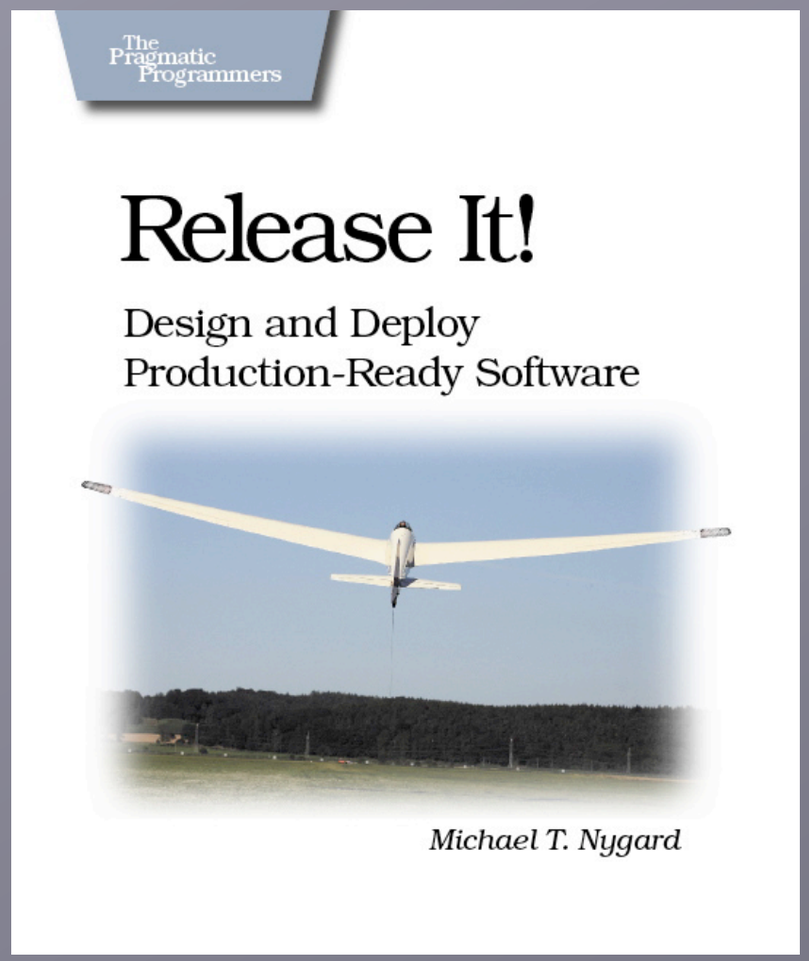
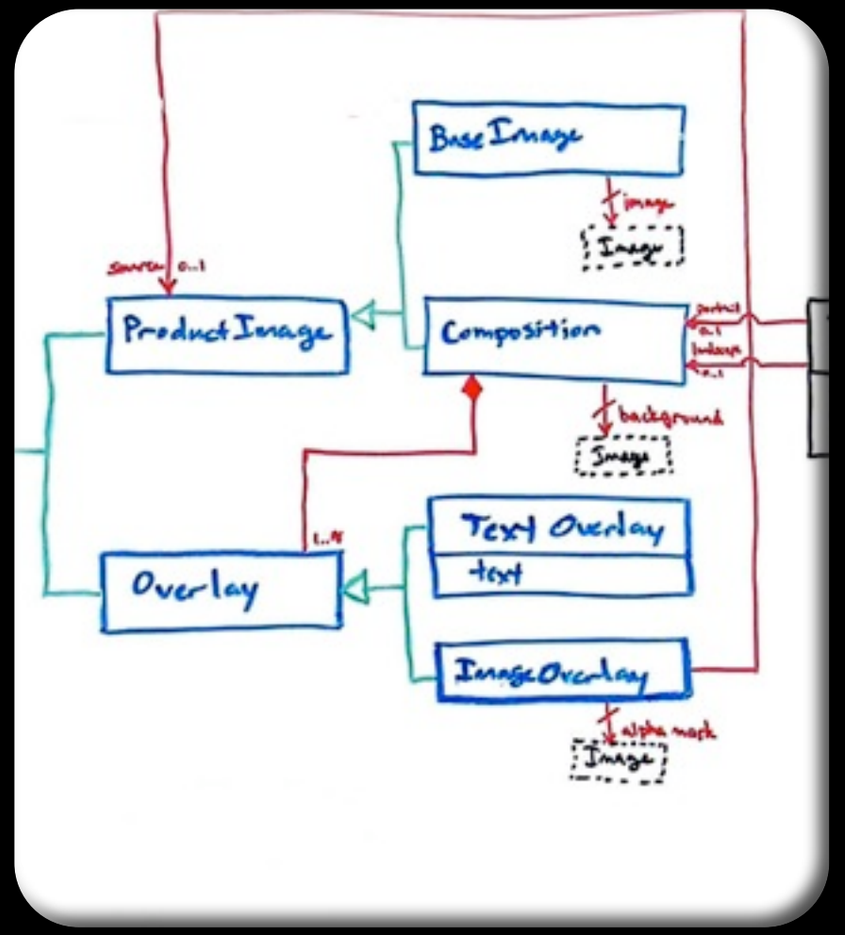
Failure Comes in Flavors
Part I: Anti-Patterns





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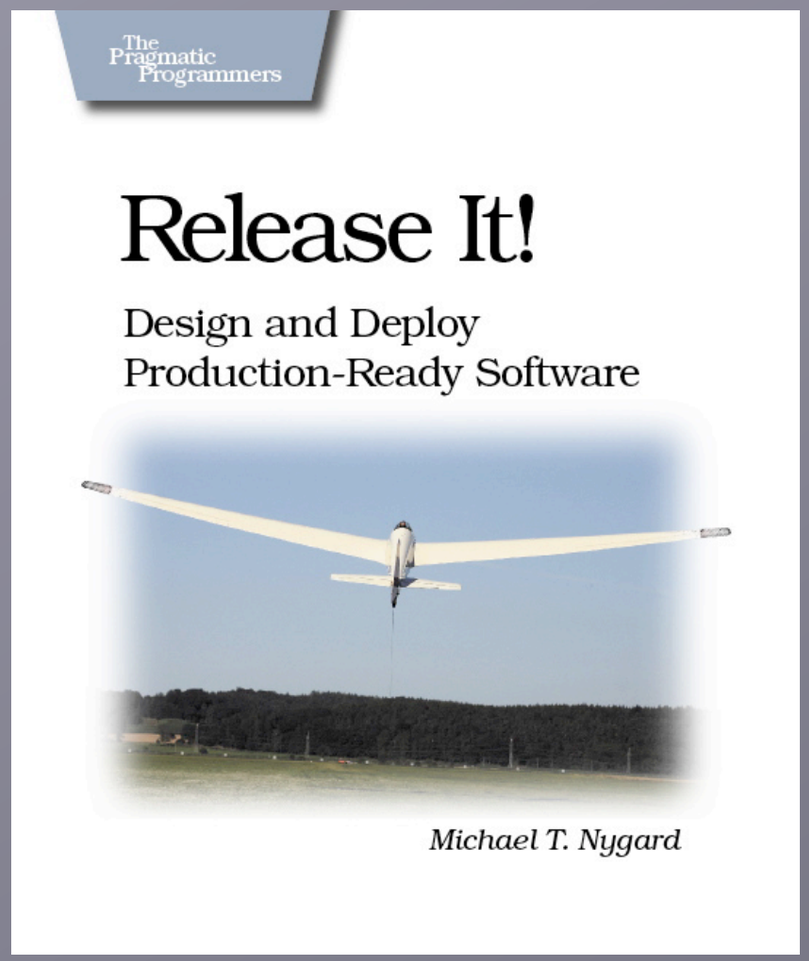

