UNIVERSITY OF CAMBRIDGE

AUTO–ID LABS

Innovation in Warehouse Management Systems

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Cambridge Auto-ID Lab &

Distributed Information and Automation Laboratory

www.autoidlabs.org.uk **www.ifm.eng.cam.ac.uk/dial**

GS1 Transport & Logistics Workshop | Rome | 06 October 2014

Agenda

1. Adaptive storage location assignment

2. Customer intervention

3. IT architectures for logistics integration

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1. Adaptive storage location assignment
Industrial motivation

Order picking → most labour-intensive operation in warehouses with manual systems and accounts for 55% of warehouse operating expenses **(De Koster et al., 2007; Tompkins et al., 2007)**

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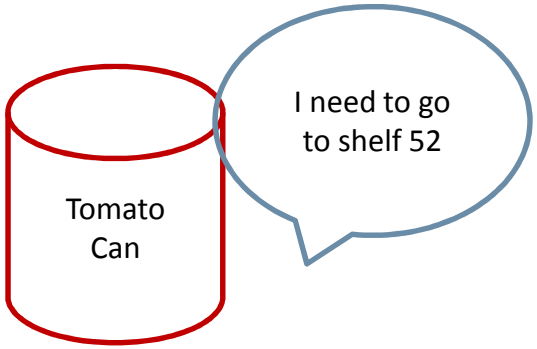
1. Adaptive storage location assignment
Industrial motivation

Dedicated

Tomato Cans should always be stored in shelf 52!



+ Easy to pick
- Requires more storage space

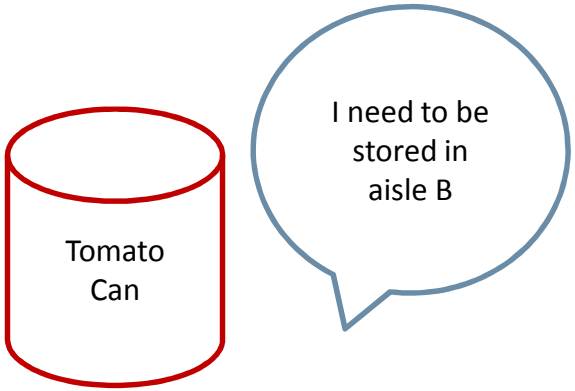
Random

All the products are allowed to be stored anywhere!

+ Space utilisation
- Picking is time-consuming

Class-based

All kinds of tomatoes should gather in aisle B!



+ Combines benefits
- Requires classes specification

(Gu et al., 2007)

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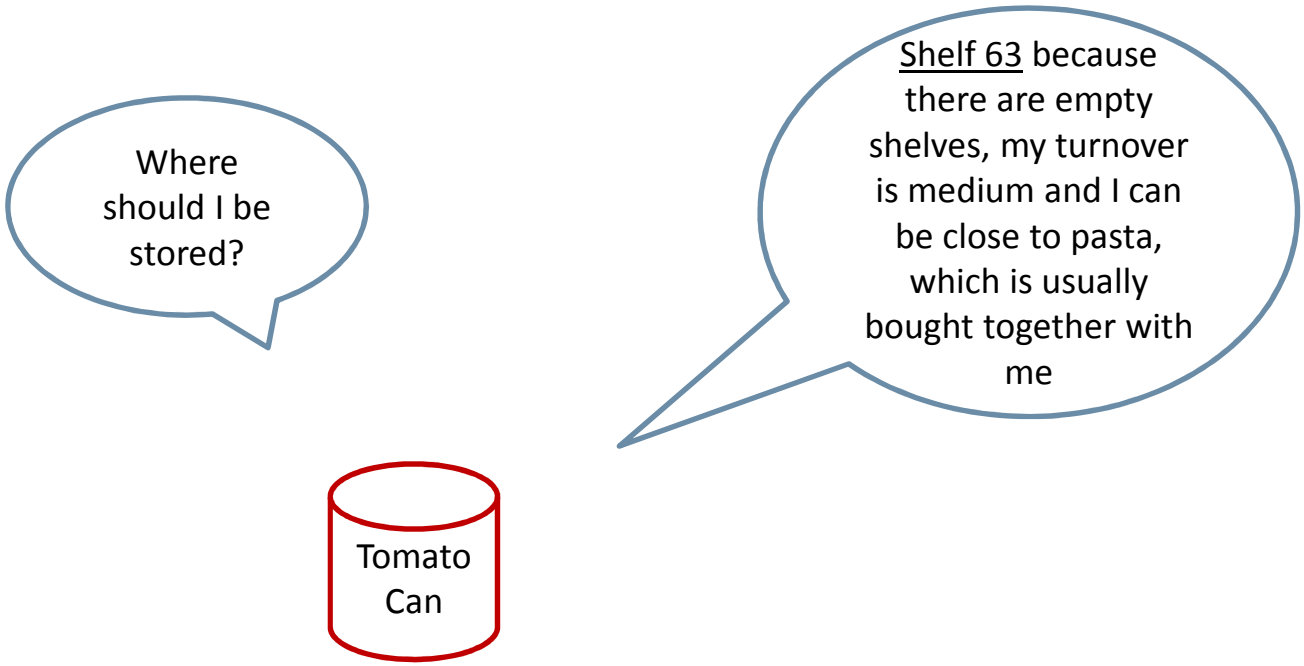
1. Adaptive storage location assignment
The notion

Determine the optimal storage assignment for the **newly delivered product instances** in a timely manner based **on historical product data**. (Chiang et al., 2011)



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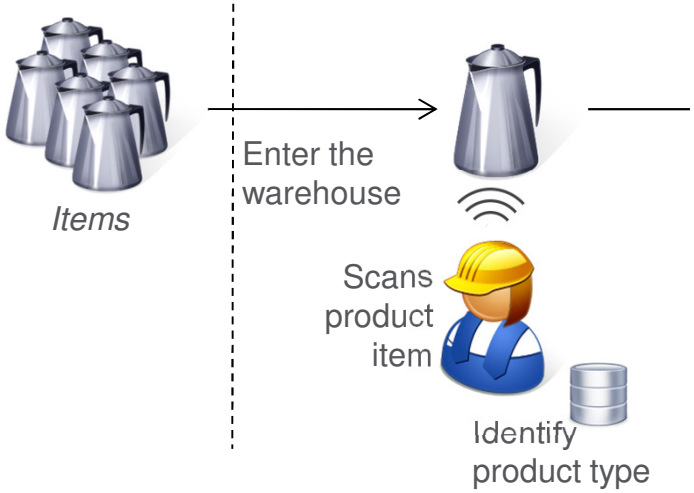
1. Adaptive storage location assignment
The process



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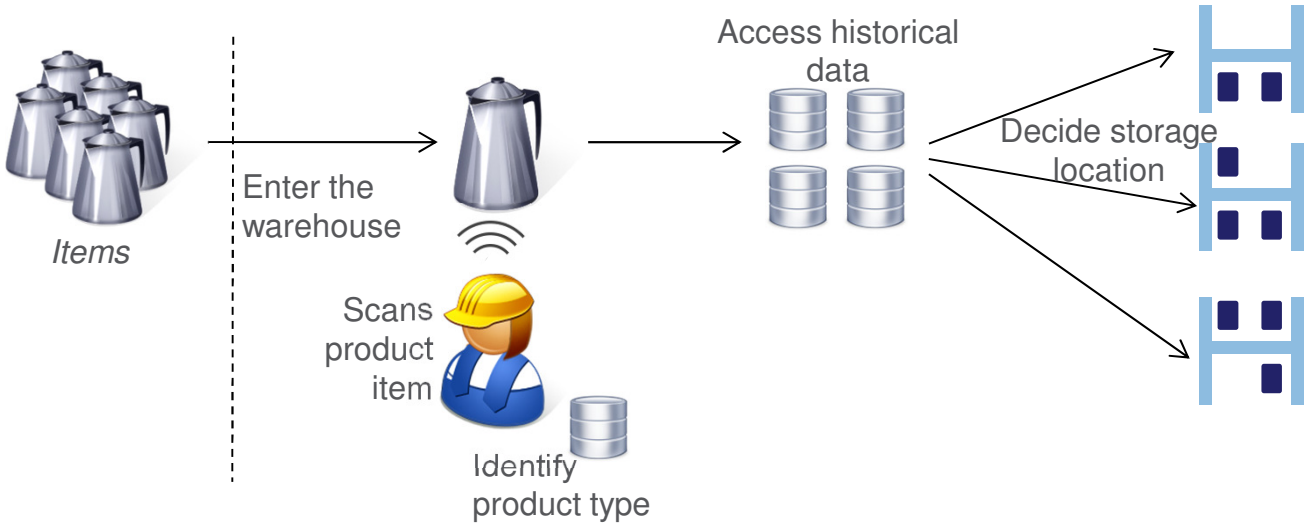

