

# An Integrated Network Modeling Framework for Analysis of Multi-line Order Pick Systems

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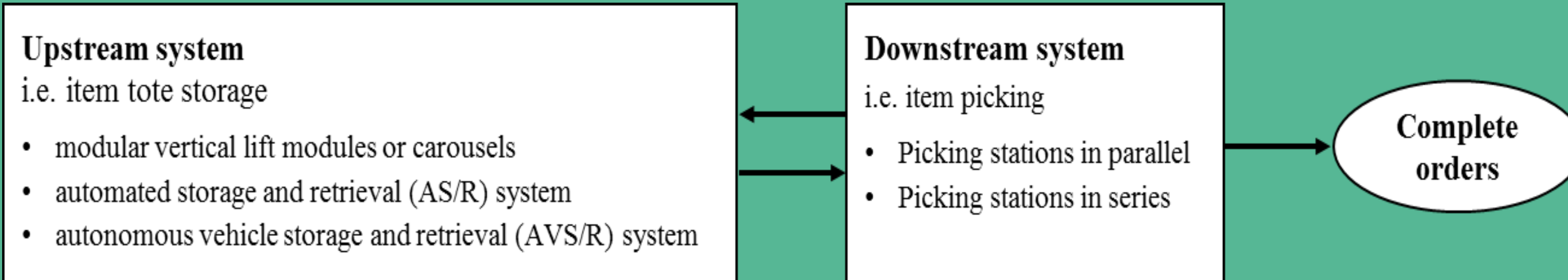
## Robotized and Automated Warehouse Systems for E-Commerce Order Fulfillment



### Questions for technology selection:

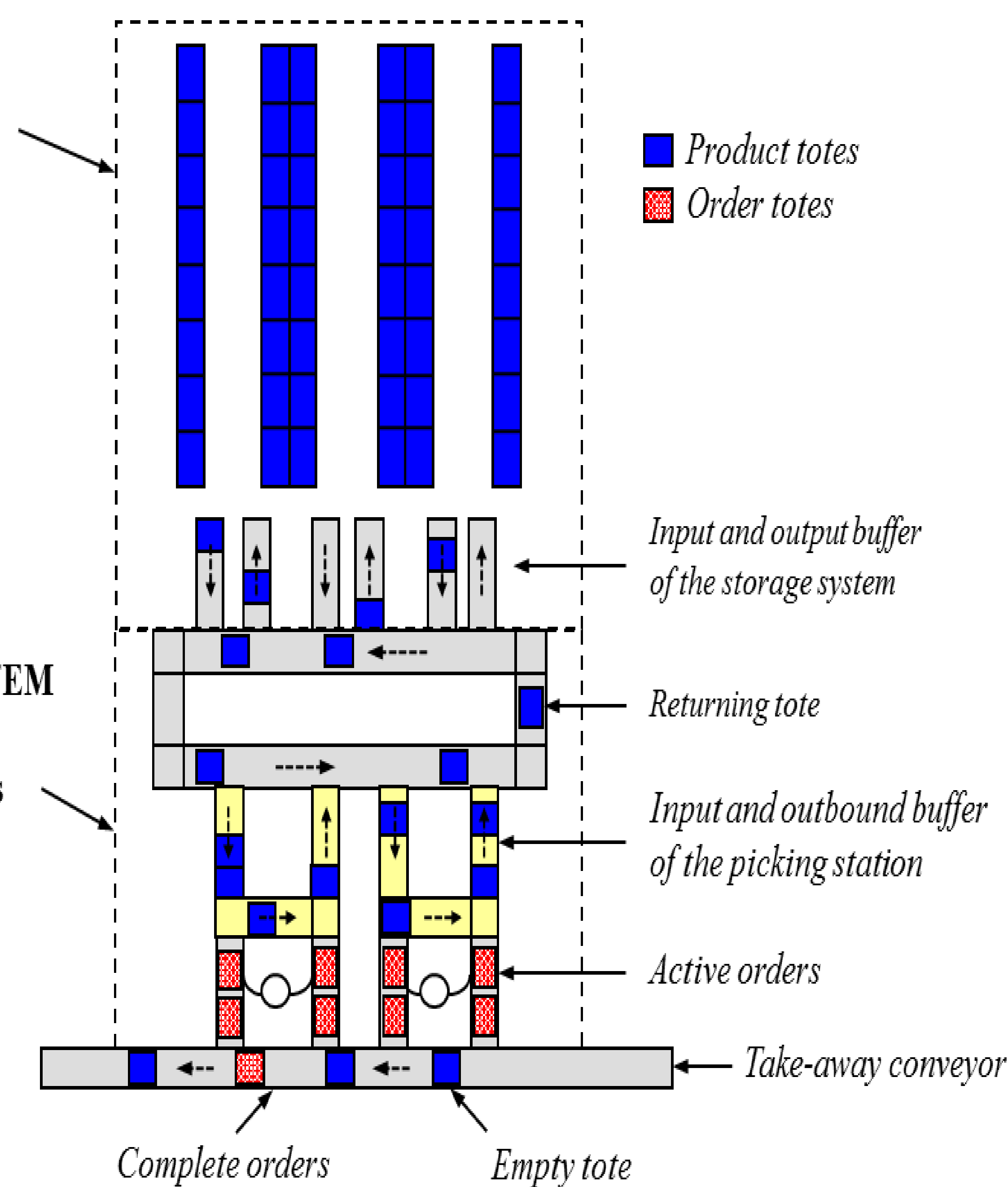
- Which system is better for multi-line orders?
- How do we analyze performance?
- Are existing analytical models sufficient?

