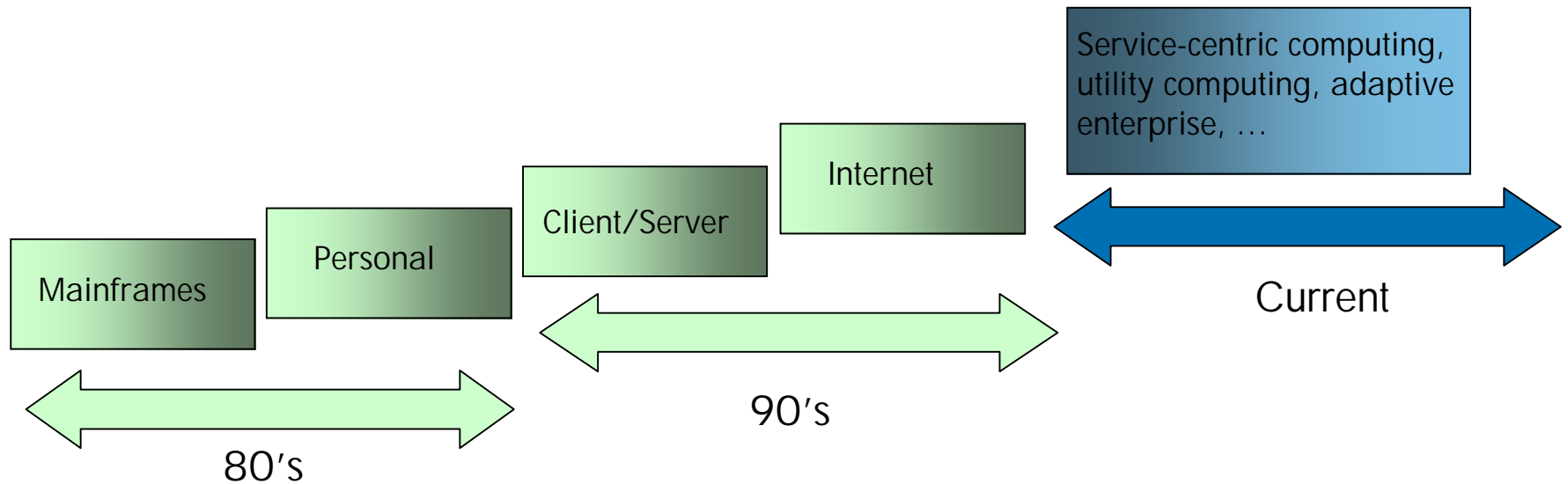




Enterprise IT Trends and Implications on System Architecture

Partha Ranganathan and Norm Jouppi

Motivation



Role of computing in enterprise changing

- IT infrastructure now closely tied to business process
 - E.g., e-commerce, supply-chain, customer-service
- Direct impact on top-line and bottom-line (sales, revenues)
- Driving changes in enterprise IT environments

