COLLABORATIVE TRUCK SCHEDULES

BEATING CONGESTION IN FUTURE SMART PORTS

Amr Eltawil, Professor of Industrial Engineering, and
Ahmed Azab, PhD Scholar, Egypt-Japan University of Science and Technology

The Internet of Things (IoT) is already transforming business and industry all over the world. By the year 2020, approximately 80 billion connected devices will be operating within the IoT, according to Frost & Sullivan. The IoT is the future not only in the service sector, but also in the industrial sector and on a global level. We will be able to monitor, track, and manage the flow of material, information and money through global and local supply chains using smart systems.

Decision makers will also be more confident in making decisions that are based on real time and accurate data. This data will be collected by sensors and processed in the cloud continually. Resources consumption will be smarter with higher utilization of our equipment and facilities. The integration among systems will require a certain level of collaboration between stakeholders to achieve the desired functions and expected efficiency.

This paper will give an example of one type of experimental terminal collaboration that could take place within future IoT-based, smart container terminals.

DYNAMIC TRUCK SCHEDULING

Container Terminals (CTs) around the world have been transforming from manual to digital systems, and more recently, from digital to smart and intelligent systems.

The relationship and interaction between container terminals and trucking companies is very important to consider within the new IoT-based smart terminal. Both stakeholders' decisions affect each other's operational efficiency and productivity. One of the most effective and commonly-used ways to organize and manage the pickup and delivery operations of containers between the CTs and the trucking companies is the Truck Appointment System (TAS). Truck Appointment Systems are typically used by the terminal operators to schedule the arrival of external trucks while taking into consideration the terminal workload.

In general, appointment systems don't consider two important issues. The first one is the convenience of the trucking companies aiming to dispatch their trucks at their preferred arrival time. Collaboration on this matter will result in a better experience and better decisions. The second issue is the dynamic nature of the scheduling problem where both the demand for and supply of containers are changing dynamically. The introduction of the IoT will allow real-time data to be collected from sensors implemented on all the CT equipment, allowing agility and fast adaptation to new circumstances. In this technical article, we introduce the new concept of Dynamic Collaborative Truck Appointment Systems (DCTAS) as a future solution for smart CTs that can also be applied in the currently developing terminals.

Many terminals face the problem of

random arrival patterns of external trucks, if the terminals don't apply a strict appointment system [1]. On the other hand, if the terminal is implementing an appointment booking system, some companies may have to pay a penalty or wait for longer if they deviate from their confirmed appointment times. These situations of course will not be pleasant for the trucking companies' drivers and managers. Moreover, congestion resulting from the random, walk-in, and no-show arrivals puts more pressure on the shoulders of the terminal managers. An additional disadvantage is the environmental impacts of longer waiting and service times experienced by these trucks, which results in excess emissions.

To resolve these problems, scheduling the arrival of external trucks considering both the terminal dynamic operations and the preferred arrival time of the external trucks is badly needed. Future autonomous, smart terminals relying on IoT will need a system like DCTAS to be fully implemented and adopted by both terminals and trucking companies for smooth and streamlined operations.

DCTAS: A NEW CONCEPT

Our research team at Egypt Japan University of Science and Technology has developed a new IOT-connected system to automate truck appointments, DCTAS.

The basic idea behind the proposed new concept of DCTAS is to schedule the appointments of external trucks based on both the trucking companies' convenience and terminal workload, considering the dynamic and stochastic nature of the appointment scheduling problem [2].

The new DCTAS aims to reduce the truck turnaround time of external trucks which leads to reduce both congestion and transportation cost, and at the same time improve the utilization of terminal resources and increase productivity. To achieve these goals, the proposed comprehensive DCTAS includes a web based system and a mobile application system that communicate with a discrete event simulation model of the terminal, all integrated in one simulation optimization approach to develop dynamic truck appointment schedules. The operational scenario of the proposed DCTAS is shown in figure 1 and the sequence of operations is as follows:

- Input parameters to the system are collected from the terminal in real time using the advanced monitoring devices and sensors. These parameters will be sent to the database and pass through an information system to organize them.
- Some inputs need to be entered by humans, such as the trucking companies' preferred times to dispatch their trucks to the terminal. Such inputs are entered using the web based or mobile application appointment request system.
- All input data and parameters are organized, processed and stored in the TAS database using the software we have developed, Dynamic Collaborative Information System (DCIS).
- Using the background optimization model and the CT simulation model, the DCTAS determines the optimum schedules of truck arrivals to the CT. The proposed schedules will reduce the

