**Container Terminal Operations: Design Considerations and Decision Models**

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Today, more than 60% of the deep-sea cargo volumes are transferred using containers. High demands on container-mode transportation have put a tremendous pressure on container terminals to improve their operational efficiencies. The operations at an automated container terminal such as vessel loading and unloading, and stacking of container vessels for intermediate storage, are performed using a fleet of quay cranes, automated vehicles, and stacking cranes. For instance, the unloading operations include transport of containers from the ship using quay cranes, transport of the containers to the stacking area using vehicles, and subsequent stacking of the containers using stacking cranes.

Performance analysis of the container handling operations is of immense interest to Stevedoring companies because it can not only provides estimates for the throughput capacity and expected throughput times but it can also be used to optimize the system design parameters for better performance. The main research focus has been on building simulation and optimization models to address strategic and tactical issues such as container stowage problem at ships and in the stack, as well as analyze the performance of control policies such as vehicle dispatching rules and quay crane scheduling.

Analytical models have also been built to analyze specific system design aspects, for instance, models are developed to analyze the container discharge and loading at any given berthing point and study Automated Guided Vehicles (AGV) transportation system using a closed queuing network model. However, in literature, integrated analytical models for analyzing the performance of loading and unloading operations by considering some of the stochastic inputs are scarce.

In the first part of this talk, we will discuss the design issues and existing analytical models for container terminal operations. In the second part of the talk, we will present an integrated stochastic model for the loading and unloading of containers at the seaside by considering the queuing dynamics among the quay crane operations, vehicle transport operations, and stack side operations. By accounting for the stochastic interactions among quay cranes, vehicles, and stacking cranes, realistic estimates of system performance measures such as throughput capacity, resource utilization, the container waiting times for resources, and the expected cycle times are obtained. The results from the model are validated using detailed simulations. Further, the following design questions are answered using this stochastic model:

* What is the effect of the type of vehicle (automated lift vehicle vs. automated guided vehicle) on system performance?
* What is the effect of the vehicle dwell point policy on system performance? Where should a vehicle dwell after completing a loading or unloading operation?

We believe that the stochastic model of the container handling operations can be used for rapid design conceptualization for container port terminals and improve container handling efficiencies.