IK1611, Spring term 2013 Dimensioning of Communication Systems

https://www.kth.se/social/course/IK1611/page/ik1611-dimensioning-of-communi-3/

Project Work

Mozhgan Mahloo
KTH/ICT/CoS/ONLab

Outline

- Project description
  - Background
  - Log files
  - Considered queuing models
- What to do in the project
  - Brief explanations and hints for all the questions
  - ABC of using Matlab
- Requirements
  - Report
  - Deadline

Project background

- A company founded by former KTH students has a *website*
  - To provide reviews of different commercial products over the Internet
  - Types of reviews: Everything! E.g. Cars, travel resorts, movies, music, games, etc.
  - Data provided through a website, which the users can visit for free
  - The main income is from the advertisement on this website

Project background

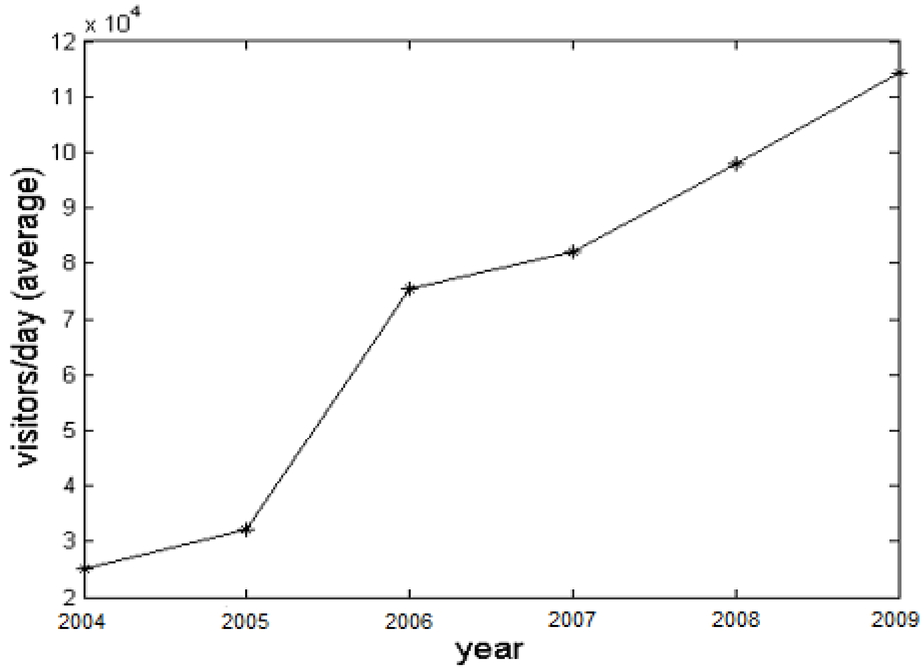


Figure 1: Growth of the Web site's number of visitors

- The average number of visitors per day is continuously growing, and has done so ever since the founding of the company

Project background

- Problem of the company
  - Customers experience *long response times*
- Now, you are the *consultant*, and your task is
  - Suggest *two models (M/M/1 and IPP/M/1)* for the web server
  - Find system's parameters, according to the model
  - Suggest what to do in order to *lower the waiting times*
  - Write a report with your suggestions
  - Present your work at a seminar

Log files

Example:

⋮

1.23	3.44
1.33	3.47
3.50	0
1.55	3.80
1.76	4.12
4.13	0
2.05	4.30
2.47	4.50
3.03	4.82
3.47	5.23
3.82	5.72

⋮

- Each row: Data of each request arriving at the server
  - 1st column: arrival time of a request
  - 2nd column: departure time of a request
  - If the customer is *rejected*, the 2nd column of that request in the record is set to *zero*
  - Time unit: minutes

Log files

- Log files available to the consultants are corresponding to *the record from different days*
  - You can access the log files from the course home page
  - Provided log files can be grouped as

    d1=(v1,w1,v2), d2=(w2,v3,w3), d3=(v4,v5,v6), d4=(v7,v8,v9)
  - Each group of log files represents a typical day, and each of them is *equally probable*
  - Each log file belonging to a group represents approximately 8 hours of the corresponding typical day
  - ***The files corresponding to ***d4*** are cut to maintain reasonable size***

Log files

- *"cpu_load"*: illustrate the approximate working rate of the system
  - Contains CPU loads for a number of different arrival rates

Queuing models – M/M/1

- Well-known M/M/1 queuing system with *a limited number of queuing places*
  - Since customers are rejected, it is not a good idea to use a model with an infinite queue

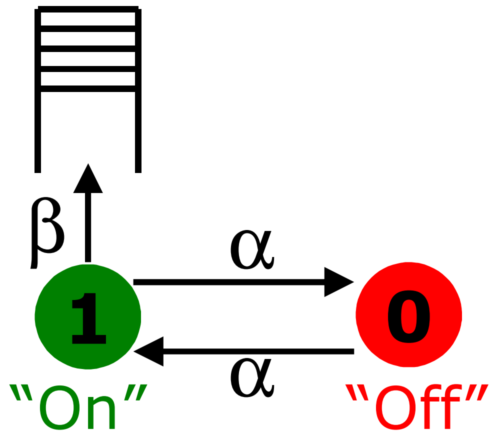
Queuing models – M/M/1

- For this queuing model, three parameters have to be found
  - The arrival rate (λ)
  - The service rate (μ)
  - The number of places in the system (L)