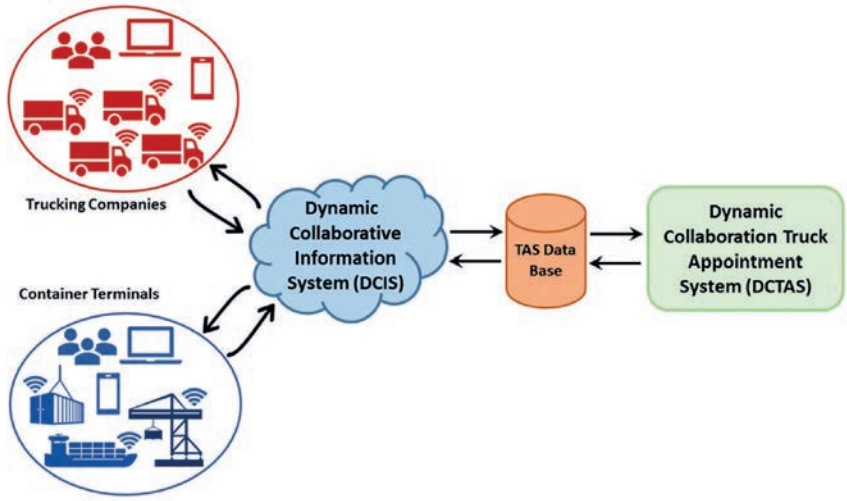

Figure 1: collaborative TAS structure for the IoT-based container terminals.

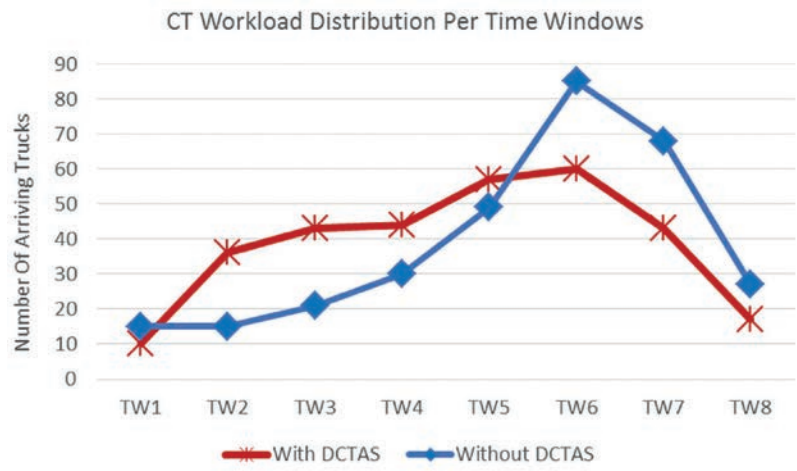

Figure 2: redistributing the arrivals to less congested time windows

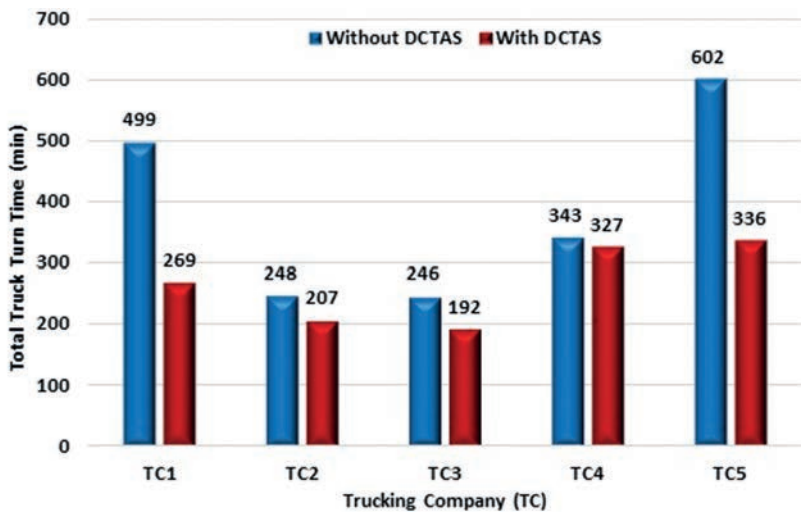

Figure 3: turnaround time reduction after using the DCTAS

inconvenience to the companies caused by shifting their arrivals away from the preferred arrival times. Moreover, the system considers simultaneously the cost of congestion at the terminal gates and yards that result from the long truck turn times inside the terminal.

