DevOps

Martin Kellogg

Reading quiz: DevOps

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DevOps

Today's agenda:

- **Operations, Toil, and the DevOps philosophy**
- Achieving reliability
  - the service reliability hierarchy + SLAs/targets
  - monitoring and reliability testing
  - incident/emergency response
  - preventing problems before they occur
  - post-mortems + learning from failure

Operations

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- deploying new versions of the software

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  - other advantages: easy to staff for, off-the-shelf tooling, etc.

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Traditional approach to operations can work in either of these models!

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- But, they are serious concerns for modern systems with high release cadences, especially those that are:
  - microservices
  - delivered via the web
  - use “continuous delivery”

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    - similar to organizational motivation for **microservices**

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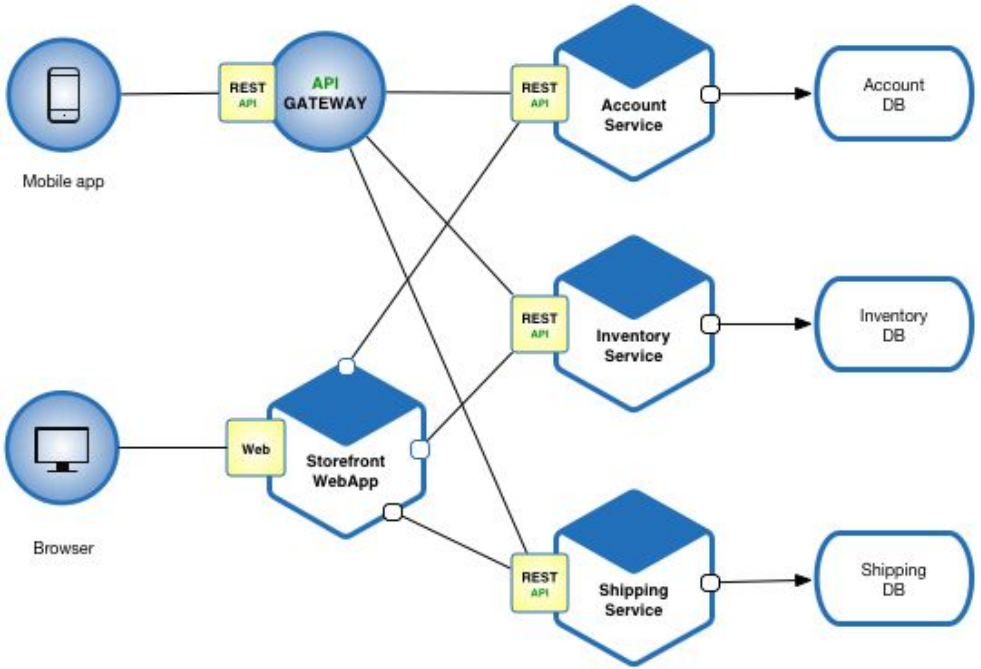

[https://microservices.io/]

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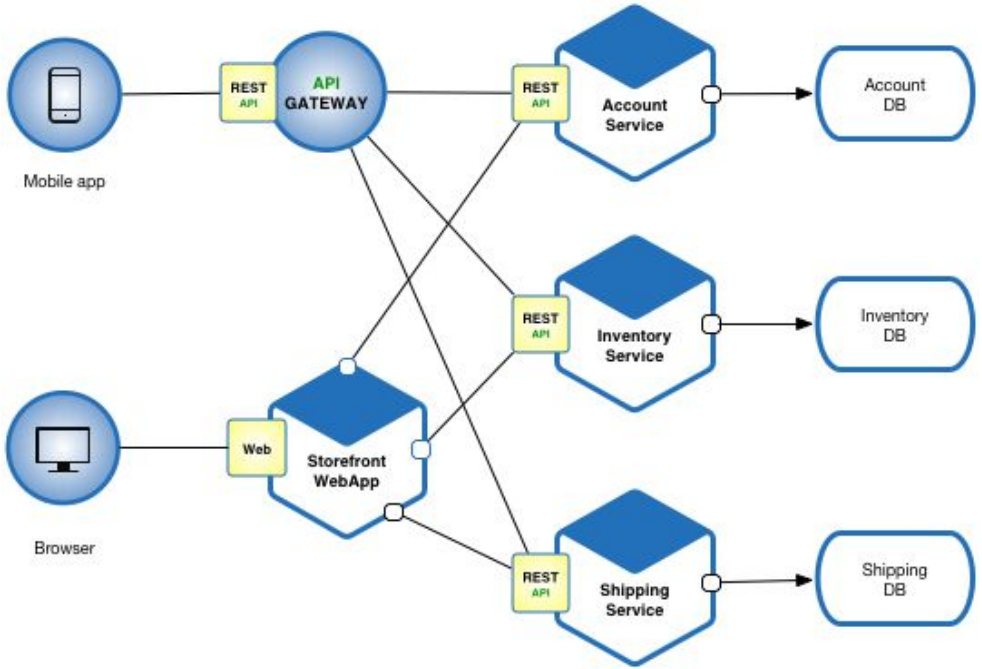

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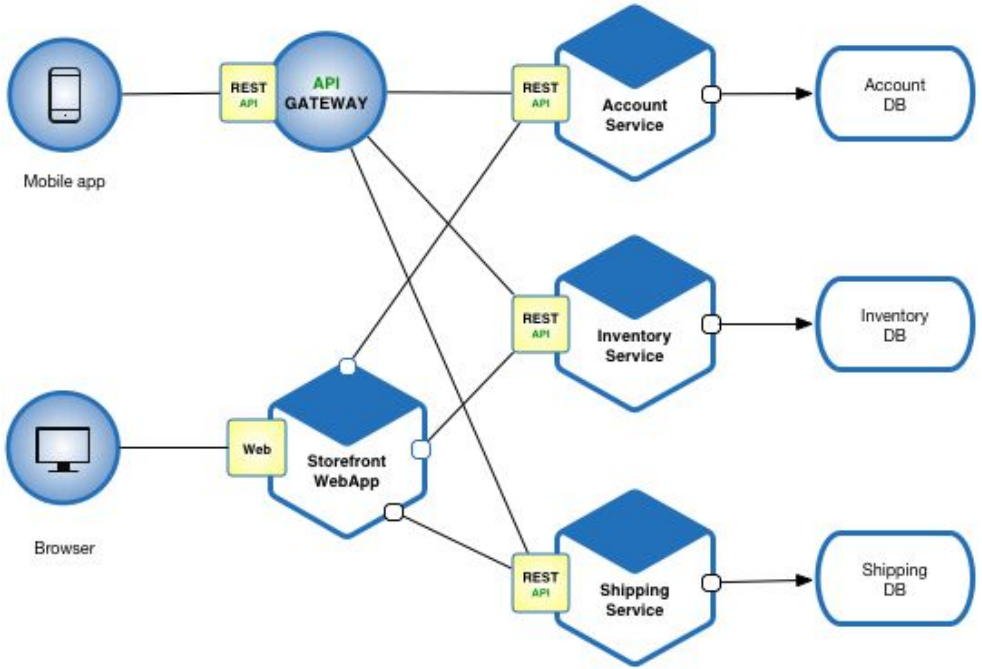

