Service Design Best Practices

James Hamilton

2009/2/26 Principals of Amazon

Amazon Web Services

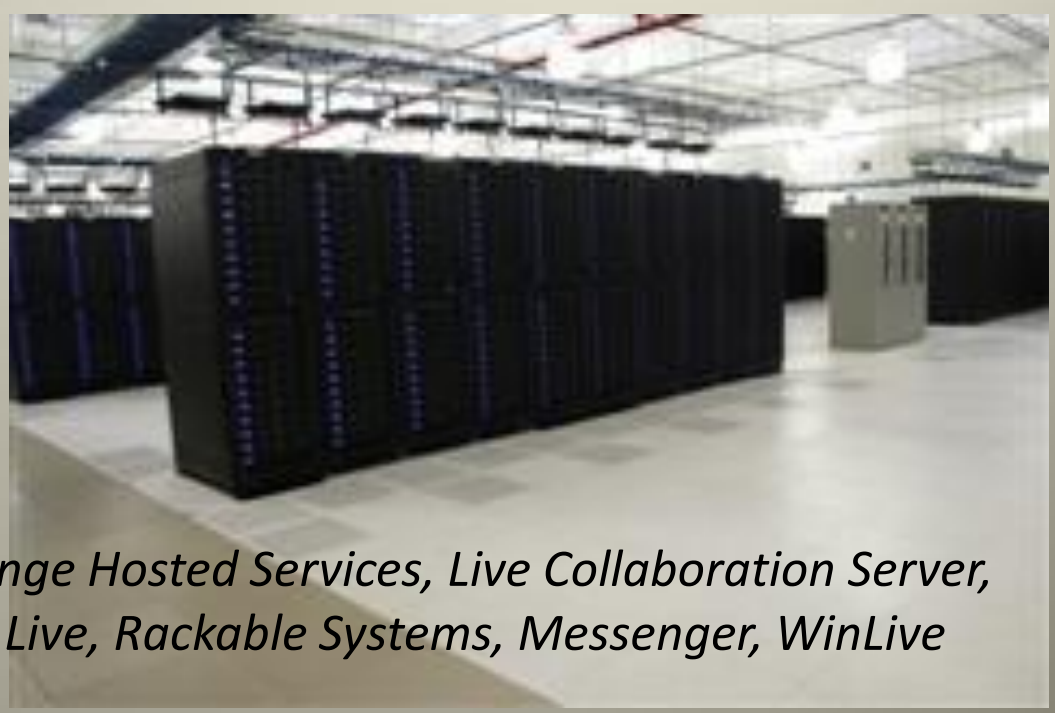
e: James@amazon.com

w: mvdirona.com/jrh/work

b: perspectives.mvdirona.com

Agenda

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

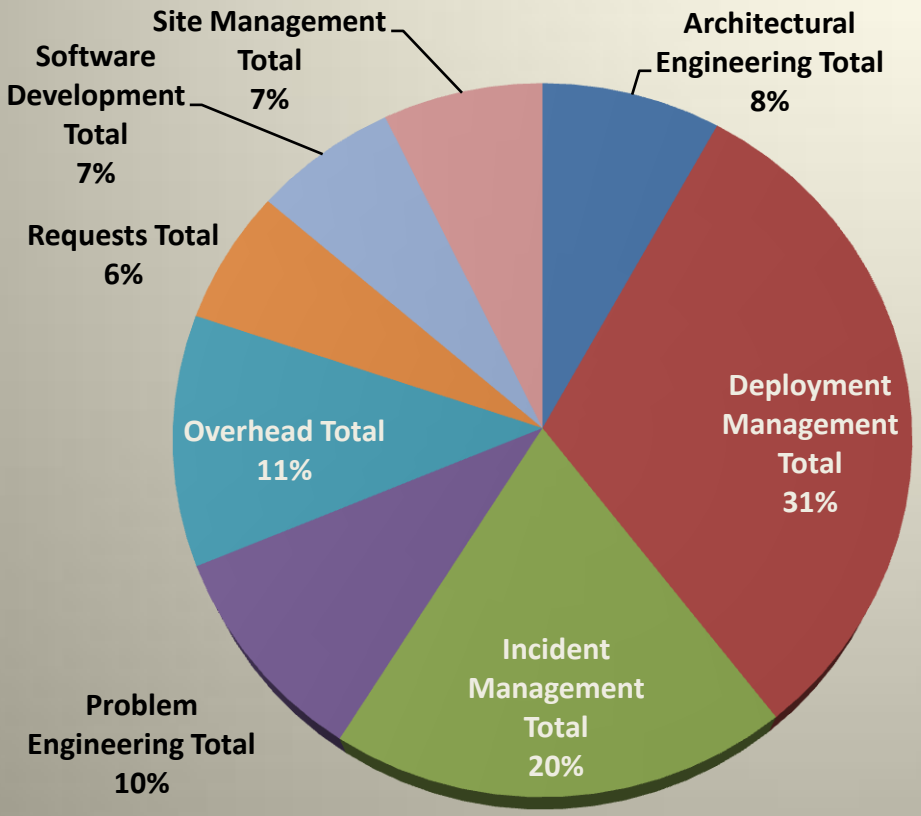


Contributors: *Search, Mail, Exchange Hosted Services, Live Collaboration Server, Contacts & Storage, Spaces, Xbox Live, Rackable Systems, Messenger, WinLive Operations, & MS.com Ops*

Motivation

- System-to-admin ratio indicator of admin costs
  - 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?

