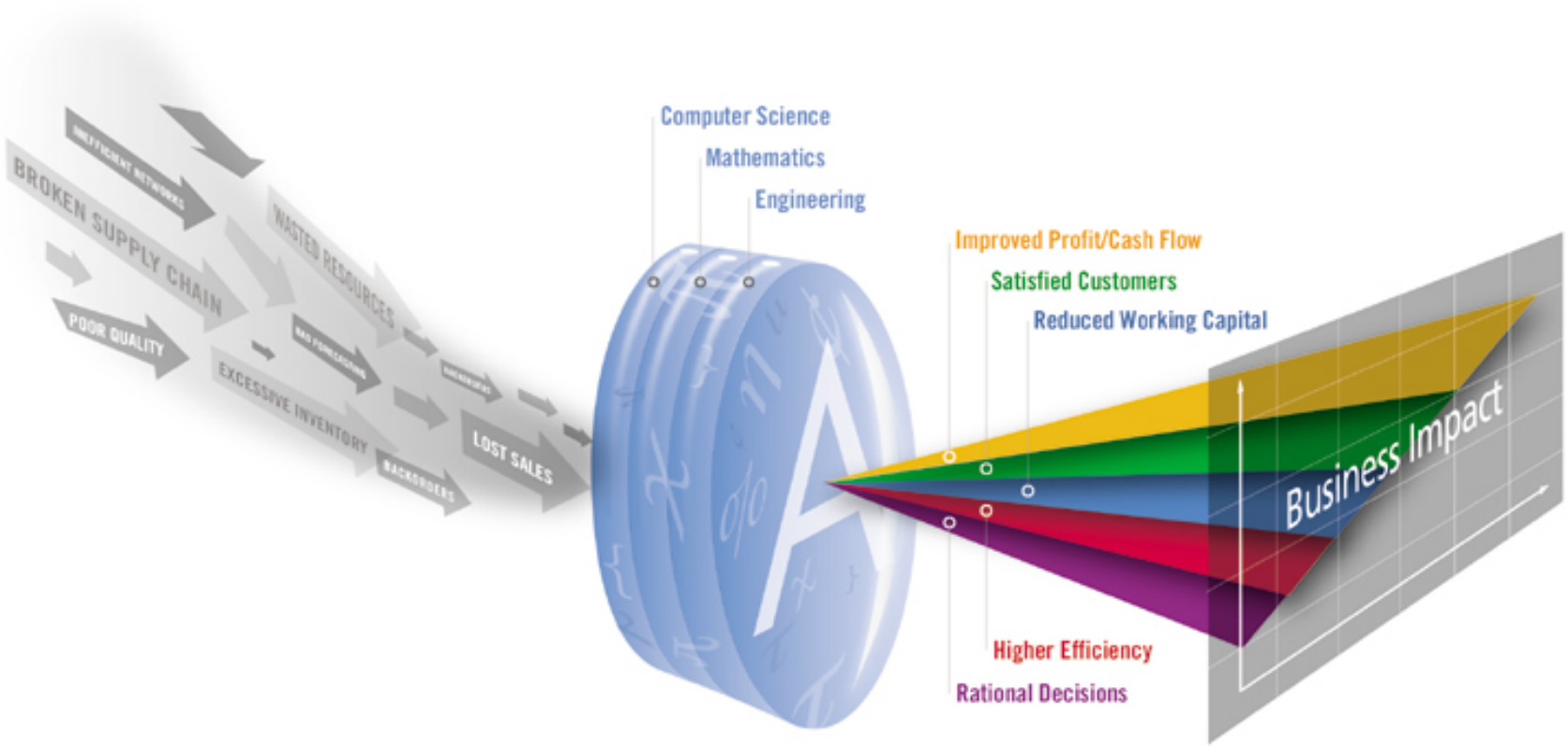
The Use of Operations Research Techniques to Improve the Design of a Hewlett-Packard Printer Production Line