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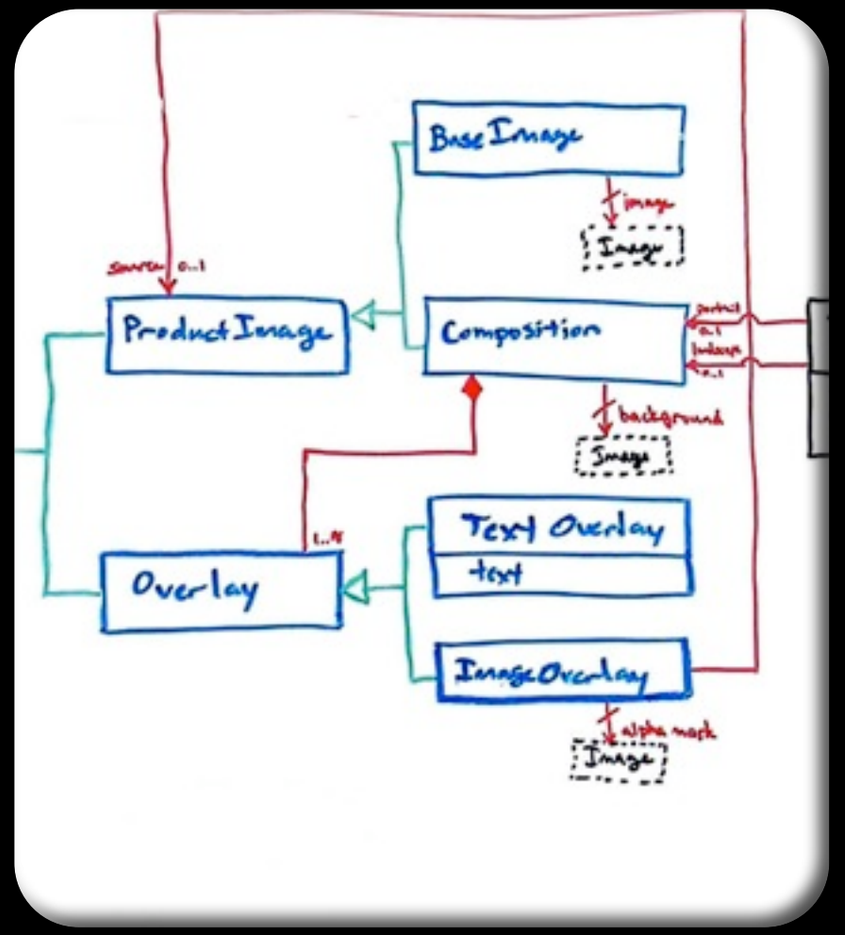


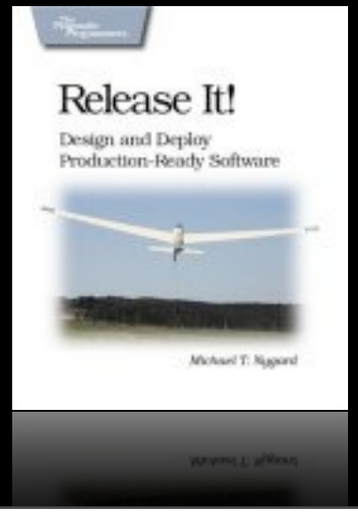
About the Author

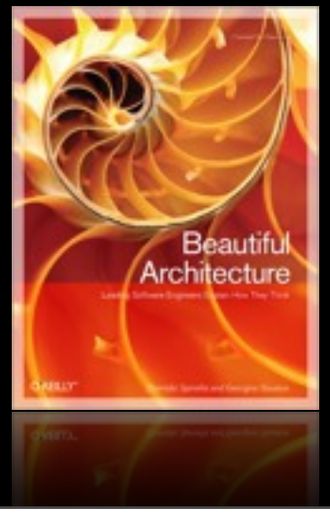
Michael Nygard

Application Developer/Architect – 20 years

Web Developer – 14 years

IT Operations – 6 Years





About This Talk

Consequences of Production Failures

Stability Antipatterns

Failure-Oriented Mindset

Consequences of Failure

High-Consequence Environments

Users by the million

24 hours a day, 365 days a year

Millions in hardware and software

Revenue in the millions or billions

Highly interdependent systems

Aiming for the Wrong Target

Projects cancelled before release.

The consultants' exodus.

Strong QA practices.

Clearly defined roles and responsibilities.

Separation between Development and Operations.

What you say:

"It hasn't really crashed. All the daemons are still running, it's just that the threads got deadlocked on a connection pool."

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"It hasn't really crashed. All the daemons are still running, it's just that the threads got deadlocked on a connection pool."

What they hear:

"... bla bla bla ... **dead demons crashed the pool** ..."

Assumption #1

Users care about the things they do–features–not the software or hardware.

We naturally focus on our work–the hardware and software–but we need to focus on features.

Assumption #2

Failure is an invariant

No matter what you do, some portion of your application will be malfunctioning some appreciable part of the time.

Your can choose to engineer safe failure modes into your system or to accept whatever random failure modes naturally occur.

Engineering Failure Modes

Tolerance
Absorb shocks, but do not transmit them.

Severability
Limit functionality instead of crashing completely.

Recoverability
Allow component-level restarts instead of rebooting the world.

Resilience
Recover from transient effects automatically.

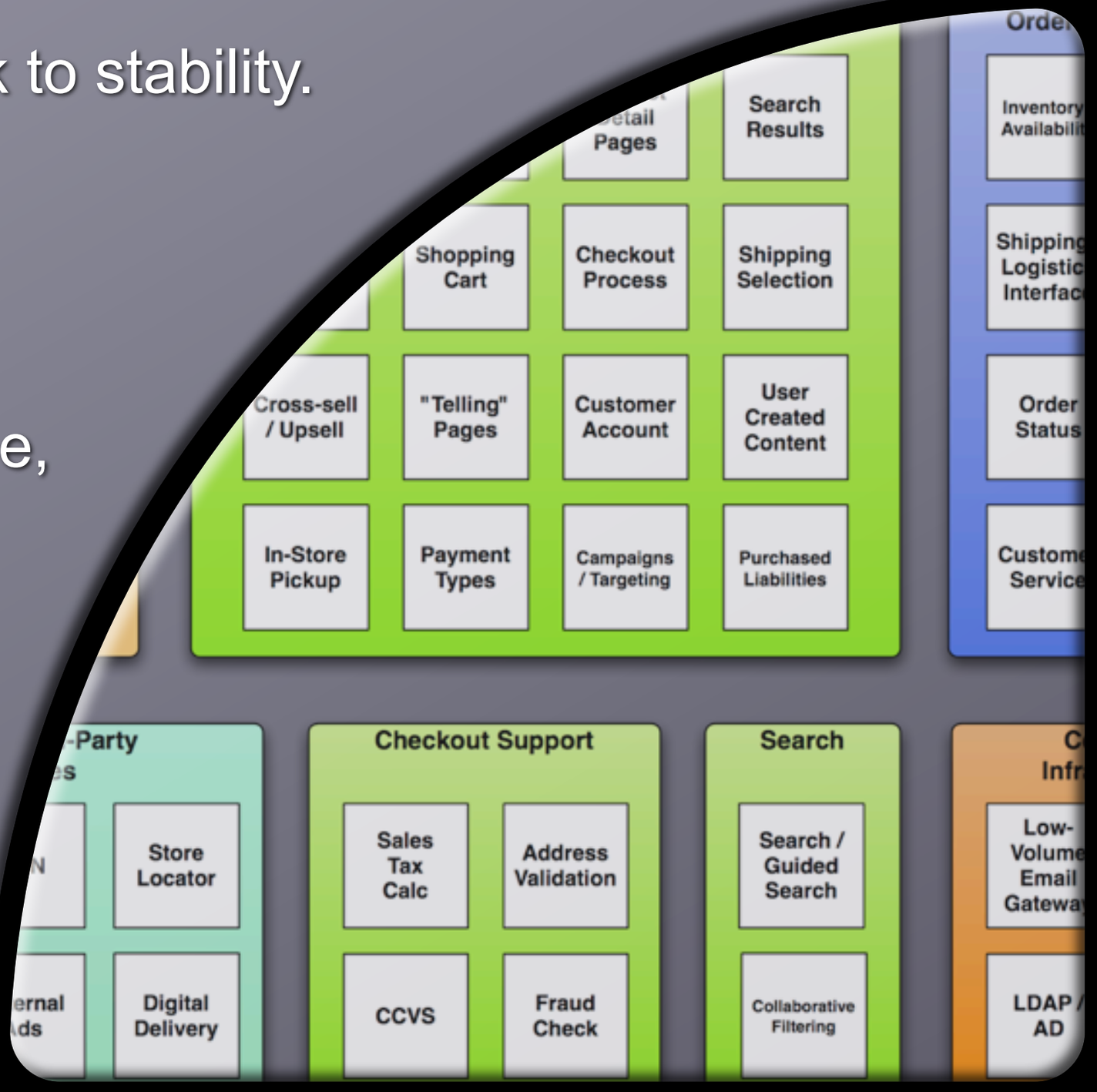
These produce consistent availability of features.

