Urban Consolidation Centers – an Analysis of Internal Processes Using Discrete Event Process Simulation

Max Wuennenberg

Content

Introduction

Introduction

- Continuous growth in the Courier, Express and Parcel (*CEP*) shipment sector (4.7 % per year expected up to 2026) [1]
- Increasing challenges for urban delivery traffic due to the rapidly rising importance of online retail [2]
- Services such as same-hour-delivery collide with conflicting environmental and social interests
- Urban consolidation centers (*UCCs*) as a possibility to meet these challenges
  - Located close to delivery areas
  - Function as a transshipment hub
  - Serve as interfaces between larger delivery vehicles such as trucks and small, environmentally friendly transportation alternatives for the last miles (e.g., cargo bikes)

This article presents a simulation-based approach for the analysis of UCCs and the identification of feasible design parameters

State of the art and research objectives

Urban consolidation centers for parcel distribution

- Shipments are pre-sorted at regional distribution centers
- Delivery to UCCs is provided by trucks in the 3.5- to 12-tons-range in the morning
- UCCs are usually located in areas with high population density
- UCCs are normally implemented using containers, swap-bodies, trailers, or buildings
- Shipments usually have a low weight and a low value
- Shipments are grouped using load carriers (roll containers or pallets)

Equipment and operations within storage processes

Technologies and organizational approaches considered in this work

- Two relevant types of load carriers (roll containers and Euro pallets)
- Four main types of identification technologies: smartphone, glove with built-in scanning device (*ID glove*), stationary camera, RFID scanner
- Row storage scheme
- Three types of storage strategies: First In – First Out (*FIFO*), Last In – First Out (*LIFO*), chaotic

Research objective

Shortcoming of previous research works

“Consideration of UCCs from a macro perspective rather than the processes inside the depot”

Resulting research questions

1. How can different UCC types be evaluated under variation of relevant layout parameters, as well as material flow and storage strategies by means of DES?
2. Which recommendations can be derived for the planning and dimensioning of UCCs, the processes to be carried out and the selection of identification technologies?

Modelling

Concept

<table>
<tr><th>Design Parameters</th><th colspan="11">Characteristics of Design Parameters</th></tr>
<tr><td>Parcel flow</td><td colspan="2">A</td><td colspan="4">B</td><td colspan="3">C</td><td colspan="2">D</td></tr>
<tr><td>Load carrier</td><td colspan="5">Roll container</td><td colspan="6">Euro pallet</td></tr>
<tr><td>Handling equipment</td><td colspan="5">Manual operated pallet truck</td><td colspan="6">Electric pallet truck</td></tr>
<tr><td>Identification technology</td><td colspan="2">Smartphone</td><td colspan="4">ID glove</td><td colspan="3">Camera</td><td colspan="2">RFID</td></tr>
<tr><td>Storage strategy</td><td colspan="3">FIFO</td><td colspan="5">LIFO</td><td colspan="3">Chaotic</td></tr>
<tr><td>UCC type</td><td>10 ft container</td><td colspan="3">20 ft container</td><td colspan="3">Swap body</td><td colspan="3">Small storage room</td><td>Large storage room</td></tr>
</table>

- ➢ Selection and definition of relevant design parameters
- Parcel flow: distinct combination of parcel volume and weight (flows with heavier parcels possessing a lower number of parcels overall etc.)
- Load carrier: calculation of number of parcels that can be transported with each load carrier using average parcel sizes from the respective parcel flow

- ➢ Quantification using Methods-Time Measurement

Implementation

1. Preliminary calculations

- Determination of the load capacity (average number of parcels) of a load carrier
- Determination of the required number of load carriers
- Selection of suitable UCC types

2. Setup of the simulation model

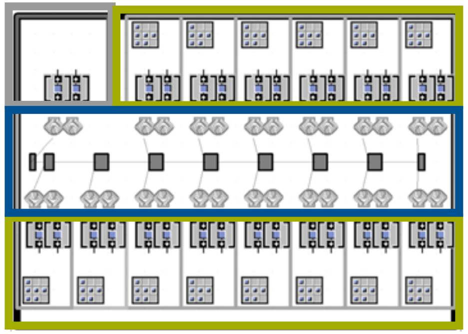
- Composition of transport module, workstation module and storage module
- Prediction: assumptions regarding future system behavior with respect to distinct metrics

3. Determination of meaningful output metrics

- Floor space utilization
- Total lead time = sum of storage time and retrieval time

Layout – 20-feet container

Simulation model – 20-feet container



Case study: application in Munich Schwabing-West

Overview of the validation scenario

District of Munich Schwabing-West [3, 4]

- 68 204 inhabitants
- Average delivery rate of 0.2 parcels per inhabitant and day