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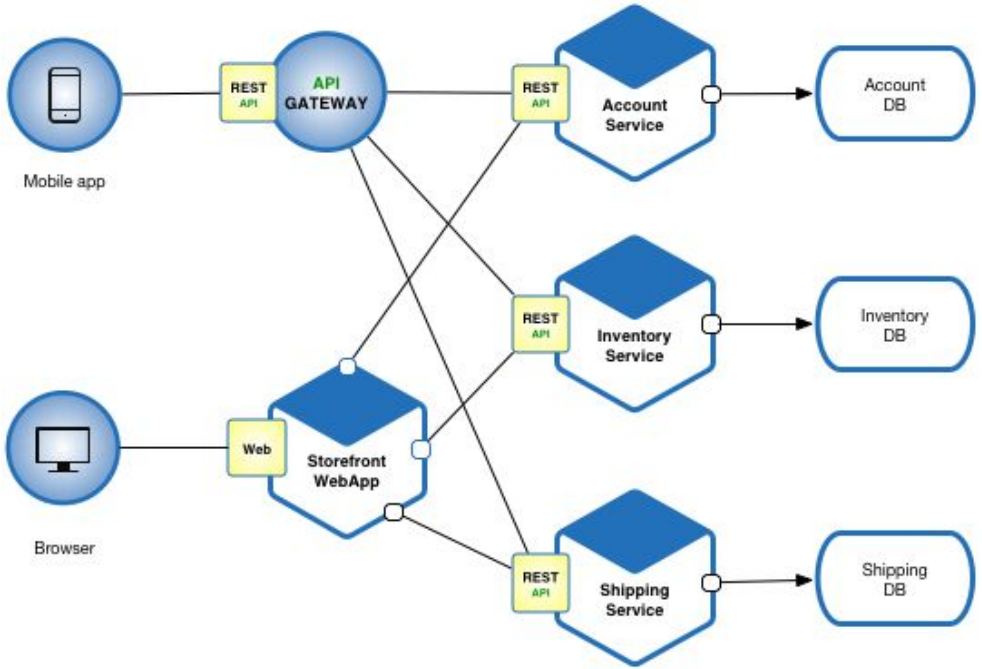

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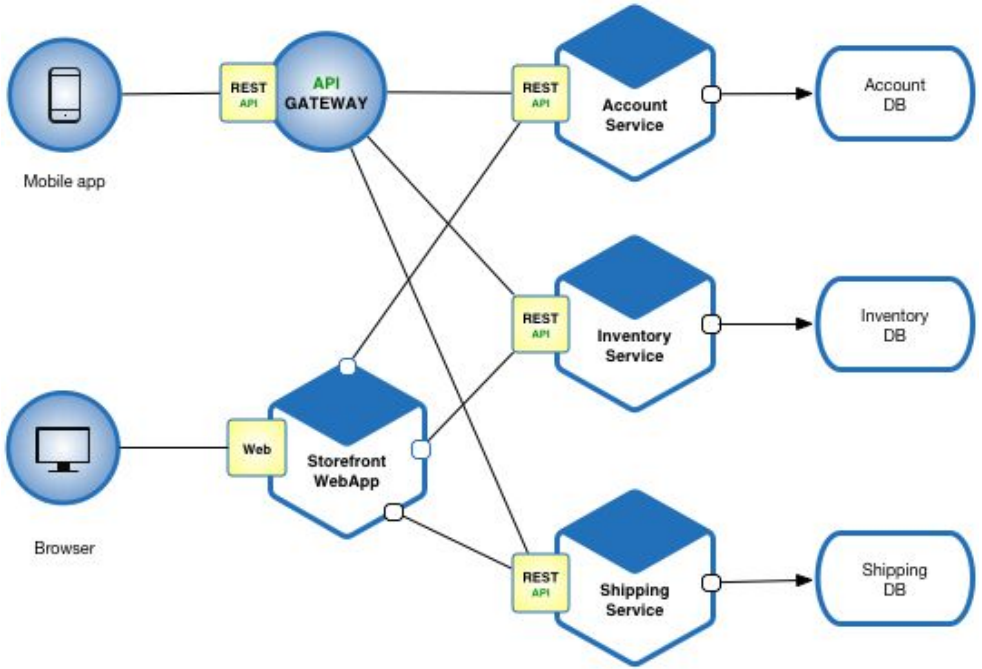

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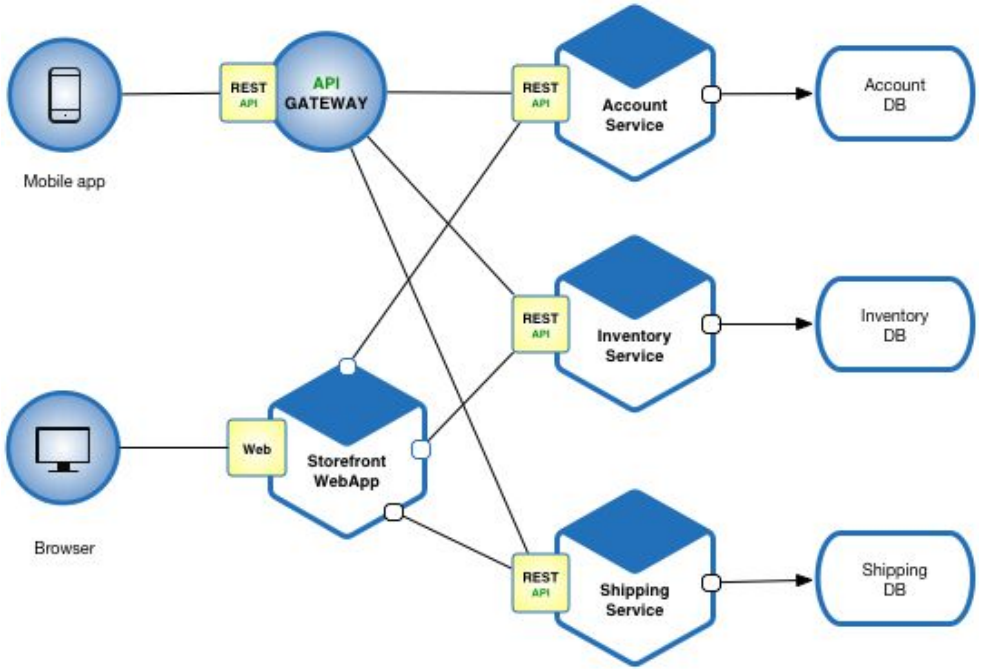

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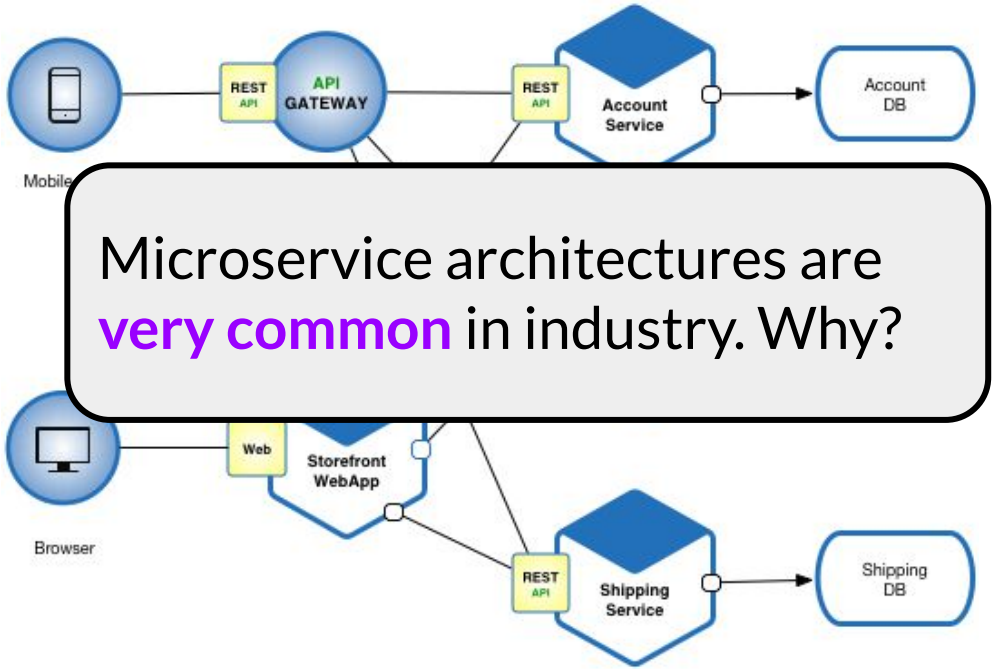

