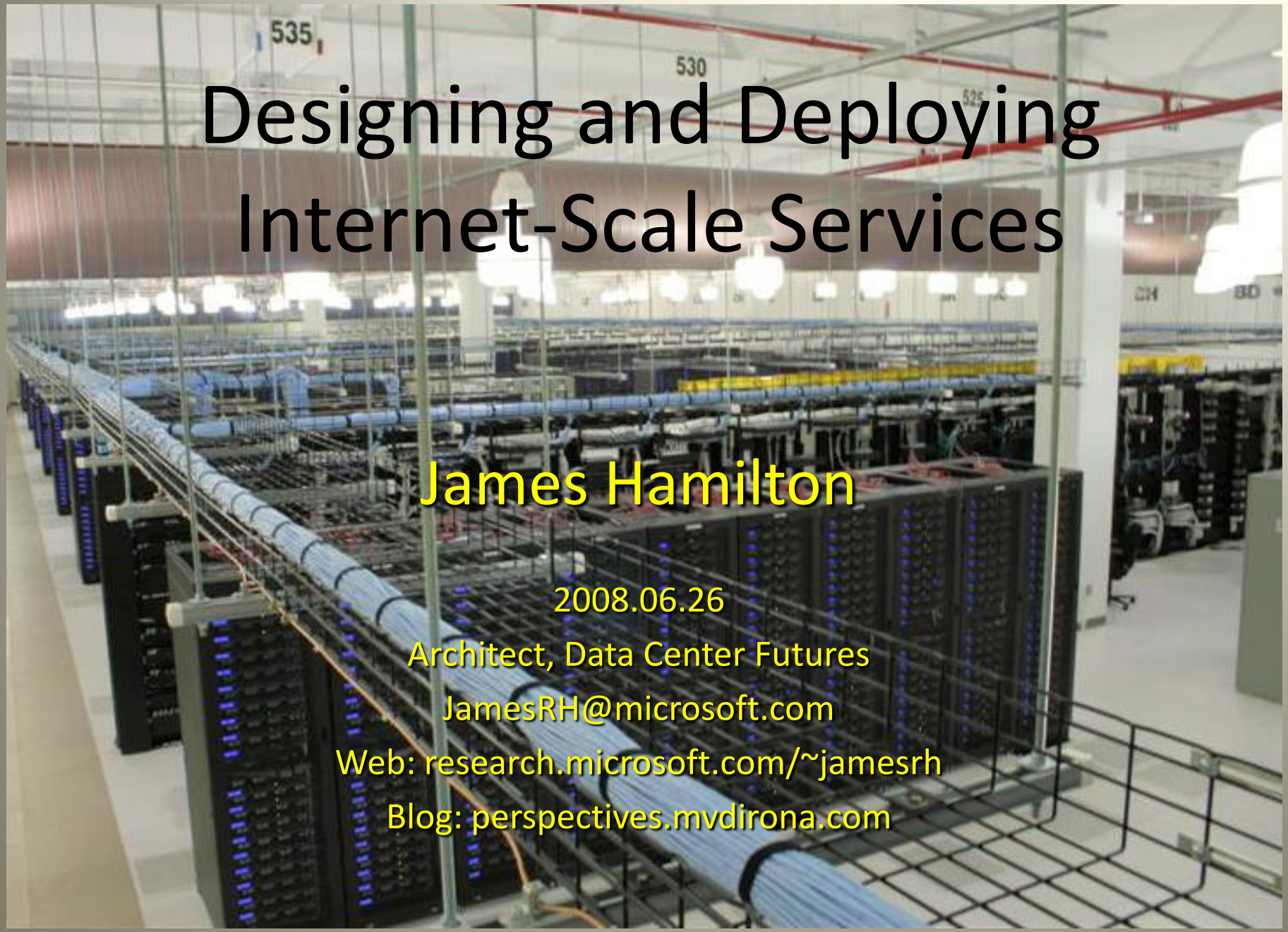


Designing and Deploying Internet-Scale Services

James Hamilton

2008.06.26

Architect, Data Center Futures

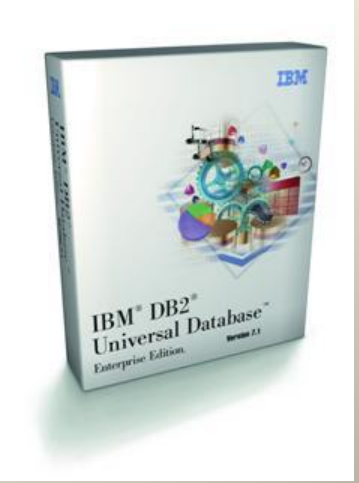
JamesRH@microsoft.com

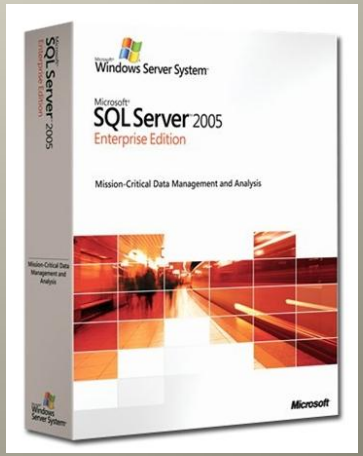
Web: research.microsoft.com/~jamesrh

Blog: perspectives.mvdirona.com

Background and biases

- 15 years in database engine development
  - Lead architect on IBM DB2
  - Architect on SQL Server
    - Led variety of core engine teams including SQL client, SQL compiler, optimizer, XML, full text search, execution engine, protocols, etc.
- Led the Exchange Hosted Services Team
  - Email anti-spam, anti-virus, and archiving for 2.2m seats with $27m revenue
  - ~700 servers in 10 data centers world-wide
- Architect on Windows Live Platform Services
- Currently Data Center Futures Architect
- Automation & redundancy is only way to:
  - Reduce costs
  - Improve rate of innovation
  - Reduce operational failures and downtime





Agenda

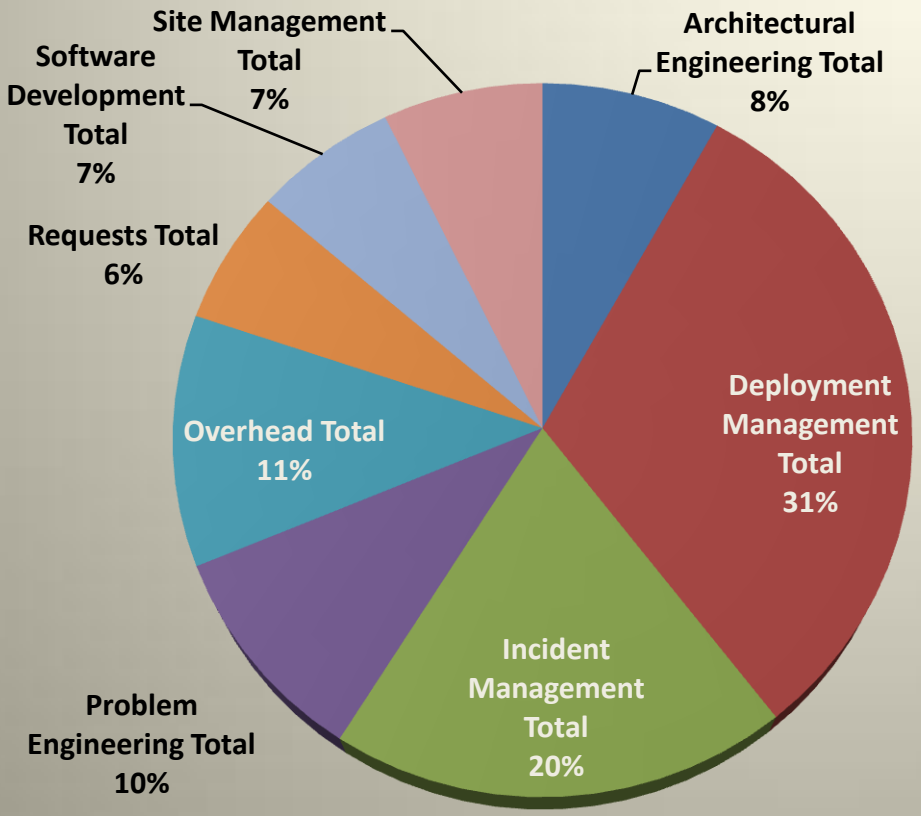
- Overview
- Recovery-Oriented Computing
- Overall Application Design
- Operational Issues
- Summary

Contributors: *Search, Mail, Exchange Hosted Services, Live Collaboration Server, Contacts & Storage, Spaces, Xbox Live, Rackable Systems, Messenger, WinLive Operations, & MS.com Ops*

Motivation

- System-to-admin ratio indicator of admin costs
  - Tracking total ops costs often gamed
    - Outsourcing halves ops costs without addressing real issues
  - Inefficient properties: <10:1
  - Enterprise: 150:1
  - Best services: over 2,000:1
- 80% of ops issues from design and development
  - Poorly written applications are difficult to automate
- Focus on reducing ops costs during design & development

What does operations do?