Specific Trends

Facilities

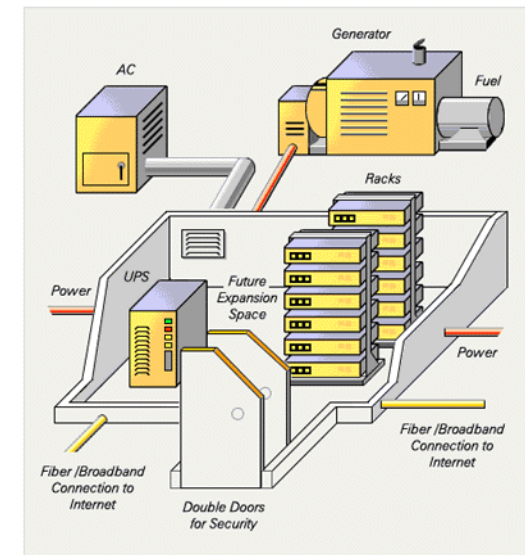
Hardware

Software

Metrics

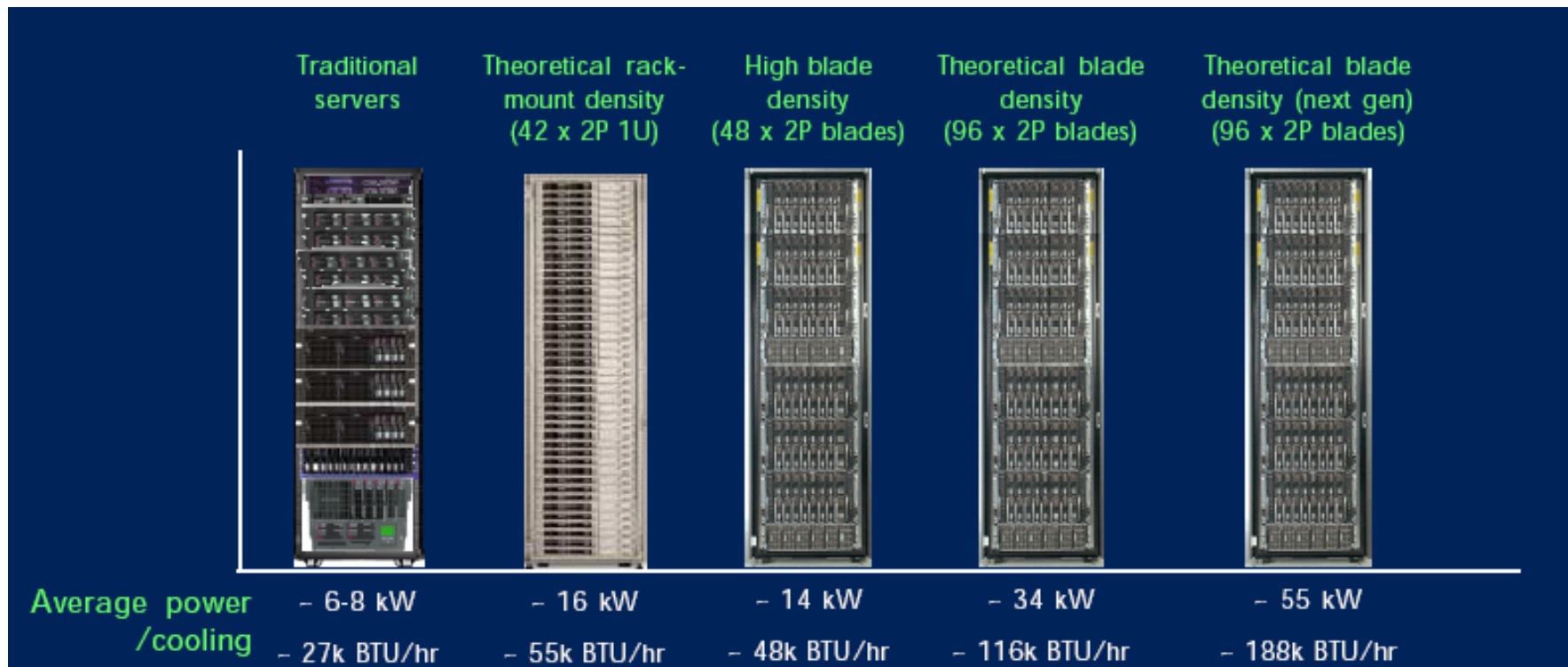
Facilities Trends

- Consolidation of data centers
- Implications
 - Increased facilities challenges
 - Power delivery
 - Electricity consumption
 - Heat extraction
 - Operations and management for large-scale
 - People costs often largest fraction of IT costs



Hardware Trends: Modularization

- Blade servers – miniaturization/modularization
- Implications
 - More modularity => “The enclosure is the computer”
 - More compaction => Power density, maintenance



