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Research Objective

This study proposes and analytically evaluates a collaborative material handling strategy to minimize the total unloaded travel in LTL cross-docks (XD).

Motivation

The current material handling paradigm in XDs is that material handlers (MHs) are responsible for unloading a single inbound trailer (*i.e.*, dedicated strategy). Hence, under this strategy the unloaded travel for each MH equals the loaded travel. However, if we break this paradigm by allowing MHs to collaborate, the unloaded travel may be dramatically reduced. Reducing the total travel distance in XDs positively affects their bottom-line.

Material Handling Strategies

Dedicated Strategy: After transporting a load from inbound to outbound trailer, return to the same inbound. (CURRENT)

Optimal Shared Strategy: A centralized decision support system optimizes the MHs' routes to minimize the total unloaded travel. (proposed by Carlo and Santiago-Montaño ISERC 2018)

Monomaniacal Strategy: After delivering a load to an outbound trailer, the MHs travel counterclockwise to the next available inbound trailer. (NEW)

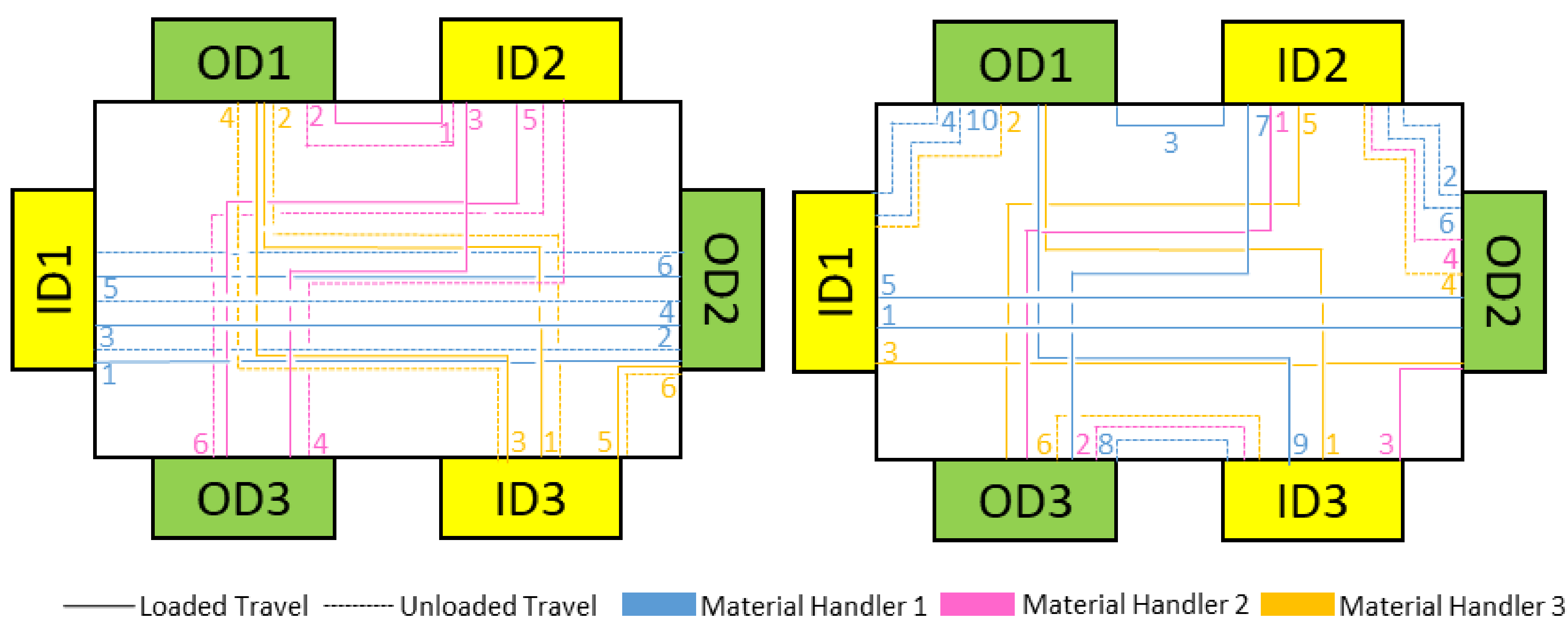


Fig. 1. Sample dedicated (left) and monomaniacal (right) unloading process.

Modeling Assumptions

The following modeling assumptions are made:

- inbound and outbound door assignments are given;
- unloading sequence in inbound trailers (LIFO) is given;
- material handling equipment (MHE) used in the XD can carry one load per trip and are readily available;
- the number of MHE equals the number of inbound trailers;
- the number of inbound trailers equals the number of inbound doors;
- each MH starts in a different inbound door and ends in the same door they started;
- all travel distances are known and measured rectilinearly;
- acceleration/deceleration and congestion are not considered;
- there is no staging at the XD.