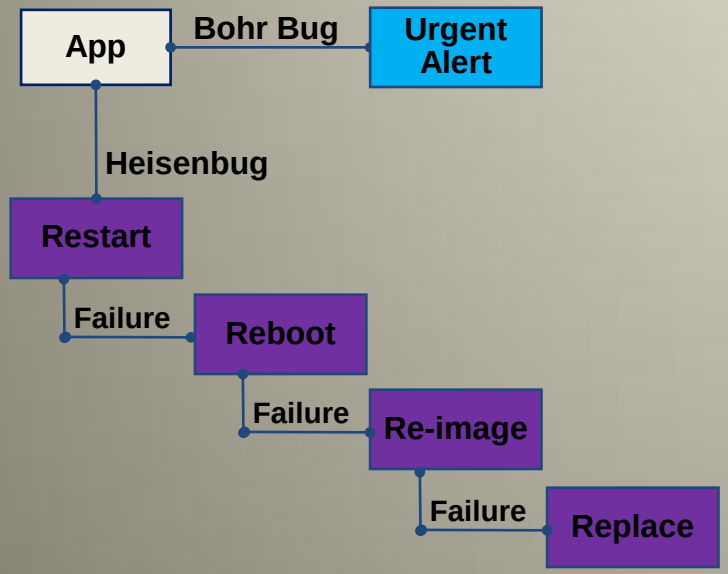


Source: Deepak Patil, Global Foundation Services (8/14/2006)

- **51% is deployment & incident management (known resolution)**
- **Teams**: Messenger, Contacts and Storage & business unit IT services

ROC design pattern

- Recover-oriented computing (ROC)
  - Assume software & hardware will fail frequently & unpredictably
- Heavily instrument applications to detect failures



Bohr bug: Repeatable functional software issue (functional bugs); should be rare in production

Heisenbug: Software issue that only occurs in unusual cross-request timing issues or the pattern of long sequences of independent operations; some found only in production

Overall application design

- Development and testing with full service
  - Single-box deployment
  - Quick service health check
- Pod or cluster independence
  - Zero trust of underlying components
- Implement & test ops tools and utilities
- Simplicity throughout
- Partition & version everything

Design for auto-mgmt & provisioning

- Never rely on local, non-replicated persistent state
- Support for geo-distribution
- Auto-provisioning & auto-installation mandatory
  - Explicitly install everything & then verify
  - Manage "service role" rather than servers
- Multi-system failures are common
  - Limit automation range of action
- Force fail all services and components regularly
  - Don't worry about clean shutdown
    - Often won't get it & need this path tested

Release cycle & testing

- Ship frequently:
  - Small releases ship more smoothly
  - Increases pace of innovation
  - Long stabilization periods not required in services
- Use production data to find problems (traffic capture)
  - Measurable release criteria
  - Release criteria includes quality and throughput data
- Track all recovered errors to protect against automation-supported service entropy
- Test all error paths in integration & in production
- Test in production via incremental deployment & roll-back
  - Never deploy without tested roll-back
  - Continue testing after release

Design for incremental release

- Incrementally release with schema changes?
  - Old code must run against new schema, or
  - Two-phase process (avoid if possible)
    - Update code to support both, commit changes, and then upgrade schema
- Incrementally release with user experience (UX) changes?
  - Separate UX from infrastructure
  - Ensure old UX works with new infrastructure
  - Deploy infrastructure incrementally
  - On success, bring a small beta population onto new UX
  - On continued success, announce new UX and set a date to roll out
- Client-side code?
  - Ensure old & new clients both run with new infrastructure

Graceful degradation & admission control

- No amount of "head room" is sufficient
  - Even at 25-50% H/W utilization, spikes will exceed 100%
- Prevent overload through admission control
- Graceful degradation prior to admission control
  - Find less resource-intensive modes to provide (possibly) degraded services
- Related concept: Metered rate-of-service admission
  - Service login typically more expensive than steady state
  - Allow a single or small number of users in when restarting a service after failure

