Modelling Multi-tier Enterprise Applications Behaviour with Design of Experiments Technique

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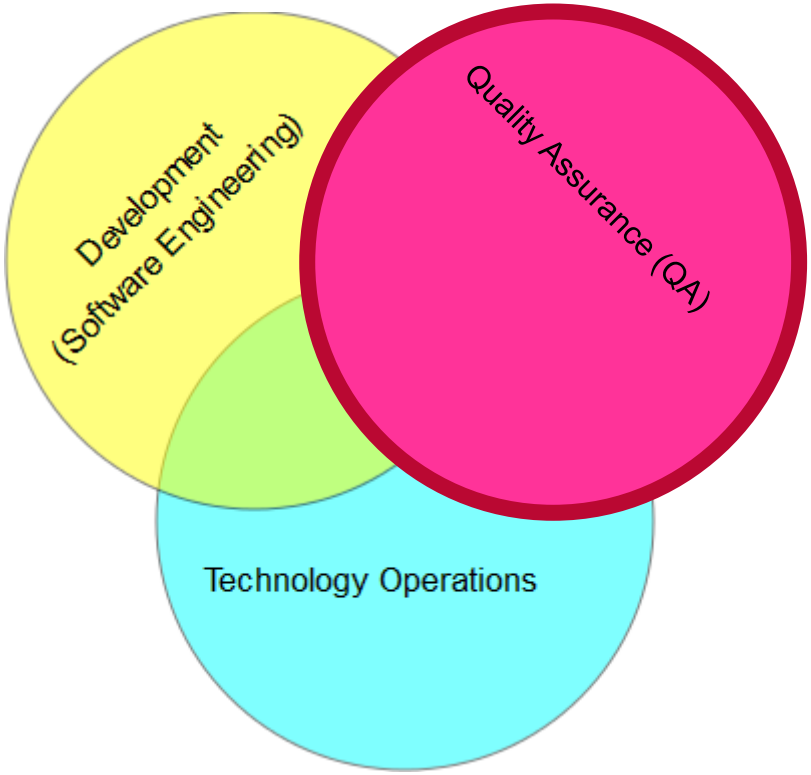
DevOps



https://upload.wikimedia.org/wikipedia/commons/b/b5/Devops.svg

Research Aim and Objectives

Aim:

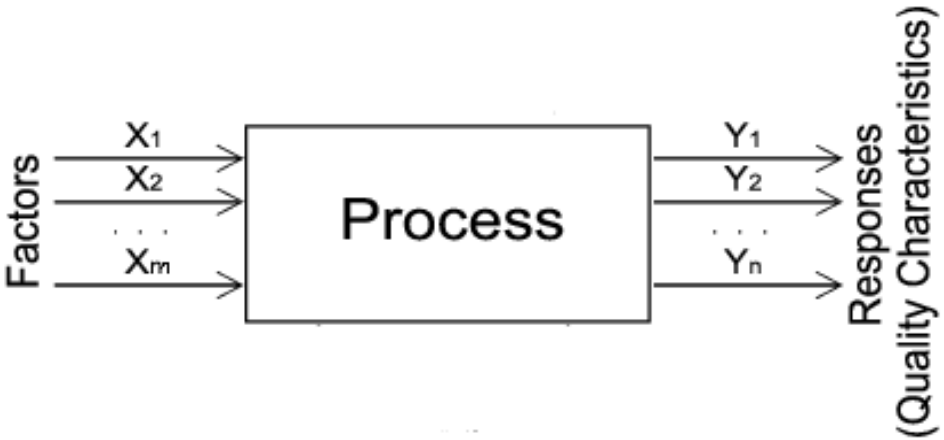
Is DoE good to model and predict application performance?

