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IPIC 2021, International Physical Internet Conference 2021
June 14-16, 2021

We introduce protocols that can be applied at each hub to dynamically generate consolidation sets of parcels/modular containers and requests for on-demand transportation services ensuring reliable pickup and delivery within the promised time windows.

- *Concepts*
  - *Slack and Assigned Dwell Time*
  - *Information Sharing*
  - *Package Signaling and On-Demand Transportation*
  - *Maximum Latency*
  - *Priority Loading*

- *Local Latency Protocol (LLT)*

- *Maximum Latency Protocol (MLT)*

- *Results of Proposed Protocols*

- *Current Contracts vs. Proposed On-Demand Models*

At every intermediary node, we can calculate the latest departure time with respect to the promised delivery time and planned package route.

latest departure time p

p

p

p

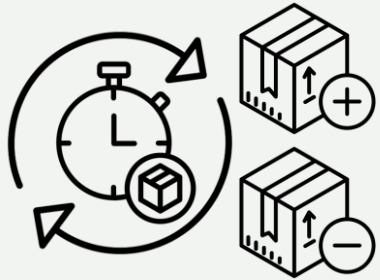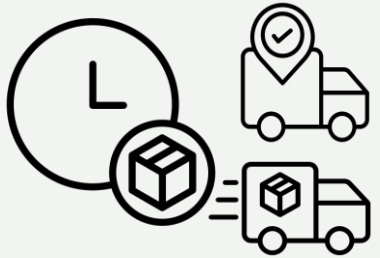n

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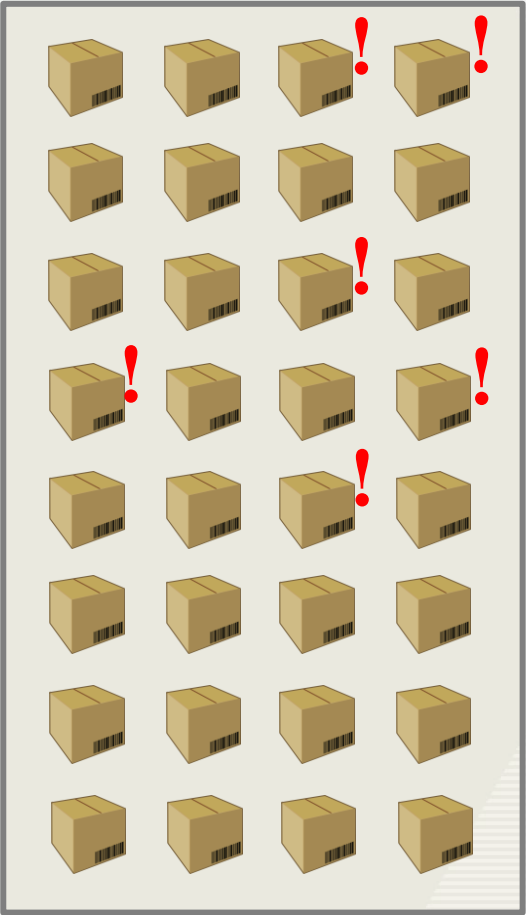
p

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- *Estimated Time of Arrival*
- *Volume/Dimensions and Containerization Status*
- *Path/Next Hub*
- *Updated Maximum Dwell Time*

Packages at a facility going to the same next hub

JIT Protocol with Fixed dwell time

Any container remaining dwell time <= y hours — No

Yes

Arrival + Sorting time of incoming containers < Remaining dwell time of current urgent containers — No

Yes

Total Volume : Combine current containers and containers arriving until truck arrival and compute total volume

Request smallest truck s.t
Volume of truck <= Total Volume

Request smallest truck s.t
Volume of truck <= Current Volume

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  Maximum Latency (MLT)

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$$L^M_{c,n} = T^{ld}{}_{c,n} + m\left(\sum_{i \in \boldsymbol{H_c}} D_{c,i}\right)$$

$\boldsymbol{T^{ld}{}_{c,n}}$: Latest departure time at hub n based on the dwell time pre-calculated
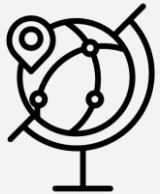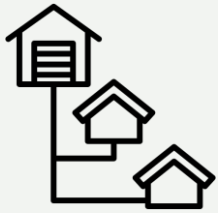
$\boldsymbol{D_{c,i}}$: Dwell time assigned to container c at each hub i element of $\boldsymbol{H_c}$