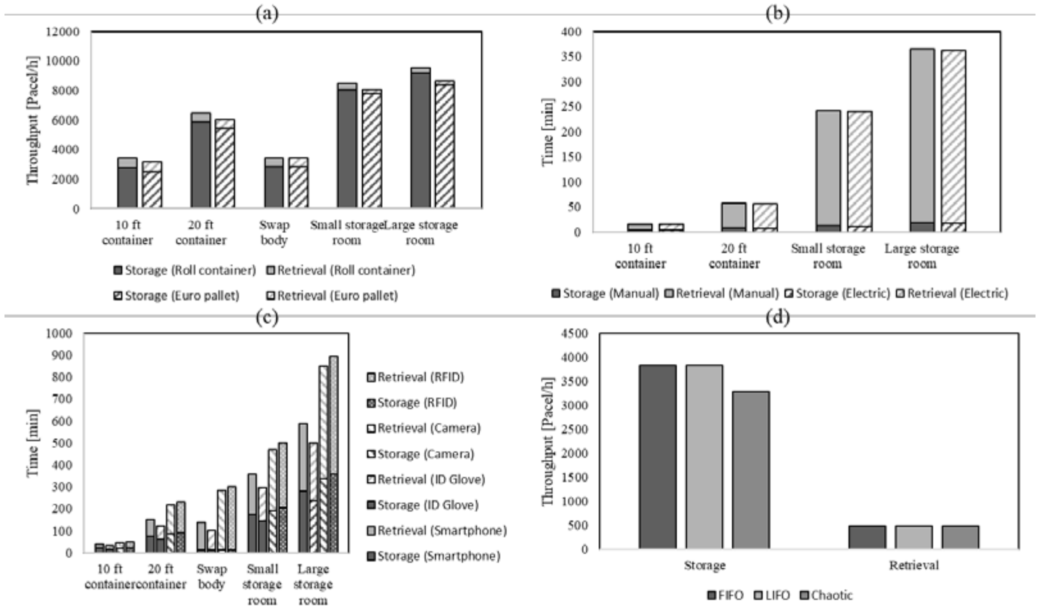
➢ 13641 parcels per day

- Five main CEP providers

➢ 2730 parcels per CEP provider and day

➢ Two UCCs per provider needed assuming a UCC delivery radius of 1 km

Results of the application (I/II: Logistics-related)



a) Storage time per parcel tends to increase with a larger number of load carriers. Roll containers have reduced operating times compared to pallets and for this reason, they can reduce the total storage time significantly. Regarding floor space utilization, roll containers show a better utilization rate than pallets
b) Electric pallet trucks show a shorter storage time due to their better maneuverability and speed
c) The ID glove has the shortest total lead time for all UCC layout types, while stationary RFID scanning causes the longest lead time
d) The chaotic storage principle achieves the largest storage time and thus the lowest efficiency. The FIFO and LIFO principles have a lower storage time and therefore a higher throughput

Results of the application (II/II: Monetary)

a) Euro pallets have the lowest investment costs in most UCC type scenarios. On the other hand, roll containers have lower variable costs.
b) Hand pallet trucks are more economical than electric pallet trucks due to their lower purchase price.
c) The use of a smartphone as an identification device in parcel sorting is the most cost effective. The ID glove can reduce variable costs even more in most cases, but it is not always the most cost-effective solution overall due to its high purchase price. The use of cameras and RFID results in higher capital costs and lower storage performance
d) The chaotic storage can be observed to have the highest personnel costs among the three storage strategies

Discussion

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Findings

- ✓ Relevant design parameters and UCC types have been determined
- ✓ A simulation model has been set up and adapted for the different UCC types

→ UCCs have been evaluated using discrete-event simulation and under the variation of different design parameters

- ➢ Logistical performance in the UCC could be significantly increased
- ➢ Personnel costs could be lowered through the reduction of working time
- ➢ However, due to the high purchase price, introducing technological equipment is not necessarily an absolute ideal solution for all UCC scenarios

Limitations

Not all possible cross-combinations of parameters were tested during validation due to high computing times

Time window per day for employees was set to eight hours for all simulation runs

The process was only simulated for one UCC within one day

Outlook

In the future, the simulation model could be extended to several UCCs over a longer time interval

Test trials in “living laboratories” could help to further optimize UCC systems

Conclusion

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- UCCs become an increasingly important and conceivable solution to make the last mile delivery of CEP service more efficient.
- By using UCCs and working closely with cities and municipalities, logistics and traffic, problems can be mitigated to help reduce congestion and emissions in inner-city residential areas.
- The consideration of costs involved depending on the choice of configuration parameters helps to select an appropriately designed UCC
- The use of roll containers, or (alternatively) electric pallet trucks combined with ID gloves supports in finding a balance between costs and achieved logistics performance

Literature

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Thanks for your attention!

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Max Wuennenberg, M.Sc.
Research Associate
Technical University of Munich
School of Engineering and Design
fml – Chair for Materials Handling, Material Flow, Logistics

Tel. +49 89 289 15975
max.wuennenberg@tum.de
www.mec.ed.tum.de/fml