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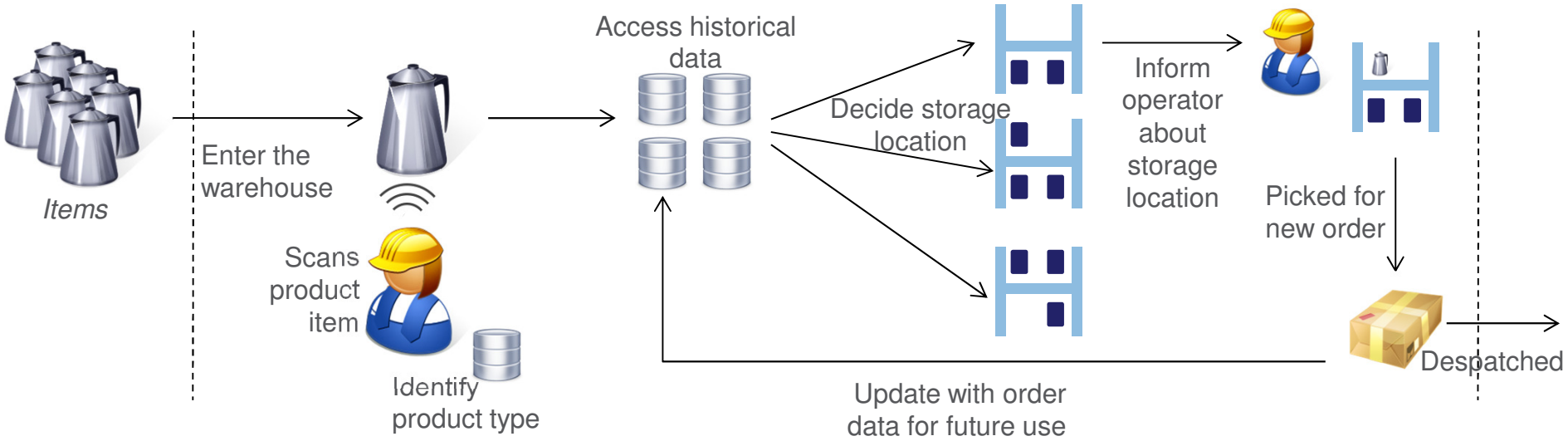
The process



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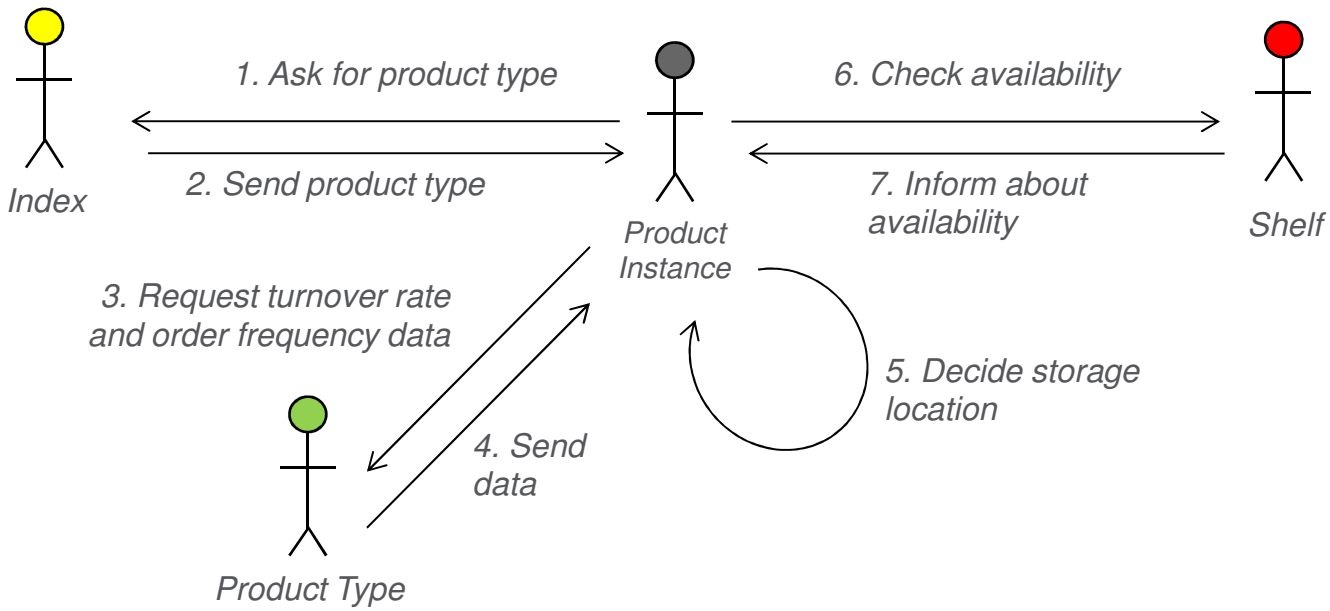
1. Adaptive storage location assignment
Agents interaction and decision making



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1. Adaptive storage location assignment
Case example

JAMES AND JAMES

1300 storage locations

up to 6 product types/storage location

~40 items/storage location

7.5 deliveries/day, 7 product types/delivery

1000 orders/day

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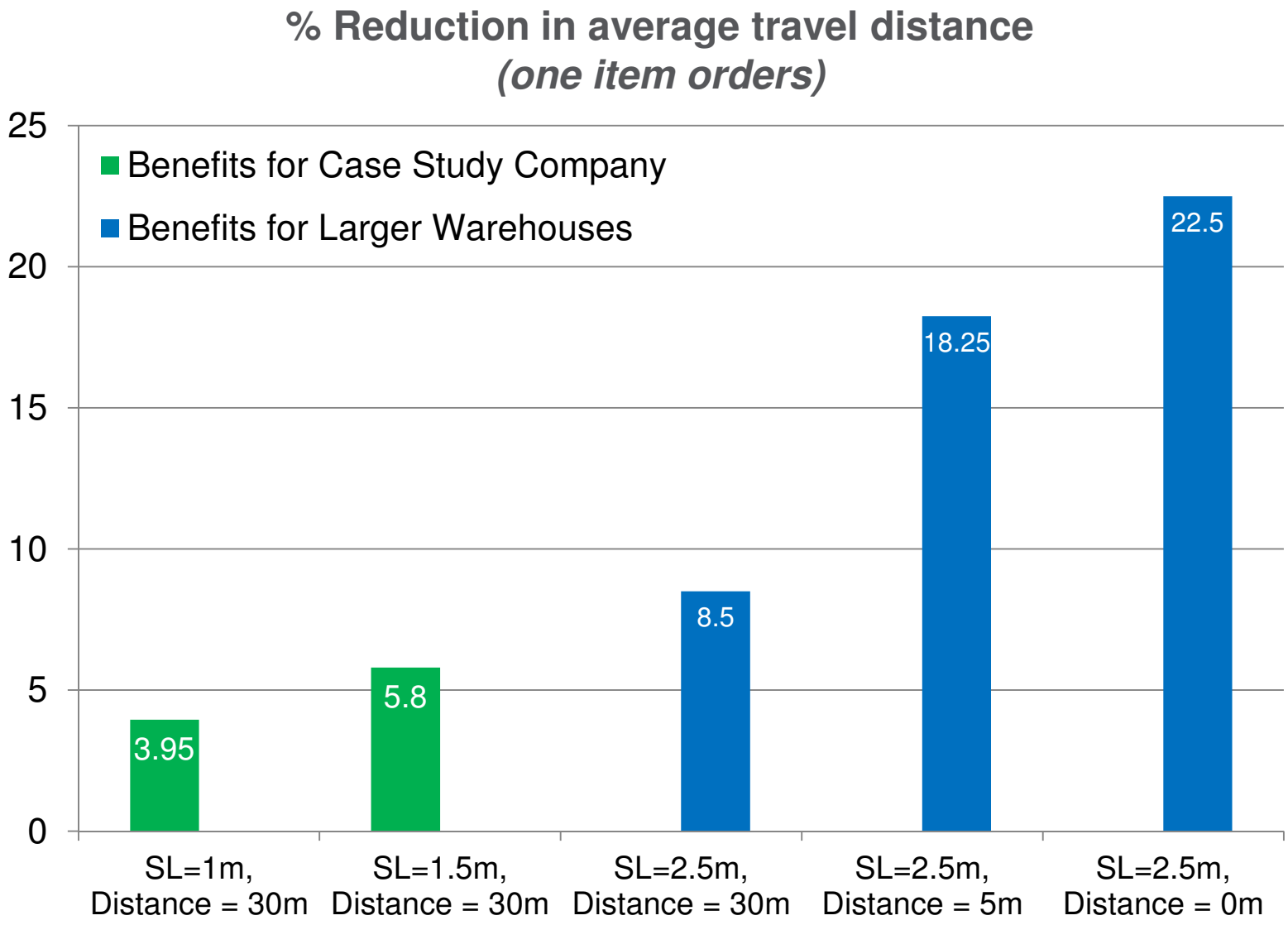
1. Adaptive storage location assignment
Some results



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1. Adaptive storage location assignment
Other findings

An adaptive strategy can be **beneficial** in today's warehouses…

…but **not in all of them**. Customer demand and disruptions matters

The **faster your requirements/needs** change the better such an adaptive strategy will be

Some companies **already gather information** they could use more effectively

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1. Adaptive storage location assignment
GS1 standards

