Fit for Purpose Architecture Selection and Design

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- William Clarke – Poughkeepsie
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- Danny Williams – UK
- Jeffrey Callan - Waltham
- Wakaki Thompson – Wayne
- Edward Hoyle - Winston Salem
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Caveats

- This presentation covers both platform positioning and selection
  - Positioning: Generalized discussion of platform design & attributes
  - Selection: Evaluating options for workloads in a specific customer context

- By definition there will be exceptions to any generalization
  - Broad technology & market observations – a starting point for discussion
  - Not all customers are the same – primary focus is on medium to large customers

- Agreement on common terminology definitions is key
  - Similar terms can sometimes mean different things for different platforms
  - Speaker will try to define terms – audience should ask if unsure
Many Factors Affect Choice

Would you purchase a family car solely on one factor?

<table>
<thead>
<tr>
<th>Car</th>
<th>Server Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase price</td>
<td>Purchase price</td>
</tr>
<tr>
<td>Gas mileage, cost of repairs, insurance cost</td>
<td>Cost of operation, power consumption, floor space</td>
</tr>
<tr>
<td>Reliability</td>
<td>Reliability</td>
</tr>
<tr>
<td>Safety, maneuverability, visibility, vendor service</td>
<td>Availability, disaster recovery, vendor service</td>
</tr>
<tr>
<td>Storage capacity, number of seats, towing capacity</td>
<td>Scalability, throughput</td>
</tr>
<tr>
<td>Horsepower</td>
<td>Chip performance</td>
</tr>
<tr>
<td>Dash board layout</td>
<td>Instrumentation and skills</td>
</tr>
<tr>
<td>Automatic or manual</td>
<td></td>
</tr>
<tr>
<td>Handling, comfort, features</td>
<td>Manageability</td>
</tr>
<tr>
<td>Looks, styling, size</td>
<td>Peer and industry recognition</td>
</tr>
</tbody>
</table>
Selecting a Platform

System z

System x

Time Horizon

ISV Support

Non-Functional Requirements

Geographic Considerations

Power, cooling, floor space constraints

Strategic Direction and Standards

Cost Models

Skills

Power

Technology Adoption Level

Platform Architecture

Politics

Deployment Model

Scale

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Strategic Direction and Standards

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System z

System x
Local Factors are Important

- Local factors (constraints)
  - Skills
  - Technology adoption levels
  - Platform management practices
  - Number of servers
  - Organizational considerations
  - Data center issues
  - Culture

- Develop comparison metrics
  - Consistent, collectable, usable

- Become best of breed
Design Decisions Often Involve Tradeoffs

- Designs involve tradeoffs
  - Cost
  - Availability
  - Throughput
  - Simplicity
  - Flexibility
  - Functionality

- Designs are different because needs are different
Strategic and Tactical Platform Choices

**Tactical Choices**
- Can lower decision costs
- Based on momentum, skills, and legacy
- Narrow focus can lead to sub-optimal solutions

**Strategic Choices**
- Can lower long term costs
- Can run afoul of legacy
- New technologies may change business process & strategy

**IT Decision**
- Balance tactical & strategic
- Balance of established and visionary patterns
- Mergers and acquisitions can add non-strategic solutions

Over time all strategic choices become legacy
Reference Architectures

- Pattern for repeated decisions
  - Lower decision making cost
  - Lower implementation variability

- Larger than single decision - unlike a standard

- Based upon
  - Actual implementations
  - Architectural decisions

- Can be long term decision setting
## Functional and Non-Functional Requirements

### Functional

**“What it does”**
- Correct business results
- Inputs
- Outputs
- Behaviors
- External interfaces
- Screen layouts

### Non-Functional

**“How well it does it”**
- Availability requirements
- Transactions per minute
- Security requirements
- Ease of provisioning and support
- Disaster recovery requirements
- Future growth

Select platforms based upon non-functional requirements driven by business value

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Complete your sessions evaluation online at [SHARE.org/BostonEval](http://SHARE.org/BostonEval)
Future Proof

• May select a platform for an unclear future need
  • Potential acquisition or new business volumes
  • More stringent future non-functional requirements
  • Proposed new regulation
  • Money in this year’s budget

• Platform features can help mitigate
  • Capacity on demand
  • More scalable servers
  • I/O drawers and/or cages
Select a Platform Based Upon All NFRs