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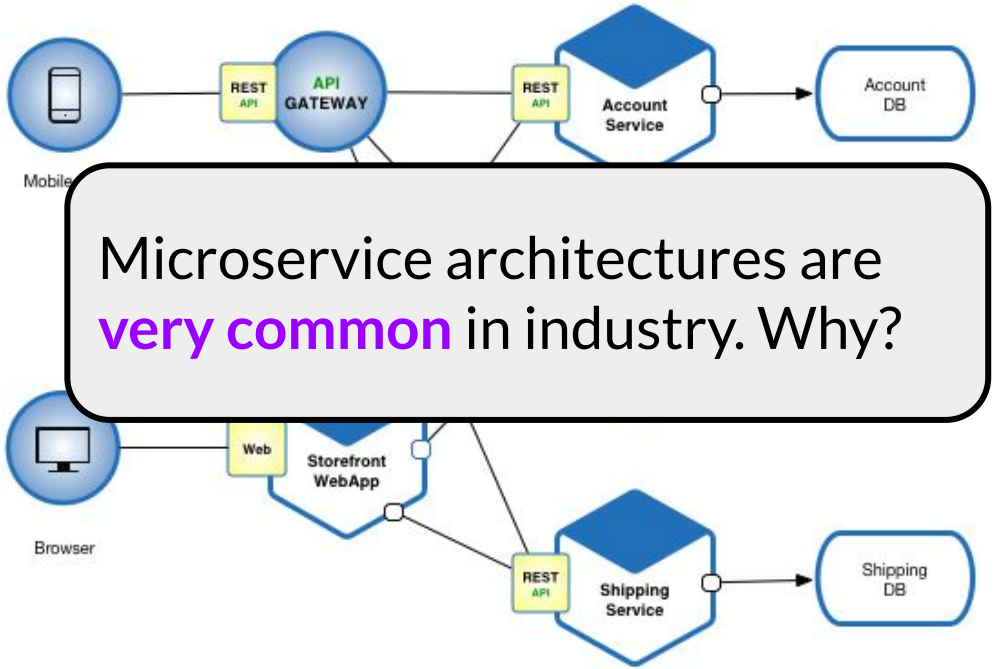

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Operations: the DevOps approach

Key idea: combine the development and operations teams

- “DevOps” is a portmanteau of “developers” + “operators”
- DevOps teams are organized around services/projects
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- may still have some dedicated ops roles (e.g., SREs at Google)

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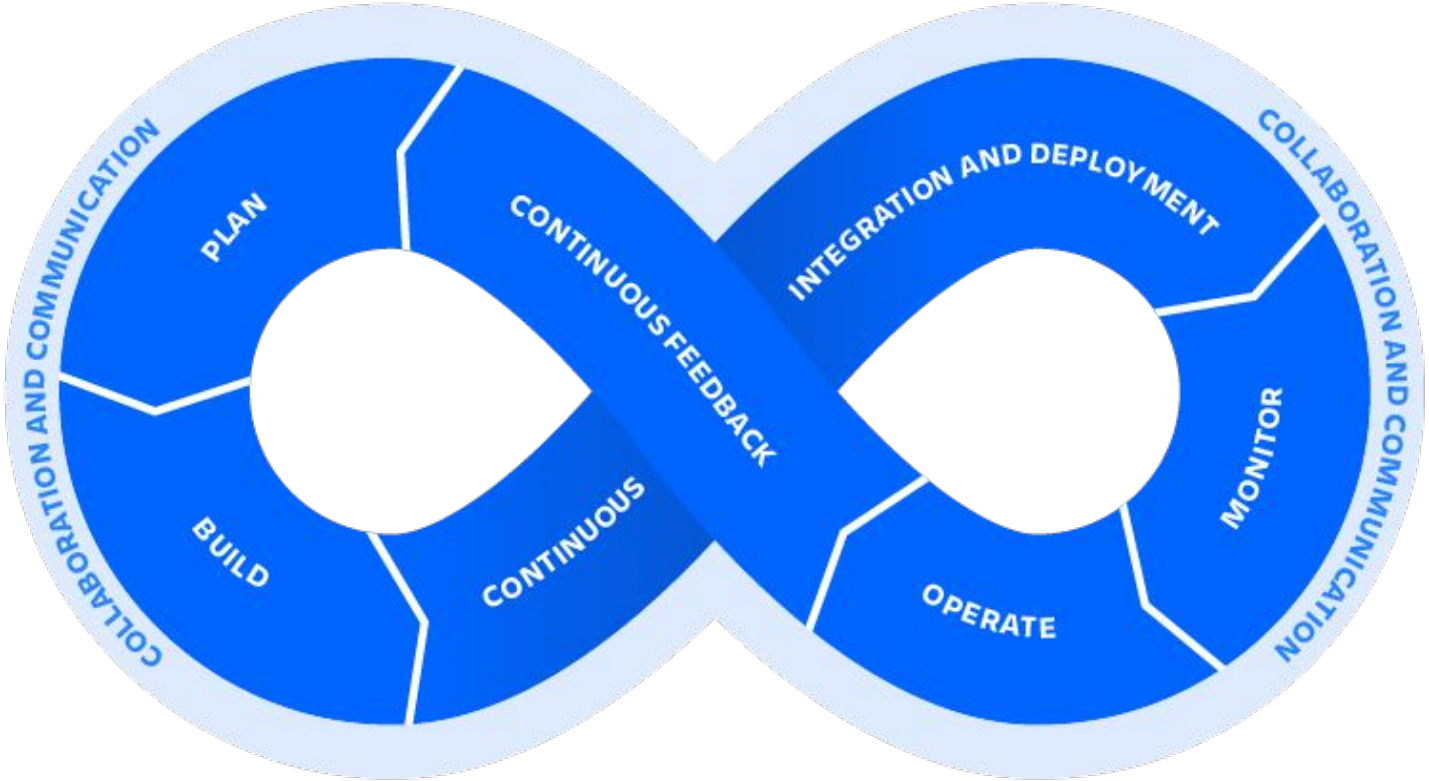

figure credit: Atlassian

Operations: toil

> *If a human operator needs to touch your system during normal operations, you have a bug. The definition of normal changes as your systems grow.*
>
> Carla Geisser, Google SRE

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A key advantage of DevOps is that it encourages **removing** toil

- if operators are separate from devs, devs have no incentive to avoid toil

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- **automatable**: if human judgment is essential for the task, there's a good chance it's not toil

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- **O(n) with service growth**: if the work involved in a task scales up linearly with *service size*, *traffic volume*, or *user count*, that task is probably toil

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A task doesn't need to have **all** of these attributes to be toil. But, the more closely work matches one or more of these descriptors, the **more likely** it is to be toil.