Requirements:		GS1 standards:
A. Identify cases	→	GTIN
B. Identify items	→	GTIN, SGTIN
C. Identify storage locations (shelves)	→	GLN,SGLN
D. Identify human operators (pickers) via handheld devices	→	GSRN
E. Calculate picking time and distance	→	EPCIS events
F. Collect and store product information for later use	→	Potential use of GPC for mapping to product category

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Agenda

1. Adaptive storage location assignment

2. Customer intervention

3. IT architectures for logistics integration

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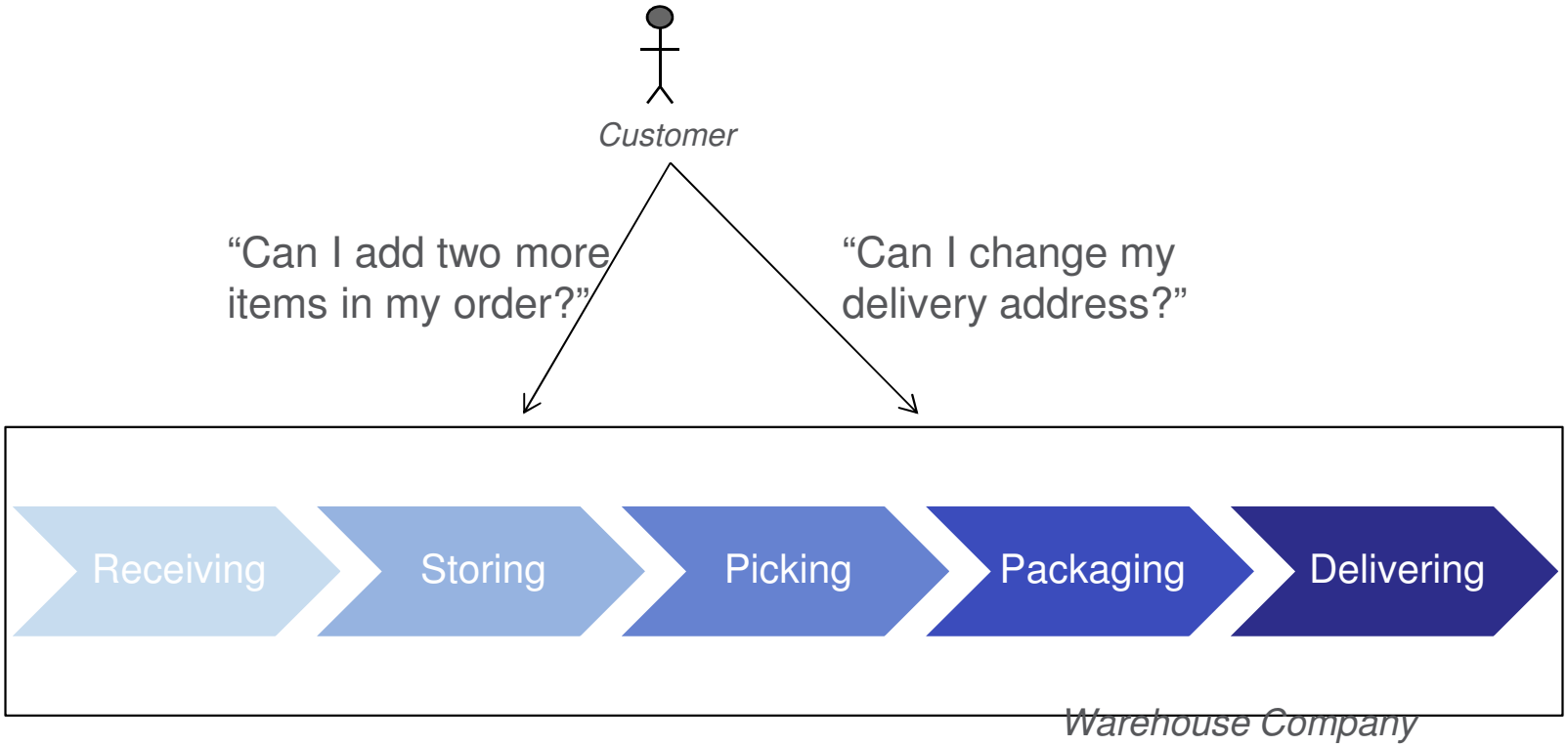
2. Customer intervention
The notion

Is it possible for a customer to automatically influence his own logistics orders during processing/delivery?



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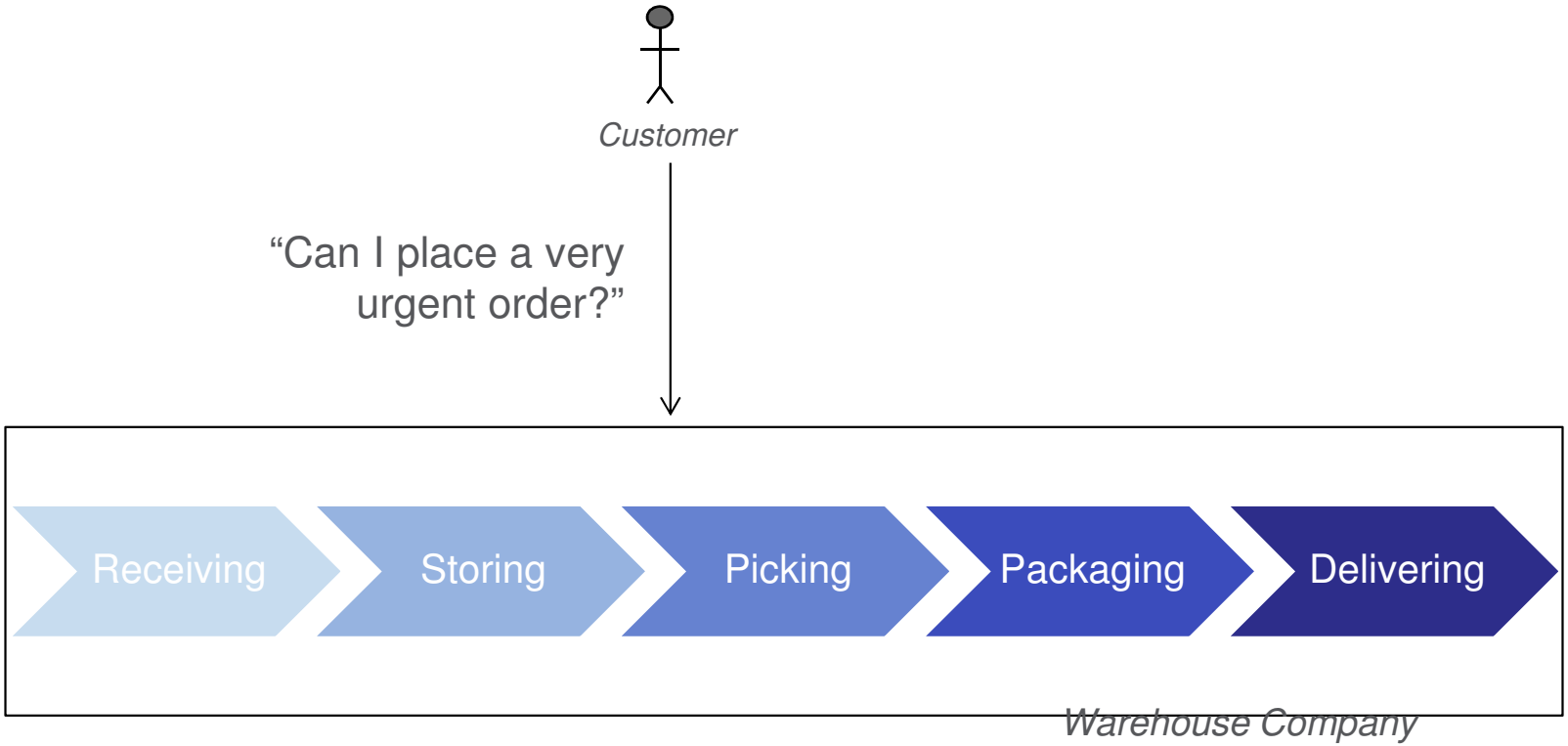