Stability Antipatterns

Integration Points

Examine every arrow in the architecture diagram with deep suspicion

- Integrations are the #1 risk to stability.
- Your first job is to protect against integration points.
- Every socket, process, pipe, or remote procedure call can and will eventually kill your system.
- Even database calls can hang, in obvious and not-so-obvious ways.



“In Spec” vs. “Out of Spec”

Example: Request-Reply using XML over HTTP

“In Spec” failures

- TCP connection refused
- HTTP response code 500
- Error message in XML response

Well-Behaved Errors

“Out of Spec” failures

- TCP connection accepted, but no data sent
- TCP window full, never cleared
- Server never ACKs TCP, causing very long delays as client retransmits
- Connection made, server replies with SMTP hello string
- Server sends HTML “link-farm” page
- Server sends one byte per second
- Server sends Weird Al catalog in MP3

Wicked Errors

Integration Points

- Be defensive. Assume every integration point can hang.
- Use timeouts everywhere.
- Time out on the whole communication, not just the connection.
- Beware vendor libraries.

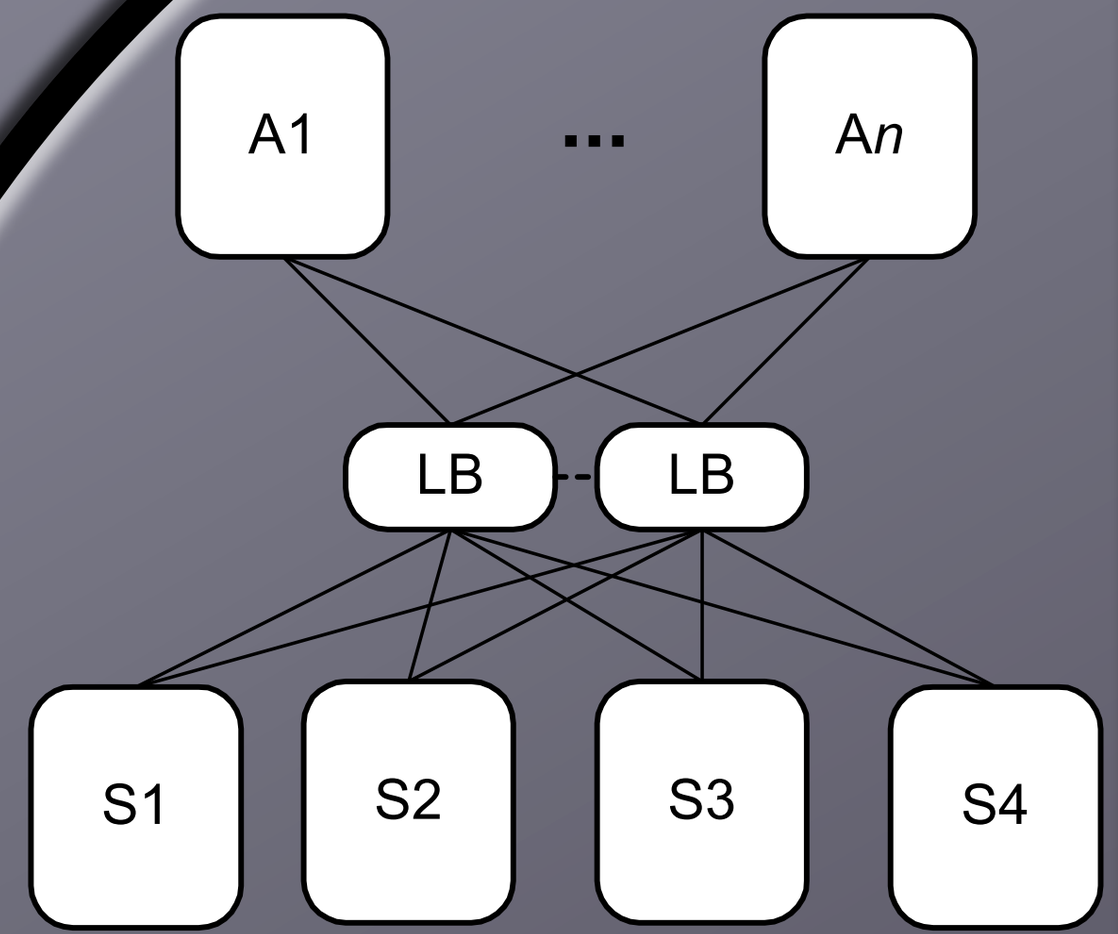
Remember This

- Beware this necessary evil.
- Prepare for the many forms of failure.
- Know when to open up abstractions.
- Failures propagate quickly.
- Large systems fail faster than small ones.
- Apply “Circuit Breaker”, “Use Timeouts”, “Use Decoupling Middleware”, and “Handshaking” to contain and isolate failures.
- Use “Test Harness” to find problems in development.

Chain Reaction

Failure in one component raises probability of failure in its peers

- Example:
  - Suppose S4 goes down
  - S1 - S3 go from 25% of total to 33% of total
    - That's 33% more load
- Each one dies faster
- Failure moves horizontally across tier
- Common in search engines and application servers