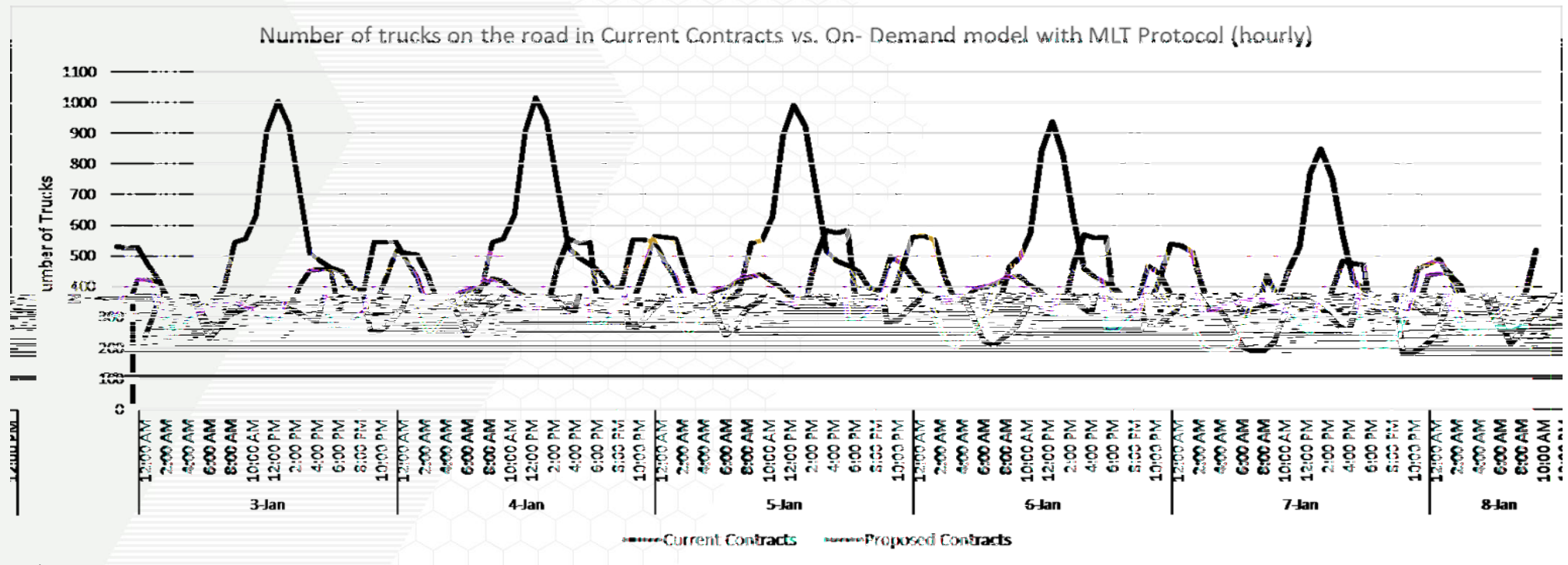$\boldsymbol{H_c}$: Set of hubs remaining in the assigned path of container c
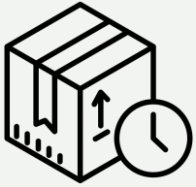
larger trailers moving less often rather than smaller ones moving too often

MLT Protocol with Flexible Dwell Time

Urgent Volume : Combine current urgent packages with urgent packages arriving until y hours

x% of largest truck ≤ Urgent Volume ≤ 100% of largest truck — No

Yes

Request smallest truck s.t Volume of truck ≥ Total Volume of packages

Urgent Volume < x% of largest truck — No

Yes

Combined Volume : Combine non-urgent packages with urgent packages

x% of largest truck ≤ Combined Volume ≤ 100% of largest truck — No

Yes

Arrival + Sorting time incoming container

x% > Post-M... ume > 100% — No

Yes

Request sm... truck s.t Volume of truck ≥ To... olume of current + incoming packag...

Request sm... truck s.t olume of current ntil truck arrival

Request largest tru... Load all urgent packag... and add non-urgent until tr... k full

...ge trucks ...s and add ...ck full

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Number of trucks on the road in Current Contracts vs. On- Demand model with MLT Protocol (hourly)

Hourly Distribution of Number of trucks on the road

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Thanks