Engineering Adaptive Software Systems: Review

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Final exam

- **All materials presented in class**
  - Including some papers (those marked “all read”)
  - All on-line lecture notes covered in class
- **Study sample final questions**
- **Study test I questions**
  - Maybe several questions similar to the test
- **Study “Your turn” and “quiz” questions from lectures**
- **Key questions discussed in class with your peers**

Format

- **Quantitative skill tasks**
- **Multiple choice**
- **Essay questions**
  - Argue convincingly, Define terms

Topics

- **Motivation**
- **IoT**
- **CBS**
- **Autonomic computing**
- **DevOPs**
- **MAPE-K (review the use cases in Assignment 1, 2, Test)**
- **ACRA**
- **Maturity levels**
- **Cloud, Big Data, Containers (as presented in class and tutorials)**
- **PID**
- **Queuing models (open, close)**
- **Control Theory Models**
- **Model Based Adaptation**
  - Model tuning and estimators
  - MIAC, MRAC
  - MPC
- ~~**Policies**~~

Interesting Potential Final Exam Questions

- **Describe the motivation for Autonomic Systems**
- **What is ACRA?**
- **Give an example of adaptive loop for a domain of your choice**
- **Detail the monitoring, analysis, planning, execution for**
  - a self - healing example (MS Word crash)
  - Self-optimization of cost in cloud for an application
  - Etc..
- **Contrast DevoPs, IoT and Autonomic computing in terms of Adaptive components**

PID controllers

- You have a software system and you monitor the response time, y, each second, T. The software system is controlled each second as well, through an input u. The input u comes from a PID controller, using the typical negative feedback scheme. We also know, empirically, that, the response time depends on the input with this relation y(t) = y(t-1)+K*u(t), where t is time and t=1,2,3...; K is a constant and K=0.5; u is the input.
- The goal of the feedback loop is to maintain the response time to a set value, y_r, of 10 seconds.
- At time t=0, the measured response time is 15 seconds and e(0)=1. Assume the PID controller has Kp(proportional)=0.2; ki=0.1;kd=0 Assume also that the metrics (including the response time) stay constant between samples, e.g. the measured values you use at t=1 are the measured values at t=0;
- What is the value of u and y at t=2, t=3? Use 2 decimals..

Queuing Models

An e-commerce application has 2 main functions: Browse(B), and Search(S) and is deployed on a 3 tier architecture consisting of a Web Server(WS), Application Server(AS) and Database Server(DS).

One Browse request will spend 2 ms, 3ms and 4ms at WS, AS, and DS respectively;

One Search request will spend 1 ms, 1.5 ms and 2ms at WS, AS, and DS respectively;

Consider you have an open queuing model that describes the system and the arrival rates are: Browse with 0.1 requests/ms and Search with 0.1 requests/ms.

1. What is the response time of Browse and Search?

2. Considering a feedback loop with a Controller that computes the number of servers at runtime, what number of DS servers will give a response time of ? seconds (round up to the closest integer).

Control Theoretic Models

You have a software system and you monitor the response time, y, each second, T. The software system is controlled each second as well, through an input u. The input u comes from a Controller C, using the typical negative feedback scheme. We also know, empirically, that, the response time depends on the input with these relations

$x(t+1)=x(t) +0.2*u(t)$

$y(t) = x(t)$

where t is time and t=0,1,2,3...;

Is the system observable? Prove it

Is the system controllable? Prove it

Assume at t=0, x(0)=3 and the desired value of y is 4; What u should the controller generate such that y achieves the desired value at t=1?