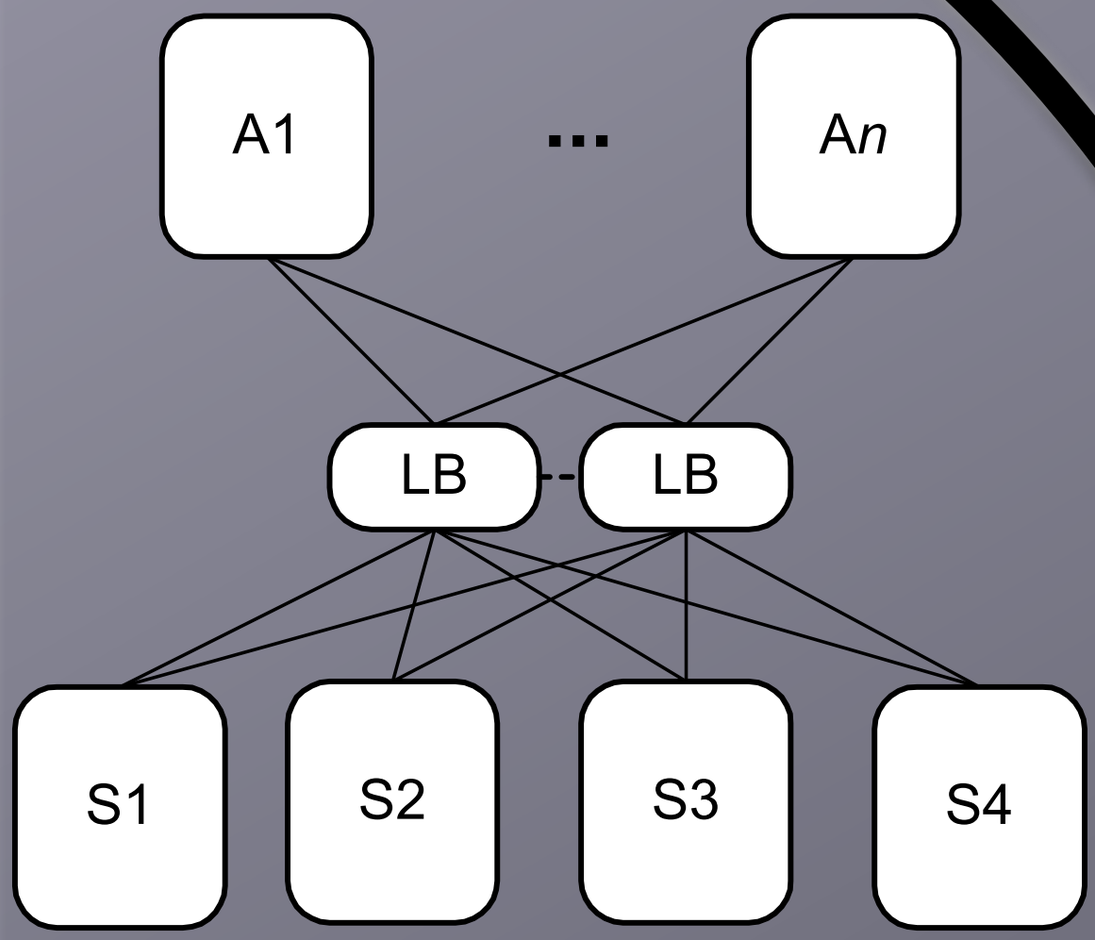


Remember This

- One server down jeopardizes the rest.
- Hunt for Resource Leaks.
- Defend with “Bulkheads”.

Cascading Failure

Failure in one system causes calling systems to be jeopardized



Example:

System S goes down, causing calling system A to get slow or go down.

- Failure moves vertically across tiers
- Common in enterprise services and SOAs

Remember This

- Prevent Cascading Failure to stop cracks from jumping the gap.
- Think “Damage Containment”
- Scrutinize resource pools, they get exhausted when the lower layer fails.
- Defend with “Use Timeouts” and “Circuit Breaker”.

Users

Can’t live with them...

- Ways that users cause instability
  - Sheer traffic
  - Flash mobs
  - Click-happy
- Malicious users
  - Screen-scrapers
  - Badly configured proxy servers

The first type of “bad” user

- Front-page viewer
  - Creates useless sessions
  - Ties up memory for no reason
- Application servers are all fragile to sessions
  - Users can always create session floods, deliberately or inadvertently, killing memory
  - DDoS attacks usually break app servers

Handle Traffic Surges Gracefully

- Turn off expensive features when the system is busy.
- Divert or throttle users. Preserve a good experience for some when you can't serve all.
- Reduce the burden of serving each user. Be especially frugal with memory.
  - Hold IDs, not object graphs.
  - Hold query parameters, not result sets.
- Differentiate people from bots. Don't keep sessions for bots.

The second type of “bad” user

- Buyers
  - Most expensive type of user to service
  - Secure pages, requires more CPU cycles
  - More pages (10 – 12 per session)
  - External integrations: credit card processor, address verification, inventory management, shipping and fulfillment
- High conversion rate is bad for the systems!
- Your sponsors may not agree.

Remember This

- Minimize the memory you devote to each user.
- Malicious users are out there.
- But, so are weird random ones.
- Users come in clumps: one, a few, or way too many.

Blocked Threads

Request handling threads are precious. Protect them.

- Most common form of “crash”: all request threads blocked
- Very difficult to test for:
  - Combinatoric permutation of code pathways.
  - Safe code can be extended in unsafe ways.
  - Errors are sensitive to timing and difficult to reproduce
  - Dev & QA servers never get hit with 10,000 concurrent requests.
- Best bet: keep threads isolated. Use well-tested, high-level constructs for cross-thread communication.
  - Learn to use java.util.concurrent or System.Threading

Example: Blocking calls

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Object obj = items.get(id);
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- Remote system stopped responding due to “Unbalanced Capacities”
- Threads piled up like cars on a foggy freeway.

Remember This

- Scrutinize resource pools. Don't wait forever.
- Use proven constructs.
- Beware the code you cannot see.
- Defend with "Use Timeouts".

Attacks of Self-Denial

Good marketing can kill your system at any time.

- Ever heard this one?
  - A retailer offered a great promotion to a “select group of customers”.
  - Approximately a bazillion times the expected customers show up for the offer.
  - The retailer gets crushed, disappointing the avaricious and legitimate.
- It’s a self-induced Slashdot effect.

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Victoria’s Secret: Online Fashion Show

BestBuy: XBox 360 Preorder

Amazon: XBox 360 Discount

Anything on FatWallet.com

Defending the Ramparts

- Avoid deep links
- Set up static landing pages
- Only allow the user's second click to reach application servers
- Allow throttling of incoming users
- Set up lightweight versions of dynamic pages.
- Use your CDN to divert users
- Use shared-nothing architecture

One email I saw went out with a deep link that bypassed Akamai. Worse, it encoded a specific server and included a session ID.

Another time, an email went out with a promo code. It could be used an unlimited number of times.

Once a vulnerability is found, it will be flooded within seconds.

Remember This

- Keep lines of communication open
  - Support the marketers. If you don't, they'll invent their way around you, and might jeopardize the systems.
- Protect shared resources
- Expect instantaneous distribution of exploits

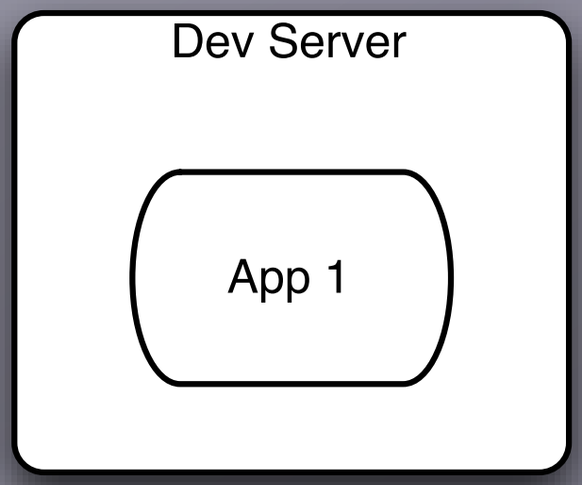
Scaling Effects

Understand which end of the lever you are sitting on.