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- **overhead** is also different than toil
  - tasks like team meetings, setting and grading goals, and HR paperwork (that are not tied to operations) are overhead

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- career stagnation (it doesn't get you promoted)
- lowers morale (it's boring)
- creates confusion (easy to forget to do a manual task!)
- slows progress (could be doing useful work instead)
- sets precedent (avoid letting toil become normal!)
- promotes attrition ("I want to work on something interesting!")

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- SRE motto: “Hope is not a strategy”

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    - makes technical debt riskier to take on (why?)

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  - so, availability is the first thing we need to worry about when trying to make a service reliable

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    - **throughput** (how many requests can you serve per hour)

Reliability: setting expectations

- To determine if your system is behaving reliably, you need **metrics** that approximate whether it does what your users expect
  - **availability** is often a good metric to start with
  - other metrics will depend on the **meaning** of “correct” in your service’s context. Possible metrics:
    - **latency** (time it takes to serve client requests)
    - **throughput** (how many requests can you serve per hour)
    - **durability** (how much of your data can you still retrieve after a fixed time has passed)

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Sometimes SLAs are written into contracts with your customers!

Aside: subtleties in metrics

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E.g., consider two systems:

- system A serves 200 requests in every even-numbered second, and 0 requests in every odd-numbered second
- system B serves 100 requests every second

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green is 85th % latency

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red is 95th % latency

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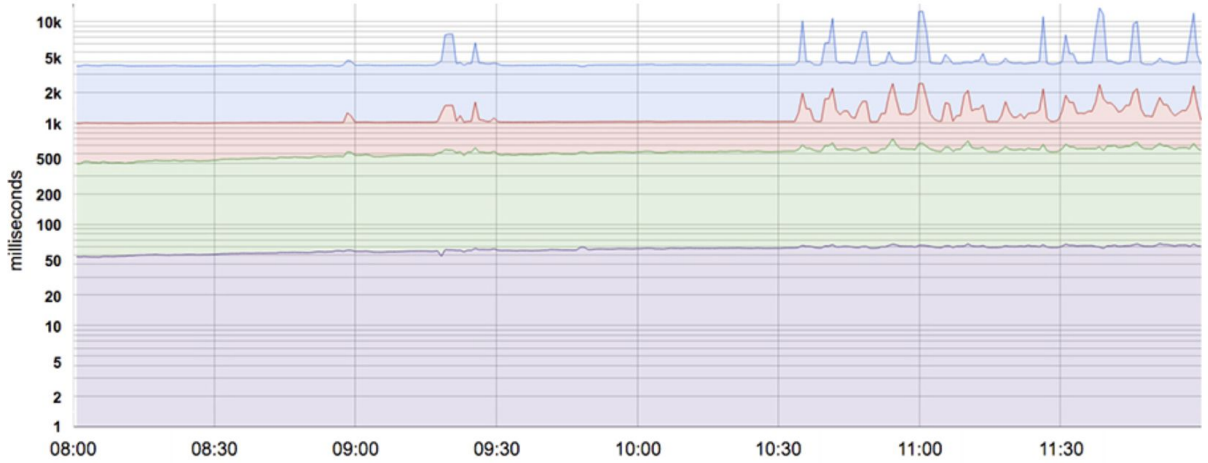

blue is 99th % latency

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- include as **few metrics** as possible while still covering what matters
  - avoid metrics that aren't useful in arguing for priorities

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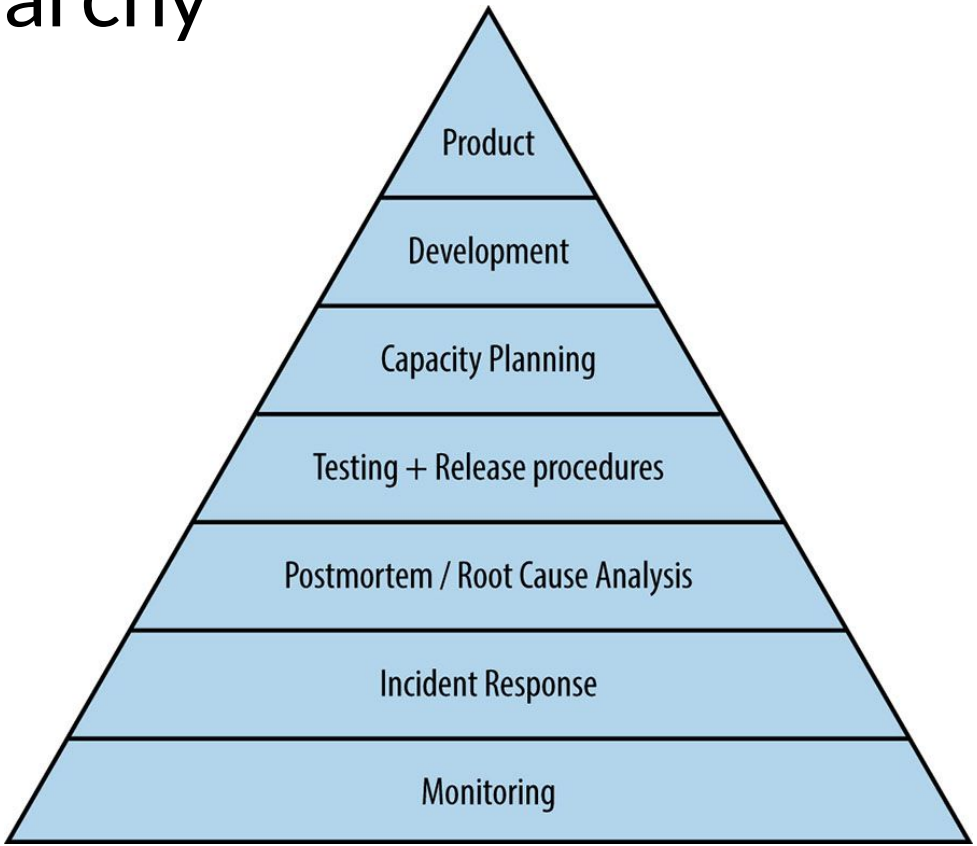
  - Then, make sure that those metrics actually look good.
- How do we think about how to do this?
  - **insight**: there is a **hierarchy** of system components that need to be working well in order to meet an SLA

Service Reliability Hierarchy

- analogy to Maslow's "Hierarchy of Needs" for humans



[Image credit: https://sre.google/sre-book/part-III-practices/]

Maslow’s Hierarchy of Needs

Maslow's hierarchy of needs

[Image credit: https://www.thoughtco.com/maslows-hierarchy-of-needs-4582571]