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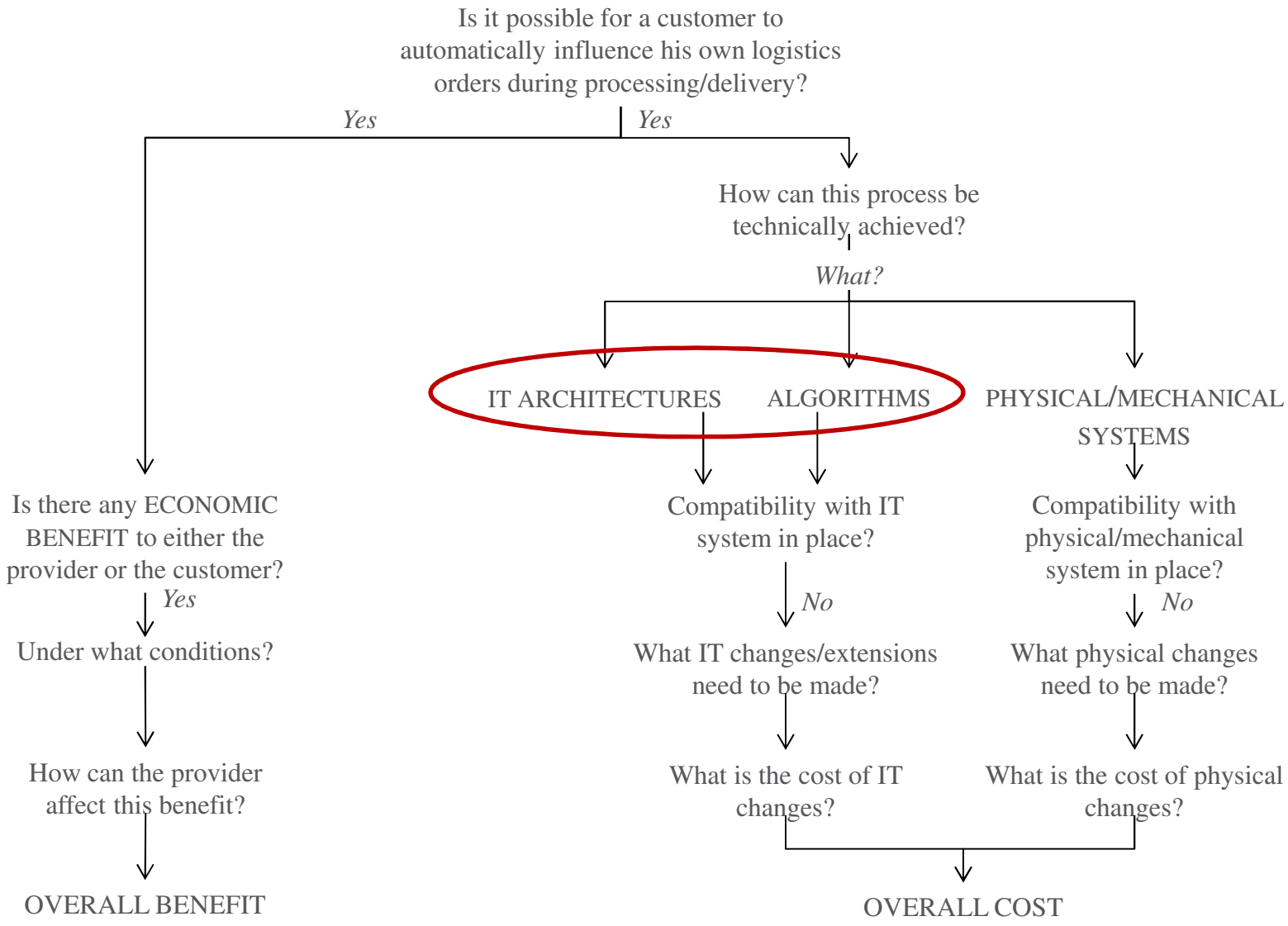
2. Customer intervention
Open challenges



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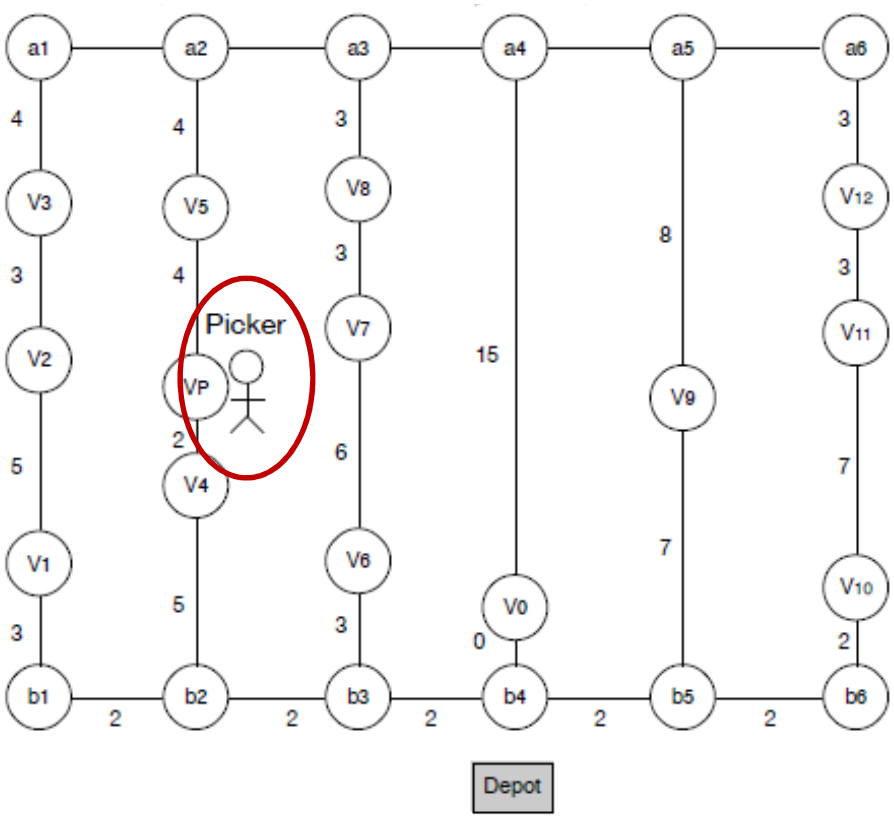
2. Customer intervention
Interventionist routing algorithm



(a) Graph of the order-picking layout

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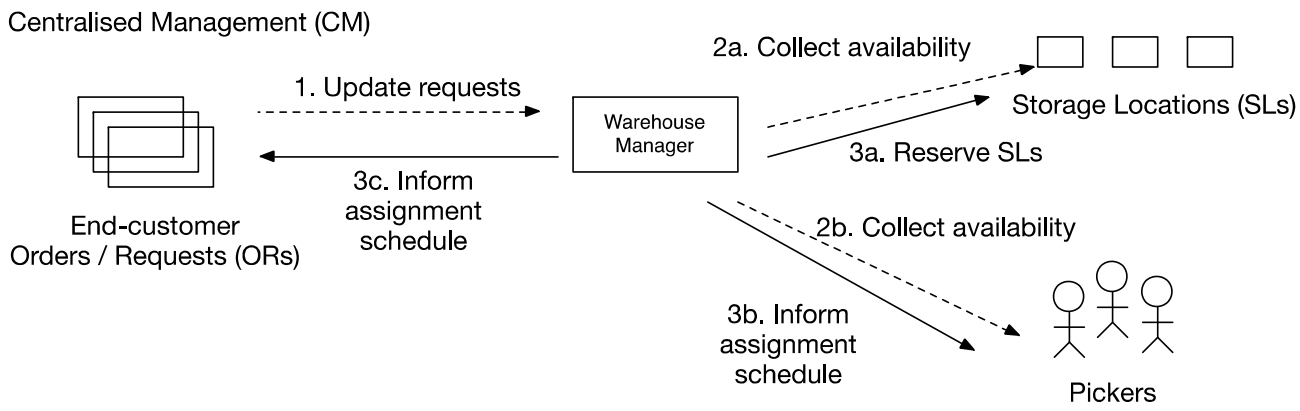
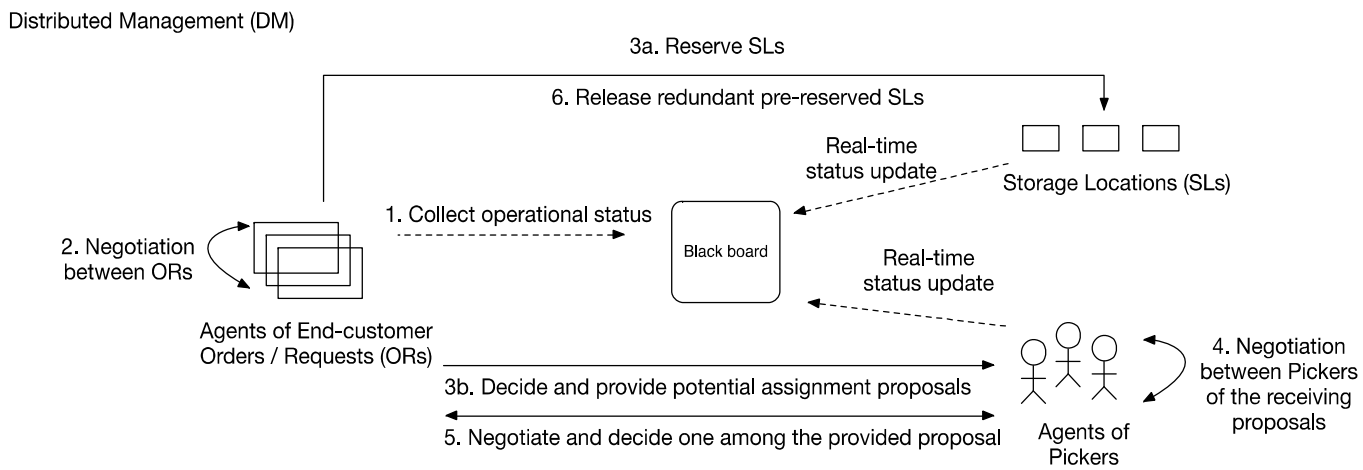
2. Customer intervention
Potential architectures





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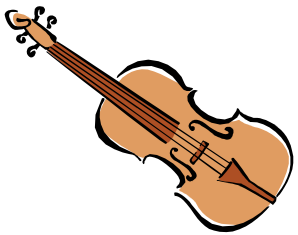
Product Intelligence: What is it?