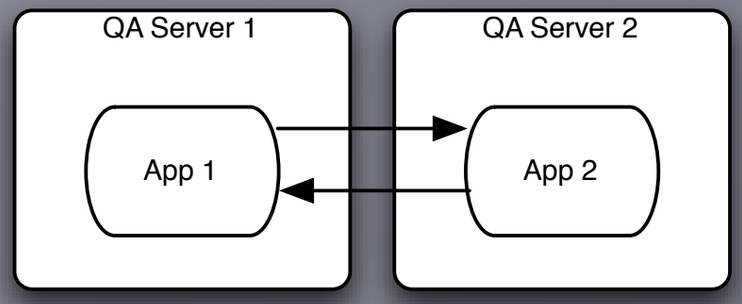
- Ratios in dev and QA tend to be 1:1
  - Web server to app server
  - Front end to back end
- They differ wildly in production, so designs and architectures may not be appropriate

Example: Point to Point Cache Invalidation

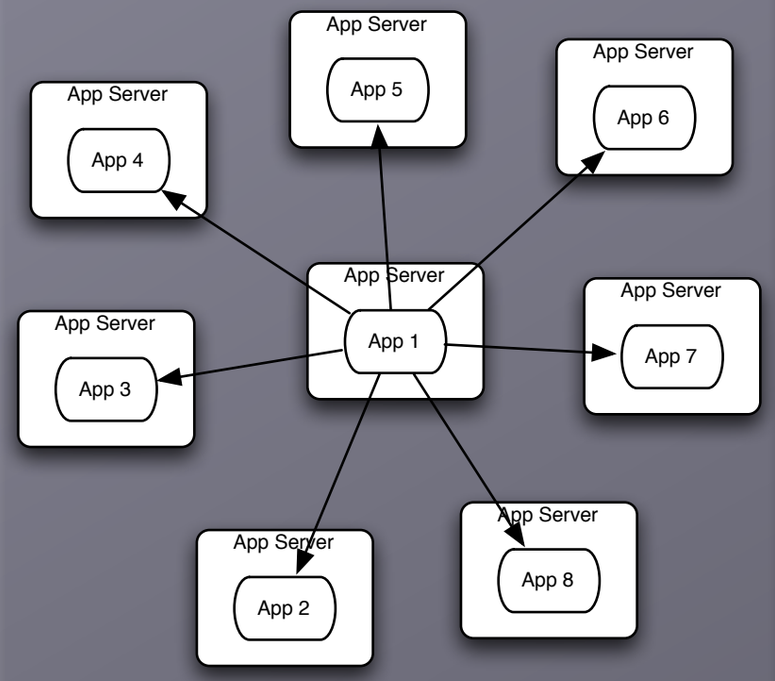
Development



QA



Production



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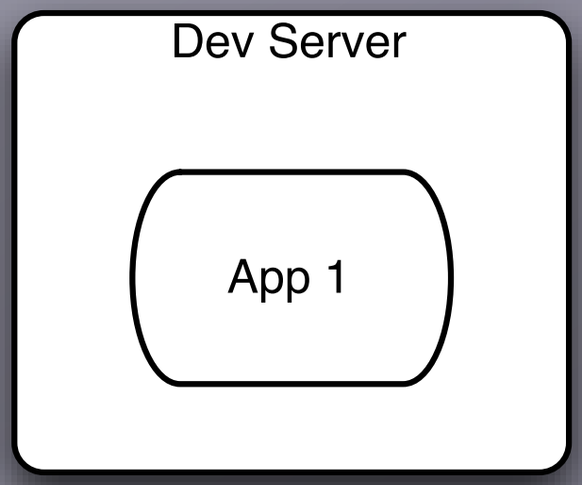

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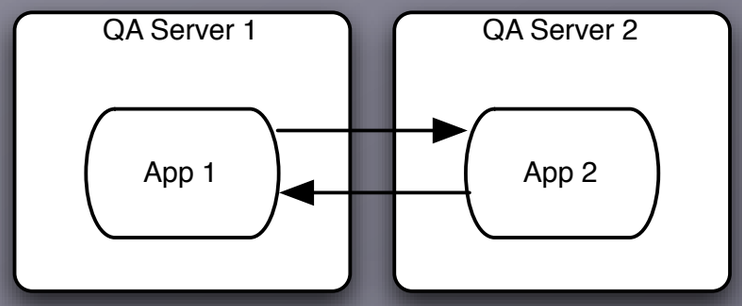

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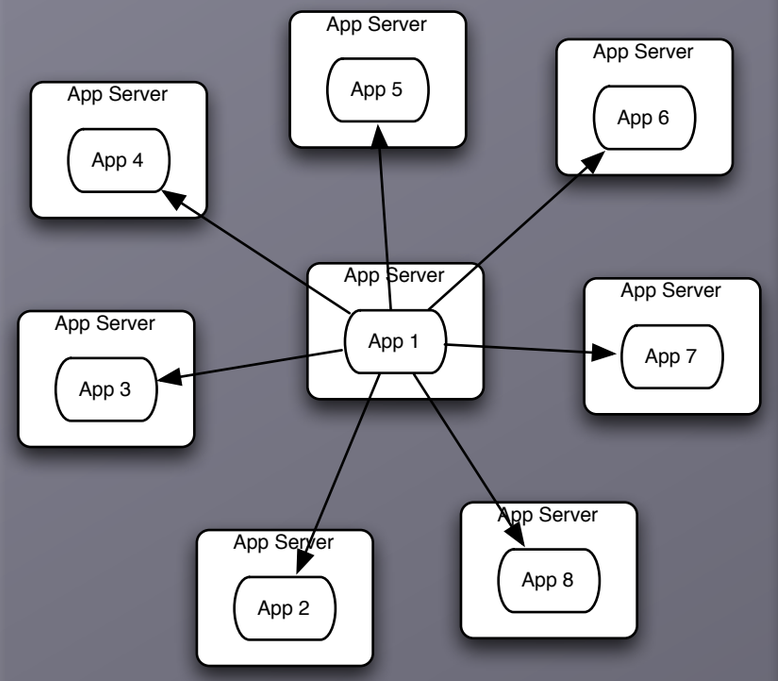
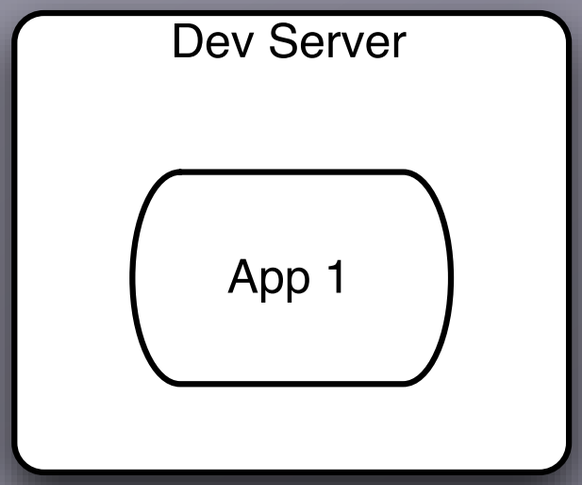