Objectives:

1. Introduce DoE.
2. Build app performance model.
3. Model prediction accuracy.

Test environment: 3-tier web-based enterprise application

Design of Experiments: Introduction



Linear Regression model: $\boldsymbol{Y = I + A * X + \varepsilon}$

where

$$Y = \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} \quad I = \begin{bmatrix} I_1 \\ I_2 \\ \vdots \\ I_n \end{bmatrix} \quad A = \begin{bmatrix} a_{11} a_{12} \dots a_{1m} \\ a_{21} a_{22} \dots a_{2m} \\ \vdots \quad \vdots \quad \vdots \quad \vdots \\ a_{n1} a_{n2} \cdots a_{nm} \end{bmatrix} \quad X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_m \end{bmatrix} \quad \varepsilon = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

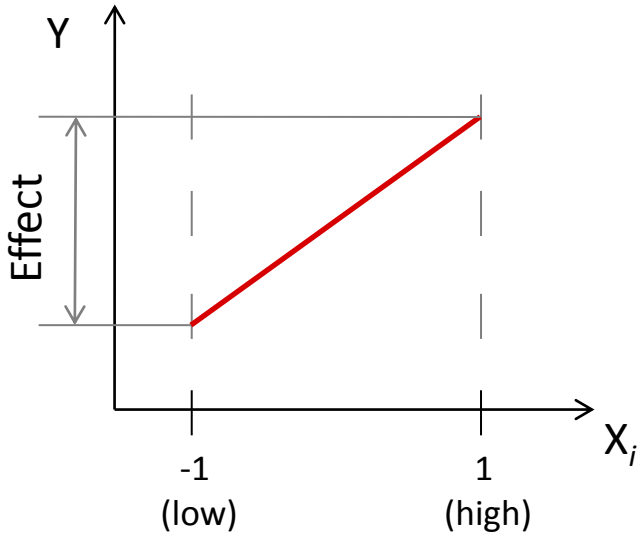
I – intercept
ε – error term

Design of Experiments: Introduction

1. How to choose values for factors?
2. How many experiments to fit the model?
3. What if there are too many factors?

DoE: Screening Procedure

Two levels for each factor



	Levels	
	Low (-1)	High (1)
Number of users	3	20
User think time, s	10	1
Execution time, min (steady state)	10	30
Workload mix (user class)	I	III