Commoditization & Virtualization

- **Commoditization**

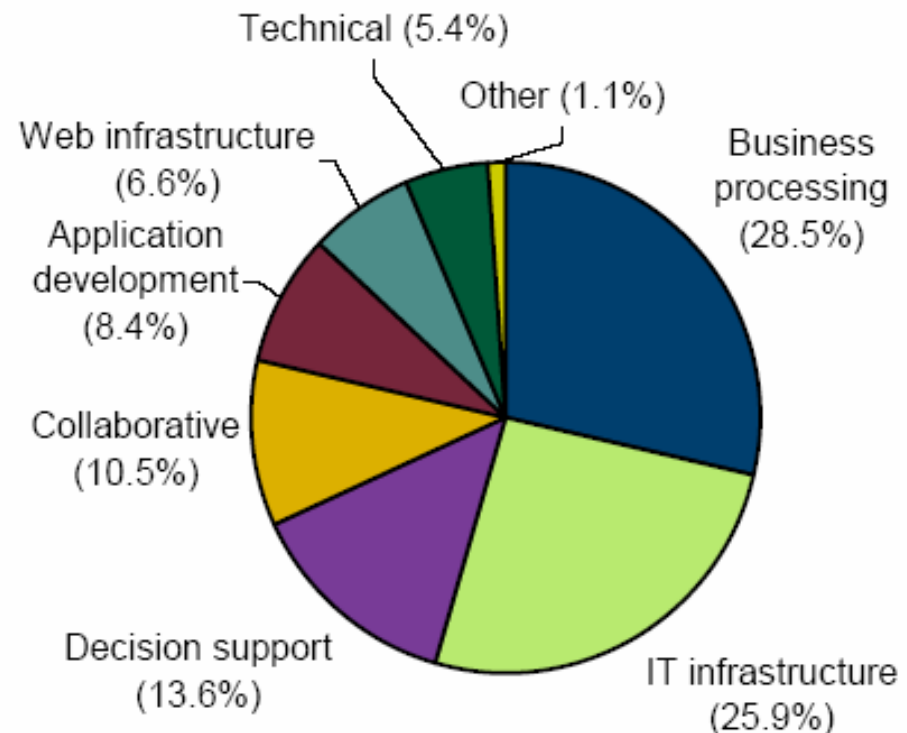
- Cheaper-cost systems: average server price falling [IDC]
- Implications
 - A few modular building blocks?
 - Focus beyond performance to usability

- **Virtualization**

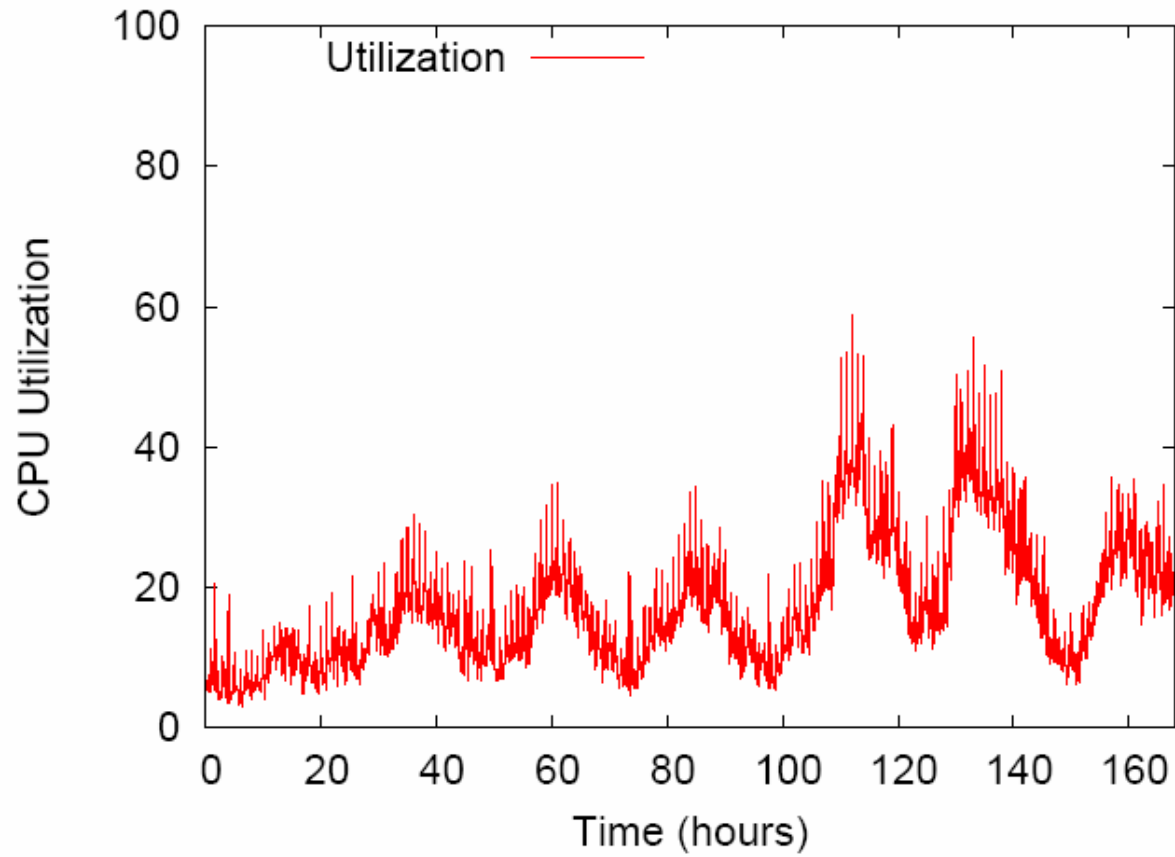
- Virtualized abstraction for hardware: at multiple levels
- Implications
 - Role of physical boundaries blurred => harder designs
 - Greater consolidation => more resource utilizations
 - Additional control point => opportunity for optimization