1 server
1 local call
No TCP connections

Example: Point to Point Cache Invalidation

Development



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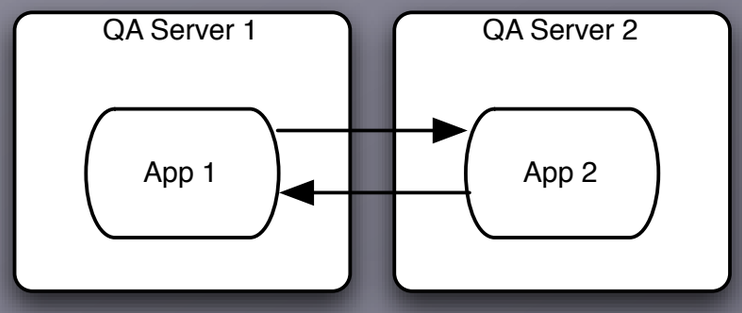
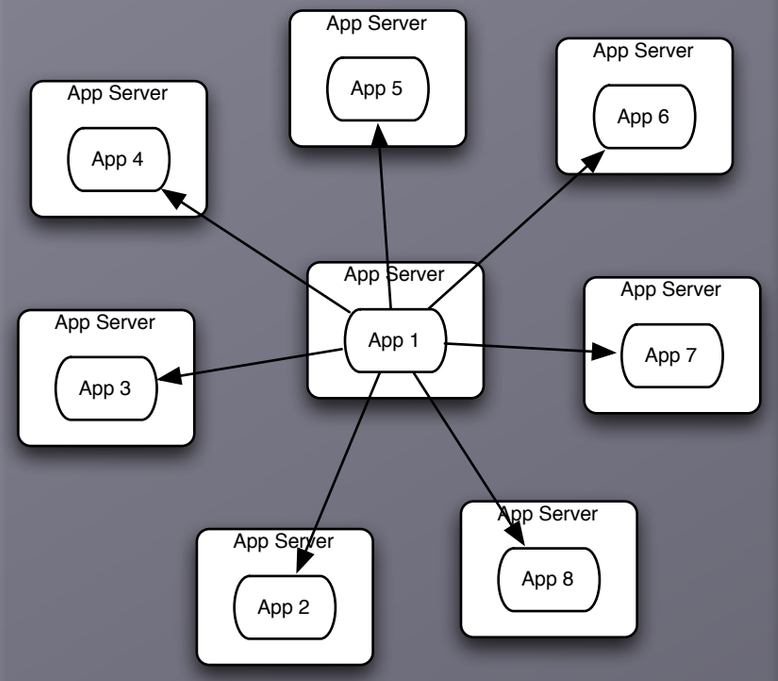


2 servers
1 local call
1 TCP connection

Production



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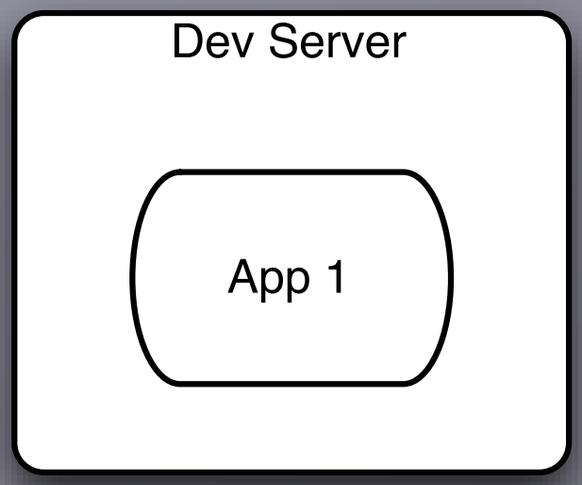

1 server
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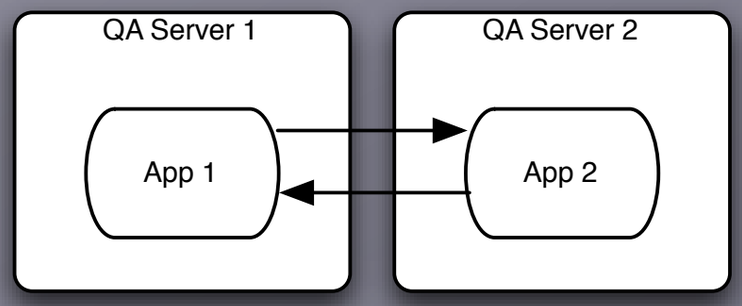
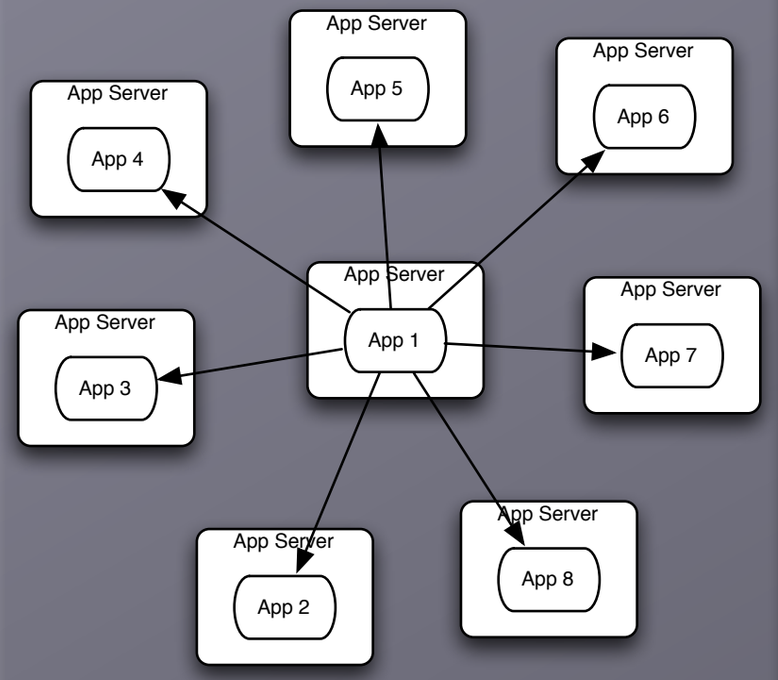