Linking physical items to information and rules governing the way they are intended to be handled and that enables the product to support or influence operations.

Customised violin



Information

Rules

Product ID
Type = “Customised Violin”
seller.address = “Shanghai, China”
receiver.address = “Cambridge, UK”
deliverBefore = 24.12.2013, 12:00 GMT
route = “Shanghai; Istanbul; Frankfurt; Birmingham; Cambridge”
deliveryDate = 22.12.2013, 13:30 GMT
newDeliveryDate()

```
deliveryDate = newDeliveryDate;
if (deliveryDate > deliverBefore) then {
  routes = identify.newRoutes(receiver.address,
  deliverBefore, currentLocation);
  newRoute = evaluate(routes);
  route = newRoute;
  inform.transportationProvider(route);
}
```

“Put this box in the next flight to London”

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Product Intelligence: What is it?

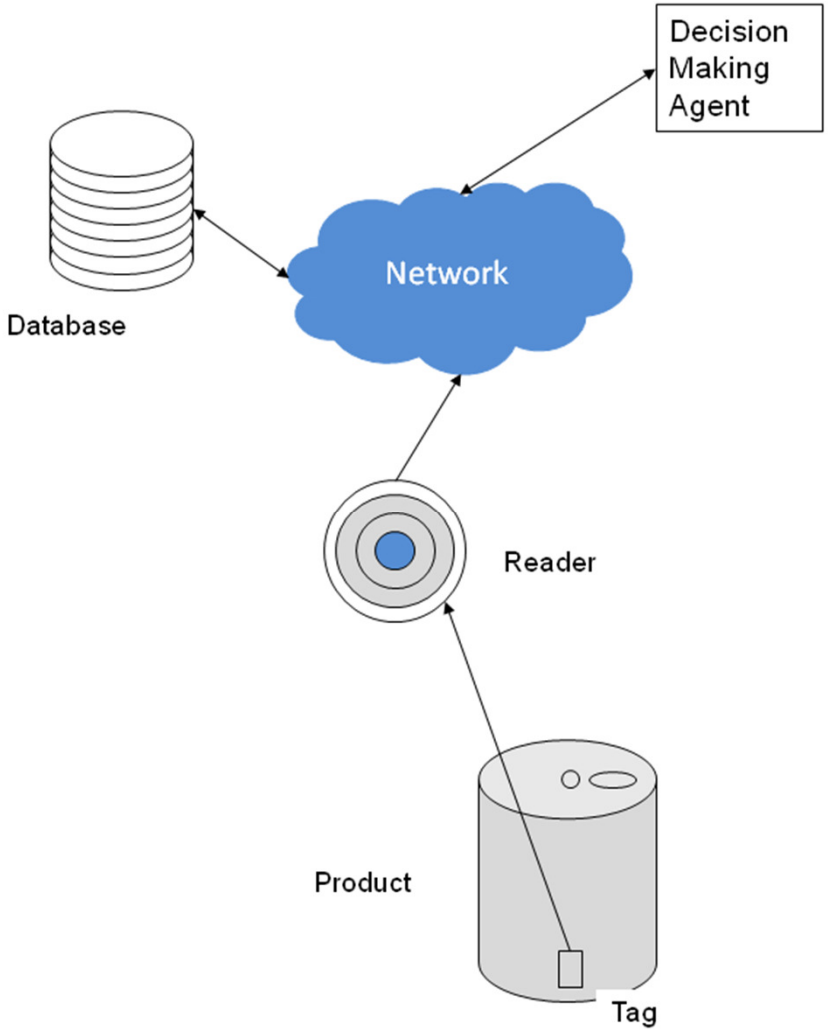
1. Possesses a unique identity

2. Is capable of communicating effectively with its environment

3. Can retain or store data about itself

4. Deploys a language to display its features, production requirements etc.

5. Is capable of participating in or making decisions relevant to its own destiny



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2. Customer intervention
Other uses of the approach

1. Substitutes

Ordered but
out of stock

Pick this instead

2. Arrival of new orders

3. Problems with pickers

Broken trolley

Sickness/Accident

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2. Customer intervention
GS1 standards

Requirements:		GS1 standards:
A. Identify orders/customers	→	GSRN, SSCC
B. Identify items	→	GTIN, SGTIN
C. Identify storage locations	→	GLN,SGLN
D. Identify human operators (pickers) via handheld devices	→	GSRN
E. Calculate picking time and distance	→	EPCIS events

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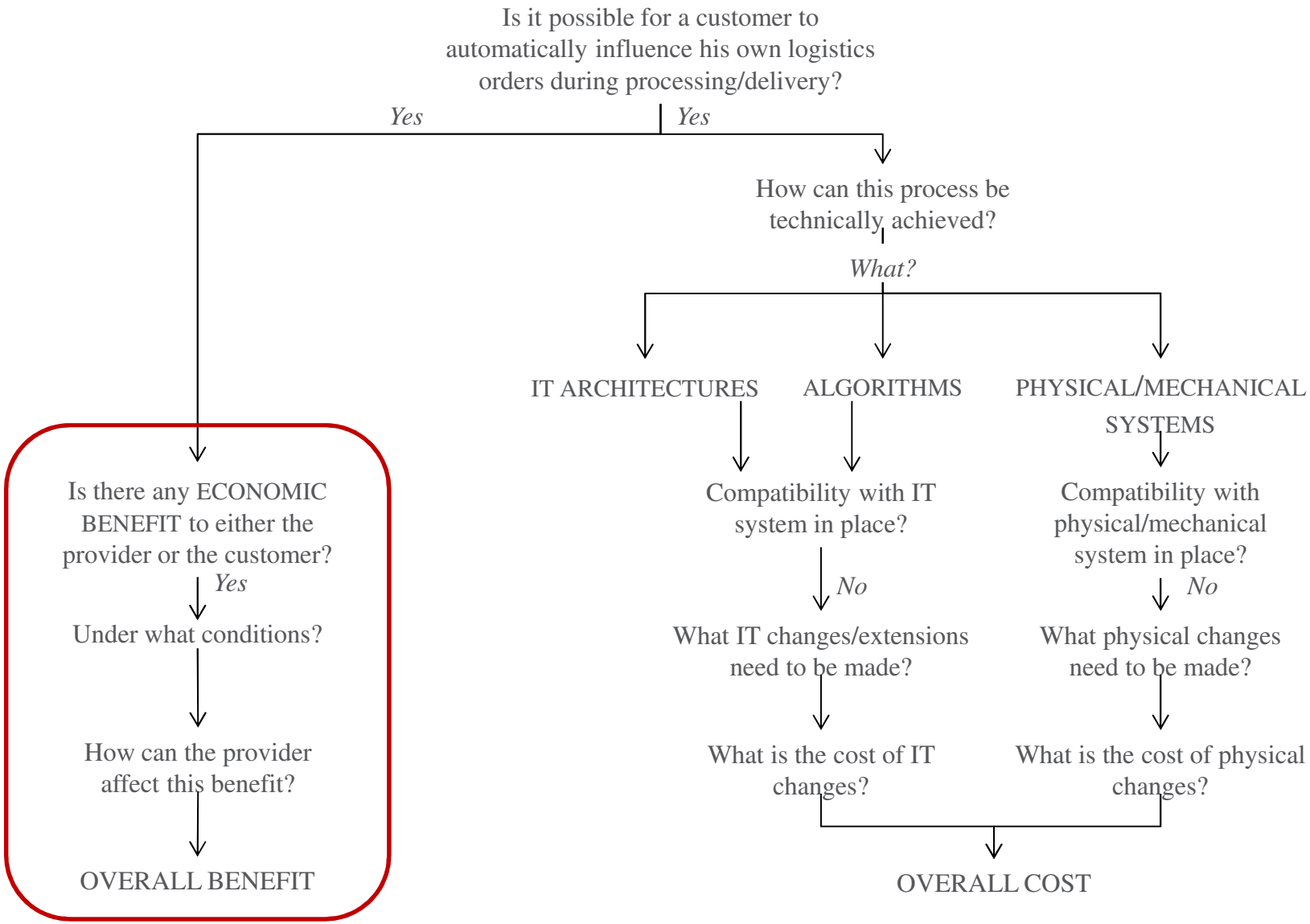
2. Customer intervention
Open challenges



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2. Customer intervention
Fixed and Flexible offerings

*Given a range of **logistics offerings** currently offered to customers, under which circumstances should the provider **offer the opportunity for intervention**, and, if so, how should the extra options/services offered be **priced**?*

Fixed offerings		**Flexible offerings**
Details of offering are fixed upfront when order placed	*vs.*	Details of offering may vary after the order is placed