Software trends: Workload Mix

- Business processing/IT
 - ERP, CRM, OLTP, file servers, sys mgmt, ...
- Implications
 - Increased complexity
 - Business-critical
 - Behavior trends

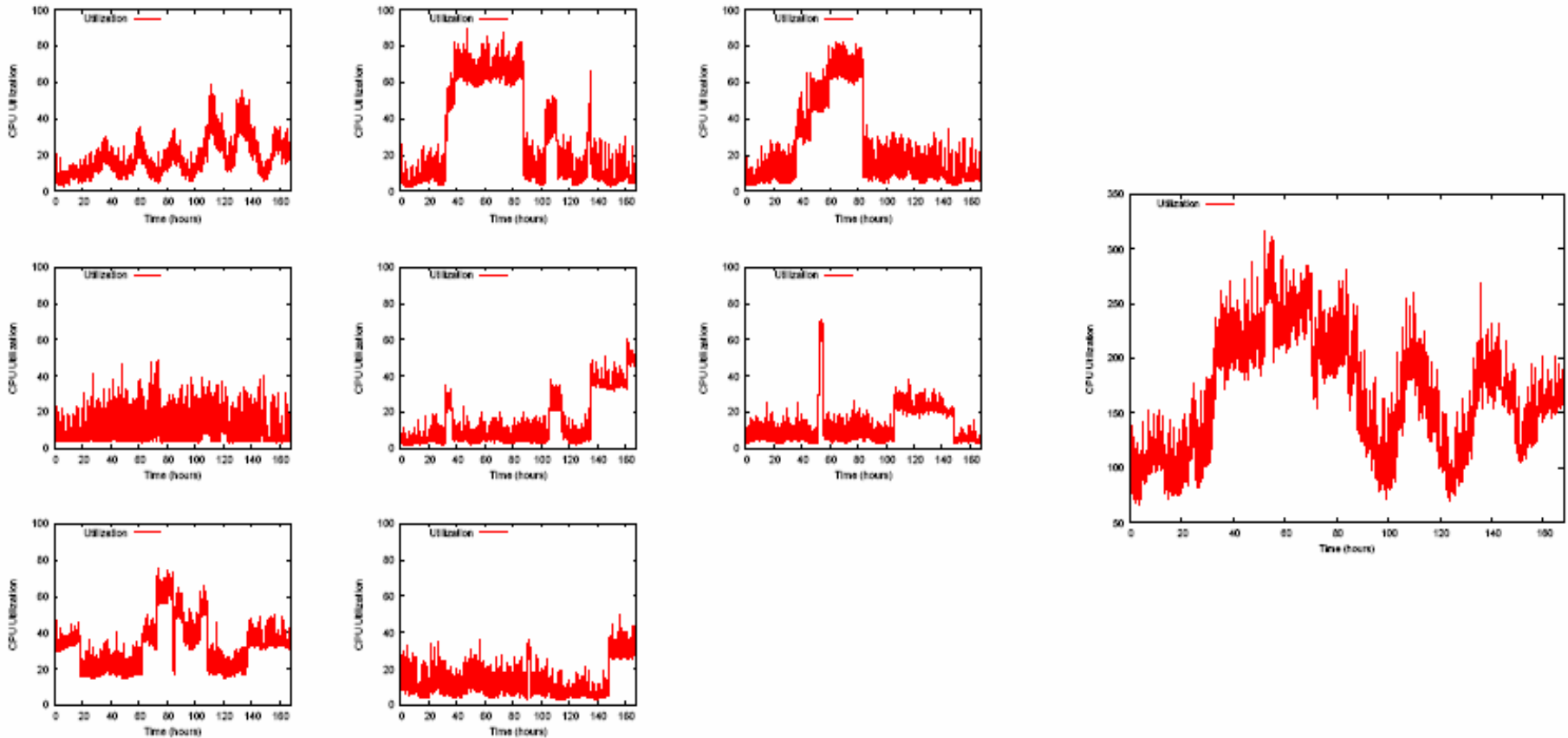


Software trends: Workload Behavior



Nominal different from peak

Software trends: Workload Behavior



Sum-of-peaks >>> peak-of-sums (system-of-system)

Metrics' Trends

- Utility service-level agreements and cost functions
- Implications
 - Performance one aspect
 - Scalability, reliability, availability, manageability
 - Multi-service environments more complex

Implications on Enterprise Architecture

How do we understand enterprise environments?

How do we improve enterprise environments?

Benchmarks, metrics, tools, models...

- **What is the right benchmark?**
 - Current: SPEC, SPLASH, TPC -
 - Needed: ERP, CRM, file server, ...
- **What is the right objective function?**
 - Current: MIPS, EnergyDelay
 - Needed: SLA, risk, utility functions,
- **How do we measure/simulate/model?**
 - Current: vTune/SimpleScalar/Wattch, ...
 - Needed: full IT environments (e.g., splice)

Architectural Design Implications

- How do we optimize for nominal instead of peak?
 - Understanding inflection points in efficiency curves
 - E.g., nominal-efficient power supplies
- How do we optimize for system-of-system?
 - Optimize outside the box
 - E.g., Enclosure-level, data-center level architecture designs

Architectural Design Implications

- How do we factor in facilities challenges?
 - Power-optimized architectures, holistic designs
 - E.g., temperature-aware scheduling
- How do we respond to changing metrics?
 - Emphasis on reliability, availability, security, manageability, ...
 - E.g., DIVA, Intel Vanderpool/Silverveil
- How do we deal with diversity (workload/service, SLA)?
 - Adaptivity, heterogeneity
 - E.g., heterogeneous multi-core architectures
- How do we deal with commoditization?
 - Value over carefully-chosen modular building blocks
 - E.g., Federated array of bricks project for storage

Summary

- **Interesting transformation in enterprise computing**
 - IT closely tied to business process
 - Dramatic changes in facilities, hardware, software, metrics
- **Corresponding new challenges for arch research**
 - **Open questions on benchmarks, metrics, tools, models**
 - Focus on long-term behavior of enterprise-level workloads
 - Need to scale tools/instrumentation to higher levels
 - **Interesting architectural directions to leverage trends**
 - Optimize at higher-levels (e.g., enclosure) for nominal behavior
 - Holistic solution for total cost of ownership (RAS, supply-chain)

Questions?

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