



# Applied Innovation

From Ideas to business results

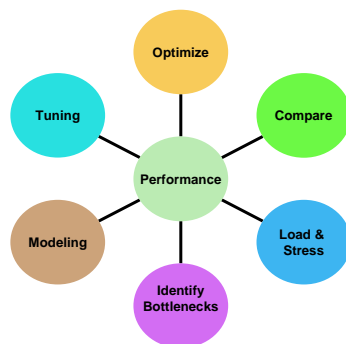


## Performance Tuning Using Design Of Experiments

- Landscape of Performance Testing
- Design Of Experiments
- Performance tuning Of Storage System Using DOE



## Landscape of Performance Testing



- How to optimize the performance?
- How to maximize the performance?
- How to compare performance of two products?
- How to identify factors impacting performance?
- How to study the robustness of product?

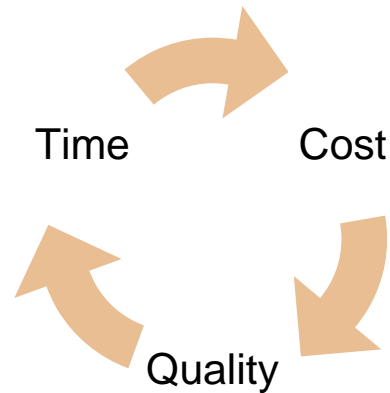
One thing common among them is EXPERIMENTS!



## Economics of Experiments



- How long it will take?
- How much it cost?
  - Physical resources
  - Human resources
- How much information it produces?
- Did it meet the objective?

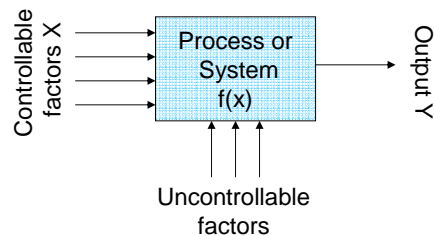


## Design Of Experiments (DOE)



- Efficient procedure for experimentation
  - Provides significant insight about a system with lesser efforts
- Useful for various types of performance testing tasks
  - Tuning, comparison, modeling, screening for key factors
- Steps defined to minimize experimental errors
- Provides statistical framework to analyze the results
  - ANOVA, Regression

DOE Process Model



### Motivation

- Reliable results out of performance testing
- Reduction of performance testing costs
- Reduction in performance test cycles



## DOE vs. Conventional Approach



	Conventional way	DOE
<b>Experimental designs</b>	One Factor at a Time (OFAT) or trial and error methods (T&E)	Full factorial, fractional factorial, Taguchi designs
<b>Information yield</b>	Only Information about one factor is available	Information about main effects of factors involved and factor interaction effects is available
<b>Estimation of uncontrolled factor effects</b>	Not possible to assess	Possible to assess
<b>Experimental error</b>	Experimenter should control	Replication, Randomization and Blocking reduces the error
<b>Reliability of results</b>	Depends on maturity of the experimenter and number of data points collected. More the better	Improve the reliability of results to great extent
<b>Efforts</b>	Significantly high as experiment basic design is OFAT or T&E	Depends on the design.



## Storage Array Performance Tuning – Experiment Details



### Experimental Setup

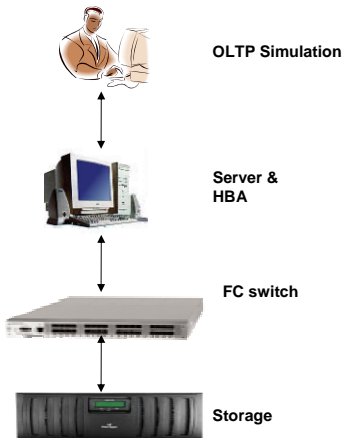


Figure 1. Experimental Setup

### Application Profile

Application factors	Specifications
Application Block Size	8 KB
Read and Write Ratio	60 and 40 %
Application Type	Random
No of Outstanding I/Os	500

**Measure of performance –  
Throughput measured in MBps**



## Experimental Design



### Factors

- Cache Partition size (CPS)
- LUN strip size (LSS)
- Cache Segment size (CSS)

### Factor levels

CPS (MB)	LSS(KB)	CSS(KB)
100	64	16
600	256	64
1360	512	-

### Design particulars

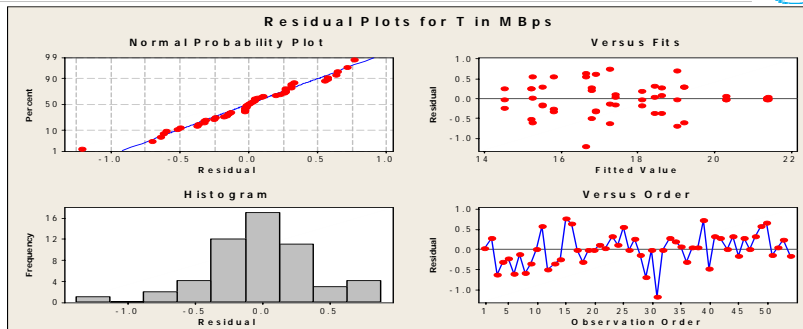
- 3 factor mixed level design
- Full factorial design
- Replicates
- Randomized
- Unblocked