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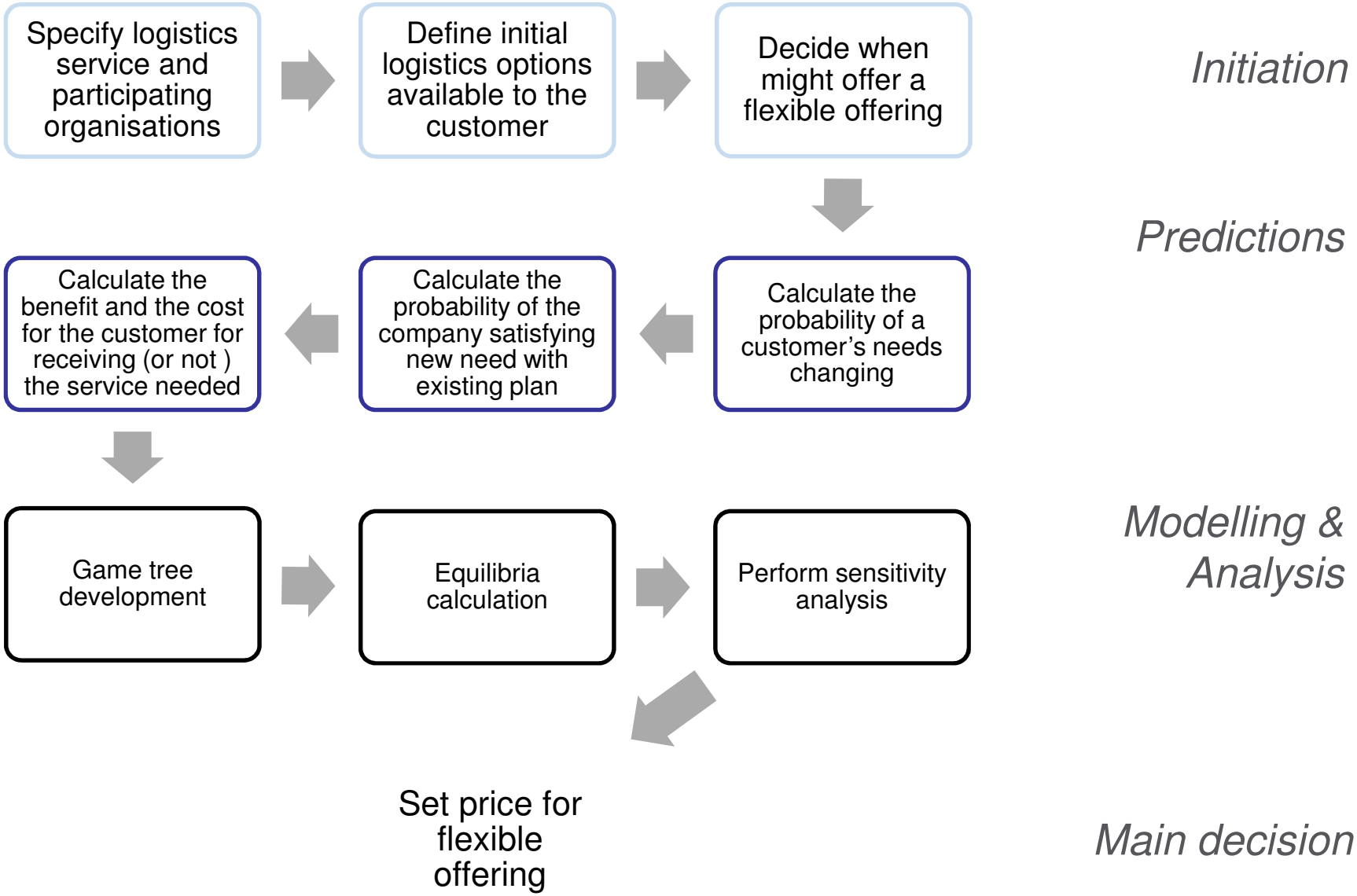
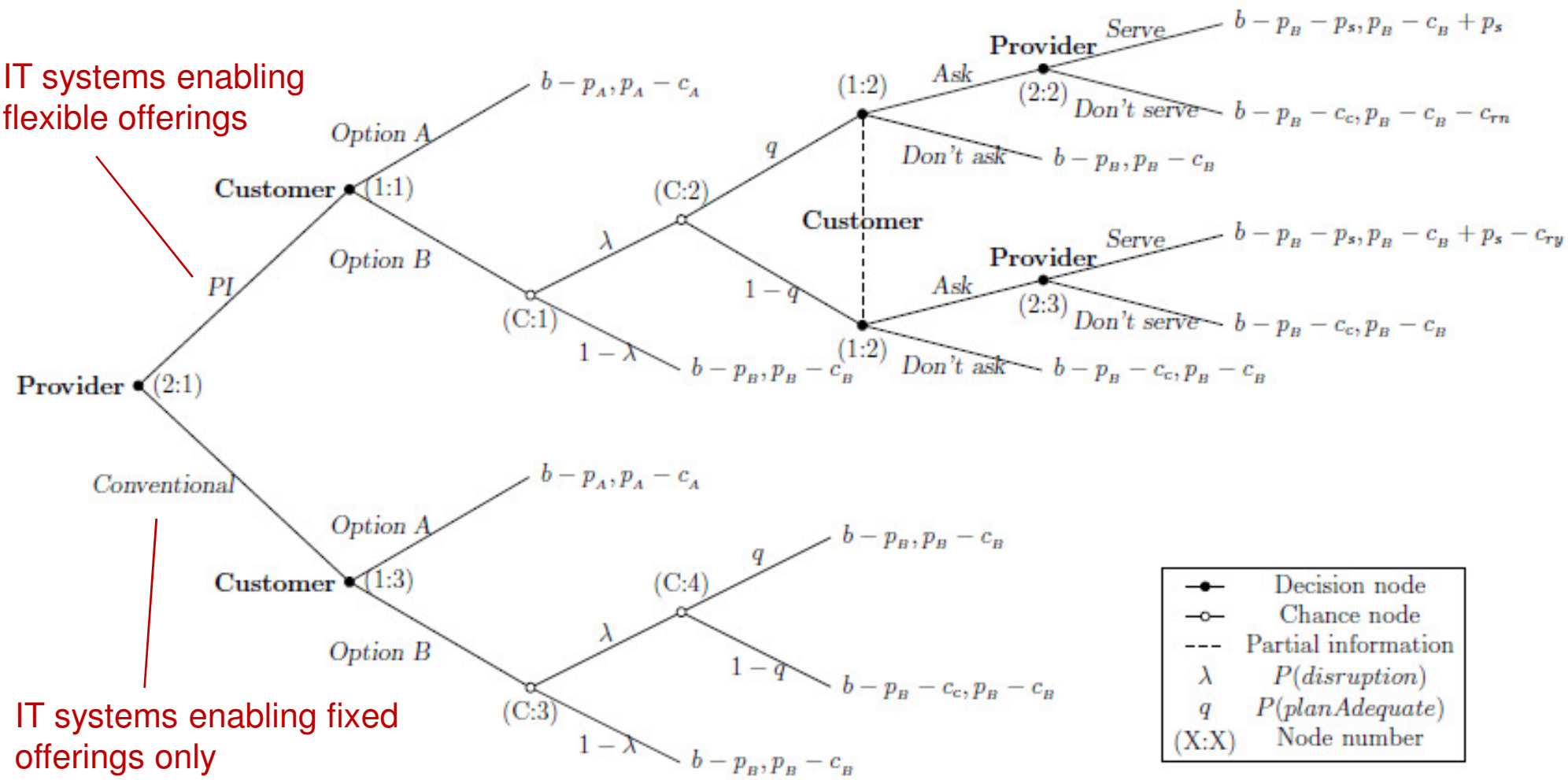
2. Customer intervention