### Existing models are typically isolated, Analyze only upstream storage system

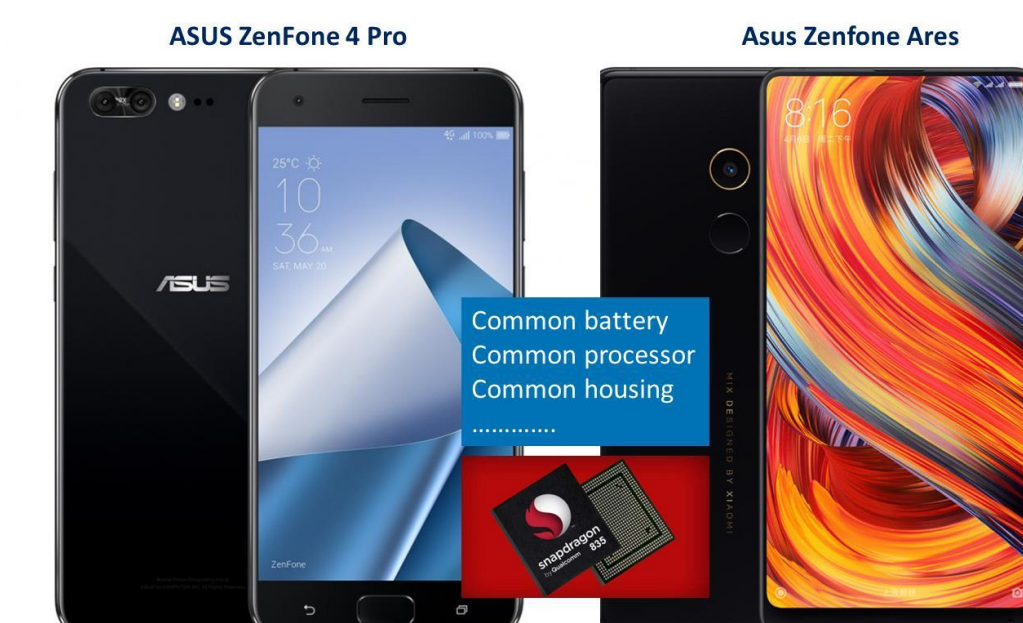
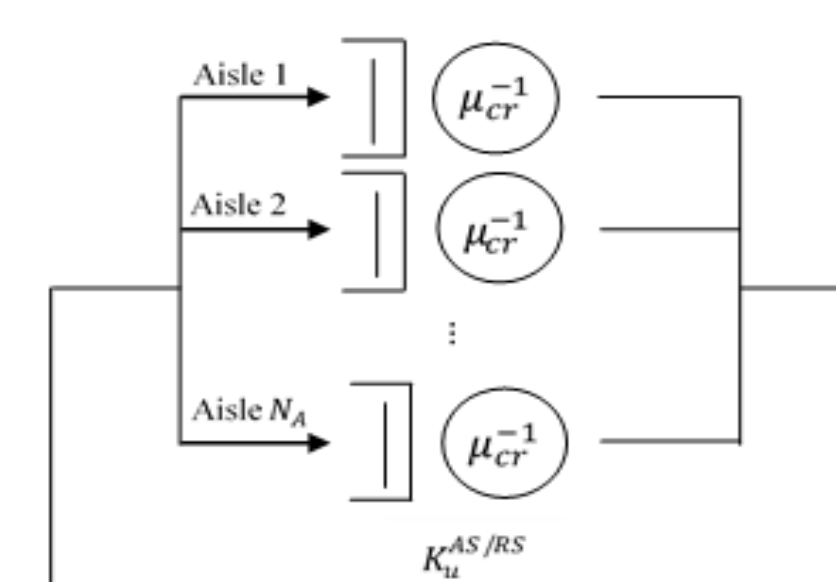