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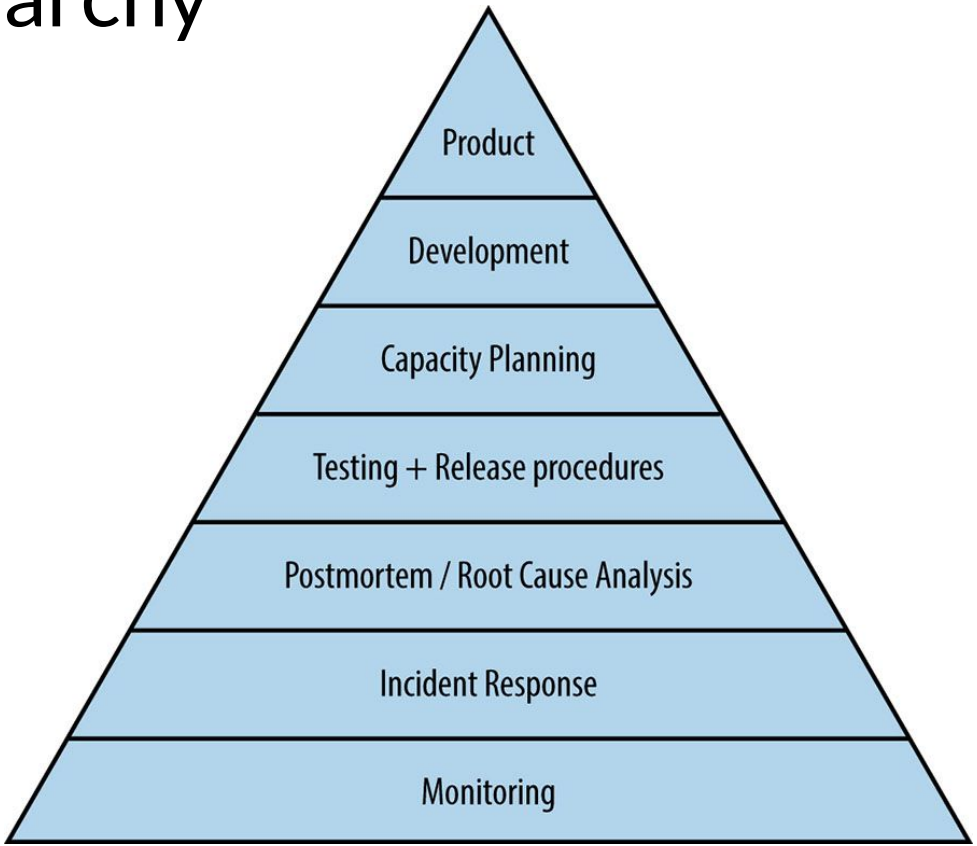

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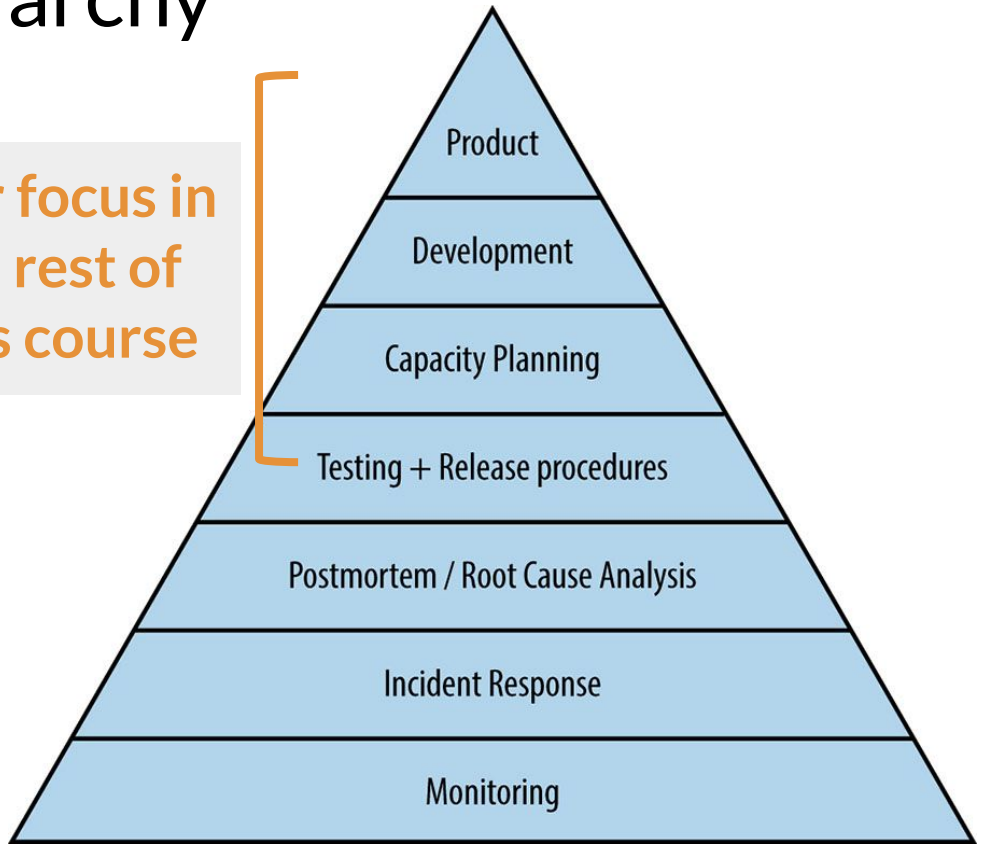

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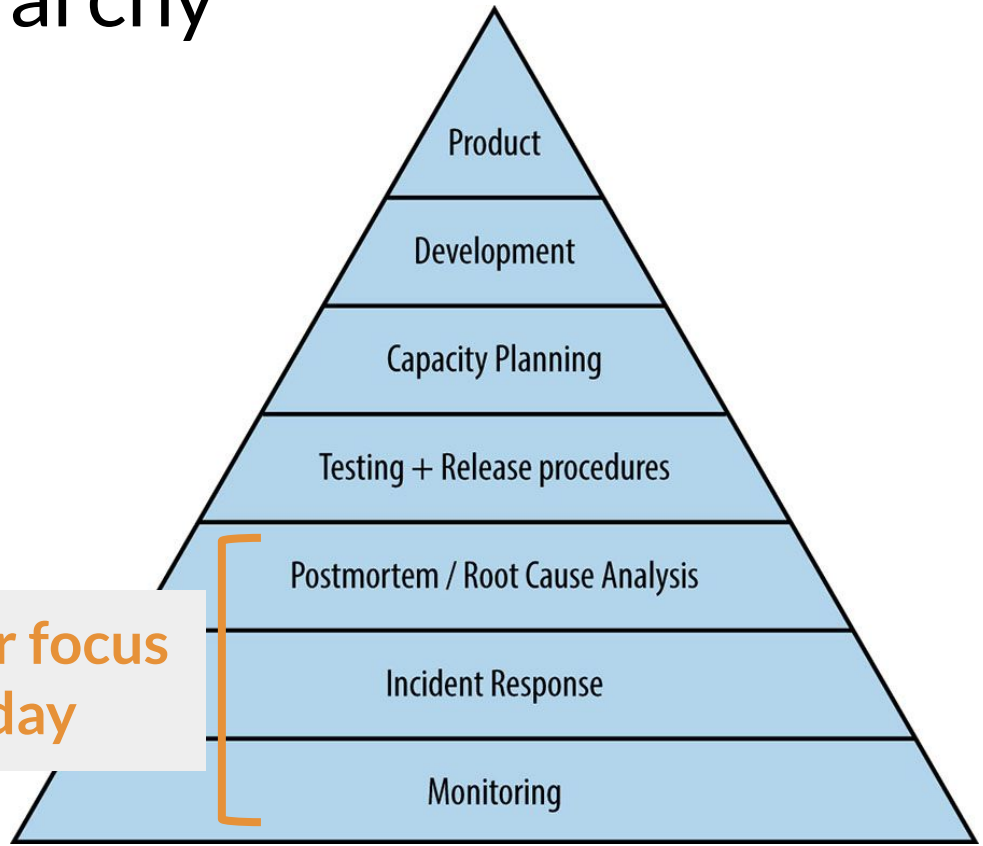