Guidelines for a provider considering flexible offerings



2. Customer intervention
Game theoretic model

IT systems enabling flexible offerings



IT systems enabling fixed offerings only

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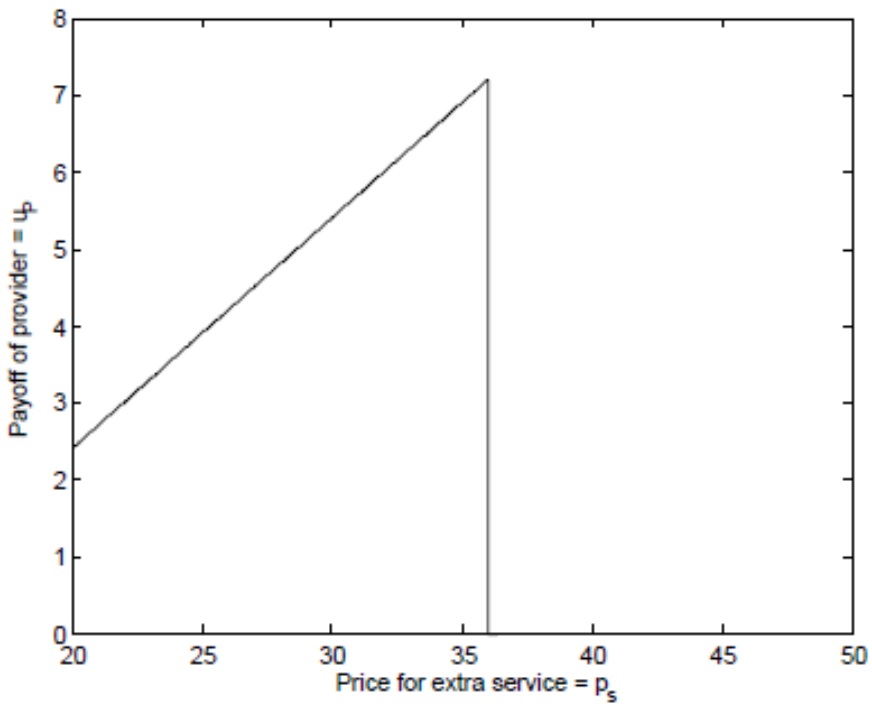
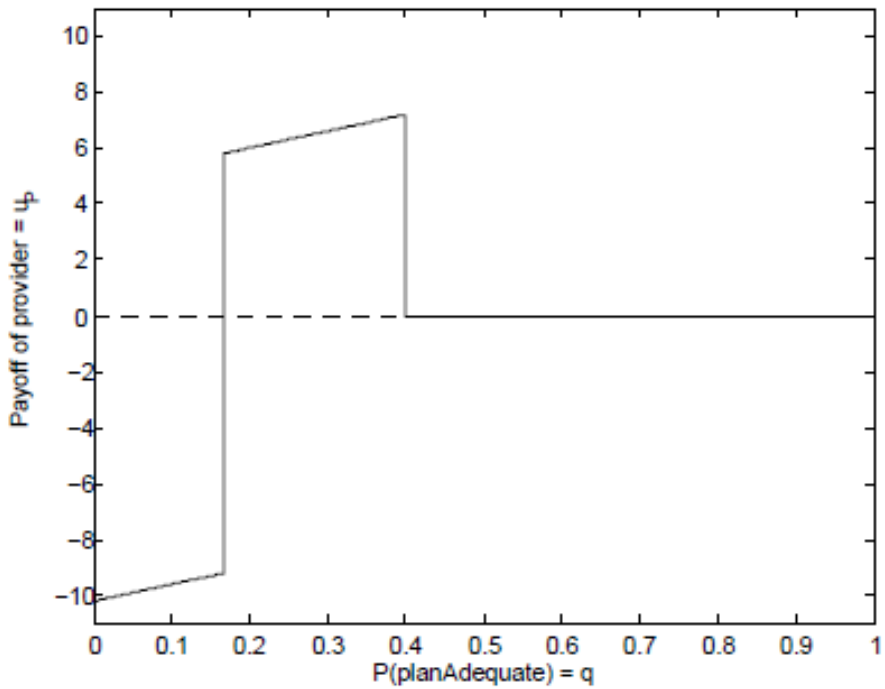
2. Customer intervention
Provider returns



Different price requested



Different probability for customer disruption

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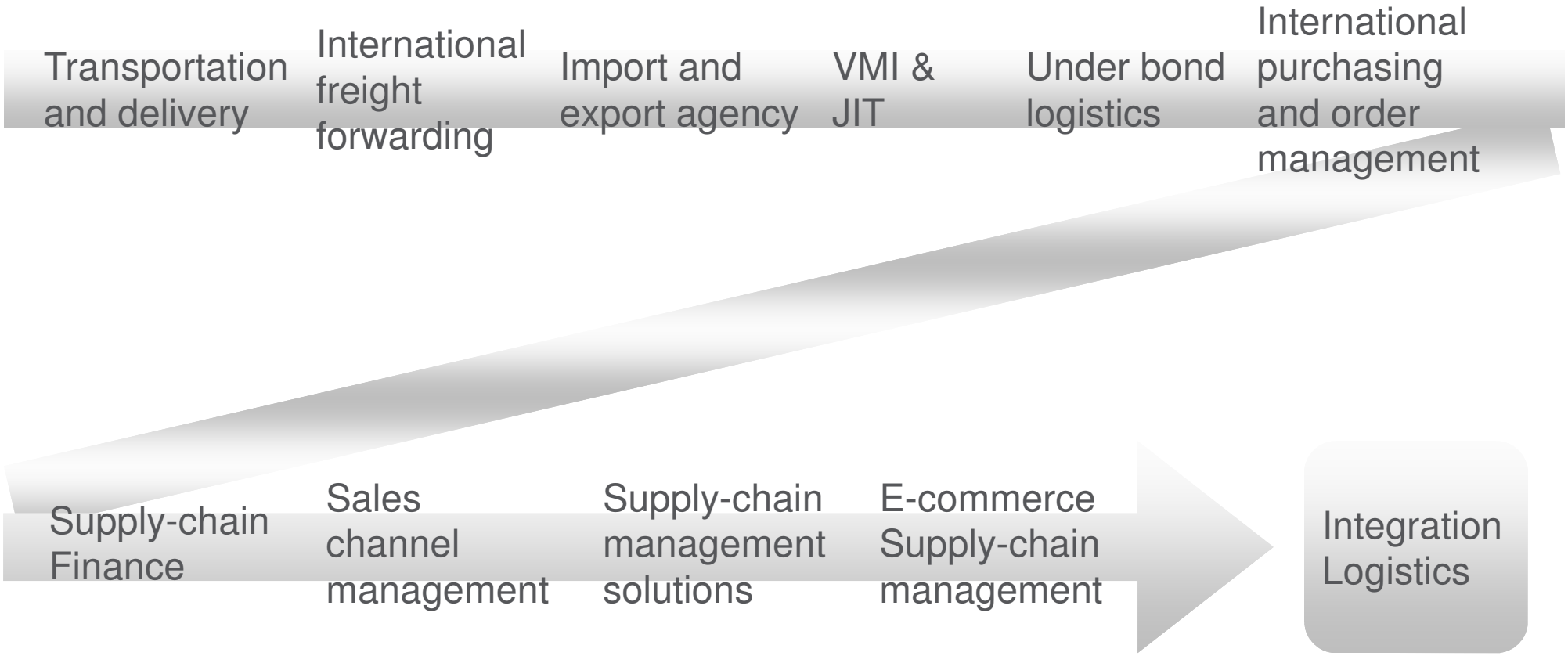
Integrated logistics



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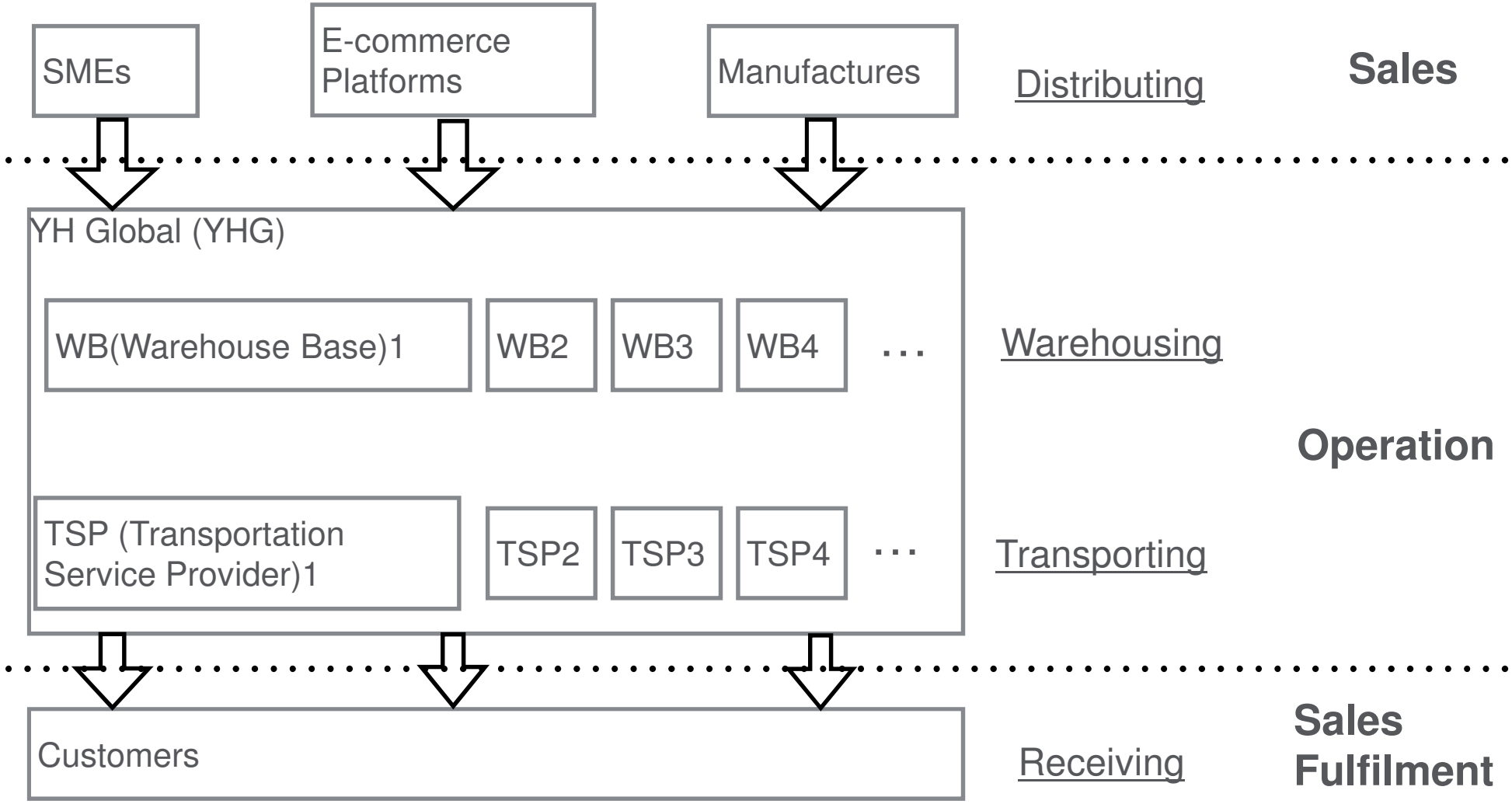
3. IT architectures for logistics integration
Integrated logistics