Mitchell Burman

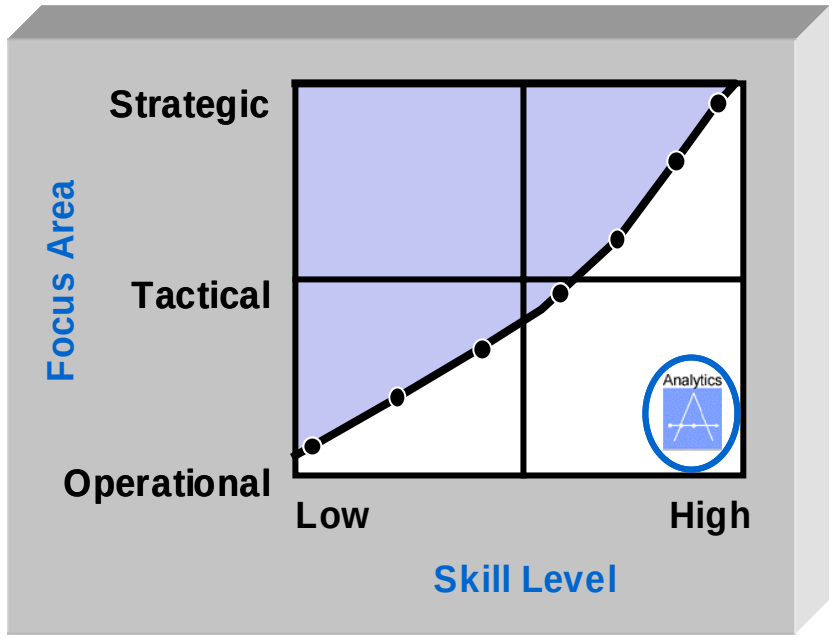
Analytics' Focus



Analytics Operations Engineering

Quantitative Analysis

- Inventory Optimization
- Forecasting & Scheduling
- SKU Rationalization
- Distribution Efficiency
- Quality Engineering
- Supply-Chain Management



Selected Results (Confidential)

Supply Chain Design & Mgt

• IBM	$750m Savings
• Samsonite	$25m Savings
• Boeing	$9m Inventory Reduction

SKU Rationalization & Pricing

• Unisource	>$10m Profit Increase*
• Broder	$30m Inventory Reduction
• Superior	>10% Profit Increase

Productivity

• HP	$280m Increase
• Truck Mfr.	>10% Increase
• Baxter	$5m Scrap Reduction

Fleet Management

• United	$30m Savings
• Flight Options	$6m Profit Increase
• Active Aero	15% EBITDA Increase*

** Estimates based on work in progress*

Selected Analytics Clients

- Acme Steel
- Active Aero (Berkshire)
- Alcan
- Atkins (Parthenon)
- Baxter Healthcare
- BICC General
- Boeing
- Boston Scientific
- Broder Brothers (Bain)
- Cambridge Industries (Bain)
- DESA (HIG)
- Endres (JMH Capital)
- Flight Options
- FluidSense
- GMAC
- Harley-Davidson
- Hewlett Packard
- ICI (Imperial Chemical)
- 3i (Advent)
- Intel
- J.M. Huber Corporation
- Johnson & Johnson
- Karsten Textilia (Brazil)
- Kraton Polymers (TPG)
- Lockheed Martin
- Lone Star Industries
- Motorola
- Northrop Grumman
- Nutraceutical (Bain)
- Palm Coast Data (Tinicum)
- Primedica
- Raytheon/Flight Options
- Samsonite (Bain)
- SAPPI Paper
- Superior Essex
- Team Products (HIG)
- Thomson Legal & Regulatory
- Truck Mfr. (BCG)
- Unisource (Bain)
- US Can (Berkshire)
- Western Mining (Australia)
- Wolverine (Parthenon)

Presentation Outline

- Business Need
- Application of Technology
- Benefits
- Summary

The Product

- HP Desk Jet Printer
- >$1,000,000,000 in demand
- Encroaching competition (Canon)