NFR #1

Platform A

Platform B

Requirement

NFR #2

Platform A

Platform B

Requirement
Traditional Deployment Models

**Centralized**
- Components are all together
- Very granular resource sharing
- OS workload management
- Strongly integrated and stacked

**Virtualized**
- Components split across virtual images
- Coarser grained resource sharing
- Virtualizer workload management
- Stacked and integrated over network

**Dedicated**
- Components split across servers
- No resource sharing between servers
- Limited workload management
- Integrated over physical networks

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Emerging Deployment Models

Cloud
- Self service
- Rapid provisioning
- Advanced virtualization
- Flexible pricing
- Elastic scaling
- Standardized offerings
- Network access

Hybrid
- Combination of other deployment models
- Potential uses
  - Intelligent offload
  - Centralized management
  - SOA services
- Transcends computing silos
Clouds vs. Systems Pools

- **Automated**
  - Capable of automation
  - Limited choice & complexity
  - Small relative to HW footprint

- **Repeated**
  - Used frequently
  - Low relative effort to automate

- **Low on-going support**
  - Limited maintenance, capacity planning, performance tuning
  - HW/OS able to dynamically handle needs
Choosing a Platform – ISV Considerations

• For a given deployment
  • Eliminate platforms that don’t support the ISV
  • Choose a different ISV
  • Get ISV to support platform

• Select platform on non-functional requirements
  • Not just on middleware brand
  • NFRs vary using the same middleware

• Consider platform agnostic middleware
  • NFRs can change over time
  • Agnostic middleware offers more flexibility
Deployment Models and Underlying Hardware

Centralized
- Scalability and performance critical
- Stress on data delivery features
- Large emphasis on single server availability

Virtualized

Dedicated
- Acquisition costs emphasis
- Industry standard components
- Commodity availability features common
- Cost per unit of work is typically higher

Degree of Sharing / Robustness

More

Less
Server Scalability, Utilization, and Throughput

- Throughput measures work
  - Requires performance objective
  - Can be higher with discretionary work

- Factors that affect throughput
  - Cache or data coherence
  - Contention for shared resources
  - Path length and latency
  - Balanced system design

- Mixed workloads can stress platform design

- Isolated capacity can lower throughput
  - Dedicated servers or partitions
  - Passive clusters
  - Separate environments
  - Business decision
Driving High Effective CPU Utilization

- High CPU utilization
  - Minimize core based SW costs
- Must run out of CPU last
- Over size I/O and memory if work is unpredictable

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Cache Effectiveness

- Throughput can decline when cache is starved
- Area A
  - CPU frequency, memory latency, and threading affect slope
  - Cache is not yet a bottleneck
- Area B
  - Insufficient cache dominates
- Performance affected by
  - Size and distance of cache
  - Working set size and context switch rates
Memory Architectures

- **NUMA Memory Model**
  - Non-uniform access to memory
  - Useful for partitioned workloads
  - More components
  - Latency limits throughput

- **Flat Memory Model**
  - Consistent access to memory
  - Ideal for shared workloads
  - Fewer components
  - Increasingly critical with scale

Diagram:

![Interconnect Diagram]

Point to point crossbar interconnect
Relative Server Capacity

• Base core capacity

• Server specific factors
  • Efficiency
  • Additional cycles/capabilities

• Relative server capacity
  • Workloads vary over time
  • Local metrics or relevant benchmarks

• General purpose vs. specialized servers
Workload Attributes and Market Segmentation

**Transaction Processing and Database**
- High Transaction Rates
- High Quality of Service
- Peak Workloads
- Resiliency and Security

**Analytics and High Performance**
- Compute or I/O intensive
- High memory bandwidth
- Floating point
- Scale out capable

**Business Applications**
- Scale
- High Quality of Service
- Large memory footprint
- Responsive infrastructure

**Web, Collaboration and Infrastructure**
- Highly threaded
- Throughput-oriented
- Scale out capable
- Lower Quality of Service
High Level Workload Definition

• Workloads are a combination of:
  • Application function: What it does and how it does it
  • Data structure: Data residency, topology, access model
  • Usage pattern: Utilization profile over time, mix of use cases
  • Service level: Non-functional requirements
  • Integration: Interaction between application & data components

• The workload requirements will create varying demands when determining server alternatives
Workload Architectures – More Technical View

