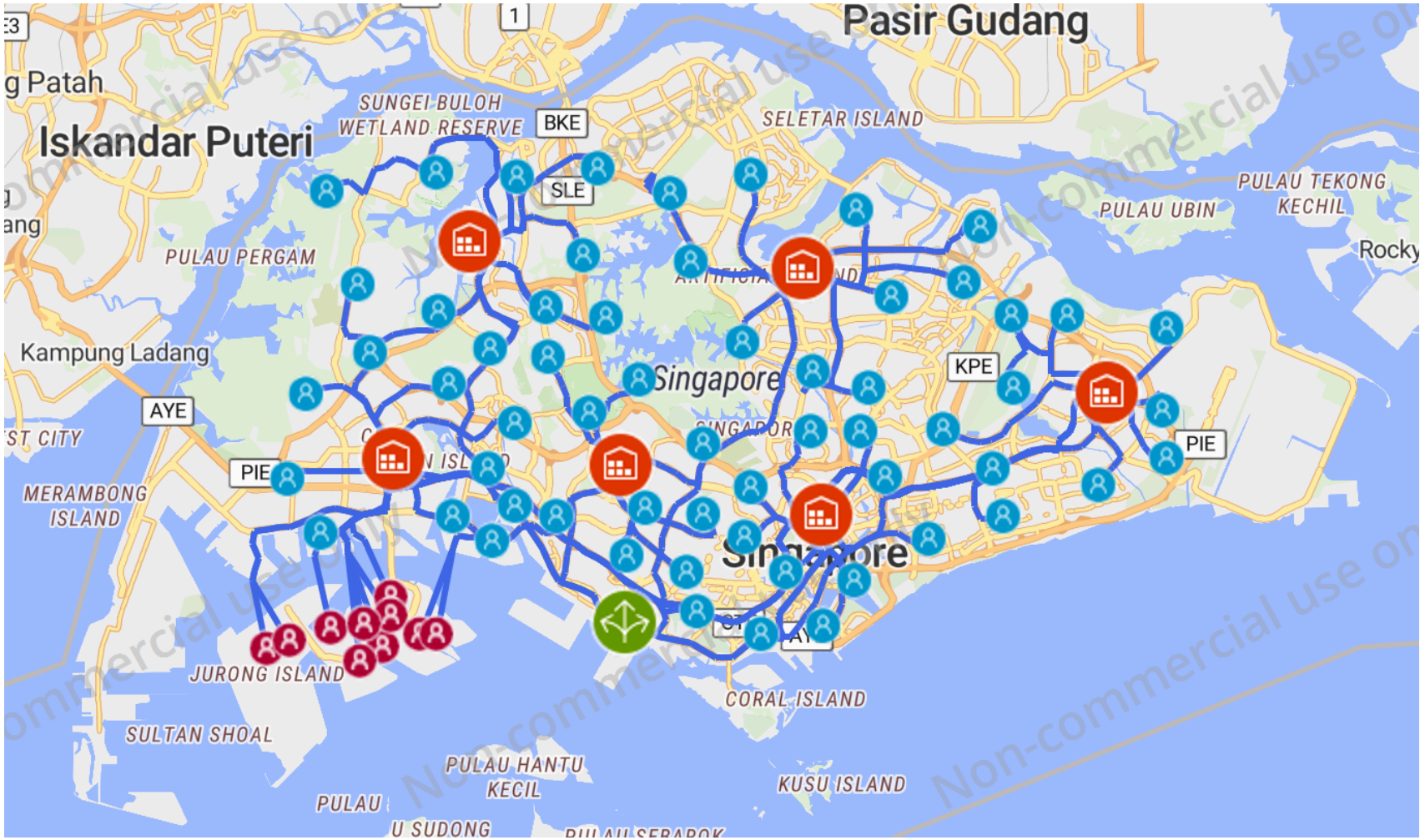
激活 Windows
转到"设置"以激活 Windows。

Dedicated Mechanism

从每个小组中提出1/2个客户，在服务完目标用户后，再独立单独选择库存最多的客户

供应网络配置

Supply chain



配送能力配置

The constrain of capacity

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#	Facility	Product	Policy Type	Policy Parameters	Initial Stock, units	Periodic Check	Period
	Filter	Filter	Filter	Filter	Filter	Filter	Filter
1	DC 1	(All products)	Regular policy	Quantity = 950	0		1
2	DC 2	(All products)	Regular policy	Quantity = 950	0		1
3	DC 3	(All products)	Regular policy	Quantity = 950	0		1
4	DC 4	(All products)	Regular policy	Quantity = 950	0		1
5	DC 5	(All products)	Regular policy	Quantity = 950	0		1
6	DC 6	(All products)	Regular policy	Quantity = 950	0		1