Method

A linear integer program was designed to optimize the total material handling distance required to unload all pallets under both collaborative strategies. The formulation operates at the load (pallet) level and has an underlying Multiple Traveling Salesmen Problem structure. The only difference when solving the optimal and monomaniacal strategies is with respect to the unloaded distances. Lingo 11.0 was used to solve the model. The total travel for the dedicated strategy is twice the loaded travel, which is computed using the flow matrix and travel distances from the door assignment.

Experimental Results

A 12 door rectangular XD with 4 doors on the longer side and 2 on the shorter side is used to compare the three strategies. Half of the doors are inbound and the rest are outbound. The door assignments were heuristically optimized with SA for the dedicated strategy. Each trailer has 10 pallets that need to be cross-docked. Each inbound trailer interacts with between 3 and 6 outbound trailers. Ten instances are randomly generated.

A. Comparison of strategies without LIFO assumption

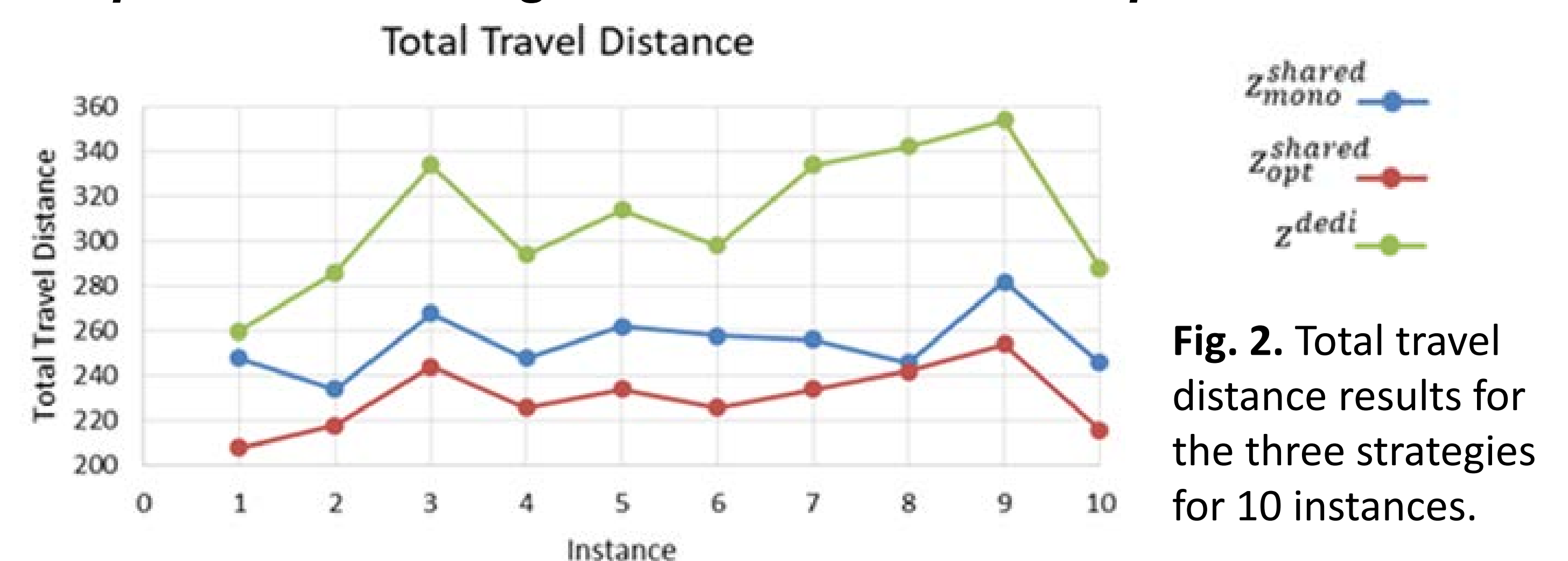


Fig. 2. Total travel distance results for the three strategies for 10 instances.

- Monomaniacal outperformed dedicated in all instances by an average of **17.45%** for total travel (34.91% in unloaded travel distances).
- Optimal shared outperformed monomaniacal strategy by **10.82%**.
- Pairwise Tukey test with a 95% confidence level confirms that the three operational strategies are statistically different.

B. Optimizing inbound door assignment without LIFO

- The optimal inbound door assignment for the dedicated was also optimal for both collaborative strategies.

C. Effects of LIFO in monomaniacal strategy

- The precedence constraints did not affect the objective function value.

Practical Relevance of the Work

This work proposes a new implementable material handling operational strategy for XDs that could significantly reduce the logistics costs without requiring any investment.

Implementation Challenges

Implementing a shared strategy might face some resistance by the MHs:

- union or haulers' rules and regulations;
- convincing MHs that the policy is fair and beneficial from the perspective of the MHs and the inbound trailers.