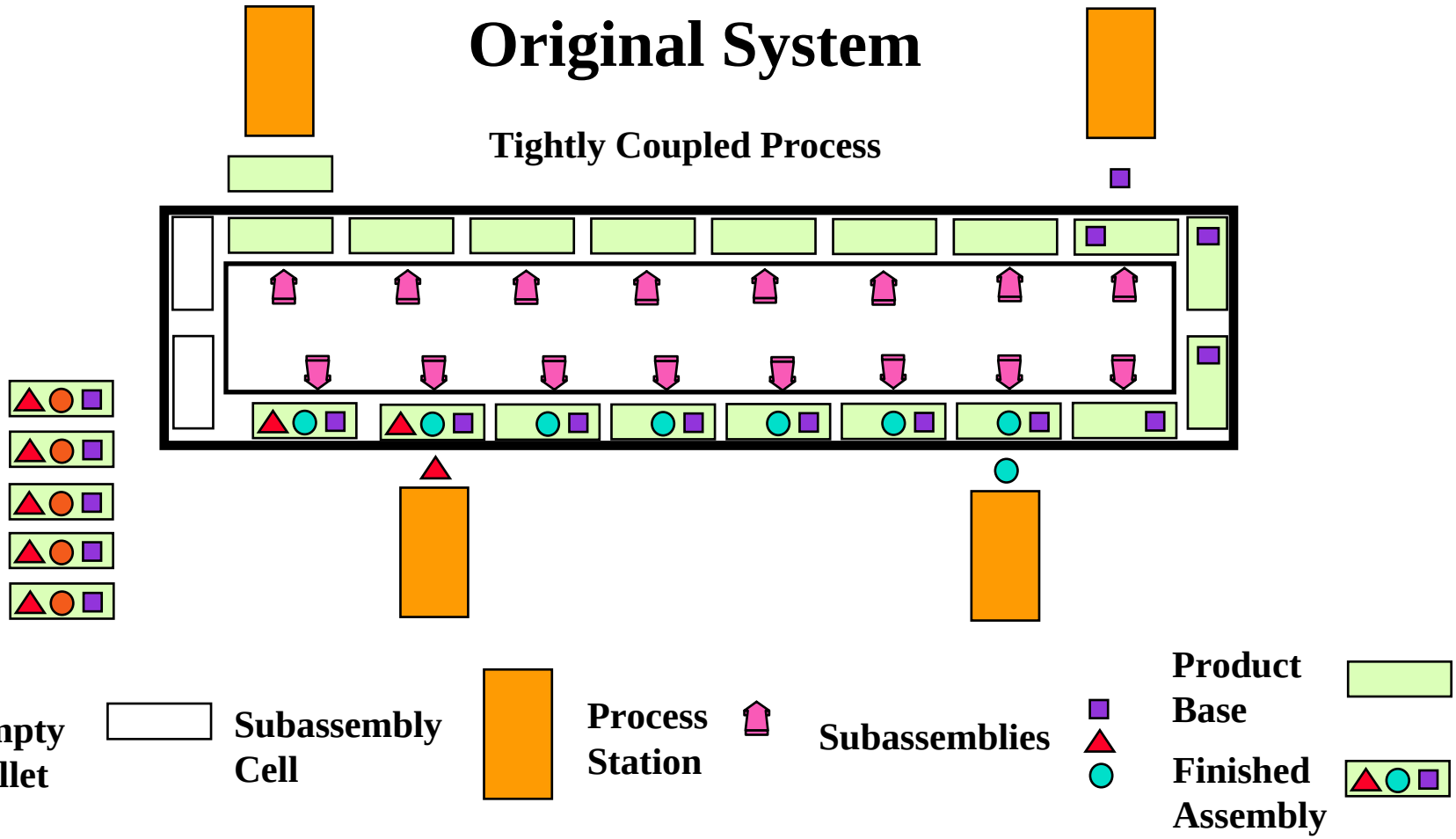
Business Need

- HP background
- Vancouver Division (VCD) background
- VCD Business requirements
- “HP Way”

VCD Business Strategy

- Productivity improvement to meet business needs
- Automation for attaining productivity objectives

Eclipse Project Design



Buzacott Approximation

Single Machine $$E_1 = \frac{MTTF}{MTTF + MTTR} = 0.98$$

MTTF = Mean Time to Fail
MTTR = Mean Time to Repair

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Systems with no buffers $$\frac{MTTR}{MTTF} = 0.0204$$

100 Machines $$E = \frac{1}{1 + \frac{100\ MTTR}{MTTF}} = 0.328$$

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100 Machines $E = \frac{1}{1 + 0 \frac{MTTR}{MTTF}} = 0.328$