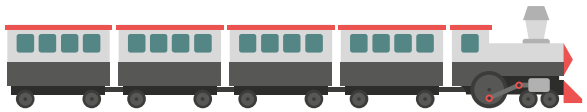
每天订购950货物，作为配送能力限制

First periodic check	Policy Basis	Stock Calculation ...	Time Unit	Time Period	Inclusion Type
Filter	Filter	Filter	Filter	Filter	Filter
1/1/20 1:00 AM	Quantity	0	day	(All periods)	Include
1/1/20 1:00 AM	Quantity	0	day	(All periods)	Include
1/1/20 1:00 AM	Quantity	0	day	(All periods)	Include
1/1/20 1:00 AM	Quantity	0	day	(All periods)	Include
1/1/20 1:00 AM	Quantity	0	day	(All periods)	Include
1/1/20 1:00 AM	Quantity	0	day	(All periods)	Include

订购时间为每早1点钟

配送控制

DC每天的请求950个货物，与前一天剩余库存作为当天配送能力，每晚在通过库存控制器进行调整



库存控制说明

Controllong inventory

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15	[Inventory Contr..	(All products)	Most Inventory (..	No parameters	[DCs]

#	Customer	Product	Demand Type	Parameters
	Filter	Filter	Filter	Filter
6	Inventory Control 4	Product	Periodic demand with first occurence	Order interval=1, Quantity=50
7	Inventory Control 3	Product	Periodic demand with first occurence	Order interval=1, Quantity=50
8	Inventory Control 2	Product	Periodic demand with first occurence	Order interval=1, Quantity=50

Currency	Expected Lead Time	Time Unit	Backorder Policy
Filter	Filter	Filter	Filter
USD	3	hour	Not allowed
USD	3	hour	Not allowed
USD	3	hour	Not allowed

库存控制器

每天晚上，将由10个库存控制器，分批请求DC，将全部库存控制在50以内，从而控制每天配送能力950+50=1000以内

Customers	Times	End Time
Inventory Controller 1	07:10 PM	10:10 PM
Inventory Controller 2	07:20 PM	10:20 PM
Inventory Controller 3	07:30 PM	10:30 PM
Inventory Controller 4	07:40 PM	10:40 PM
Inventory Controller 5	07:50 PM	10:50 PM
Inventory Controller 6	08:00 PM	11:00 PM
Inventory Controller 7	08:10 PM	11:10 PM
Inventory Controller 8	08:20 PM	11:20 PM
Inventory Controller 9	08:30 PM	11:30 PM
Inventory Controller 10	08:40 PM	11:40 PM

需求配置说明

Demand of inventory controllers

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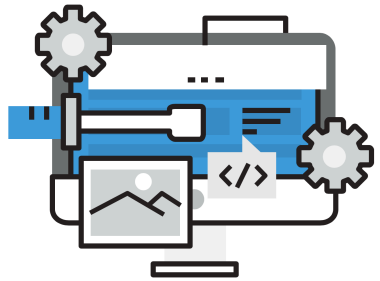
#	Customer	Product	Demand Type	Parameters	Revenue	Currency	Expected Lead Time	Time Unit	Backorder Policy
	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter
57	Group 4 Customer 2	Product	Periodic demand with first occurence	Order interval=1, Quantity=Uniform(50;150)	0	USD	6	hour	Not allowed
58	Group 4 Customer 1	Product	Periodic demand with first occurence	Order interval=1, Quantity=Uniform(50;150)	0	USD	6	hour	Not allowed
59	Final 6 Customer 2	Product	Periodic demand with first occurence	Order interval=1, Quantity=100	0	USD	3	hour	Not allowed
60	Final 6 Customer 1	Product	Periodic demand with first occurence	Order interval=1, Quantity=100	0	USD	3	hour	Not allowed