- Shared data and work queues
- Highly threaded
- Parallel data structures
- Small discrete applications

Mixed
Workload Characteristics

**Shared Data & Work Queues**
- Single thread performance key
- Benefits from large shared caches
- Fast lock processing
- Hypervisor spin lock detection

**Shared Data & Work Queues**
- Little pressure on any resource
- Minimal memory footprint
- Ripe for virtualization
- May have inactive, low or spiky use

**Parallel Data Structures**
- High sustained thread use/count
- High memory and I/O bandwidth
- Benefits from large private caches
- Efficient use of dedicated resources

**Parallel Data Structures**
- Different SLAs
- Varying size & number of threads
- Large close caches
- Variable context switch rates

**Highly Threaded**
- Lots of software threads
- Modest thread interaction
- Benefits from large private caches
- Low latency memory access

**Highly Threaded**
- Benefits from large private caches
- Low latency memory access
## Workload Characteristics and Platform Requirements

<table>
<thead>
<tr>
<th>Examples</th>
<th>Characteristics</th>
<th>Platform Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLTP databases</td>
<td>Low thread interaction</td>
<td>Single instances can run on almost any hardware</td>
</tr>
<tr>
<td>N-Tier transaction processing</td>
<td>High memory bandwidth</td>
<td>High internal bandwidth</td>
</tr>
<tr>
<td>XML parsing</td>
<td>Low context switch rates</td>
<td>Thread speed and number is workload dependent</td>
</tr>
<tr>
<td>HPC applications</td>
<td></td>
<td>Scale on large SMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High internal bandwidth</td>
</tr>
<tr>
<td></td>
<td>Thread interaction raises contention &amp; coherence delays</td>
<td>Small numbers will virtualize on any hardware</td>
</tr>
<tr>
<td></td>
<td>Coherency traffic increases memory &amp; cache bus utilization</td>
<td>Robust SMP allows better virtualization flexibility</td>
</tr>
<tr>
<td></td>
<td>High context switch rates</td>
<td>Scale on robust SMP</td>
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<tr>
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<td>High memory bandwidth</td>
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<td>Shared Data &amp; Queues</td>
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<tr>
<td>Parallel Data Structures</td>
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<td>Large, close caches</td>
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<tr>
<td>Highly Threaded</td>
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<td>High memory bandwidth</td>
</tr>
<tr>
<td>Small Discrete Applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td></td>
<td></td>
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</tbody>
</table>

- OLTP databases
- N-Tier transaction processing
- XML parsing
- HPC applications
- Structured BI
- Web app servers
- SAP app servers
- HTTP, FTP, DNS
- File and print
- Small end user apps
- z/OS and IBM i
- Hypervisors with virtual guests, WPAR
- Different SLAs
- Varying sizes and number of threads
- May be N-Tier or independent
- Variable context switch rates
- Scale on robust SMP
- Cluster technology dependent
- Large shared caches and wide busses
- Fewer, bigger threads
- Scale well on clusters
- Large private caches
- High thread count
- High memory and I/O bandwidth
- Often on dedicated machines
- Scale on large SMP
- Can scale on clusters
- High thread count
- Low latency memory access
- Large private caches
- Single instances can run on almost any hardware
- Small numbers will virtualize on any hardware
- Robust SMP allows better virtualization flexibility
- Scale on robust SMP
- High internal bandwidth
- Thread speed and number is workload dependent
- Large, close caches
- High memory bandwidth

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Amdahl’s Law

- Limits to parallel applications
  - Not all applications benefit from, or are coded for, more threads
  - Individual thread performance matters
  - Benchmarks often exploit unrealistic parallelism
  - Applies to SMPs and clusters

\[
\text{Speedup} = \frac{1}{(1 - P) + \frac{P}{N}}
\]

- \( P \) = Proportion of a program that can be made parallel
- \( N \) = Number of threads

Graph:
- Amdahl’s Law
  - \( N = \text{Infinity} \)

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Multiple Platforms May be Appropriate

- A business service
  - May have multiple workload types
  - Can exhibit multiple workload types based on usage patterns

- Impact on selection
  - A mix of optimized platforms may be more cost effective
  - Other local factors and non-functional requirements apply
Capacity and Performance - Deployment Models

- Deployment Considerations
  - Network effects
  - Sharing of resources
  - Workload management
  - Multi-programming level