  ⟹ ***in the server and in the queue***

Queuing models – IPP/M/1

- IPP/M/1 queuing system with *a limited number of queuing places*
  - Still an exponential service time
  - But the arrival process is called *Interrupted Poisson Process*
    1. When the process is in state '1', it sends requests with intensity β to the queue
    2. When the process is in state '0', no request is sent



Queuing models – IPP/M/1

- For the complete IPP/M/1 model, there are four parameters
  - The arrival rate when the arrival process is in state ‘1’ (β)
  - The rate by which the arrival process changes states (α)

  IPP

  - The service rate (μ)
  - The number of places in the system (L)

  Same as for M/M/1 model

Queuing models – IPP/M/1

- Times between arrivals in an IPP process have the following *Laplace transform*

$$B^*(s) = \frac{\beta(s+\alpha)}{s^2 + (\beta + 2\alpha)s + \beta\alpha}$$

$$E[x] = -B^{*\prime}(s)\,|_{s=0}\,;$$

$$E[x^2] = B^{*\prime\prime}(s)\,|_{s=0}\,;$$

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Brief explanations and hints

1) Estimate the parameters λ and λ_{eff} for M/M/1 model
   - Hint: count the number of requests in a certain period
2) Estimate the parameter L

   ****Observe that is* L *the same for both models*
   - Hint: find the moment that a request is rejected and count the number of requests at that moment

Brief explanations and hints

Example:

1.23	3.44
1.33	3.47
3.50	0
1.55	3.80
1.76	4.12
4.13	0
2.05	4.30
2.47	4.50
3.03	4.82
3.47	5.23
3.82	5.72

- *3.50* is the moment that a request is rejected
  - i.e. at the moment the queue in the system is full
- The requests in red are in the system at *3.50*
  - These requests arrive at the system *before* *3.50* and leave the system *after* *3.50*
  - Therefore, $L = 6$ in this case

Brief explanations and hints

3) Estimate the parameter μ

- Hint: estimate the load of the server and then use *Little's theorem*, which gives

$$\rho = \lambda_{eff} / \mu$$

(Provided "cpu_load" file contains CPU loads for a number of different arrival rates)

Brief explanations and hints

4) Determine the parameters α and β for an IPP process
   - Hint: we have two parameters, they can be estimated if we have two independent equations. Use the Laplace transform for the inter-arrival times in an IPP process.

Brief explanations and hints

- One formula for the mean of the inter-arrival times

$$E(X) = \frac{1}{n}\sum_{i=1}^{n} x_i$$

- And the other formula for the second moment of the inter-arrival times

$$E(X^2) = \frac{1}{n}\sum_{i=1}^{n} x_i^2$$

- Then use Matlab to estimate the mean and the second moment of the inter-arrival times from the log files

$$B^*(s) = \frac{\beta(s+\alpha)}{s^2 + (\beta + 2\alpha)s + \beta\alpha}$$

$$E[x] = -B^{*\prime}(s)\,|_{s=0};$$

$$E[x^2] = B^{*\prime\prime}(s)\,|_{s=0};$$

Brief explanations and hints

5) Calculate the mean number of customers in M/M/1 model with L places in the system
   - Hint: see M/M/1/L-system in lecture notes

Brief explanations and hints

6) Calculate the mean number of customers in IPP/M/1 model with ***L*** places in the system

- Hint: it is very difficult to analytically calculate the mean number of customers for IPP/M/1 model. Modify provided simulation in Matlab *(available on the course website)* so that the arrival process is an IPP process and the number of places in the system is ***L***. Simulate the system and find the mean number of customers.

Brief explanations and hints

7) Which model is best? Why? Explain what you mean by ‘best’. Would your conclusion change if you change what you mean by best?
   - Hint: Compare the results in questions 1-6

8) Suggest a practical way of decreasing the mean response time for a request. Make your solution scalable. You should account for 20% increase of the traffic load each year.

ABC of using Matlab

- Recommended books
  - Getting started with Matlab7
    a quick introduction for scientists and engineers
  - Introduction to Matlab6 (or 7)
    Delores M. Etter and David C. Kuncicky with Doug Hull

⇨ *From KTH library*

ABC of using Matlab

- Load *.mat
  - filename=`…\v1.mat'; %file path
  - load(filename);
  - v1_size=size(v1);
- Draw figures
  - plot(…), rid(…), legend(…)

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Report

- *All calculations, all results, and all Matlab programs* shall be in the report
  - Explain how you have solved the problems you encounter
  - Put the Matlab program in an appendix
  - Be brief, but do not leave out any important information
  - Your report should not be longer than ***4*** pages (excluding appendix)
  - The deposition of your report must follow the eight points above, one section for each point

Deadline

- Time schedule
  - The part with M/M/1 solutions (questions 1-3): ***By 18th February***
  - Final report addressing questions 1-3, 5 and 8: ***By 4th March***
  - Oral presentation of the results: ***15th March 1-3pm***
  - Feedback on your final report will be sent out: ***8th March***
  - If your report has not passed, you have one more chance to complete it. The completed report shall be handed in not later than ***15th March***

The project group will pass the project

with **grade D and E** (passed) if

- the part with M/M/1 solution is handed in by the due time,
- the final report will be handed in by the due time,
- the group will give an oral presentation of the results.

with **grade C** (good) and **B** (very good) if

- all requirements for the grade D are fulfilled,
- the final report includes the analysis for IPP/M/1 model,
- the report is good written and gives good and realistic recommendations for the company.

with **grade A** (excellent) if

- all requirements for the grade B are fulfilled,
- the proposed solution for the company is the **best solution**.

Thank you and Good luck ☺

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E-mail: mahloo@kth.se