Customers	Times	End Time
Group 1 Final 1	08:10 AM	11:10 AM
Group 1 Final 2	08:20 AM	11:20 AM
Group 2 Final 1	08:30 AM	11:30 AM
Group 2 Final 2	08:40 AM	11:40 AM
Group 3 Final 1	08:50 AM	11:50 AM
Group 3 Final 2	09:00 AM	12:00 AM
Group 4 Final 1	09:10 AM	12:10 AM
Group 5 Final 1	09:20 AM	12:20 AM
Group 5 Final 2	09:30 AM	12:30 AM
Group 6 Final 1	09:40 AM	12:40 AM
Group 6 Final 2	09:50 AM	12:50 AM
其他	02:00 AM	08:00 AM

需求配置说明

提前期设置为6/3小时，每天进行请求超时订单全部Drop，Final Group中的需求分批发出



离散仿真实验

Discrete simulation experiment

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	Customers 需求分布函数	DC 的供给能力	时间种子
具体选择	$\{\mathcal{N}(10,25^2),\mathcal{N}(100,40^2),\mathcal{N}(100,50^2),$ $Uniform(50,150),Uniform(40,160),$ $Uniform(25,175)\}$	$\{950\}$	$\{0,1,2\}$

离散仿真

采用不同时间种子，在相同供给能力下，分布方式不同、方差不同的分布进行比较

Additional settings

Daily Accumulate

#	Detail by	Contains	Show
	Filter	Filter	Filter
1	Object	[Final 1 Customer 1, Final 1 Customer 2, Final 2 Customer 1, Final 2 Customer 2, Fina...	In Total Per Item
2	Product	ALL	In Total Per Item
3	Source	[DC 1, DC 2, DC 3, DC 4, DC 5, DC 6]	In Total Per Item
4	Period	ALL	In Total Per Item

Additional settings

Daily Accumulate

#	Detail by	Contains	Show
	Filter	Filter	Filter
1	Type	ALL	In Total Per Item
2	Object	[DC 1, DC 2, DC 3, DC 4, DC 5, DC 6]	In Total Per Item
3	Destination	[Group1 Customer 1, Group1 Customer 10, Group1 Customer 2, Group1 Customer ...	In Total Per Item
4	Vehicle type	ALL	In Total Per Item

实验指标

考虑所有Customer的需求被DC的满足的情况以及他们的运输费用

均匀分布实验结果分析

Uniform distribution

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	$Uniform(15,185)$	$Uniform(25,175)$	$Uniform(50,150)$
Dedicated Mechanism	90.16%	90.43%	91.16%
Long-Chain Mechanism	91.73%	91.70%	91.56%
Pooling Mechanism	91.76%	91.76%	91.73%

不同需求分布服务水平统计

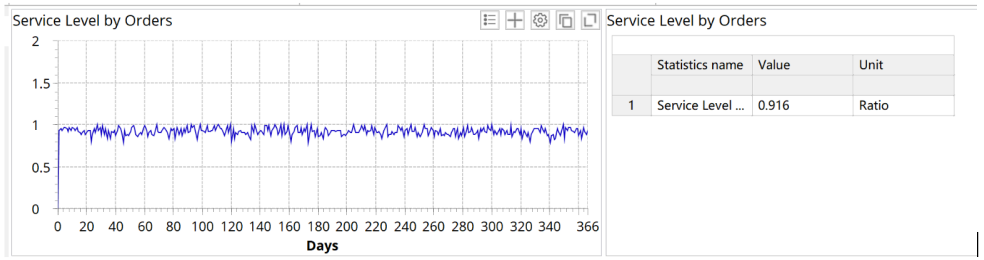
	Round 1	Round 2	Round 3
Dedicated Mechanism	90.1%	90.0%	90.4%
Long-Chain Mechanism	91.6%	91.5%	92.1%
Pooling Mechanism	91.7%	91.6%	92.0%