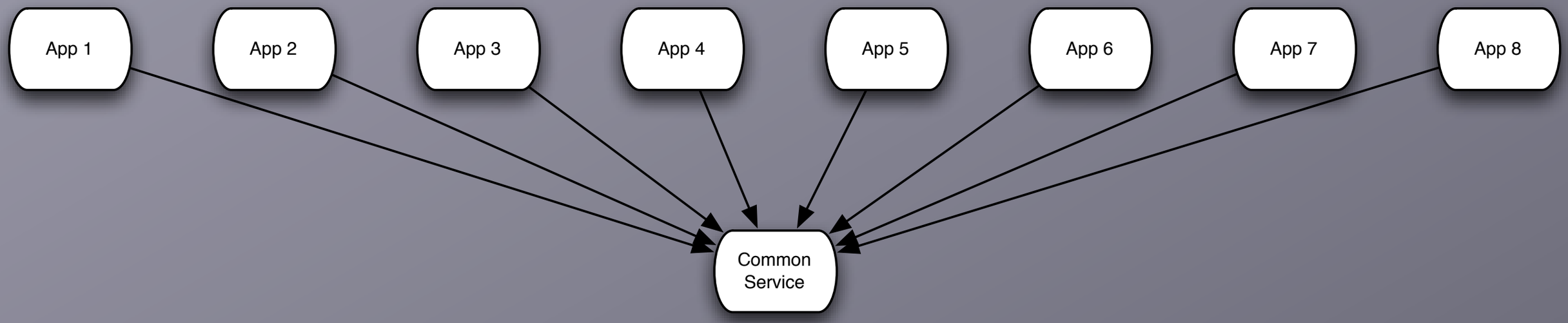
2 servers
1 local call
1 TCP connection

Production



8 servers
1 local call
7 TCP connection

Example: Shared Resources



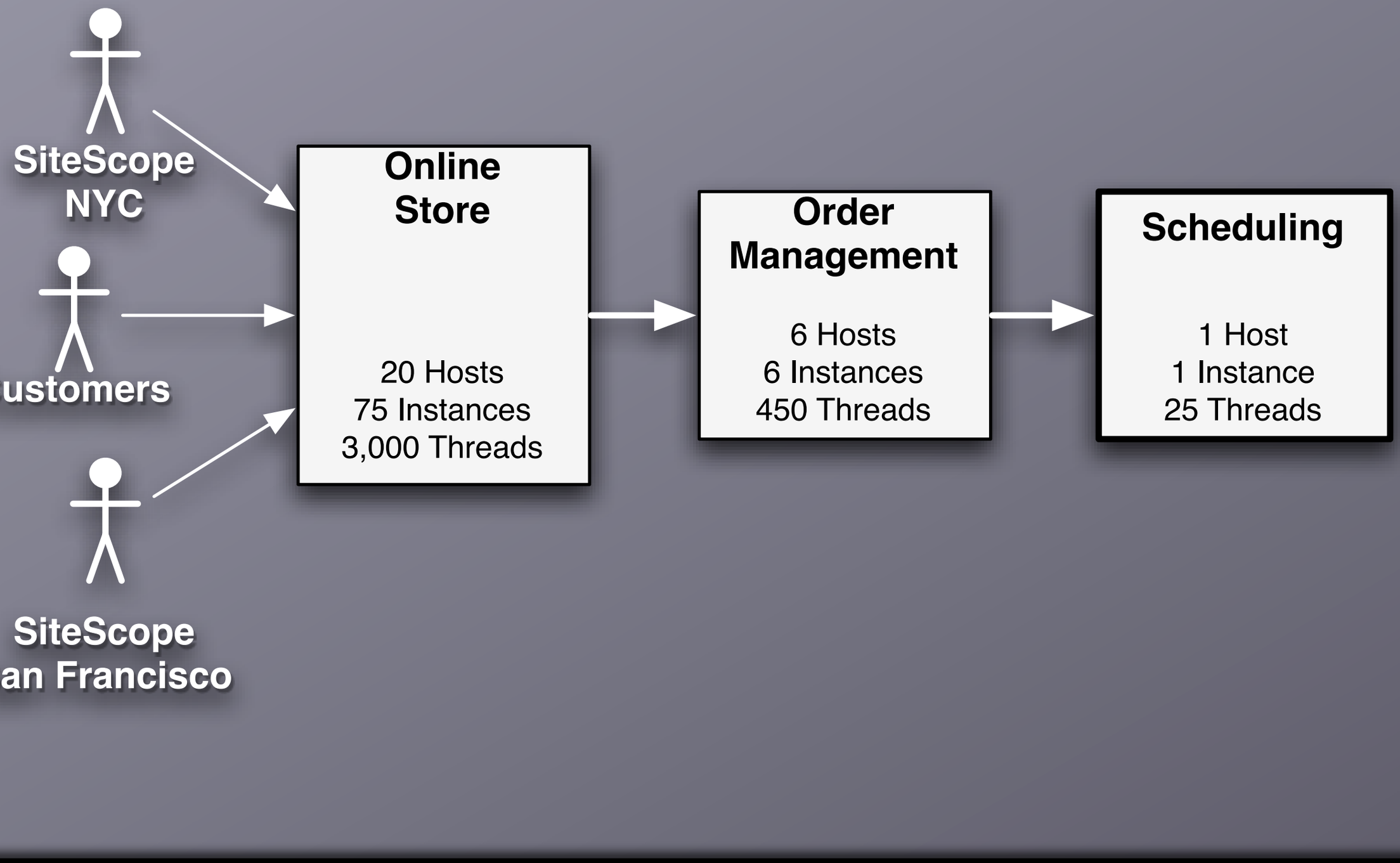
Shared resources commonly appear as lock managers, load managers, query distributors, cluster managers, and message gateways. They're all vulnerable to scaling effects.

Remember This

- Examine production versus QA environments to spot scaling effects.
- Watch out for point-to-point communications. It rarely belongs in production.
- Watch out for shared resources.

Unbalanced Capacities

Traffic floods sometimes start inside the data center walls.



Unbalanced Capacities

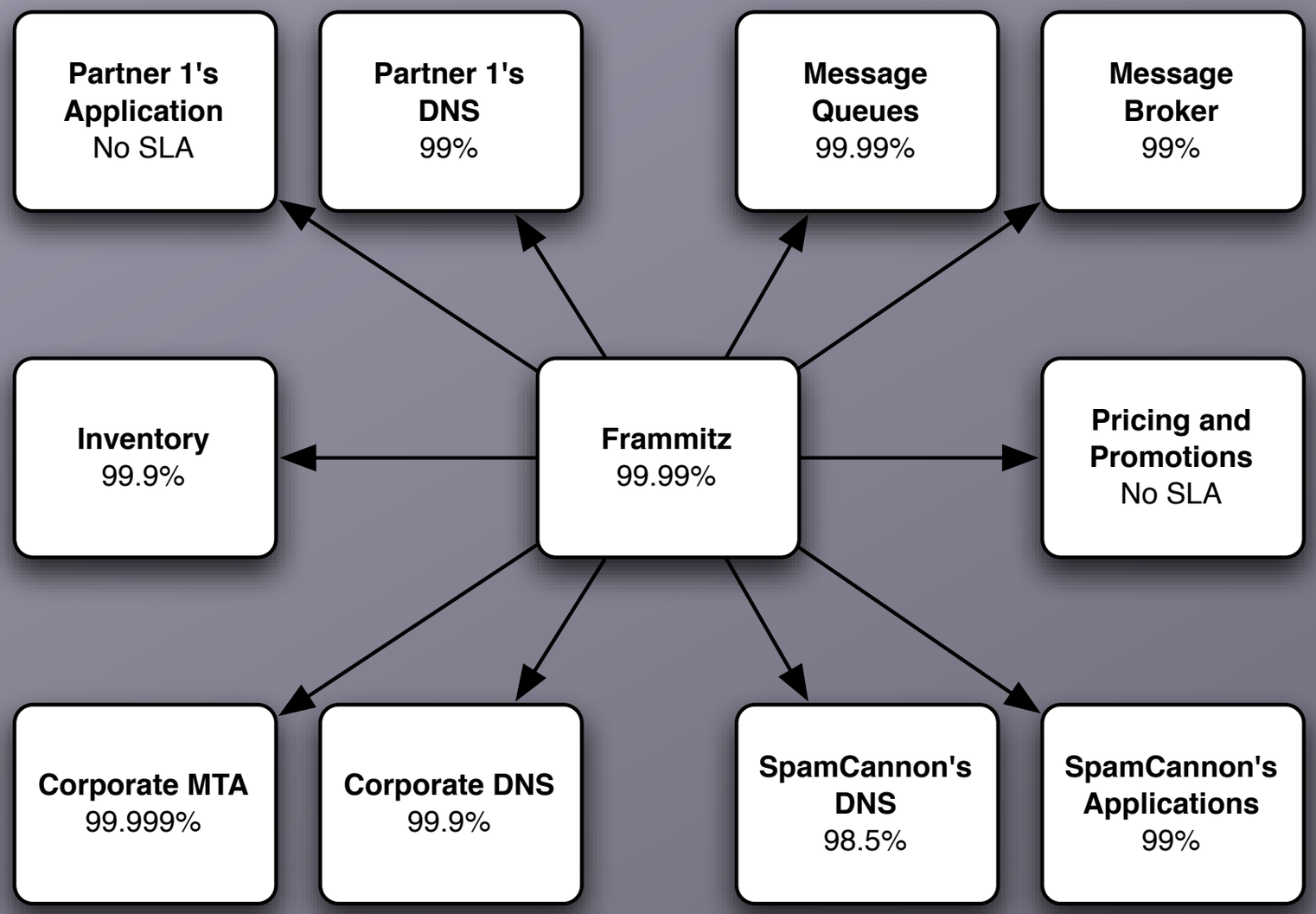
- Unbalanced capacities is a type of scaling effect that occurs between systems in an enterprise.
- It happens because
  - All dev systems are one server
  - Almost all QA environments are two servers
  - Production environments may be 10:1 or 100:1
- May be induced by changes in traffic or behavior patterns

Remember This

- Examine server and thread counts
- Watch out for changes in traffic patterns
- Stress both sides of the interface in QA
- Simulate back end failures during testing

SLA Inversion

Surviving by luck alone.



