Workload Representation in the Modeling of Border Inspection Points

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Abstract

This paper presents the modeling of a border inspection system with open workloads and compares the results with a model using closed workloads. This approach allows introducing the dynamics of arrivals and their influence on system performance.

1. Introduction

The use of biometric information, as a mechanism to authenticate international travelers at a border inspection point provides an enhancement in security through a self-contained validation of the bearer. Modeling a system like that is a challenging task, because it requires attention to multiple factors that may affect the accuracy of the model.

Emerging international standards define the format a machine readable documents (MRTD). Together with biographical data, MRTD stores document holder's biometric information. In order to minimize the likelihood of accepting false credentials, the authenticity and integrity of the data inside the traveler's MRTD are reinforced using Public Key Infrastructure (PKI). When presented with decrypted information, the immigration officer shares traveler's information with the Traveler Name Server (TNS). TNS alerts the officer about traveler's admissibility status. Concurrently, the officer interviews the traveler and collects his or her biometric information, currently a digital photo and ten fingerprints. Collected biometric information is stored and processed at the Traveler Biometric Server (TBS). If this primary inspection has a successful outcome, the traveler is admitted into the country, otherwise he or she is referred to a secondary inspection point where another officer will perform a longer interview and perform multiple checks against watch lists.

Recently, we have been engaged in the development of analytical performance models for border inspection points. The goal of modeling is to analyze suitability of system requirements, such as the organization of the PKD, optimization of workflows and maximization of the passenger throughput. A related goal has been a comparison of modeling costs and benefit between analytical models and elaborate simulation analysis models.

Our models assume that all travelers possess an MRTD. The performance model requires determining the type of workload generator, possible bottlenecks, types of scheduling policy, and the distribution of servers and resources. Workload generators are generally classified as open or closed. Open workloads are used in systems where jobs enter the system disjointedly of job completions. On the other hand, in closed workloads, a fixed number of jobs enter the system and continue circulating within the system with an associated processing time.

In this paper, we present the performance of a border inspection system under open workload conditions. The paper is organized as follows: in section 2, we show performance results with closed workload. Our inspection model using open workload is discussed in section 3. Finally, section 4 discusses the performance results from both approaches.

2. Performance with Closed Workloads

Analytical modeling of border inspection points was first presented in [1]. At the time, we used closed workload models. The number of travelers arriving to the inspection points varied from 100 to 2000 with an exponential processing time Z=40 seconds. We extended the original model to reflect recent policy extension requiring the collection of 10 fingerprints (rather than two) and a face image of the traveler at the primary inspection. In the results reported here, the number of inspection booths at the airport is assumed to be 20, although it can be easily modified.

We studied three system configurations. In the first, MRTD contains the public key certificate of issuing site (country). In the other two configurations the PKD stores MRTD certificates together with the public key of the Certificate Authority of the country of traveler's origin. The second configuration assumes availability of a dedicated PKD per booth, while the third assumes a PKD per airport (shared by all the booths).

Average waiting time was estimated given the number of travelers in the queue for each configuration. The results showed minor variations in performance between the three system configurations, when analyzing up to 40 airports. The addition of more airports to the distributed PKD greatly diminishes the performance, thus substantially increasing waiting time.

3. Performance with Open Workloads

The limitation of the model presented in [1] is its reliance on a closed workload paradigm. In this section, we describe the parameters needed for constructing the open workload border inspection system. We inferred mean service times for TBS, TNS and PKD using information from [2][3] adding assumptions where necessary.

The U.S. Customs and Border Protection (CBP) monitors flight processing times in 16 major international airports [4]. CBP data also includes the number of passengers per hour and the average number of open booths. In experiments, we used information for December 2007 from one of the terminals at the Dulles International Airport. The data set was normalized to average the number of travelers per booth per hour. Ensuing distribution is presented in Figure 1. We assumed that the passengers are evenly distributed among the available booths. For comparison with the closed workload case, the abscissa in Figure 1 has been scaled to 20 booths. When only the mean estimates were available, a good approximation to the actual distribution is given by the Poisson distribution. We also assumed some devices to have fixed-capacity service such as the TNS, TBS; the remaining devices are considered to be infinite service centers.

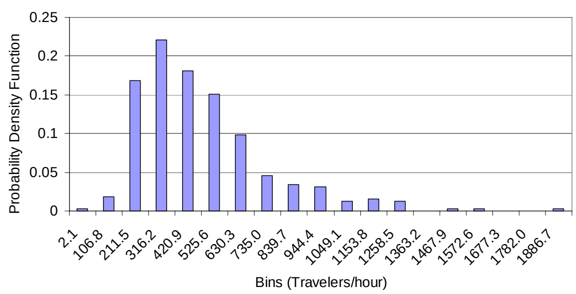

Figure 1. Probability density function of travelers in Dulles Airport – Terminal IA

The analytical model was evaluated with arrival rates provided by the above distribution. Average waiting time results are shown in Figure 2. As expected, the number of travelers that can be inspected is limited by the available primary inspection points. The trends are similar to those obtained in the closed workload case with the difference that the closed workloads cannot result in saturation.

Since CBP does not record either the waiting times per passenger nor service times, we approximated the average service time from flight processing data. The results showed a very disperse distribution, indicating that flight processing time is not a good indicator of service time. On the other hand, for large arrival rates the data band was narrower with an estimated service time of nearly 50 second. This value correlates well with the service time of 46 seconds obtained from the analytical simulations.

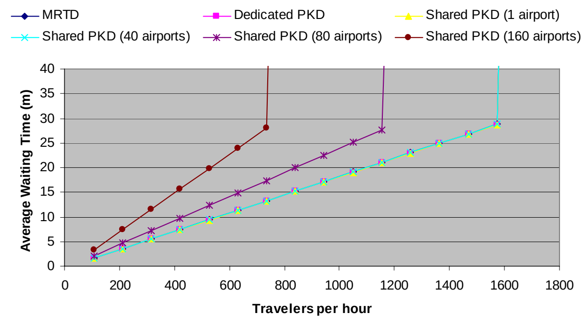

Figure 2. Open workload average waiting time in the primary inspection point

4. Discussion

In the closed workload, the service time is independent of the number of travelers in queue and average waiting time is a linear function of the queue. In the open workload case, there is a slight variation in service time with increasing arrival rates, but the average waiting time is still a linear function of the passenger arrival rate. With closed workload, the immigration officers at the primary inspection point appear busy at all times, an obviously unrealistic representation, avoided in the open workload model.

Increasing fingerprint collection requirement from 2 to 10 showed to have little influence on service time. This suggests that higher biometric security can be implemented without significant effect in passenger throughput.

References

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