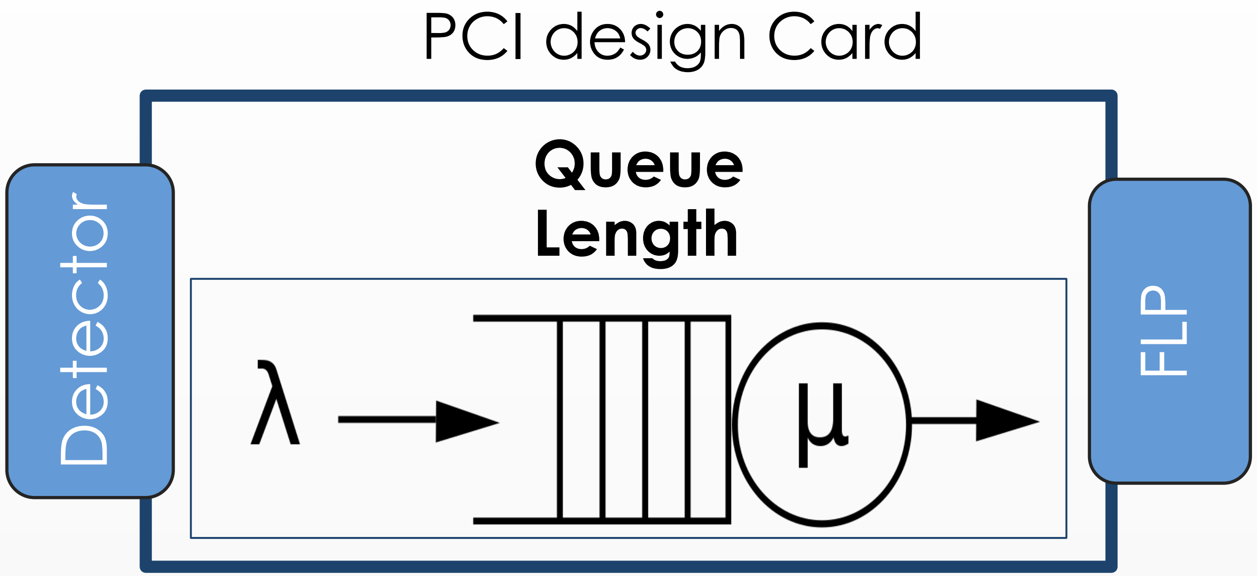
Data Acquisition Modeling of PCI Card in O2 Front-end Electronics Using Queuing Theory for Performance Analysis and Improvement

Outline

- Motivation and Problem
- Objective
- What is Queuing Theory
- Queue type
- Output graph

Motivation and Problem

- PCI card is used for data acquisition from the detector to FLP
- If the data arrives at the PCI card faster than the PCI processing, the buffer in PCI can be full and the data will be lost
- We would like to study the data flow in the acquisition process of the PCI card and performance analysis by using queuing theory and simulations
- We also optimize the design of PCI based on the study