MTTF = Mean Time to Fail
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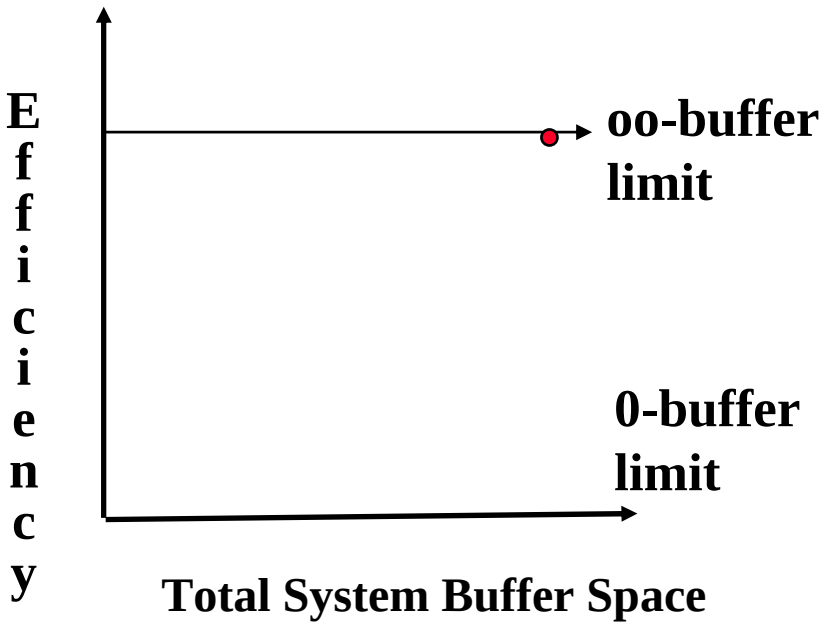
One Year Later

Business Situation Statement

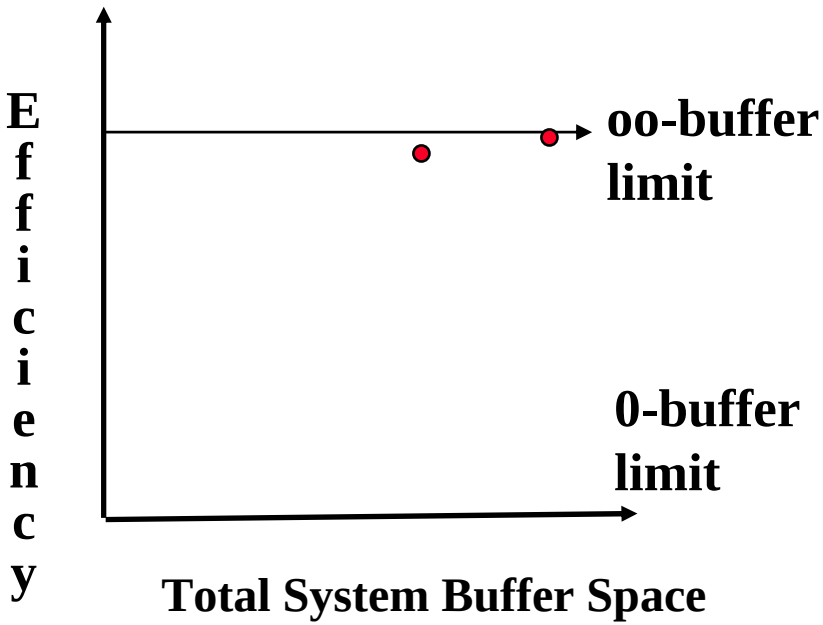
- Eclipse sub-assembly performance insufficient
- Simulation not working
- Method needed to quickly assess alternative system architectures

Buffer Analysis



- Early paradigm:
  - Large Buffers

Buffer Analysis



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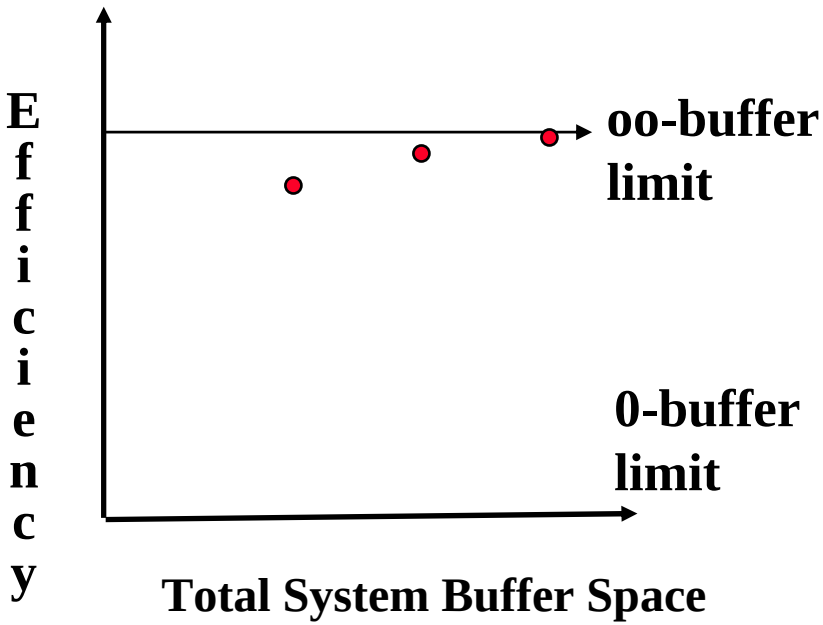