$2^4 = 16$ 5 h 20 min execution time

Full Factorial Design

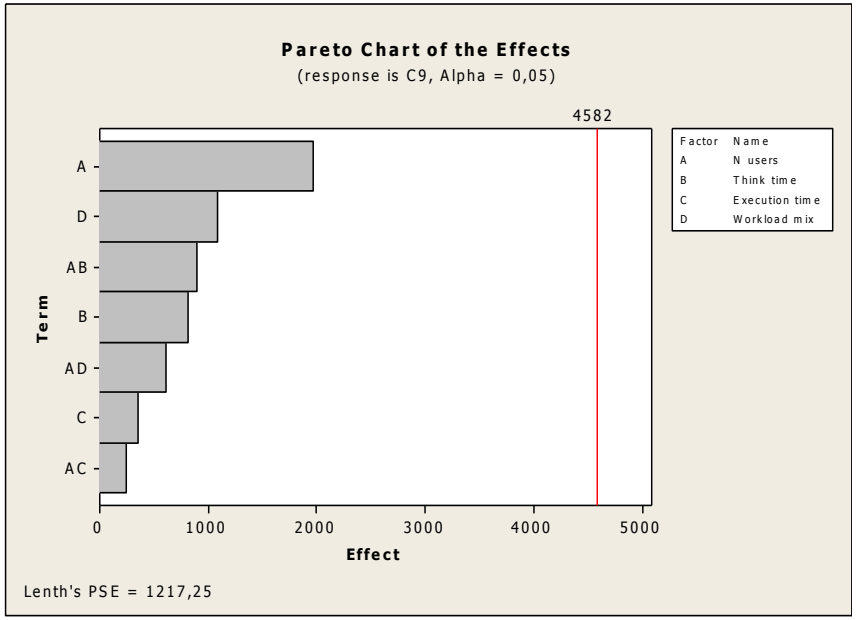
2^k runs, where

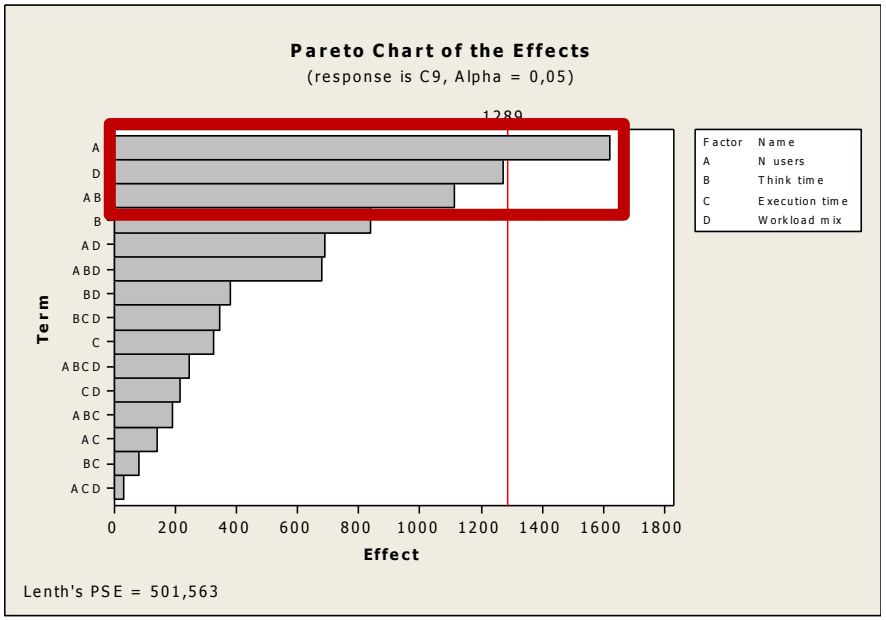
k – number of factors

Fractional Factorial Design for 4 factors

$2^{4-1} = 8$ runs

DoE: Screening procedure (contd.)





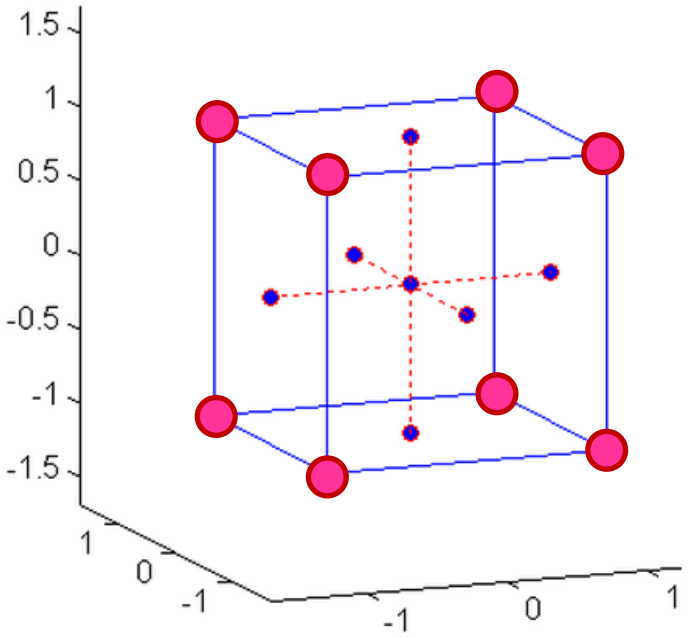
DoE: Screening procedure (contd.)