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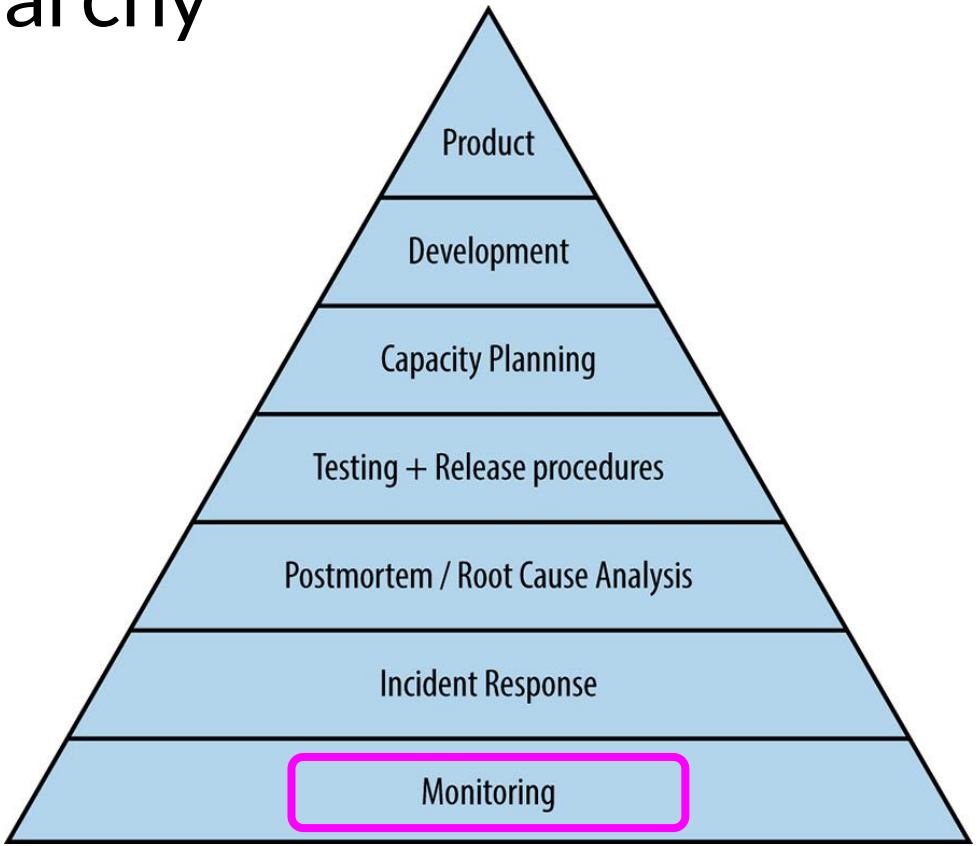

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DevOps

Today's agenda:

- Operations, Toil, and the DevOps philosophy
- Ops challenge example: deployment
- Achieving reliability
  - the service reliability hierarchy + SLAs/targets
  - **monitoring**
  - incident/emergency response
  - post-mortems + learning from failure

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Monitoring is why **logging** is so important in practice: if your monitoring depends on your logging framework, it is a very important component of your service!

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- **page** = alert send directly to a human (via a pager)

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- Example from earlier: "cleaning up a service's alerting config" = fixing **what corresponds** to pages vs email alerts vs tickets

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  - but can (**and should**) page other team members in an emergency

DevOps

Today's agenda:

- Operations, Toil, and the DevOps philosophy
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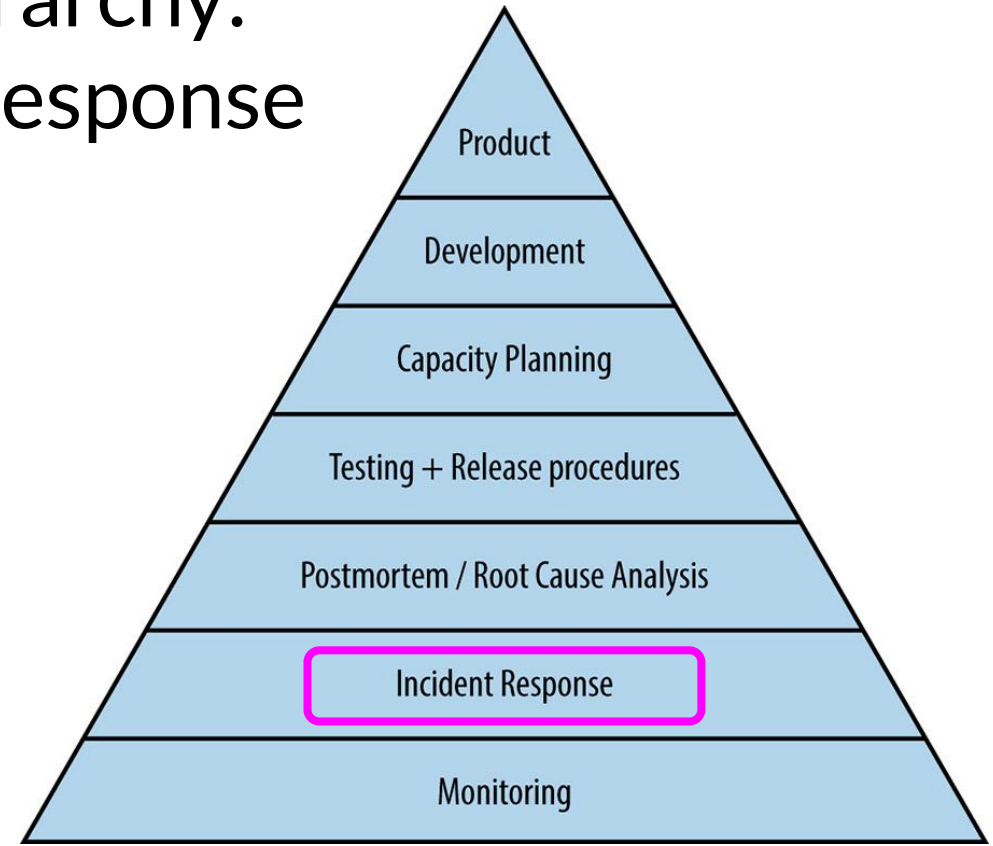
  - monitoring and reliability testing
  - **incident/emergency response**
  - preventing problems before they occur
  - post-mortems + learning from failure

Service Reliability Hierarchy: Incident/Emergency Response



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Emergency Response

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  - as the on-call, **you are in charge** in an emergency by default
- What constitutes an emergency?
  - depends on your service, but typically these qualify:
    - big % of user requests aren't getting responses
    - big % of user requests have really high latency
    - lots of your servers are unavailable/down (even if users aren't yet impacted)

Emergency Response: causes of emergencies

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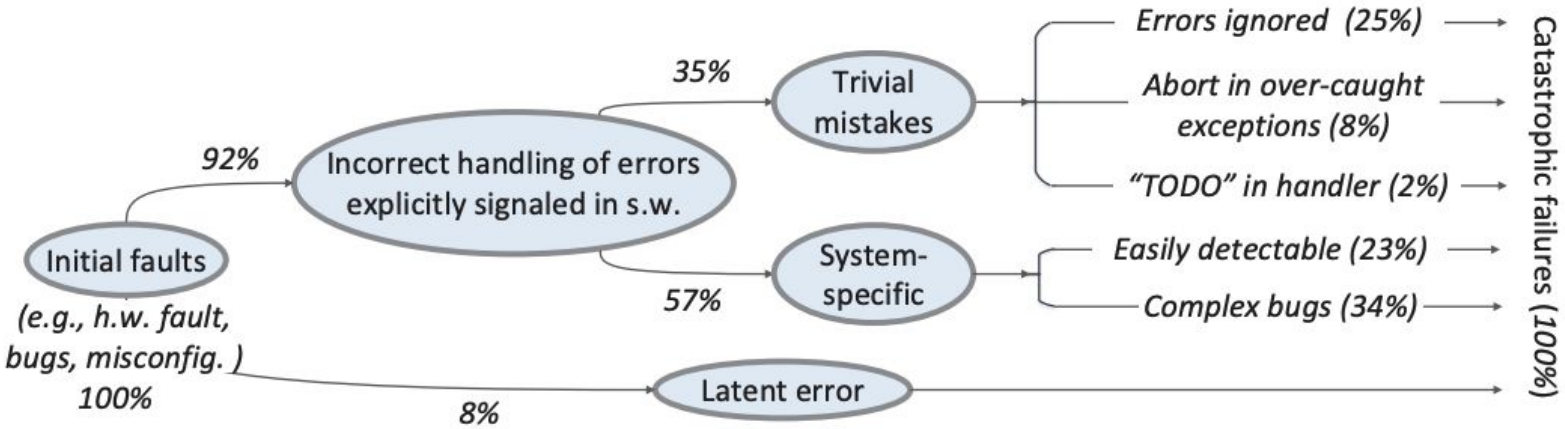

[*Simple Testing Can Prevent Most Critical Failures: An Analysis of Production Failures in Distributed Data-Intensive Systems.* Yuan et al. OSDI 2014.]

