BORDER-CROSSING DELAYS MODELING AND ANALYSIS

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Introduction

Canada and the United States are the largest bilateral trade partners in the world. Among Canada's top six border crossings, Windsor-Detroit corridor accounts for almost 30% of total Canada-U.S trade. The Government of Canada has started a project, and is working with partners to develop additional border capacity to support this trade. The project is known as either the Detroit River International Crossing or the New International Trade Corridor.

This study aims at identifying factors that contribute to cross-border delays, and ultimately will identify possible solution(s) to help reducing delays and favoring faster passage of vehicles and trucks. In general, the main contributor to waiting time in a queuing system is the variability reflected in arrivals and service time and patterns, in conjunction with the number of servers in the system. Each of these factors will impact the system's performance and consequently all the parties of interest including trade community and custom agency.

As a method of system analysis that enables us to investigate possible scenarios, an analytical approach based on queuing theory is preferred. However, as a result of complexity of the real world models and high variability, particularly in arrival patterns, analytical models may not represent the system accurately. In that case, an experimental method such as simulation will be preferred. Study on the feasibility

and accuracy of fitting an analytical model to the real world system is in progress.

Literature review

The Planning/Needs and Feasibility (P/NF, 2004) report identifies a long term strategy for the transportation network in southeastern Michigan-Southwestern Ontario, and was initiated in 2002. As part of the report, it presents a thorough analysis of the travel demand between Windsor and Detroit.. However, it only addresses the transportation system in a macro scale and neglects to address the traffic analysis in a micro level which should include statistical analysis of the system.

In 2003, McCord and his team at the Ohio State University conduct a set of experiments and developed a methodology to exploit data gathered by Unmanned Aerial Vehicle (UAV) for multiple applications. They developed two methods of estimating freeway density and flow. However, although some key measures such as average queue size can be calculated from the aforementioned method, it cannot be used to make improvements or to evaluate possible solutions to make improvements..

Haughton and Isotupa (2012) apply simulation techniques to study the impact of variability in arrival rates on the system performance. They consider the benefit of traffic flow smoothing in situations of considerable variation in mean arrival rate. They quantify the benefits not only for the customers (i.e. trucking companies), but also for servers (border administration personnel and institutions). However, the feasibility of traffic flow smoothing in real world is under question.

A considerable portion of the research work in literature that considers mathematical modeling methods for queuing operations are concerned with healthcare systems. Among them Chartnesky (1984), Barron (1980), Moore (2001), Pesata et al. (1999) can be named. The centre of attention in most of these research works is to study the scheduling

system. This will result in focusing on the arrivals, which can work very well in healthcare systems. However, as mentioned before, this control cannot be imposed on the arrivals of a traffic system due to infinite sources of arrival entities.

Ross (1978) discusses average delay in queues with non-stationary Poisson arrivals. This is due to the fact that in reality, the actual process is most often non-stationary. A single-server infinite-capacity queuing model in which arrival process is a non-stationary process is considered.

Problem Statement

From analytical standpoint and with reference to queuing theory, a border crossing plaza will be assumed as a multi-server queuing system. In order to study the arrival and service pattern there is a need to collect real data from a cross border system such as Ambassador Bridge crossing. However, due to lack of such data until now, artificial data is generated and will be used for the purpose of studying the behavior of the aforementioned system. These data are categorised based on three basic inputs of a queuing model which are arrival, service, and number of servers.

Arrivals

Arrivals into a traffic flow, in general, have a tendency to have Poisson process characteristics; see Green et al. (2007). However, the rate of such arrivals may vary from each time interval to another. Because of such variations between time intervals, a Non Stationary Poisson Process (NSPP) can be assumed as the arrival rate distribution. The NSPP which is characterised by $\lambda(t)$ (the arrival rate at time t) is useful for situations in which the arrival rate varies during the period of interest; see Banks et al. (2005).

Service time

In a cross border plaza, defining service time is more challenging task than for arrivals. The reason is that the service pattern at border plaza is highly unpredictable due to security concerns, as well as high variety of the type and amount of service each customer needs. Therefore, it is reasonable to assume that service times have general distribution. The advantage of such assumption is that the scope of service time distributions can be extended to any possible statistical distribution.

Number of servers (service channels)

The number of service channels at the custom plaza will vary between a minimum and maximum number, for example between 7 and 14. A set of heuristic will be considered so that the number of service channels can be corresponded to the change in arrival rate.

Analytical Approach and Next Steps

Based on the aforementioned arrival and service patterns the cross border traffic system can be assumed as M/G/C queuing system. In such a system inter-arrival times are exponentially distributed and independent from each other. Also, service times are considered to have general distribution. The measure of system performance will be considered the delay (waiting time) at the custom plaza.

This research, so far, has been studying the traffic flow pattern at cross border. The arrivals, services at the border, and number of service channels as the fundamentals of the traffic flow are investigated. One goal of this research is to examine the feasibility of analytical modeling of the real world system. If this attempt is successful, further steps such as performance evaluation of existing system, and examining different scenarios to improve the system's performance will be based on the analytical modeling. However, in case that analytical approach could not build a reliable modeling structure that well represent the real world system an experimental method such as simulation will be applied for further the mentioned analysis and improvements.