What SLA can Frammitz *really* guarantee?

Absent other protections, the best SLA you can offer is the *worst* SLA provided by your dependencies.

The dreaded SPOF is a special case of SLA Inversion.

Do your web servers have to ask DNS to find the application server's IP address?

Remember This

- Don’t make empty promises. Be sure you can deliver the SLA you commit to.
- Examine every dependency. Verify that *they* can deliver on their promises.
- Decouple your SLAs from your dependencies’.
- Measure availability by feature, not by server.
- Be wary of “enterprise” services such as DNS, SMTP, and LDAP.

Unbounded Result Sets

Limited resources, unlimited data volume

- Development and testing is done with small data sets
- Test databases get reloaded frequently
- Queries that perform acceptably in development and test bonk badly with production data volume.
  - Bad access patterns can make them very slow
  - Too many results can use up all your server's RAM or take too long to process
  - You never know when somebody else will mess with your data

Unbounded Result Sets: Databases

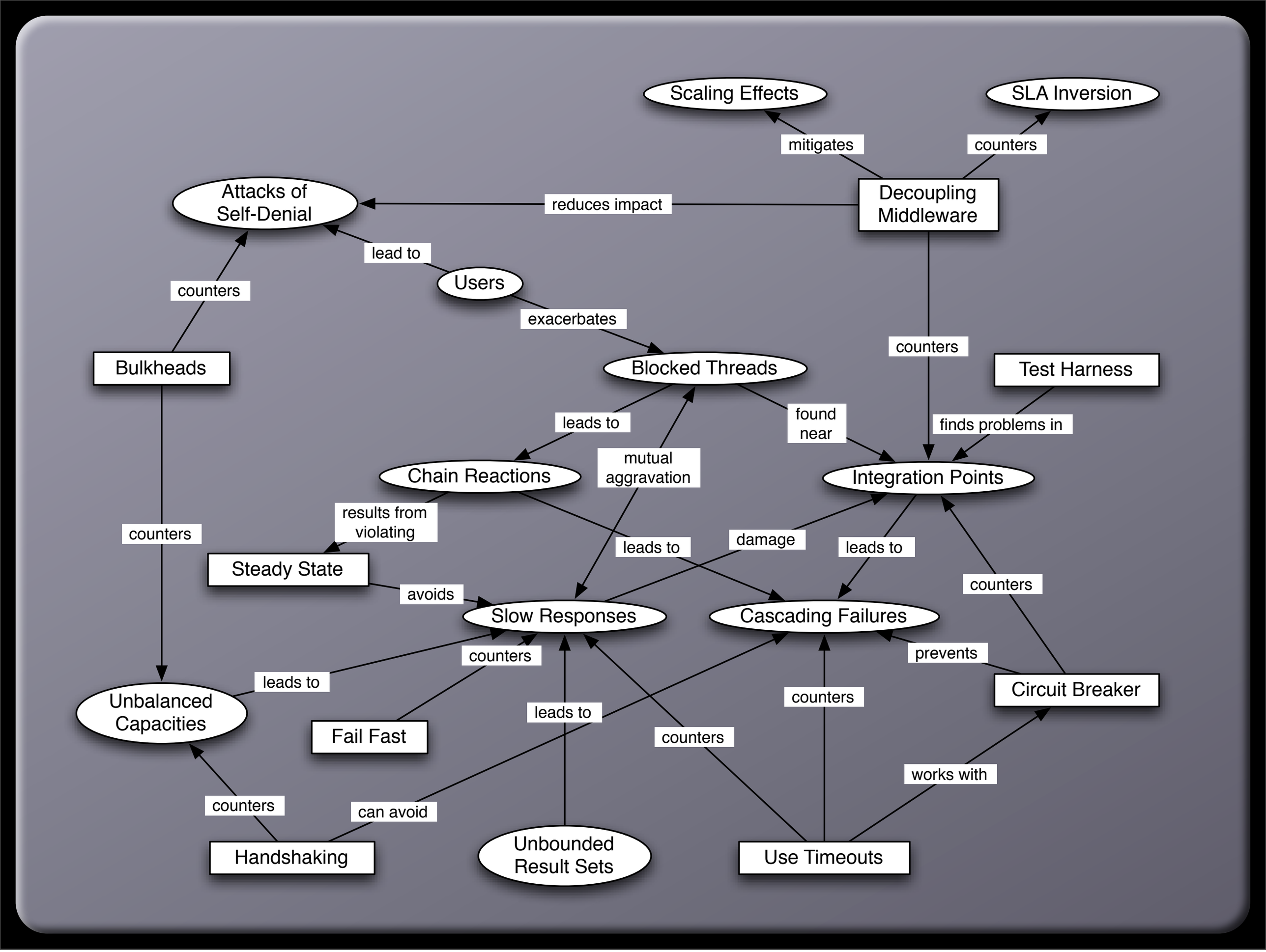
- SQL queries have no inherent limits
- ORM tools are bad about this
- It starts as a degenerating performance problem, but can tip the system over.
- For example:
  - Application server using database table to pass message between servers.
  - Normal volume 10 – 20 events at a time.
  - Time-based trigger on every user generated 10,000,000+ events at midnight.
  - Each server trying to receive **all** events at startup.
  - Out of memory errors at startup.

Unbounded Result Sets: SOA

- Often found in chatty remote protocols, together with the N+1 query problem
- Causes problems on the client and the server
  - On server: constructing results, marshalling XML
  - On client: parsing XML, iterating over results.
- This is a breakdown in handshaking. The client knows how much it can handle, not the server.

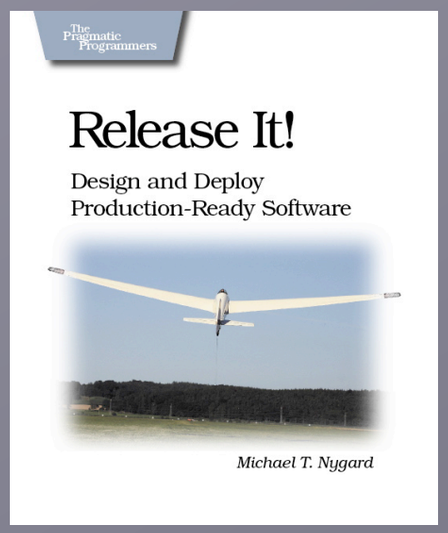
Remember This

- Test with realistic data volumes
  - Scrubbed production data is the best.
  - Generated data also works.
- Don’t rely on the data producers. Their behavior can change overnight.
- Put limits in your application-level protocols:
  - WS, RMI, DCOM, XML-RPC, etc.


Scaling Effects
SLA Inversion
mitigates
counters
Attacks of Self-Denial
reduces impact
Decoupling Middleware
lead to
counters
Users
exacerbates
counters
Bulkheads
Blocked Threads
Test Harness
found near
leads to
finds problems in
mutual aggravation
Chain Reactions
Integration Points
results from violating
counters
leads to
damage
leads to
Steady State
counters
avoids
Slow Responses
Cascading Failures
counters
prevents
leads to
Circuit Breaker
Unbalanced Capacities
counters
leads to
Fail Fast
counters
counters
works with
counters
can avoid
Handshaking
Unbounded Result Sets
Use Timeouts

Questions?

Please remember to fill out a session feedback form.



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