Physical Internet Enabled Bulky Goods Urban Delivery System
A Case Study In Customized Furniture Industry

Hao Luo, Siyu Tian & Xing T.R. Kong
Research Background

Bulky Goods Delivery
Bulky Goods in Urban Logistics

- Fitness Equipment
- Furniture
- Musical Instruments
- Household Appliances
UPS weighs strategy to deliver bulky goods to boost growth

UPS and its rival FedEx Corp (FDX.N) currently deliver parcels up to 150 pounds (68.04 kg) in weight to a person’s door step, and neither carries packages into a person’s home or handles so-called “white glove” services such as product assembly or installation.

United Parcel Service Inc (UPS.N) is in talks with at least one U.S. trucking firm to launch an in-home delivery service for large, heavy goods such as couches and treadmills, as the world’s largest package deliverer looks to cash in on one the fastest growing segments of online retail.

UPS told Reuters it is now eyeing the furniture delivery business - one of the fastest-growing segments of online retail - with Amazon.com Inc (AMZN.O), Wayfair Inc (W.N) and other e-commerce companies competing for market share against chains like Crate and Barrel and big-box stores.
Furniture is one of the typical products in bulky goods delivery. With the upgrading of consumption structure and the O2O commercial technology, customers are not satisfied with a standardized product. They are willing to participate in the design and manufacturing process. Furniture customization industry is growing as more and more promising one.

Comparing the accumulated net profit (100 million RMB) and growth rate of customized and finished furniture in China

Source: http://www.chyxx.com
Business Challenges
Characteristic and Pain Points in Customized Furniture Delivery
SPZP - Customized Furniture in China

- Funded in 2004
- 800+ Chain stores in Beijing, Shanghai, Guangzhou, Wuhan
- 2017 total revenue 5.3 Billion (RMB) rise by 32.23% over the same period of 2016
- 100+ Whole House Furniture Customization orders per Day
- Largest Furniture Database + House layout Database + House Design Database
SPZP-O2O Customization

STEP 1
Online Reservation
Reservation by Website, Smart Phone, Phone Call
FREE

STEP 2
Offline Room Measurement
Professional Quantity Surveyor onsite Measurement
FREE
SPZP-O2O Customization

STEP 3
Online Design

1000+ Professional Cloud based Online Designer FREE

STEP 4
Offline Experience

Review the Rendering in Offline Store. Pay
STEP 5

Manufacturing in Smart Factory

Cutting Robot

Drilling Robot

Packing Robot

Warehouse Robot

300,000 Pieces/Day

Flag of Industry 4.0 in China
Logistics Manager of SPZP: “If nothing changes, the logistics cost will exceed the Product Price”
**Various of Order Size**
Order size is quite different. Due to the different sizes of the customers' rooms, the quantity of products contained in each order is different.

**Multiple Components**
Most of the product form is board–shape furniture components and a large number of metal accessories.

**Unique piece**
All components are make-to-order produced, and the customized furniture produces only one single piece.

**Punctual Delivery**
The delivery time is about 3 months after make order. Hard to predict the delivery time required by the customer when ordering.
Pain Points of Customized Furniture Delivery

Heavy Workload of Material Handling
- 300+ pieces of components / order
- Unloading from the truck one by one
- Moving from unloading point to room
- Elevator may not available!!

Unclear Responsibility for Operators
- Truck driver may need to do the material handling work.
- Truck driver may need to wait during the material handling.
- Material handling operator has to go with driver

High Risk of Product Damage
- Many times loading and unloading work
- Components without any protection
- One piece damage, whole order delay
- Long time for remanufacturing

Complicated Human and Vehicle Resource Planning
- Order consolidation Planning
- Truck loading planning
- Delivery route planning
- Operator assignment planning
03 Proposed Solution
Physical Internet Enabled Bulky Goods Delivery System
Proposed Solution Framework

Supporting PI Concepts

Hyperconnected city logistics
Crainic and Montreuil (2016)

PI-hub
Furtado et al. (2013)

Design of standard container
Size Lin et al. (2014)