### System Description

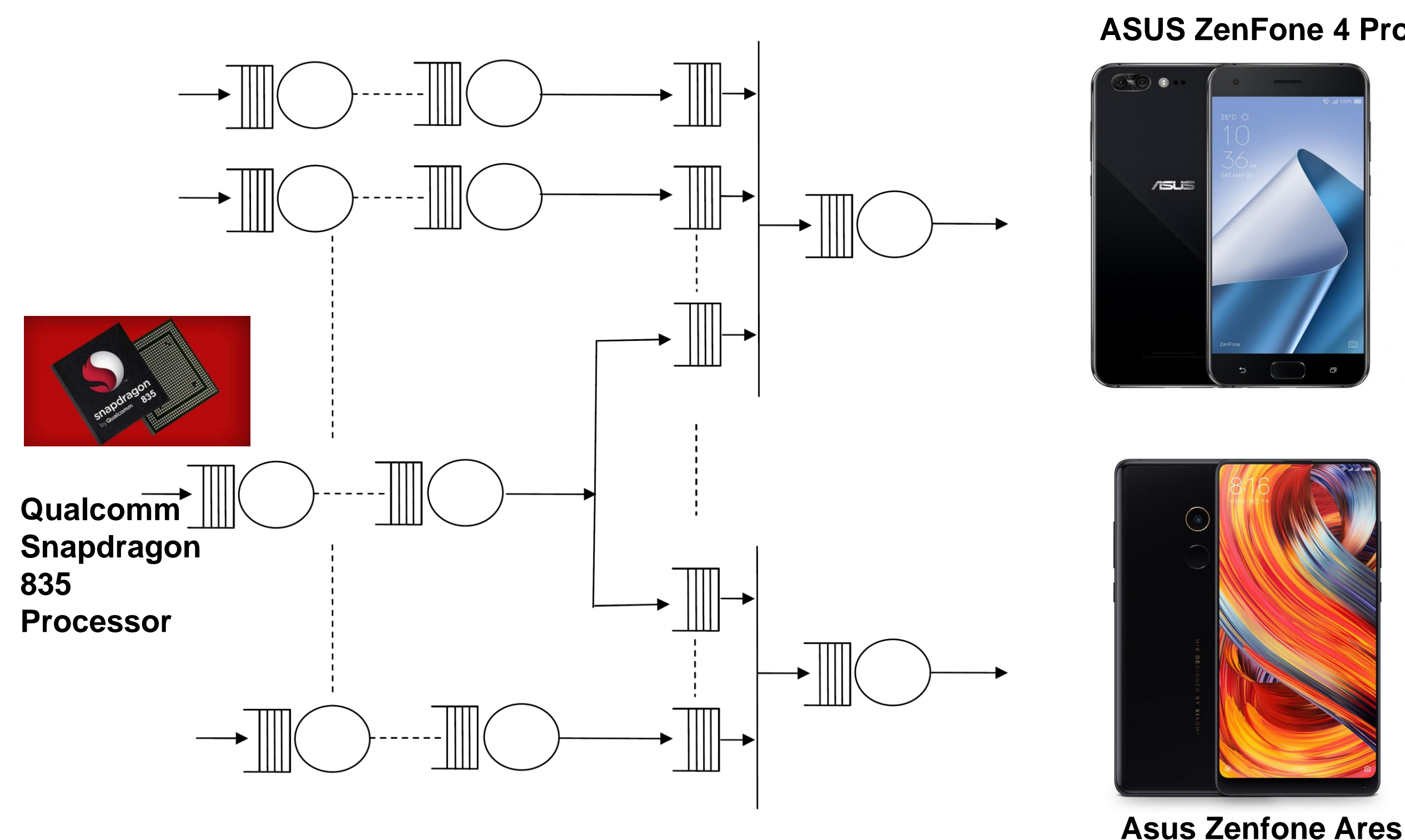
#### UPSTREAM SYSTEM i.e. item storage



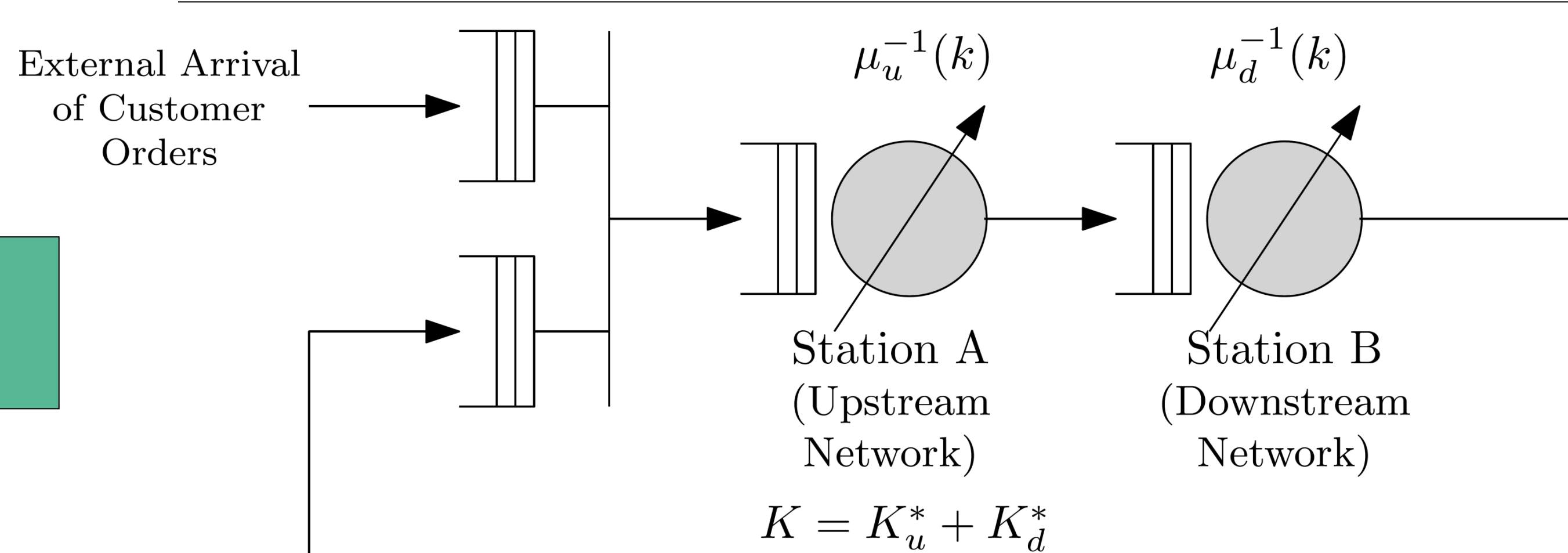
#### Upstream: Closed Queuing Network