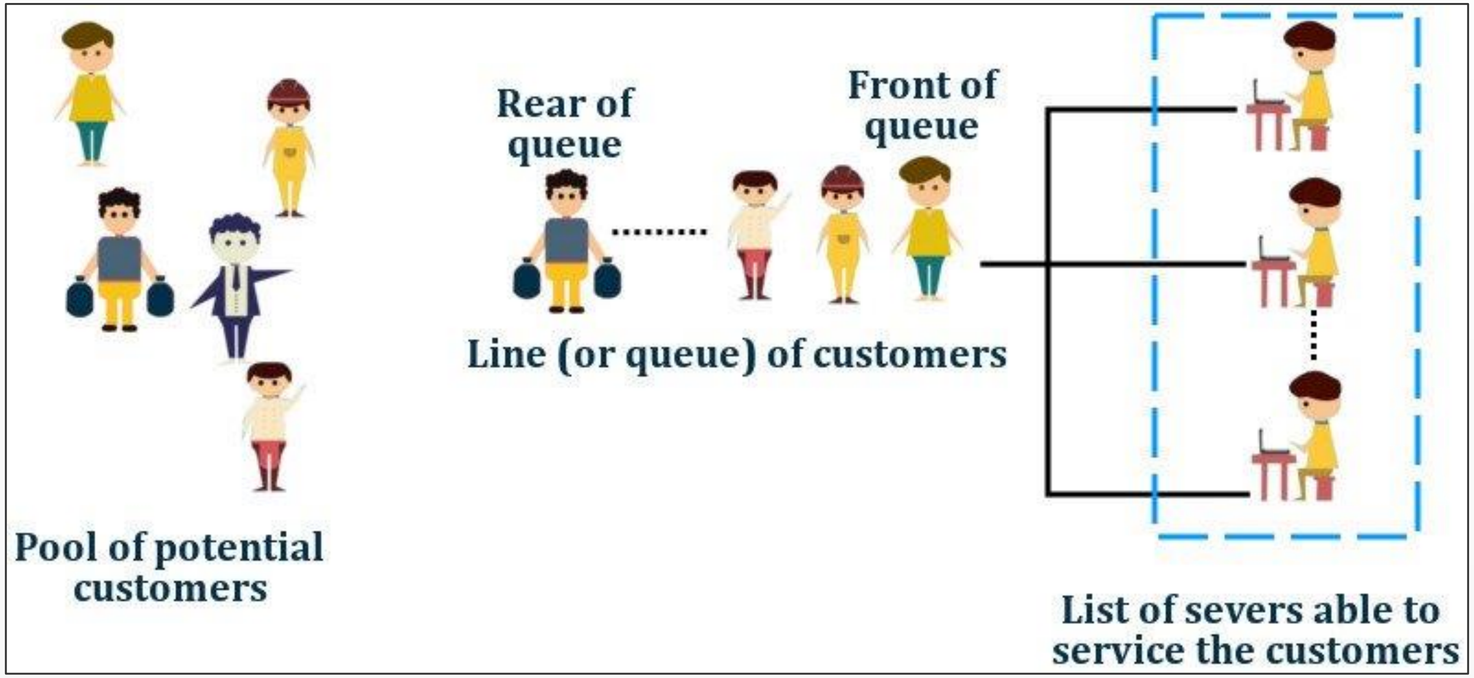


Objective

- Analyze the performance of the data flow between a detector and an FLP computer node through a PCI card by using Queuing theory
- Optimize the minimum buffer size to satisfy a loss probability requirement
- Evaluation by Simulation

What is Queuing Theory

- **Queueing theory** is the mathematical study of waiting lines, or queues.
- A **queueing model** is constructed so that queue lengths and waiting time can be predicted.
- Four primary parameter
  - Arrival rate
  - Service rate
  - Queue length
  - Number of server



Gi/G/1/k Model:

Discrete Time Markov Chains

DTMC: Discrete Time Markov Chain

- $B = T$
- $C = \beta \otimes (T^0 \alpha)$
- $E = S^0 \otimes T$
- $A^0 = S \otimes (T^0 \alpha)$
- $A^2 = (S^0 \beta) \otimes T$
- $A^1 = S \otimes T + (S^0 \beta) \otimes (T^0 \alpha)$

$$P_x = \begin{bmatrix} B & C & & & & & \\ E & A_1 & A_0 & & & & \\ & A_2 & A_1 & A_0 & & & \\ & & A_2 & A_1 & A_0 & & \\ & & & \ddots & \ddots & \ddots & \\ & & & & A_2 & A_1 & A_0 \\ & & & & & A_2 & A_1 + A_0 \end{bmatrix},$$

Loss probability

- Let z_n be probability that are n customer in the system

$$\mathbf{z}_0 = \lambda^{-1}[\mathbf{x}_0(\mathbf{T}^0\boldsymbol{\alpha}) + \mathbf{x}_1(\mathbf{S}^0 \otimes (\mathbf{T}^0\boldsymbol{\alpha}))],$$