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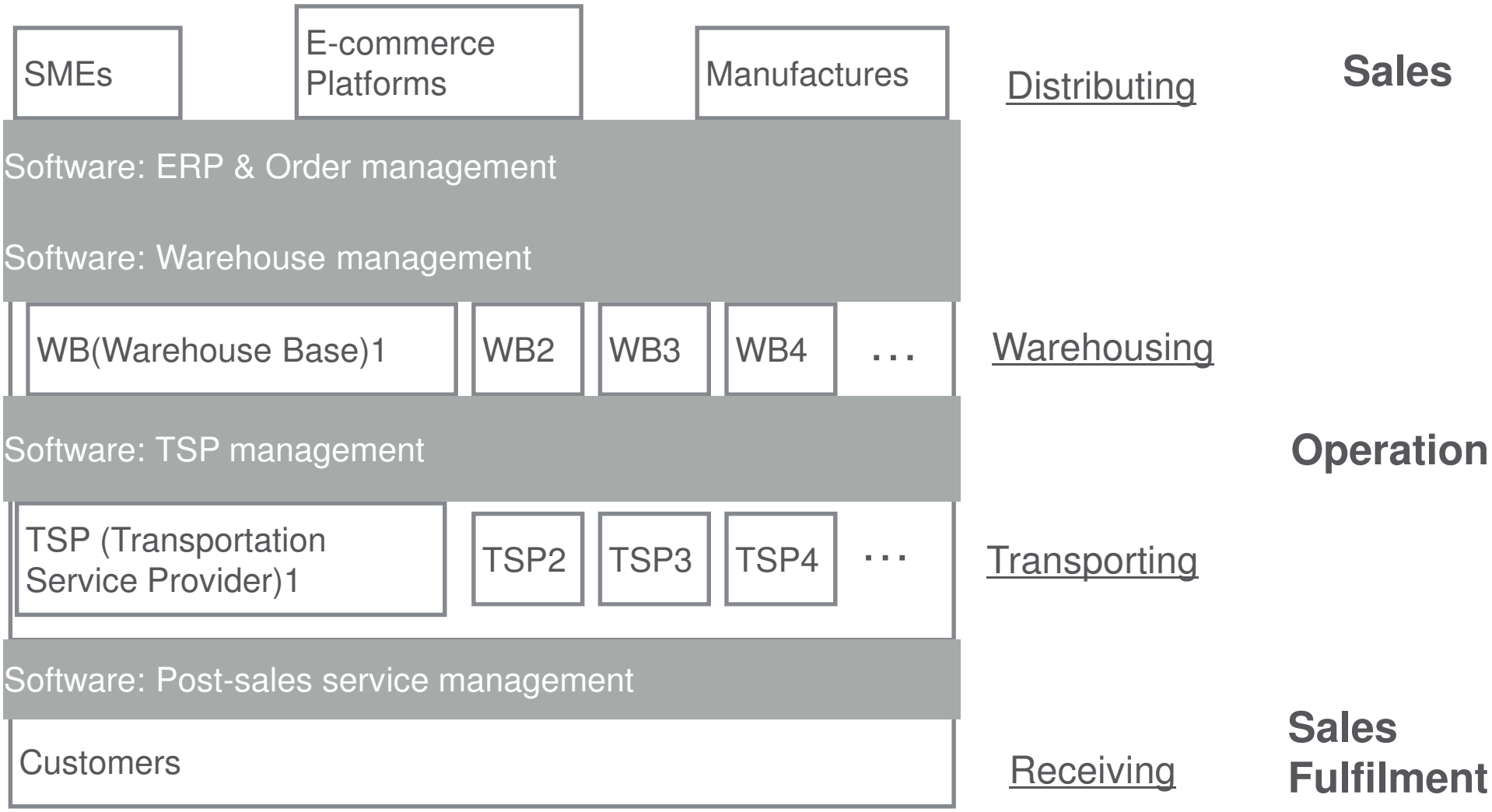
3. IT architectures for logistics integration
Integrated logistics



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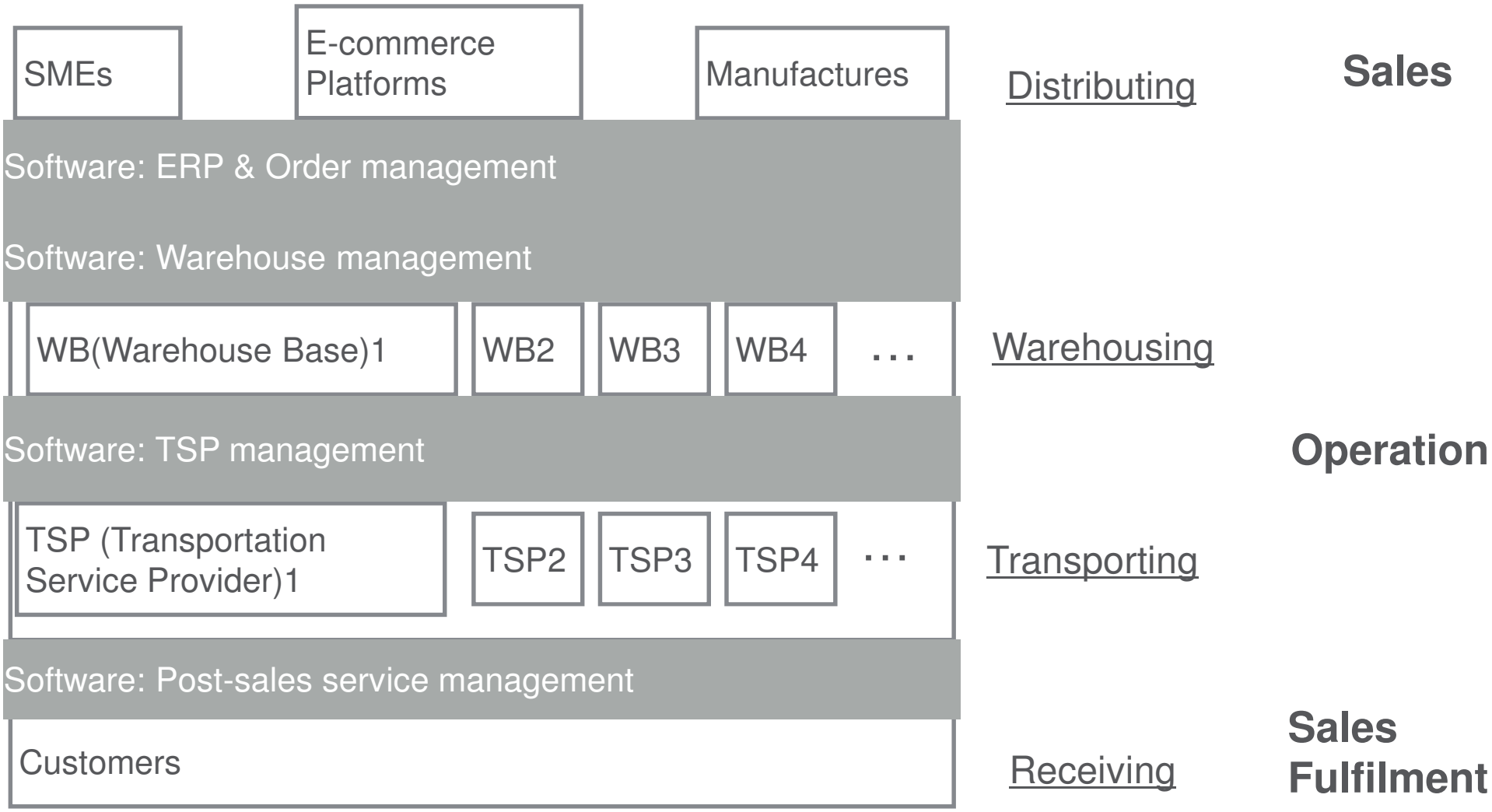
3. IT architectures for logistics integration
Integrated logistics



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3. IT architectures for logistics integration
Integrated logistics

- Objective 1- Improve **managerial efficiency**: through integrated IT system that provides directional and timely **statistical data for various level of management**;

- Objective 2 - Increase **operational efficiency**: through **automated IT system** that schedules the operations;

- Objective 3 - Improve the **company performance**: through intelligent IT system that **optimises the efficiency and resilience** of the automated schedules.

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Thank you!

Innovation in Warehouse Management Systems

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