Allocation of variation, %

Effect	Response time	CPU utilisation
N_users	26.03	54.27
Think time	4.53	42.99
User class	36.25	1.14
N_users:Think time	19.13	0.59
N users:User class	6.63	$7.886*10^{-6}$
Think time:User class	$1.5x10^{-8}$	$1.8917*10^{-4}$
N_users:Think time: User class	5.42	0.91
Error	**2.01**	**$7.6946*10^{-4}$**

DoE: Constructing the Model

Box-Wilson Response Surface Design

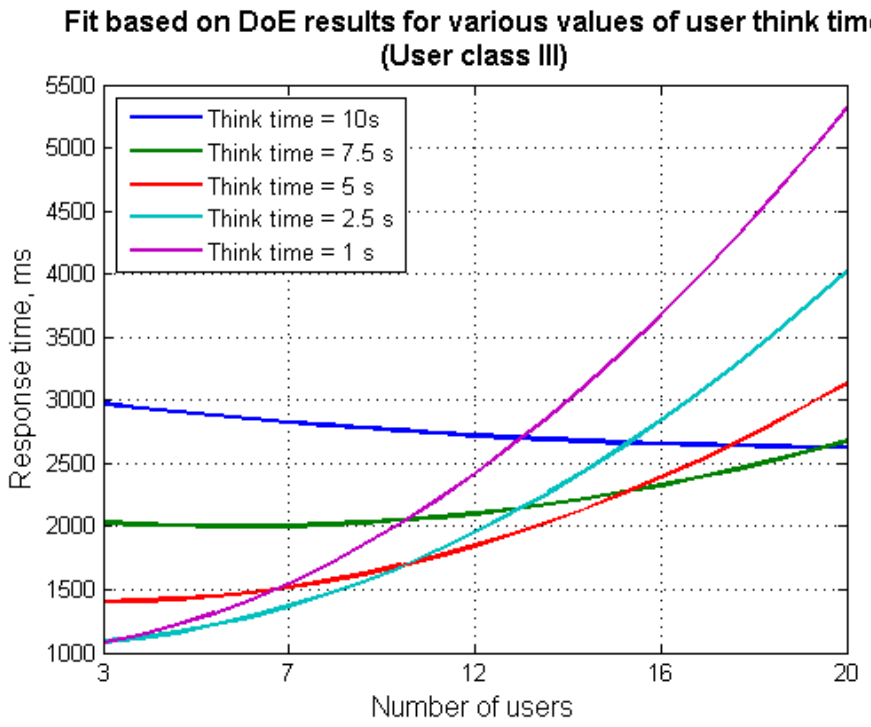


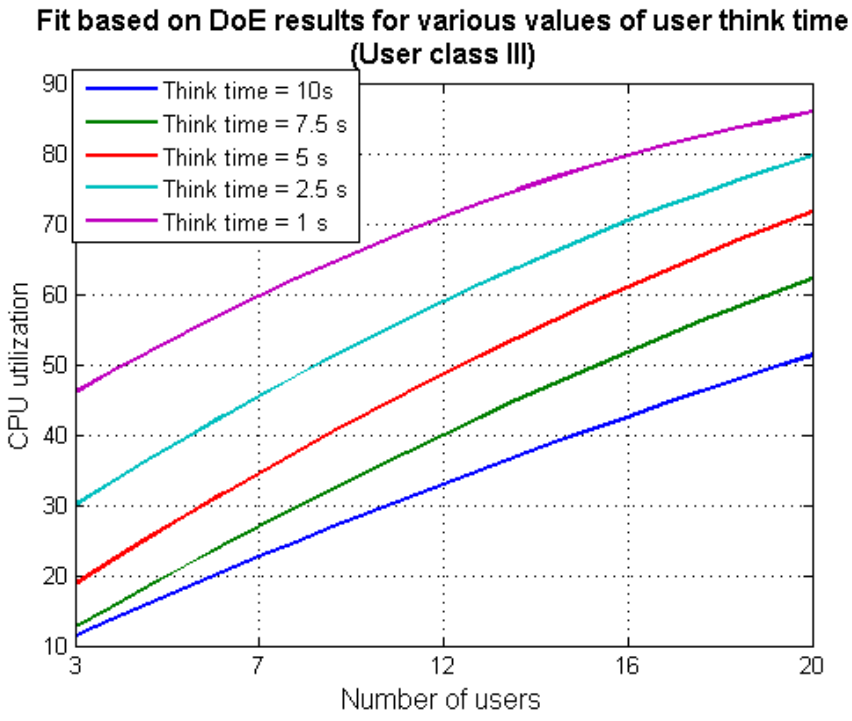
24 runs

Linear Regression Models

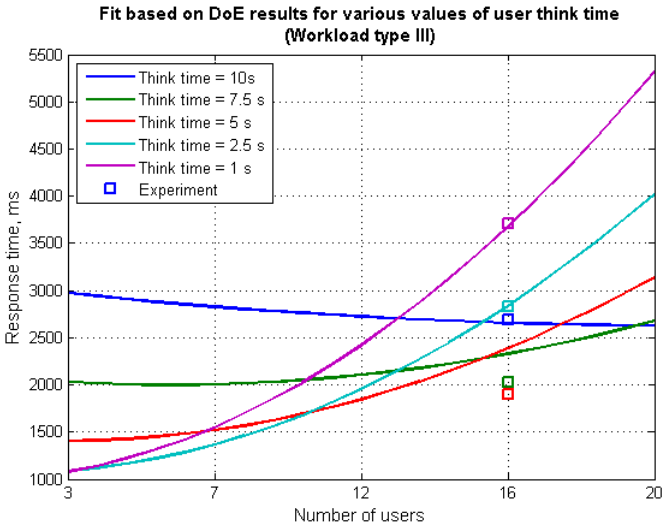
Name	Formula
Linear	$y=l+a_1x_1+a_2x_2+a_3x_3$
Interactions	$y=l+a_1x_1+a_2x_2+a_3x_3+a_4x_1{:}x_2+a_5x_1{:}x_3+a_6x_2{:}x_3$
Pure Quadratic	$y=l+a_1x_1+a_2x_2+a_3x_3+a_4x_1^2+a_5x_2^2+a_6x_3^2$
Quadratic	$y=l+a_1x_1+a_2x_2+a_3x_3+a_4x_1{:}x_2+a_5x_1{:}x_3+a_6x_2{:}x_3+ +a_7x_1^2+a_8x_2^2+a_9x_3^2$
Full Polynomial	$y=l+a_1x_1+a_2x_2+a_3x_3+a_4x_1{:}x_2+a_5x_1{:}x_3+a_6x_2{:}x_3+ +a_7x_1{:}x_2{:}x_3+a_8x_1^2++a_9x_2^2+a_{10}x_3^2+a_{11}x_1^2{:}x_2+a_{12}x_1{:}x_2^2+ +a_{13}x_1^2{:}x_3$

DoE: Constructing the Model (cont.)





Model Prediction Accuracy



Prediction accuracy: error and bias

		Total prediction error σ, %		Bias, %	
		RT	CPU	RT	CPU
Response Surface models	Linear	6.51	4.3	-3.62	-0.75
	Interactions	6.32	4.09	-2.6	-0.65
	Pure quadratic	5.11	4.93	-2.02	-0.79
	Quadratic	5.42	4.09	-1.0	-0.69
	Full polynomial	5.12	4.06	-1.97	-0.96
FF		6.896	3.987	-4.96	-0.32
MVA		40.0	11.4	-234.6	7.29

Conclusions

- DoE prediction accuracy: 5-6% for RT and 4-5% for Ucpu. Out-of-the box QN algorithm - 40% and 12% respectively.
- DoE captured app's 'anomalous' behaviour w/o information about its 'insides'.
- Screening: 3 factors - 98% of variation in RT and 99.9% in Ucpu.
- Fractional factorial designs - use with care.

Feedback and Discussion Starter Qs

1. What is the place of DoE in Continuous Testing?

2. CT presents challenges to DevOps. Design of Experiments might be a solution.

Thank you!