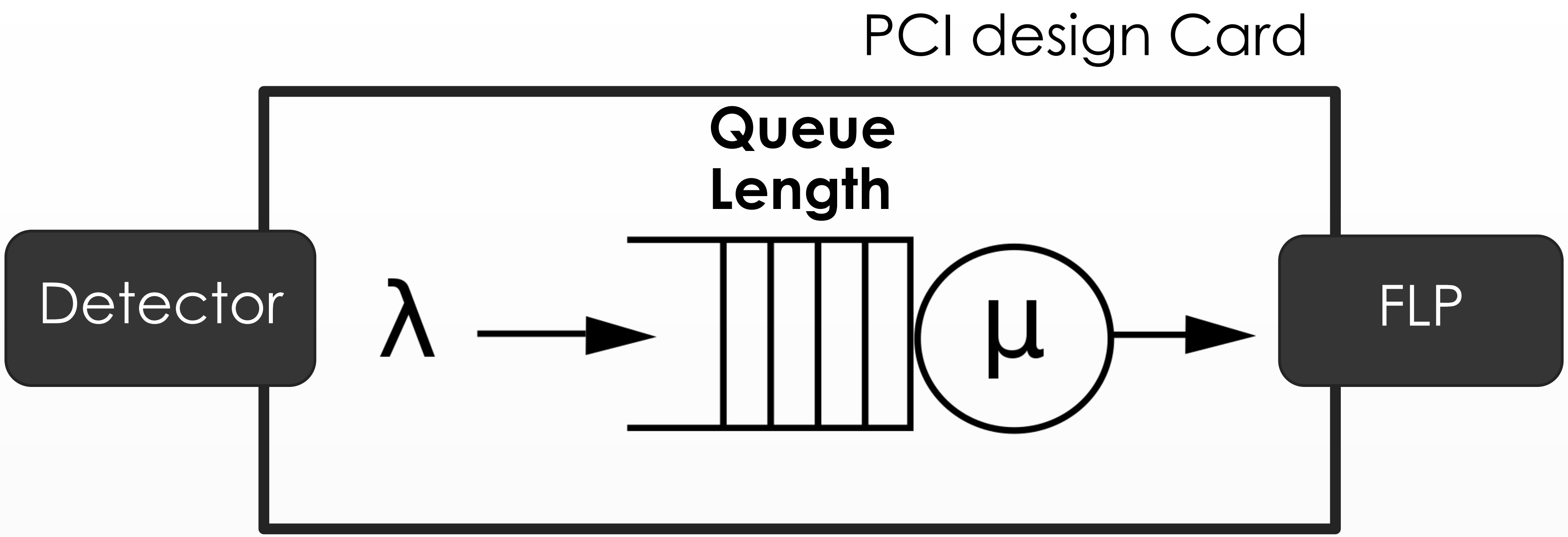
$$\mathbf{z}_i = \lambda^{-1}[\mathbf{x}_i(S \otimes (\mathbf{T}^0\boldsymbol{\alpha})) + \mathbf{x}_{i+1}(\mathbf{S}^0\boldsymbol{\beta}) \otimes (\mathbf{T}^0\boldsymbol{\alpha})], \quad 1 \leqslant i < K,$$

$$\mathbf{z}_K = \lambda^{-1}[\mathbf{x}_K(S \otimes (\mathbf{T}^0\boldsymbol{\alpha}))].$$