Supporting Methodologies

Collaboration mechanism for truck driver and material handling operator

Routing optimization and vehicle planning optimization

Mobil APP for truck driver

Mobil APP for material handling operator

Mechanical design for vehicle-mounted loading/unloading equipment

Mechanical design for container stabilization During transportation

Data Analysis for Container Size Optimization

IoT and LBS enabled Lock/unlock control

Real-time resource planning

Mobil Task Execution

PI Vehicle

PI Container

PI enabled Bulky Goods Delivery System
PI Container

* China Patent in Progress 2017.07.01

History Data of Order Size

Container Sizing Optimization

Universal wheel Design for on-site movement

IoT Locker with LBS (location base service) And Mobile App Control

NB-IoT GPS
PI Vehicle

* China Patent in Progress 2017.07.01
Mobil Task Execution

- Moving Task Location
- Moving Task Assignment
- PI container Unlock
- Assembly Instruction
- Material Handling Operator App
- Truck Driver App
- Delivery Time Table
- Delivery Task Navigation
- Material Handling Task Generation
Real-Time Resource Planning

- Real Time Delivery
- Task Tracing
- Real Time Material
- Handling Task Assignment
- Real Time Delivery
- Task Assignment
- Real Time Order
- Consolidation
- Real Time Material
- Handling Task Tracking
- Real Time Container
- Collection Task Assignment
04 Feasibility Analysis
Process Feasibility and ROI Analysis
Assumptions of Process Analysis

- 6 delivery points: Customer A, B, C, D, E and F)
- 1 product warehouse in the factory.
- 1 truck can load at most 3 customer orders
- Delivery the orders one by one in a milk run route.
- The transportation time between each delivery point is about 1 hours.
- The unloading time and material moving time for 1 order is about 3 hours.
Real-Time Resource Planning

PI enabled bulky goods delivery System

Legend:
- empty container
- PI enabled container
- driver
- material handling worker
- traditional Vehicle
- PI enabled Vehicle

Customer C
Customer B
Customer A
Customer C
Customer B
Customer A

DAY 1
Efficiency Comparison

<table>
<thead>
<tr>
<th>6:00</th>
<th>7:00</th>
<th>8:00</th>
<th>9:00</th>
<th>10:00</th>
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<th>12:00</th>
<th>13:00</th>
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</tbody>
</table>

**DAY 1**
- **Traditional delivery system**
  - ×1 driver
  - ×1 material handling worker

**PI enabled bulky goods system**
- ×1 driver
- ×3 material handling workers

**DAY 2**
- **Traditional delivery system**
  - ×1 driver
  - ×1 material handling worker

Legend:
- **on the way**
- **unloading, handling upstairs**
- **loading**
- **PI enabled container**
- **empty container**

- Driver
- Material handling worker
# Return on Investment Analysis

Investment of PI Vehicle and PI Container

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
<th>Unit Price(RMB)</th>
<th>Total Cost(RMB)</th>
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</thead>
<tbody>
<tr>
<td>Cost of PI enabled Vehicle Development</td>
<td>10</td>
<td>100,000</td>
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<tr>
<td>Cost of PI enabled Container</td>
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<td>5,000</td>
<td>250,000</td>
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<tr>
<td>Total</td>
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<td>1,250,000</td>
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# Return on Investment Analysis

## Operation Cost and Profit Comparison

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit Price (RMB)</th>
<th>Traditional Process (3 delivery point/day)</th>
<th>PI-BGDS Process (6 delivery point/day)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Quantity</td>
<td>Total (RMB)</td>
</tr>
<tr>
<td><strong>Income</strong></td>
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<tr>
<td>Transportation Fee</td>
<td>300/Point</td>
<td>3</td>
<td>900</td>
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<tr>
<td><strong>Cost</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Salary of Driver</td>
<td>300/day</td>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td>Salary of Material handling worker</td>
<td>200/day</td>
<td>1</td>
<td>200</td>
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<tr>
<td>Fuel Cost</td>
<td>20/point</td>
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<td>80</td>
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<td><strong>Profit</strong></td>
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<tr>
<td></td>
<td>320/day</td>
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</table>

**Period of Cost Recovery (10 PI-Vehicles, 50 PI-containers)**: 284 working days

**Return on investment (ROI) (240 working day/year)**: 84.48%
Conclusions

The key challenges and pain points of bulky goods delivery, especially in customized furniture industry are identified.

Preliminary attempt to apply the PI concept into real life industry. PI enabled Bulky Goods Delivery System is proposed.

The proposed solution can improve the efficiency of transportation. It also has good ROI for logistics service providers.

Future Works

Future studies will focus on making the proposed solutions more practical.

- Algorithm for PI Container sizing optimization.
- Algorithm for multi Vehicle Routing Planning
- Resource management and Dashboard System Development
- PI-Container and PI Vehicle Development
Thank you