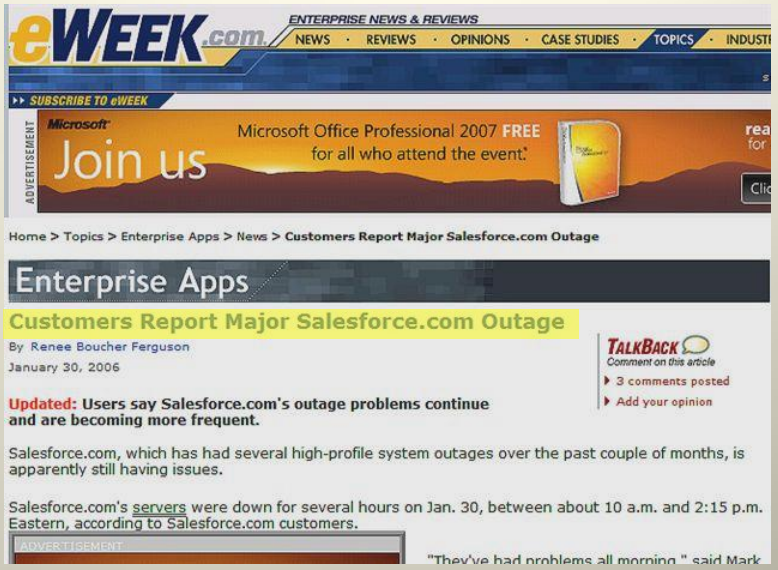
Auditing, monitoring, & alerting

- Produce perf data, health data & throughput data
- All config changes need to be tracked via audit log
- Alerting goals:
  - No customer events without an alert (detect problems)
  - Alert to event ratio nearing 1 (don't false alarm)
- Alerting is an art … need to tune alerting frequently
  - Can't embed in code (too hard to change)
  - Code produces events, events tracked centrally, alerts produced via queries over event DB
- Testing in production requires very reliable monitoring
  - Combination of detection & capability to roll back allows nimbleness
- Tracked events for all interesting issues
  - Latencies are toughest issues to detect

Dependency management

- Expect latency & failures in dependent services
  - Run on cached data or offer degraded services
  - Test failure & latency frequently in production
- Don’t depend upon features not yet shipped
  - It takes time to work out reliability & scaling issues
- Select dependent components & services thoughtfully
  - On-server components need consistent quality goals
  - Dependent services should be large granule (“worth” sharing)
- Isolate services & decouple components
  - Contain faults within services
  - Assume different upgrade rates
  - Rather than auth on each connect, use session key and refresh every N hours (avoids login storms)

Customer & press communications plan



- Systems fail & you will experience latency
- Communicate through multiple channels
  - Opt-in RSS, web, IM, email, etc.
  - If app has client, report details through client
- Set ETA expectations & inform
- Some events will bring press attention
- There is a natural tendency to hide systems issues
- Prepare for serious scenarios in advance
  - Data loss, data corruption, security breach, privacy violation
- Prepare communications skeleton plan in advance
  - Who gets called, communicates with the press, & how data is gathered
  - Silence typically interpreted as hiding something or lack of control

Summary

- Reduced operations costs & improved reliability through automation
- Full automation dependent upon partitioning & redundancy
- Each human administrative interaction is an opportunity for error
- Design for failure in all components & test frequently
- Rollback & deep monitoring allows safe production testing

More Information

- Designing & Deploying Internet-Scale Services paper:
  - http://research.microsoft.com/~JamesRH/TalksAndPapers/JamesRH_Lisa.pdf
- Autopilot: Automatic Data Center Operation
  - http://research.microsoft.com/users/misard/papers/osr2007.pdf
- Recovery-Oriented Computing
  - http://roc.cs.berkeley.edu/
  - http://www.cs.berkeley.edu/~pattrsn/talks/HPCAkeynote.ppt
  - http://www.sciam.com/article.cfm?articleID=000DAA41-3B4E-1EB7-BDC0809EC588EEDF
- These slides:
  - http://research.microsoft.com/~jamesrh
- Email:
  - JamesRH@microsoft.com
- External Blog:
  - http://perspectives.mvdirona.com