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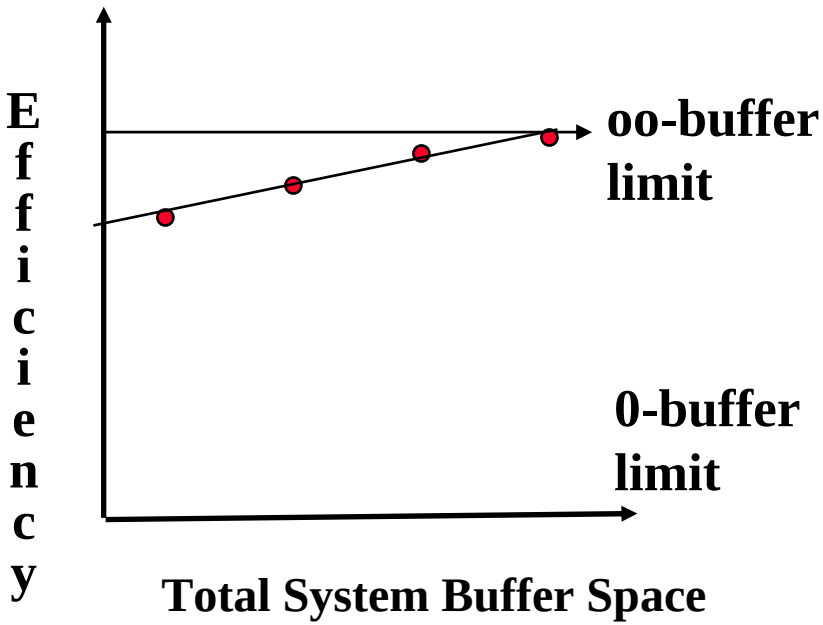
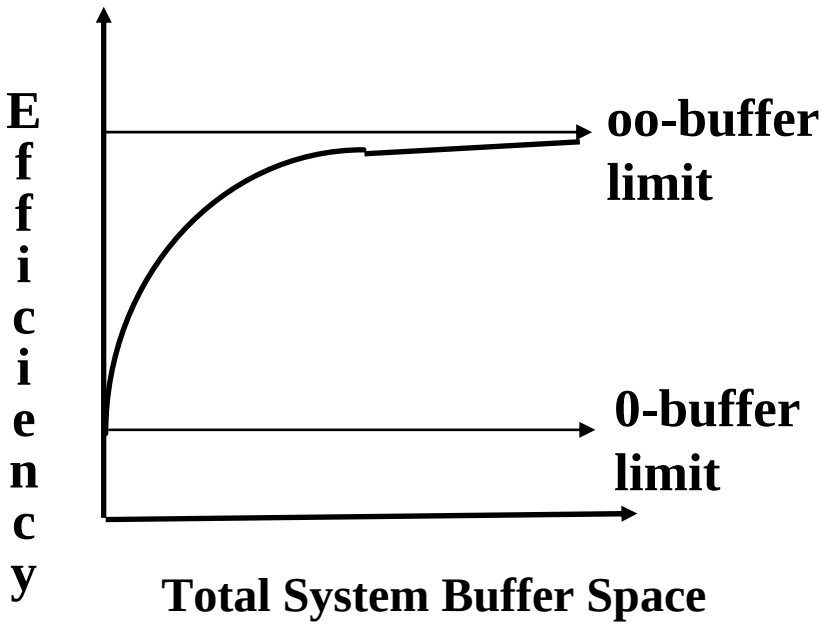
Buffer Analysis