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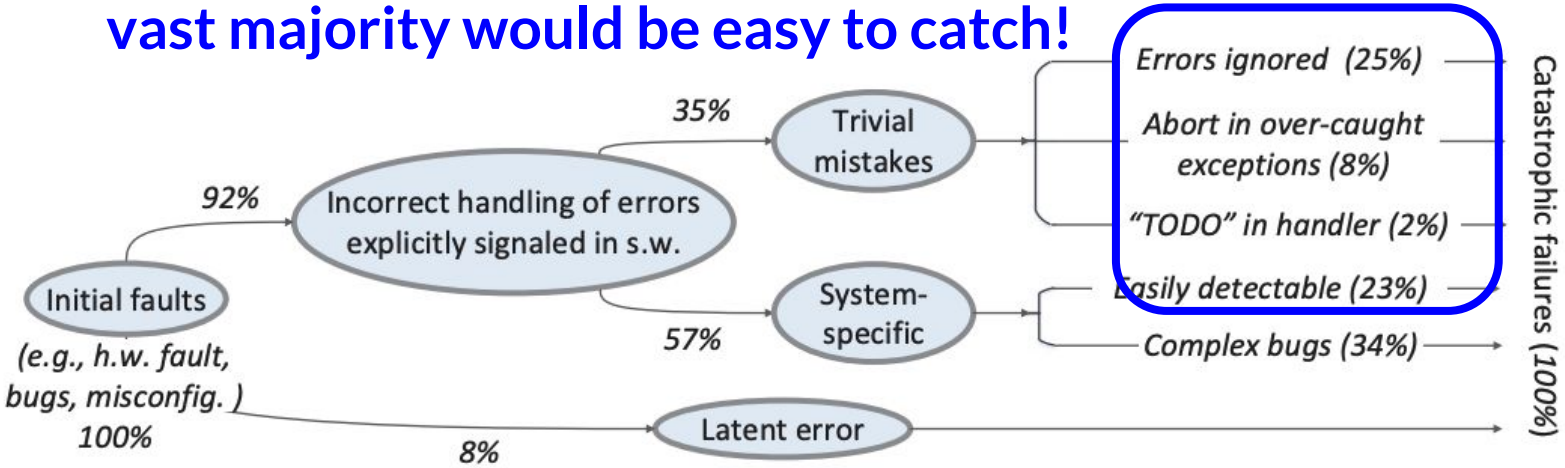

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- **configuration changes**:
  - especially for services, how the servers that run the system are configured is often as important as the code itself
  - changes to the infrastructure (e.g., adding or removing servers) are just as risky as changes to the code
    - but testing them is harder!

Emergency Response: causes of emergencies

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Implication: in large systems, you **must plan for hardware failures**, because they **will occur**

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    - computers are good at this!
    - analogy: just like hardware components sometimes fail, any step carried out by humans should be assumed to have a non-zero failure rate

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  - often, playbooks have specific guidance for particular alerts

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  - "plans are useless, but planning is indispensable"
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  - playbooks are built up over a service's lifetime (i.e., they record how previous incidents might have been avoided or mitigated)
  - often, playbooks have specific guidance for particular alerts
  - playbooks also have a psychological function: **prevent panic**

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  - **preserve evidence**: save logs, etc., for post-mortem analysis
- **Practice** makes perfect
  - don't wait for an actual emergency to find out if your playbook works: simulate one instead!

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Easy rollbacks are one motivation for “**infrastructure-as-code**”: if your infrastructure configuration is in version control, it’s easy to go back to the last working one!

DevOps

Today's agenda:

- Operations, Toil, and the DevOps philosophy
- Achieving reliability
  - the service reliability hierarchy + SLAs/targets
  - monitoring and reliability testing
  - incident/emergency response
  - **preventing problems before they occur**
  - post-mortems + learning from failure

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Preventing Problems

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- however, there are some **DevOps-specific** testing and deployment strategies that can help:
  - integrating testing and monitoring
  - stress testing services
  - canaries and "baking the binary"

Integrating Testing and Monitoring

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  - for example, should there be a **metamorphic relationship** between a pair of metrics that we're collecting?
    - if so, we can define an alert that goes off if that relationship is ever violated - similar to a **property-based test that's running on our real traffic**!

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- **Chaos Monkey** is one example of a stress testing technique
- Others include intentionally **scaling up** another service
  - i.e., simulate a spike in demand with artificial traffic

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This incubation period while the fleet is partially upgraded is sometimes called "***baking the binary***".

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Note that *C*, *R*, and *K* should all be **measurable** by your monitoring system.

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  - U=3: the randomly damaged data is also a valid identifier to a previous request.

Observe that ***order*** here is like big-O notation:

- U=1 means that only the request itself is impacted
- U=2 means that a linear-ish number of other requests will be impacted
- U=3 means exponentially more requests will be impacted
- etc.

know

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    - this might involve writing automation to trace all requests that hit the bug, restoring from a backup, etc.
- As we do all of this, it's important to **keep records**
  - they'll be useful later for **writing the post-mortem** (next topic!)

DevOps

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- Operations, Toil, and the DevOps philosophy
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  - the service reliability hierarchy + SLAs/targets
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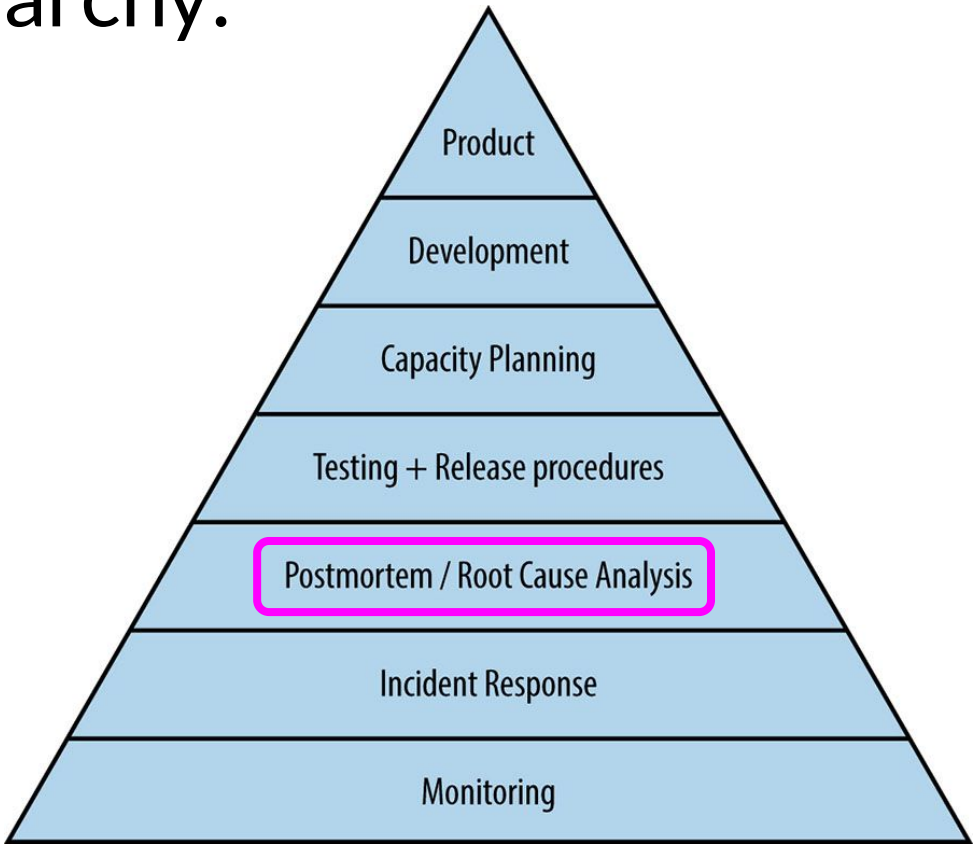
  - incident/emergency response
  - preventing problems before they occur
  - **post-mortems + learning from failure**