$Uniform(15,185)$服务水平统计

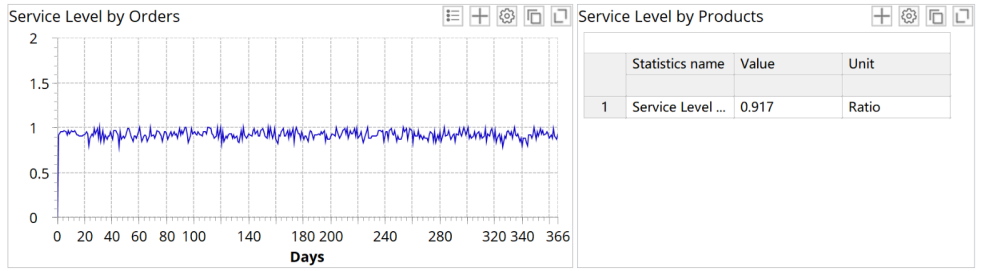
	Round 1	Round 2	Round 3
Dedicated Mechanism	610535 USD	610419 USD	610141 USD
Long-Chain Mechanism	695049 USD	693667 USD	697375 USD
Pooling Mechanism	761869 USD	760503 USD	763643 USD

$Uniform(15,185)$交通费用统

$Uniform(15,185)$ Dedicated Mechanism



$Uniform(15,185)$Long Chain Mechanism



$Uniform(15,185)$Pooling Mechanism

正态分布实验结果分析

Normal distribution

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	$\mathcal{N}(100,25^2)$	$\mathcal{N}(100,40^2)$	$\mathcal{N}(100,50^2)$
Dedicated Mechanism	91.33%	90.43%	89.83%
Long-Chain Mechanism	91.43%	91.33%	91.33%
Pooling Mechanism	91.43%	91.46%	91.40%

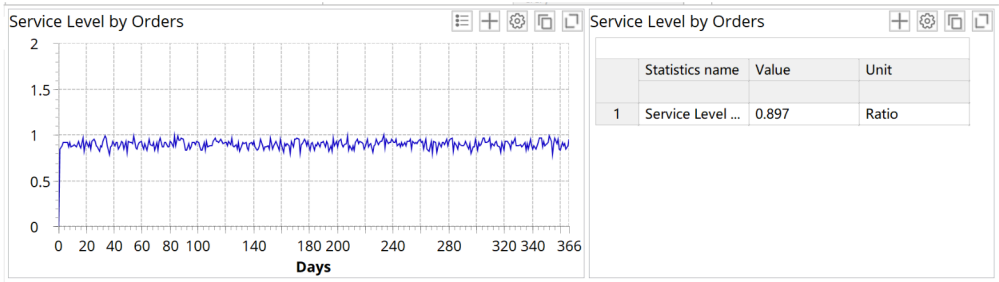
不同需求分布服务水平统计

	Round 1	Round 2	Round 3
Dedicated Mechanism	89.7%	89.9%	89.9%
Long-Chain Mechanism	91.2%	91.3%	91.5%
Pooling Mechanism	91.3%	91.3%	91.6%

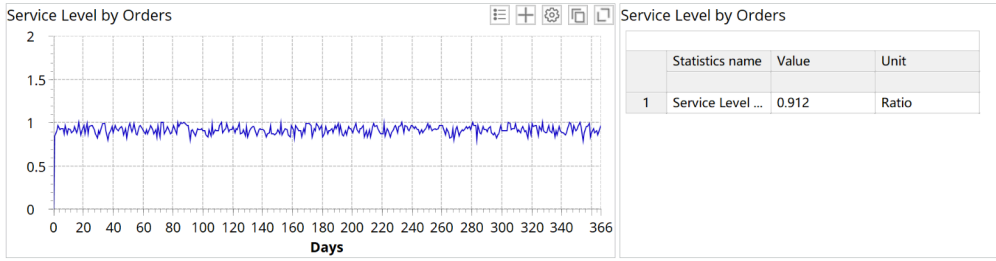
$f = \mathcal{N}(100,50^2)$时服务水平统计

	Round 1	Round 2	Round 3
Dedicated Mechanism	610690 USD	611121 USD	610456 USD
Long-Chain Mechanism	694423 USD	694529 USD	695722 USD
Pooling Mechanism	764144 USD	760989 USD	765310 USD