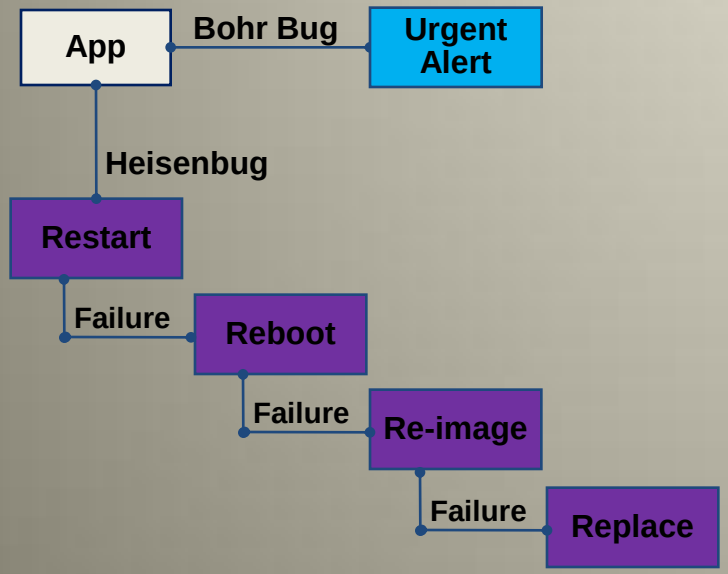


Source: Deepak Patil, Global Foundation Services (8/14/2006)

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

- Single-box deployment
- Keep testing after production deployed
- Zero trust of underlying components
- Pod or cluster independence
- Implement & test ops tools and utilities
- Partition & version everything

Design for auto-mgmt & provisioning

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

MTTF/MTDL

- Mean time to failure/Mean time to data loss
  - Precise models to many decimal places
  - Models typically ignore S/W failure & human error
  - Assume failure independence
- Unknown unknowns make MTTF/MTDL optimistic
- Threat model approach to data protection
  - List all failures or sequence that could lead to data loss
  - Document and implement mitigation for each
  - Or document & implement that risk was accepted & why

Release cycle & testing

- Ship frequently:
  - Small releases ship more smoothly
  - Long stabilization periods not required if shipping often
- Use production data to find problems (traffic capture)
  - 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
  - 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)
- 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 and set roll-out date
- Client-side code?
  - Ensure old & new clients both run with new infrastructure

Canary in the data center

- All systems produce non-linear latencies and/or failures beyond a certain load level
  - The load limit
- The load limit is release dependent
  - It changes as the application changes
- Canary in the data center
  - Route increased load to one server in the fleet
  - When it starts showing non-linear delay or failure, immediately reduce load on it or take out of LB rotation
  - Result: limit is know before full fleet finds it (avoid or fix)

Graceful degradation & admission control

- No amount of capacity head room is sufficient
- Graceful degradation prior to admission control
  - First shed non-critical workload
  - Then degraded operations mode
  - Finally admission control
- Related concept: Metered rate-of-service admission
  - Allow a single or small number of users in when restarting a service after failure

Auditing, monitoring, & alerting

- 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
- Fine-grained monitoring of all inter-service requests
- Testing in production requires very reliable monitoring
  - Combination of detection & capability to roll-back allows nimbleness

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 (“worth” sharing)
- Isolate services & decouple components
  - Contain faults within services
  - Assume different upgrade rates

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 at 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 interpreted as hiding something or lack of control

Take Aways

- Threat model approach rather than MTTF/MTTDL
  - Unknown unknowns & lack of failure independence
- Reduce application & administrative errors:
  - Easy 1-box testing of entire service
  - Automate (and test) operational actions & recoveries
- Expect application errors remain:
  - Incremental deployment with rollback
  - Deep monitoring, rapid fault detection, & enforced fault containment boundaries
  - Constant functional tests running in production
  - Canary in DC to find load limits

More Information

- Designing & Deploying Internet-Scale Services paper:
  - http://mvdirona.com/jrh/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://mvdirona.com/jrh/TalksAndPapers/JamesHamilton_POA20090226.pdf
- Email:
  - James@amazon.com
- External Blog:
  - http://perspectives.mvdirona.com