### Total experimental runs

- 54 (18 runs with replicates)



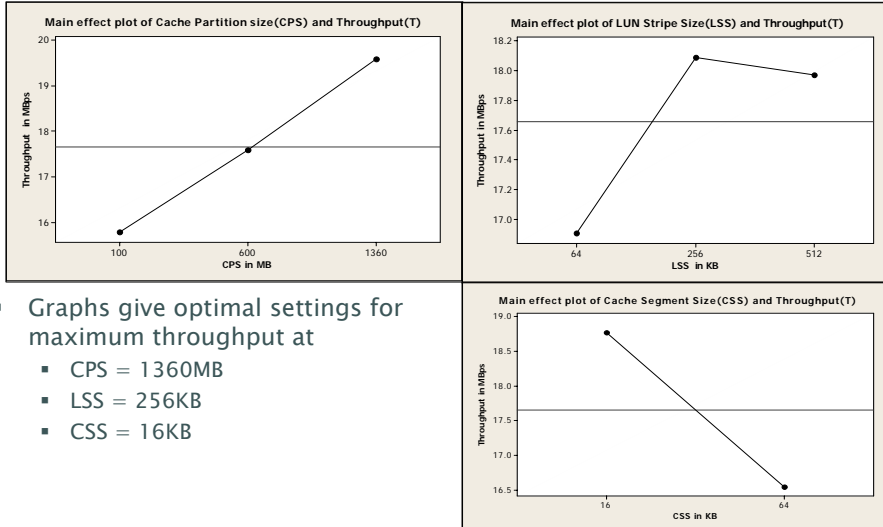
## Data Analysis – Residuals



- Approximately linear pattern in the normal probability plot shows that residuals are normally distributed
- Histogram follows normal distribution and appears to be suitable for the analysis and has adequate predictive ability
- Residual vs. fits and run order shows the data is normal, free from skews, nonrandom patterns in the observed data and no known time dependencies

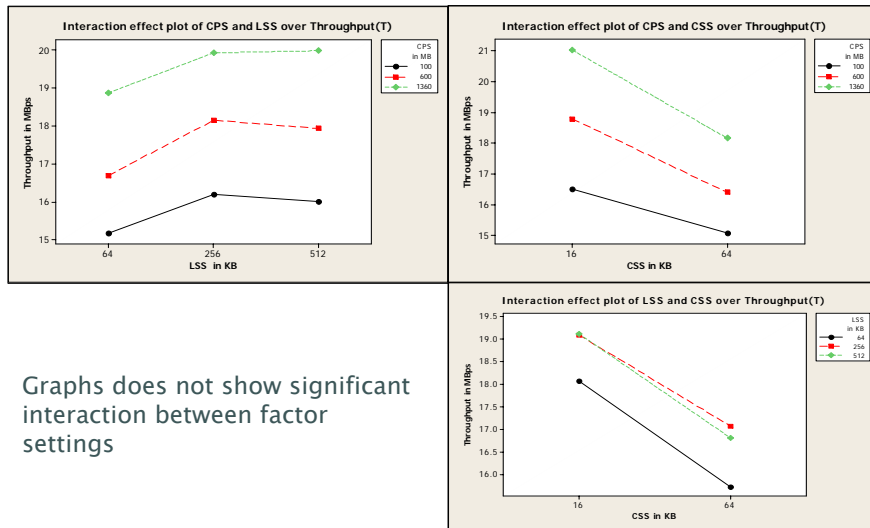


## Data Analysis – Main Effects



- Graphs give optimal settings for maximum throughput at
  - CPS = 1360MB
  - LSS = 256KB
  - CSS = 16KB

## Data Analysis – Interaction Effects



- Graphs does not show significant interaction between factor settings

## Objectives Revisited



- Successful adoption of DOE methods in identifying the optimal levels for storage array
  - Findings are statistically significant
- Found the optimal settings for CPS, LSS and CSS through main effect analysis
- Found that there is no significant interaction between CPS, LSS and CSS
- Able to derive mathematical model to predict the throughput for a given CPS, LSS and CSS settings
- Effort required for modeling the array system and identifying the optimal factor is less compare to OFAT(one factor at a time) methodology



## Thank You

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