- Early paradigm:
  - Large Buffers
- JIT
  - Buffers Unnecessary

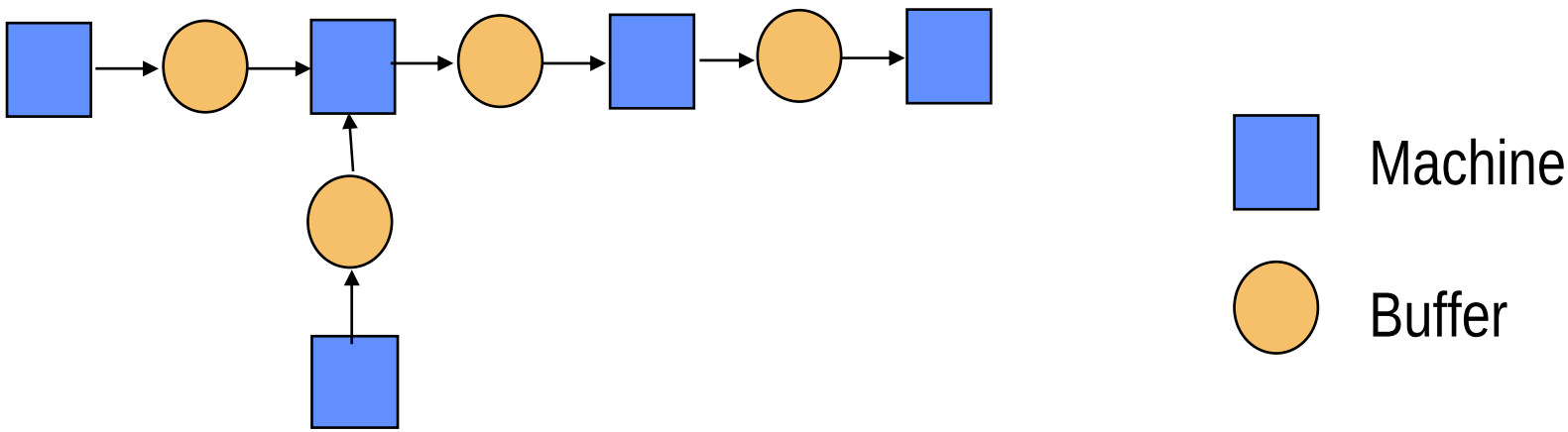
Buffer Analysis



- Early paradigm
  - Large Buffers
- JIT
  - Buffers Unnecessary
- Reality
  - The truth is in between

Important System Phenomena

- Long multi-stage process
- Failing machines
- Different operation times
- Finite storage space



Application of Technology

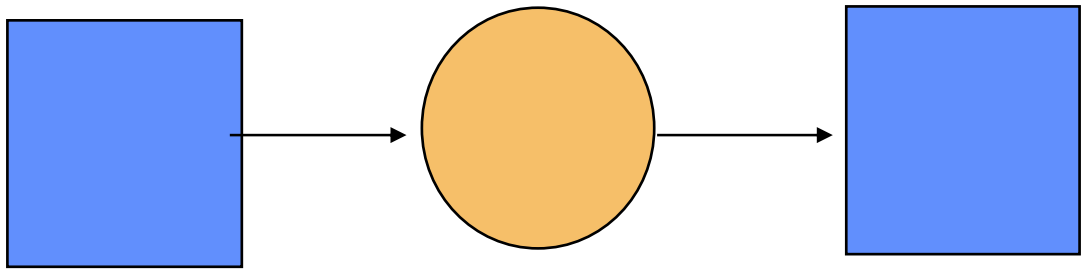
Goal: Rapidly predict performance of a production system

- **Many alternatives (695,784,701,952)**
- **Long execution times make simulation awkward**

Development of Technology

- Analytical method needed for rapid system evaluation
- Difficulty: Large state space makes brute force numerical solution of Markov chain impractical