- The developed schedules are sent to both stakeholders with some performance measure such as the congestion levels at gates and yard blocks and expected waiting times at each terminal area.
- In case the truck driver is unable to meet his planned schedule while en route to the terminal, he may revise his request, and in that case the system runs again to give him another revised optimum arrival time that will reduce the impact of his/her delay to himself and the terminal as well.
- Using this system, CT managers will be able to receive daily reports on their smart phones or smart dashboards about the terminal productivity, equipment utilization and many other online statistics that enables them to fully monitor the performance of trucking operation through the DCIS. Trucking companies' managers will receive the final schedules and related service costs. Moreover, drivers will be equipped with smart mobile application to receive their detailed schedules and stay connected to the system via GPS. The mobile app will help in estimating some performance measures such as the time and fuel consumptions and related costs.

BENEFITS OF DCTAS

Collaboration in decision making is no longer restricted to people inside the same organization. Today, with the spread of distributed and mobile applications, collaboration in decision making has become more common between supply chain stakeholders in the global market place. Also, collaboration supports the beneficial use of the IoT. The proposed DCTAS supports beneficial cooperative decision making by considering inputs from both the trucking companies and terminal operators.

TESTING DCTAS

In a theoretical experiment, the requests of five trucking companies were submitted to a simple conventional and non-automated CT. The DCTAS was used to develop truck appointment schedules for the upcoming eight time windows. The results of the system were compared to current planned schedules of the CT in order to observe the impact of using the proposed system. The results show that the total truck turnaround times for the five trucking companies were reduced and the terminal workload was smoothed out and re-distributed into a more even pattern.

Figure 2 illustrates how the DCTAS distributed the arrivals to the less congested time widows (each time widow equal one working hour). In figure 3, the trucks of the five trucking companies showed shorter turnaround times due to using the DCTAS. The experiment illustrates the possible significant impact of such a system . In an automated and connected terminal, this impact is expected to be much more significant.

The proposed real time data driven optimization model is a typical application of advanced analytics making it an important component of the proposed system. Typically, scheduling problems are classified among very hard problems to solve in operations research literature. That is why in order to solve realistic size problems many researchers rely on heuristics and metaheuristic methods. Nevertheless, the future implementation of advanced analytics in short term operational planning problems is expected to be highly impacted by the introduction of IoT. We predict that the real time availability of input data from the IoT makes available and the reduction of the planning horizons will reduce the problem's size, hence allowing the implementation of optimization algorithms that will support faster planning decisions to be made by terminal operators.

REFERENCES:

[1]Azab A., and Eltawil A. (2016). A Simulation Based Study Of The Effect Of Truck Arrival Patterns On Truck Turn Time In Container Terminals, ECMS 2016 Proceedings edited by: Thorsten Claus, Frank Herrmann, Michael Manitz, Oliver Rose European Council for Modeling and Simulation.
DOI: 10.7148/2016-0080

[2]Azab A., Karam A. and Eltawil A. (2017). A Dynamic and Collaborative Truck Appointment Management System in Container Terminals. In Proceedings of the 6th International Conference on Operations Research and Enterprise Systems- Volume 1: ICORES, ISBN 978-989-758-218-9, pages 85-95.
DOI: 10.5220/0006188100850095

ABOUT THE AUTHORS

Professor Amr B. Eltawil is the chairperson of the department of Industrial Engineering and Systems Management, of the Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt. Prof Eltawil is leading the Supply Chain and Logistics laboratory. One important research domain of the laboratory is planning and operations management decision making in container terminals using applied operations research and discrete event simulation methods. Prof Eltawil provided many training programs and consultations on all kinds of industrial engineering topics in different countries of the Middle East and the Gulf area.

Eng. Ahmed Azab is a lecturer and research assistant at Benha faculty of Engineering, Benha University, Egypt. Azab got his MSc degree in management of container terminals from the department of Industrial Engineering and Systems Management of the Egypt-Japan University of Science and Technology (E-JUST). His current research and practical interests are the supply chain management, modelling and simulation of container terminal problems, and synthesis of the web-based and mobile-based applications that support logistic services.

ABOUT THE ORGANISATION

Egypt-Japan University of Science and Technology (E-JUST) is an Egyptian public university established in partnership with the Japanese government. E-JUST is research oriented and graduate focused university focusing on applied research in different domains of engineering and technology. The university targets to cultivate an academic environment and become a benchmark for the Egyptian and African countries in education (www.ejust.edu.eg).

ENQUIRIES

Professor Amr B. Eltawil / Eng. Ahmed Azab
Industrial Engineering and Systems Management
Egypt-Japan University of Science and Technology
PO Box 179 New Borg Elarab city,
Alexandria 21934, Egypt

Emails:
eltawil@ejust.edu.eg
ahmed.azab@ejust.edu.eg

Amr Eltawil Tel: +201001679664
Ahmed Azab Tel: +201157100089

Website: www.ejust.edu.eg