Service Reliability Hierarchy: Post-mortems



[Image credit: https://sre.google/sre-book/part-III-practices/]

Post-mortems

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- good postmortems are **blameless** and **actionable**:
  - “**blameless**” = find the faults in the process, not the people
  - “**actionable**” = give specific guidance for how to avoid the problem in the future (these become tickets)

Post-mortems: blameless

- Why not assign blame after an incident?
  - After all, **someone** should be responsible, right?

Post-mortems: blameless

- Why not assign blame after an incident?
  - After all, **someone** should be responsible, right?
- Some reasons:
  - Gives people **confidence to escalate** issues without fear
  - Avoids creating a culture in which incidents and issues are **swept under the rug** (which is worse long-term!)
  - **Learning experience**: engineers who have experienced an incident won't make the same mistakes again
  - You can't "fix" people, but you can fix **systems and processes**

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Historically, software engineering adopted a lot of "blameless culture" from **aviation and medicine**, where mistakes can be fatal! We might not have the same stakes, but **all complex systems are similar** in a lot of ways.

Post-mortems: peer review

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  - leads to more actionable takeaways and better understanding of what went wrong
  - also enables engineers on different teams to learn from each others' mistakes

Post-mortems: example

Shakespeare Sonnet++ Postmortem (incident #465)

Date: 2015-10-21

Authors: jennifer, martym, agoogler

Status: Complete, action items in progress

Summary: Shakespeare Search down for 66 minutes during period of very high interest in Shakespeare due to discovery of a new sonnet.

Impact:[163] Estimated 1.21B queries lost, no revenue impact.

Root Causes:[164] Cascading failure due to combination of exceptionally high load and a resource leak when searches failed due to terms not being in the Shakespeare corpus. The newly discovered sonnet used a word that had never before appeared in one of Shakespeare's works, which happened to be the term users searched for. Under normal circumstances, the rate of task failures due to resource leaks is low enough to be unnoticed.

Trigger: Latent bug triggered by sudden increase in traffic.

[source: https://sre.google/sre-book/example-postmortem/]

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Resolution: Directed traffic to sacrificial cluster and added 10x capacity to mitigate cascading failure. Updated index deployed, resolving interaction with latent bug. Maintaining extra capacity until surge in public interest in new sonnet passes. Resource leak identified and fix deployed.

Detection: Borgmon detected high level of HTTP 500s and paged on-call.

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Action Item	Type	Owner	Bug
Update playbook with instructions for responding to cascading failure	mitigate	jennifer	n/a DONE
Use flux capacitor to balance load between clusters	prevent	martym	Bug 5554823 TODO
Schedule cascading failure test during next DiRT	process	docbrown	n/a TODO
Investigate running index MR/fusion continuously	prevent	jennifer	Bug 5554824 TODO
Plug file descriptor leak in search ranking	prevent	agoogler	Bug 5554825 DONE

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and 5 more…

[source: https://sre.google/sre-book/example-postmortem/]

Post-mortems: example

Lessons Learned

What went well

- Monitoring quickly alerted us to high rate (reaching ~100%) of HTTP 500s
- Rapidly distributed updated Shakespeare corpus to all clusters

What went wrong

- We're out of practice in responding to cascading failure
- We exceeded our availability error budget (by several orders of magnitude) due to the exceptional surge of traffic that essentially all resulted in failures

Where we got lucky[166]

- Mailing list of Shakespeare aficionados had a copy of new sonnet available
- Server logs had stack traces pointing to file descriptor exhaustion as cause for crash
- Query-of-death was resolved by pushing new index containing popular search term

[source: https://sre.google/sre-book/example-postmortem/]

Post-mortems: example

Timeline[167]

2015-10-21 **(all times UTC)**

- 14:51 News reports that a new Shakespearean sonnet has been discovered in a Delorean's glove compartment
- 14:53 Traffic to Shakespeare search increases by 88x after post to **/r/shakespeare** points to Shakespeare search engine as place to find new sonnet (except we don't have the sonnet yet)
- 14:54 **OUTAGE BEGINS** — Search backends start melting down under load
- 14:55 docbrown receives pager storm, `ManyHttp500s` from all clusters
- 14:57 All traffic to Shakespeare search is failing: see **https://monitor**
- 14:58 docbrown starts investigating, finds backend crash rate very high
- 15:01 **INCIDENT BEGINS** docbrown declares incident #465 due to cascading failure, coordination on `#shakespeare`, names jennifer incident commander
- 15:02 someone coincidentally sends email to **shakespeare-discuss@** re sonnet discovery, which happens to be at top of martym's inbox

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Post-mortems: example

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this goes on for several pages!

- **shows importance of keeping records**

ppens to be at

[source: https://sre.google/sre-book/example-postmortem/]

DevOps: takeaways

- Many modern engineering organizations prefer to combine, rather than separate, development and operations
  - this works best when most systems are services
- Major benefit of DevOps approach is elimination of toil
  - developers are best at building automation
- Planning for incidents/emergencies is critical
  - Monitoring allows on-call to quickly identify problems
  - Have a plan (ideally, in a playbook) for incidents
  - Use post-mortems to learn from prior emergencies
    - not to blame people for causing them!

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  - testing can show the presence of bugs, but not their absence
    - static analysis can show the absence of bugs

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  - especially **testing** and **static analysis**
- While I hope that you remember the specific techniques that we discussed and find ways to apply them in your work going forward, there are also some **course themes** that I want you to remember :)
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    - static analysis can show the absence of bugs
  - dynamic analyses like testing are usually precise but unsound

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  - dynamic analyses like testing are usually precise but unsound
  - static analyses are usually conservative: sound but imprecise
  - program analysis is powerful for QA, but getting it right is tricky

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- Please take a few minutes now to fill out the **course evaluation** (QR code on the slide)

Aside: cascading failures

- A common cause of failures in a microservice-based system is ***cascading failures***: one service fails (for any reason), which causes other services that depend on it to fail, which causes other services to fail, etc.
  - cascading failures are typically much harder to recover from
    - many parts of the system have failed, not just one!
  - recall the **Chaos Monkey** testing technique?
    - one of its goal is to detect such cascading failures before they actually happen in production