- Impact
  - Total resource requirements
  - Server utilization
  - Performance/capacity mgt
  - Disaster recovery
Automation and Feedback Loops

- Automation is built on feedback controls
- Scaling out lengthens feedback loops
- Long feedback loops can result in solutions that are:
  - Over-provisioned
  - Inconsistent
  - Sluggish
Scope Limitation Leads to Sub-Optimization

• A single application or department view is easiest to understand

• Issues
  • May be driven by politics
  • Runs counter to enterprise IT optimization
  • May make an enterprise view harder to establish
  • Can lead to large hidden costs
  • Server sprawl

• Enterprise wide, scope specific, reference architectures
Commit Scope

- Commit Scope
  - Data for an application must be in sync and committed together
  - Must also be backed off together

- Impact of Deployment Model
  - Latency increases the time resources are held
  - More parts increases integrity issues during commit scope

- Can be significant in HA and DR scenarios
Interference Analysis

• Interference analysis
  • Few things operate in isolation

• New application or service
  • May impact existing applications
  • May include procedural impacts including life cycle management
  • Can be significant for composite applications

• Non-functional requirements
  • A requirement or change in one NFR can affect another
Non-Functional Inheritance

- Sum of calling applications arrival rates
- Fastest of the calling applications response times
- Highest of calling applications availability
- Non-functional inheritance drives up requirements
## IBM’s Consolidation Project

<table>
<thead>
<tr>
<th>ISV Filter</th>
<th>Linux on System z</th>
<th>AIX on Power</th>
<th>Windows / Linux on System x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software available only on a particular platform</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance Filters</th>
<th>Low CPU Peak Average memory usage</th>
<th>High CPU Peaks Higher memory usage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Workload Filters</td>
<td>Transactional I/O Proximity to Data Proximity to Apps</td>
<td>Already virtualized on AIX AIX product development</td>
<td>Already virtualized on Intel Small counts of isolated images Linux not met by System z</td>
</tr>
</tbody>
</table>

This table reflects an IBM example based upon IBM’s local factors.
Platform Selection Framework

Define Business & IT Objectives
- Simplify and Reduce Complexity
- Reduce Costs
- Improve Service Levels
- Improve Profitability
- New business function
- Etc.

Define Scope
- Applications
- Infrastructure
- Prod/Dev/Test
- Logical Decomposition
- etc.

Apply Known Filters & Constraints
- Technology Preferences:
  - platforms
  - skills
  - Marketplace
  - NFRs

Determine Criteria & Assign Priorities
- Determine Categories
  - Cost
  - NFRs
  - IT Process & Support
  - Strategic Fit
- Assign Weighting
- Determine subcategories
- Assign priorities

Determine TCO

Select Platform
- For short list of platforms, complete TCO.

Provide Context

Reduce Solution Set

Customer Decision Criteria

Crunch the numbers

Report

Merge results

Examples:
- Applications
- Infrastructure
- Prod/Dev/Test
- Logical Decomposition
- etc.
Platform Selection Process

- Start with business need and scope
- Understand local standards
- Choose software stack
  - Consider operational context
- Select hardware based on NFRs & local factors
  - First data then apps
  - Consider operational context
Example Platform Selection Process

**Business & IT Objectives**
- Reduced costs
- Reduced complexity
- Improve server levels
- New business function

**Define Scope**
- Application(s) in question
- Environments considered
- Locations
- Length of decision
- Identify standards, constraints & interference

**Build Guidance Weighting Model**

**For Data then App**
- Address local factors
- Evaluate prioritized NFRs
- Assess for interference

**Technical Validation (as required)**
- Stress test
- Benchmark
- Modeling
- Solution review

**Complete TCO Analysis**

**Analyze Costs and Weights**
**Select Platform**

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Summary of Key Points

- Many factors influence platform selection – a simple matrix does not exist
- Local factors affect platform selection
- Infrastructure size matters
- Each deployment model has its place – virtualize or centralize where possible
- There is no single platform or middleware capacity metric
- Larger servers offer virtualization advantages
- Non-functional requirements are the significant element of platform selection
- Select platforms based upon workload requirements not middleware
- An enterprise wide view provides the best optimization opportunity
- The choice of cost and value elements, along with time horizon, can dictate which platform is considered the lowest cost
- Cost models have different purposes – use the right one for the job