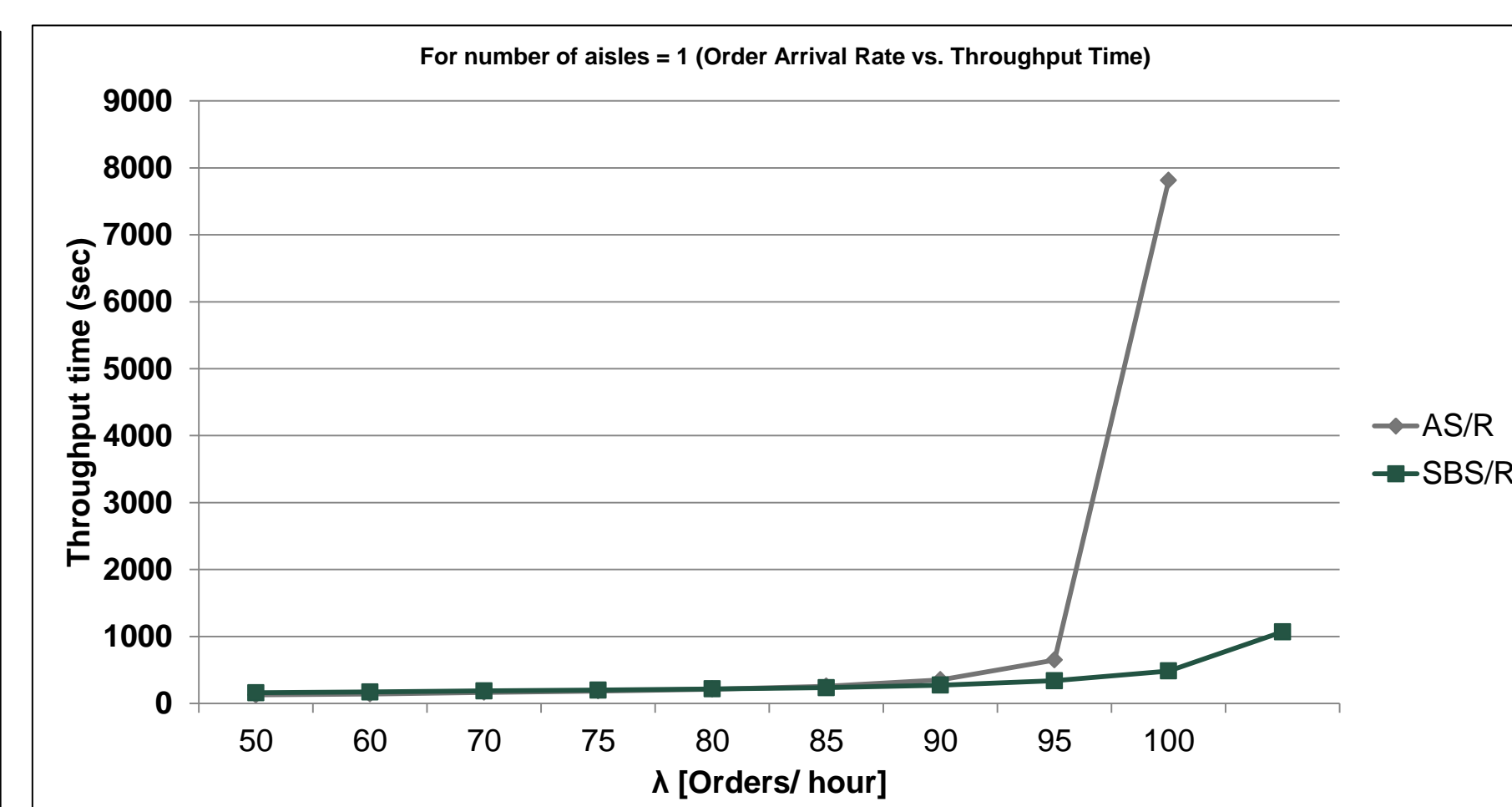
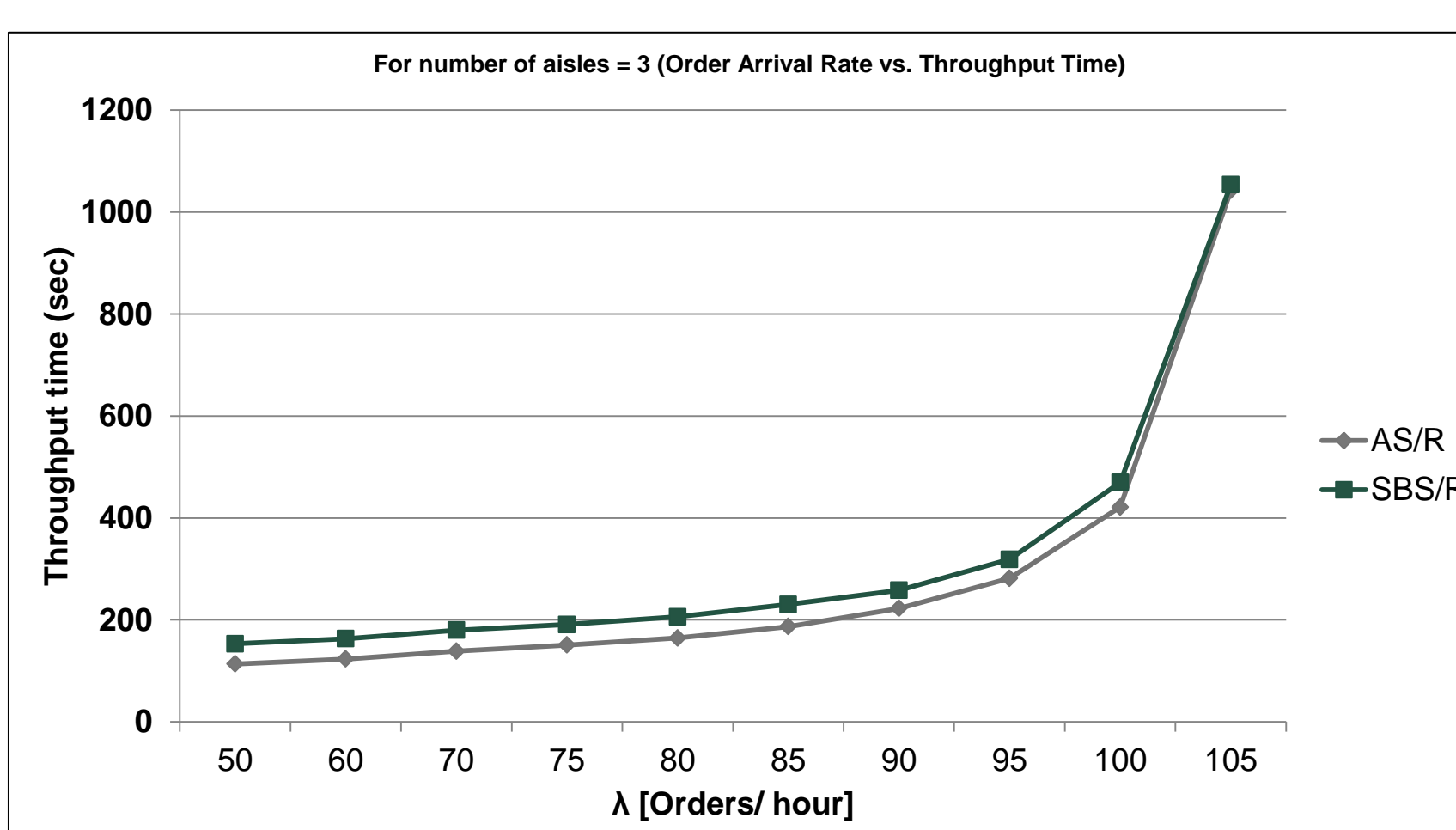
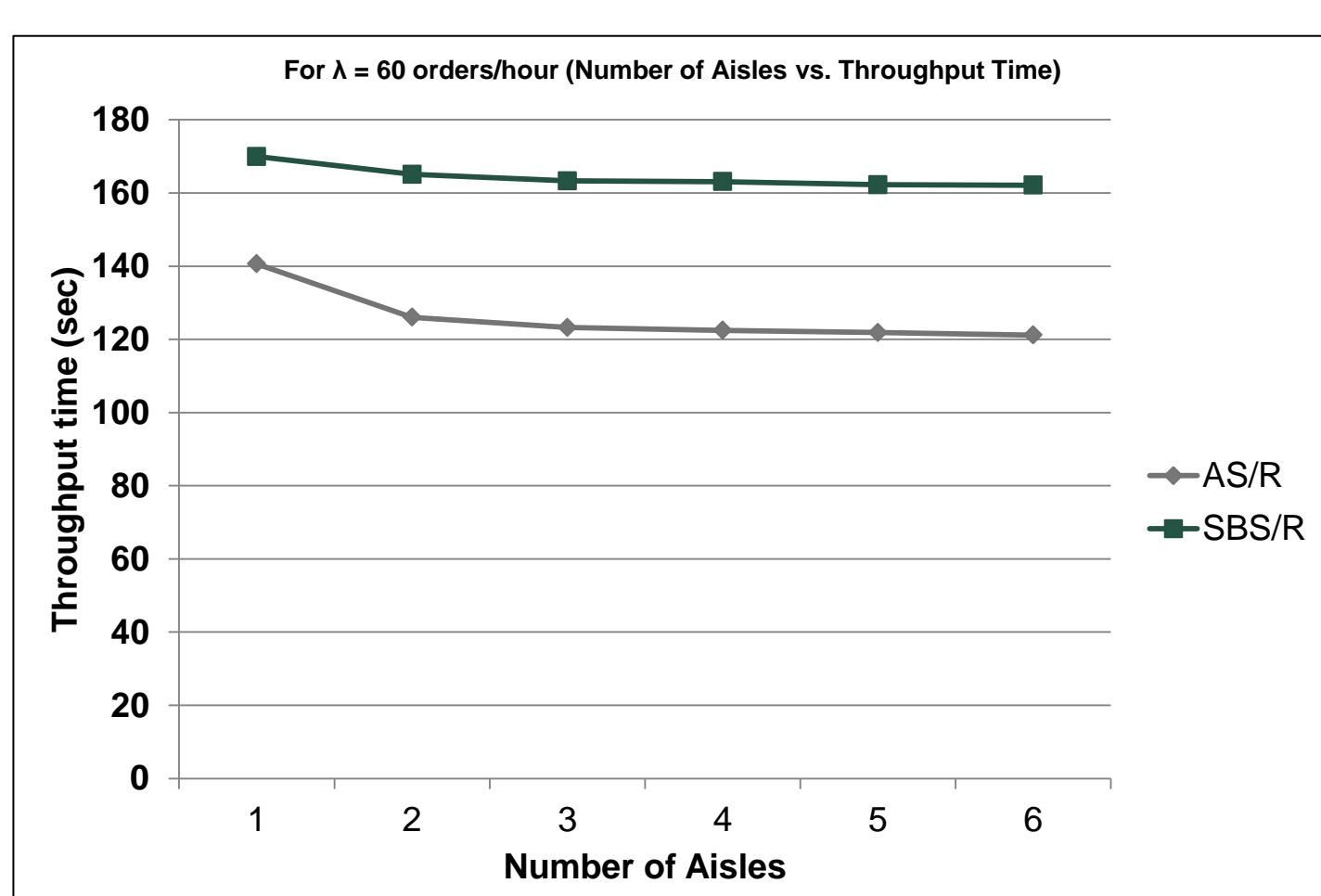
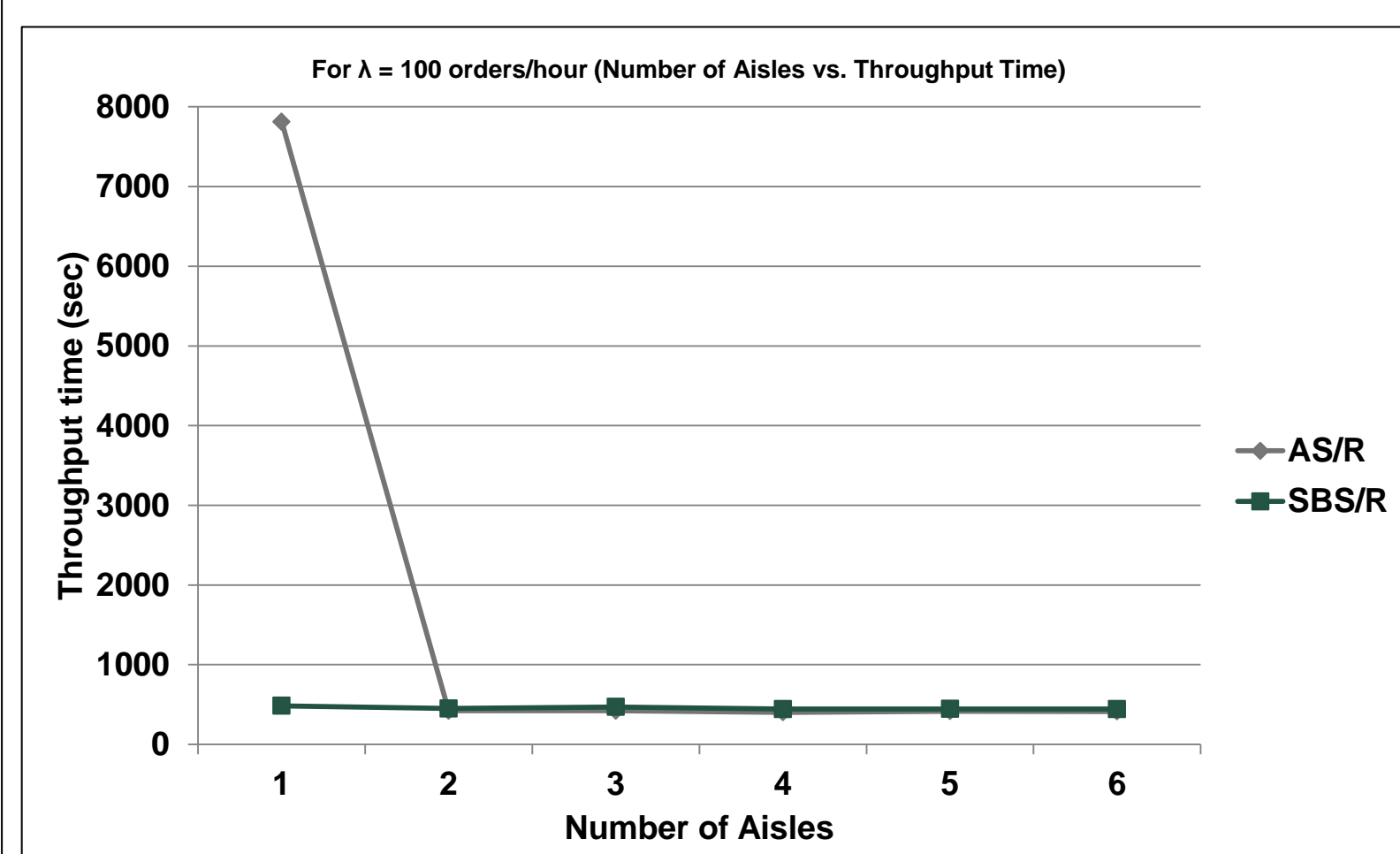
#### Downstream: Inspiration from Assembly Synchronization Networks



#### Full Model



### Preliminary Insights



- For fewer aisles and higher order arrival rates, SBS/RS outperforms AS/RS (in terms of throughput time)
- For most combinations of number of aisles and order arrival rates, AS/RS outperforms SBS/RS (in terms of throughput time)

### Future Work and Reference

- Perform numerical experiments for large number of line items per order
- Study the effect of item commonalities among order profiles
- Develop a solution method for handling order line synchronizations with item commonalities
- Understand the effect of order batch size on system performance

Reference:  
E. Tappia, D. Roy, M. Melacini, and R. De Koster, "Integrated storage order picking systems: technology, performance models, and design insights," unpublished