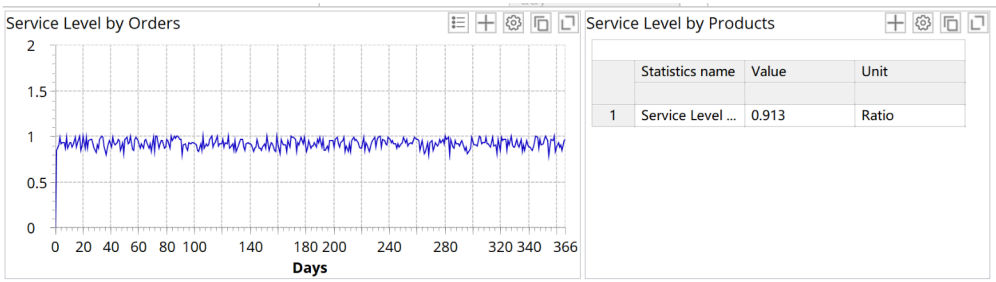
$f = \mathcal{N}(100,50^2)$时交通费用统计



$\mathcal{N}(100,50^2)$ Dedicated Mechanism



$\mathcal{N}(100,50^2)$ Long Chain Mechanism



$\mathcal{N}(100,50^2)$ Pooling Mechanism

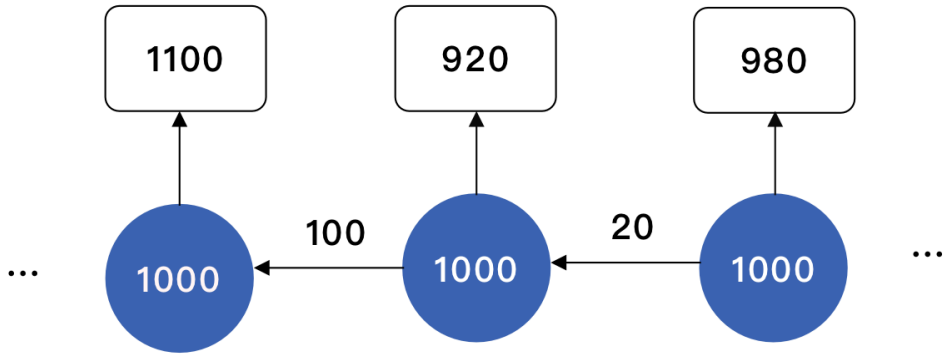
结论与原因分析

Results and analysis

同济大学 TONGJI UNIVERSITY

服务水平：Pooling Mechanism ≈ Long-Chain Mechanism >> Dedicated Mechanism

交通费用：Pooling Mechanism > Long-Chain Mechanism > Dedicated Mechanism



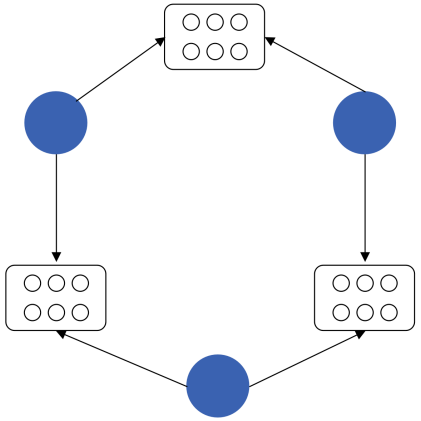
原因分析

柔性能够根据实际的需求情况进行需求的充分的调整

创新与不足

Innovation and disadvantages

创新

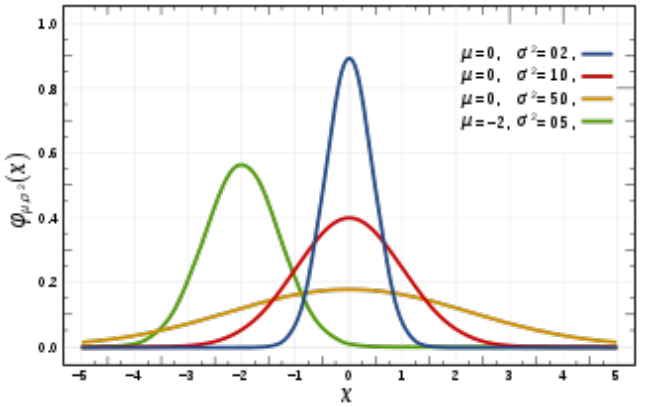


采用了更契合实际的网络

Transportation Cost

	Statistics name	Value	Unit
1	Transportatio...	757,304.661	USD

考虑了运输费用



考虑了更多分布模型

不足

由于软件限制，许多模块做出了让步；考虑的离散仿真实验仍然不足；部分问题作出了简化，如动态分配目标DC等

Thanks
for Your Listening

第五组汇报

物流导论期末课设