Dynamic batching for order picking in warehouses
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Introduction
- There is a need for more efficient ways to organize the order picking process as
  - the number of daily orders to be processed increase
  - the required lead time becomes shorter
- We propose/analyze
  - an analytical model for dynamic batching
  - the difference between static and dynamic batching

Dynamic batching
- Dynamic batching is characterized by combining product demand from multiple customer orders into one pick tour where new orders are continuously received.
- Updated picking instructions can be included in the current pick tours which allows pickers to be re-routed to pick for new orders even when they already started a pick tour.

Difference between static and dynamic batching

Flow diagram dynamic batching

Model description
- At time t, a customer order i is either assigned to a current pick batch of an order picker (current batches) or to the backlog of orders for which an initial batching is made (future batches).
- The following model can be formulated

\[
\begin{align*}
\text{minimize} & \quad \frac{1}{|M_t|} \left( \sum_{i \in J} \sum_{h \in \Omega_i} c_i \theta_{ih} + \sum_{i \in \Psi} \phi_i \right) \\
\text{subject to} & \quad \sum_{i \in J} \sum_{h \in \Omega_i} a_{ih} \theta_{ih} + \sum_{i \in \Psi} b_i \phi_i = 1, \\
& \quad \sum_{i \in J} \sum_{h \in \Omega_i} \theta_{ih} = 1, \\
& \quad \theta_{ih}, \phi_i \in \{0, 1\}. 
\end{align*}
\]

- \( \theta_{ih} = 1 \) if batch \( r_h \) is the current pick batch of picker \( j \).
- \( \phi_i = 1 \) if batch \( r_h \) is a selected future pick batch.
- \( a_{ih} = 1 \) if and only if order \( i \) is included in current batch \( r_h \) of picker \( j \).
- \( b_i = 1 \) if and only if order \( i \) is included in future batch \( r_h \).
- \( c_i, \phi_i \) be the cost to pick the orders in batch \( r_h \) for order picker \( j \) or future batch \( r_h \).

Column generation algorithm
- In order to optimize the model we apply column generation.

Results – comparison static and dynamic batching

Conclusions and further research
- Dynamic batching leads to significant improvements in throughput and other statistics.
- Well suited for e-commerce companies that deliver same-day.
- Possible extensions
  - Robust route planning
  - Joint transportation planning