Known Two Stage Models



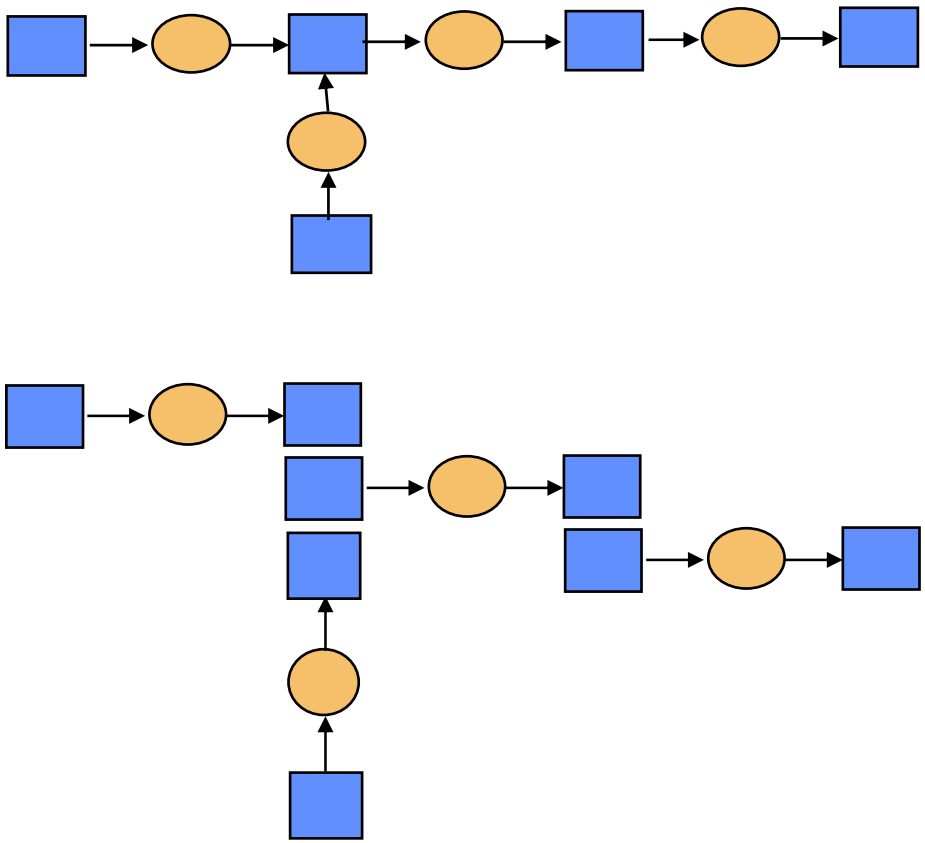
μ_1
$MTTF_1$
$MTTR_1$

N

μ_2
$MTTF_2$
$MTTR_2$

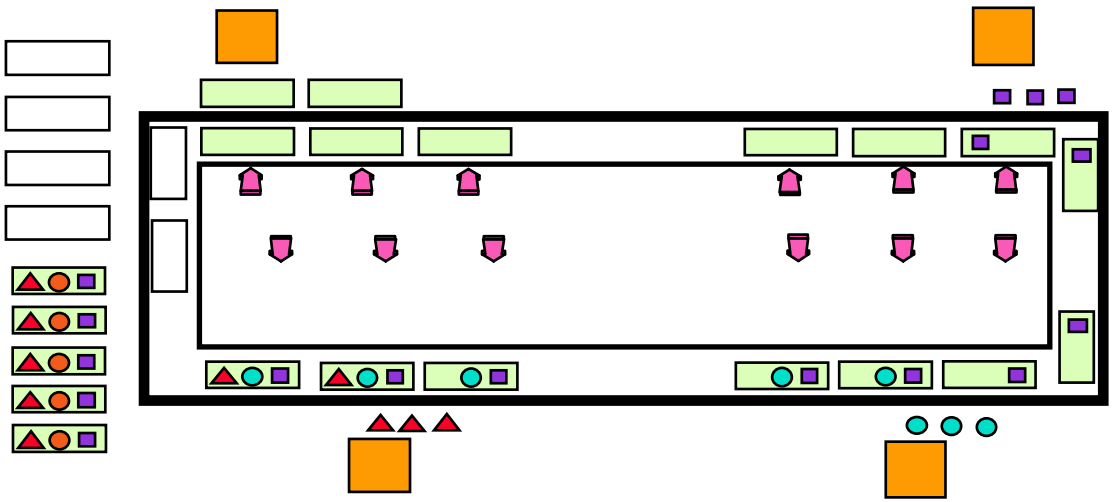
Development of Decomposition

Analysis of large system by breaking it into smaller systems



Solution Approach

- Analytical systems performance model was developed
- Hardware changes
- Critical operational targets



Cost of Changes
~$1,000,000

Implementation Results

- New system architecture
- System validation
- New methodology for system optimization

Short-Term Benefits

- Eclipse system throughput increased 25%
- $280 million in incremental revenue
- Incremental pen and media revenue
- Lower production costs

Long-Term Benefits

- More robustness and predictability for all new manufacturing system designs
- Faster production ramps
- Greater throughput and productivity

Potential long-term financial benefits far outweigh the short-term

Summary

- Realized $280 million incremental revenue
- Captured incremental market share at critical time which increased
- Leveraged the methodology into future system designs