- Let p_l be the loss probability

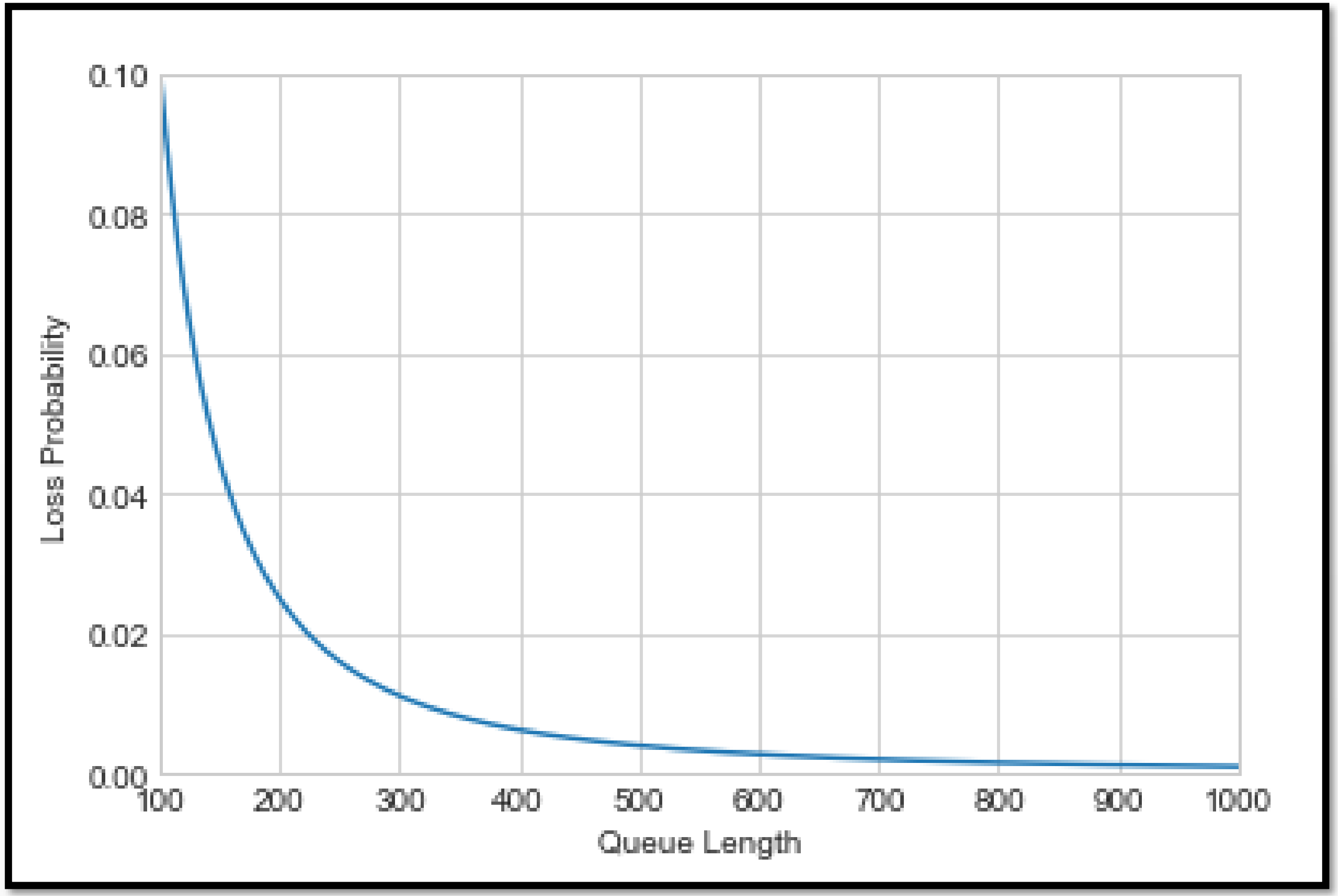
$$p_l = \mathbf{z}_K\mathbf{1} = \lambda^{-1}\mathbf{x}_K(S \otimes (\mathbf{T}^0\boldsymbol{\alpha}))\mathbf{1}.$$

Framework



- **Input parameter**
  - Arrival Rate
  - Service Rate
  - Queue Length
- **Output parameter**
  - Loss probability
  - Graph performance
- **Queue Behavior**
  - Gi/G/1/k model
  - No prioritized queue
  - FIFO scheduling

Graph



0.10
0.08
0.06
0.04
0.02
0.00
Loss Probability
100
200
300
400
500
600
700
800
900
1000
Queue Length