

ADDITIONAL MATERIAL



There is no DORA DevOps X-Ray Assessment included with the audio version of The DevOps Handbook



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THE DEVOPS HANDBOOK

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Preface

Aha!

The journey to complete *The DevOps Handbook* has been a long one—it started with weekly working Skype calls between the co-authors in February of 2011, with the vision of creating a prescriptive guide that would serve as a companion to the as-yet unfinished book *The Phoenix Project: A Novel About IT, DevOps, and Helping Your Business Win*.

More than five years later, with over two thousand hours of work, *The DevOps Handbook* is finally here. Completing this book has been an extremely long process, although one that has been highly rewarding and full of incredible learning, with a scope that is much broader than we originally envisioned. Throughout the project, all the co-authors shared a belief that DevOps is genuinely important, formed in a personal “aha” moment much earlier in each of our professional careers, which I suspect many of our readers will resonate with.

Gene Kim

I’ve had the privilege of studying high-performing technology organizations since 1999, and one of the earliest findings was that boundary-spanning between the different functional groups of IT Operations, Information Security, and Development was critical to success. But I still remember the first time I saw the magnitude of the downward spiral that would result when these functions worked toward opposing goals.

It was 2006, and I had the opportunity to spend a week with the group who managed the outsourced IT Operations of a large airline reservation service. They described the downstream consequences of their large, annual software releases: each release would cause immense chaos and disruption for the outsourcer, as well as customers; there would be SLA (service level agreement) penalties, because of the customer-impacting outages; there would be layoffs of the most talented and experienced staff, because of the resulting profit shortfalls; there would be much unplanned work and firefighting so that the remaining staff couldn’t work on the ever-growing service request backlogs coming from customers; the contract would be held together by the heroics of middle management; and everyone felt that the contract would be doomed to be put out for re-bid in three years.

The sense of hopelessness and futility that resulted created for me the beginnings of a moral crusade. Development seemed to always be viewed as strategic, but IT Operations was viewed as tactical, often delegated away or outsourced entirely, only to return in five years in worse shape than it was first handed over.

For many years, many of us knew that there must be a better way. I remember seeing the talks coming out of the 2009 Velocity Conference, describing amazing outcomes enabled by architecture, technical practices, and cultural norms that we now know as DevOps. I was so excited, because it clearly pointed to the better way that we had all been searching for. And helping spread that word was one of my personal motivations to co-author *The Phoenix Project*. You can imagine how incredibly rewarding it was to see the broader community react to that book, describing how it helped them achieve their own “aha” moments.

Jez Humble

My DevOps “aha” moment was at a start-up in 2000—my first job after graduating. For some time, I was one of two technical staff. I did everything: networking, programming, support, systems administration. We deployed software to production by FTP directly from our workstations.

Then in 2004 I got a job at ThoughtWorks, a consultancy where my first gig was working on a project involving about seventy people. I was on a team of eight engineers whose full-time job was to deploy our software into a production-like environment. In the beginning, it was really stressful. But over a few months we went from manual deployments

that took two weeks to an automated deployment that took one hour, where we could roll forward and back in milliseconds using the blue-green deployment pattern during normal business hours.

That project inspired a lot of the ideas in both the *Continuous Delivery* (Addison-Wesley, 2000) book and this one. A lot of what drives me and others working in this space is the knowledge that, whatever your constraints, we can always do better, and the desire to help people on their journey.

Patrick Debois

For me, it was a collection of moments. In 2007 I was working on a data center migration project with some Agile teams. I was jealous that they had such high productivity—able to get so much done in so little time.

For my next assignment, I started experimenting with Kanban in Operations and saw how the dynamic of the team changed. Later, at the Agile Toronto 2008 conference I presented my IEEE paper on this, but I felt it didn't resonate widely in the Agile community. We started an Agile system administration group, but I overlooked the human side of things.

After seeing the 2009 Velocity Conference presentation “10 Deploys per Day” by John Allspaw and Paul Hammond, I was convinced others were thinking in a similar way. So I decided to organize the first DevOpsDays, accidentally coining the term DevOps.

The energy at the event was unique and contagious. When people started to thank me because it changed their life for the better, I understood the impact. I haven't stopped promoting DevOps since.

John Willis

In 2008, I had just sold a consulting business that focused on large-scale, legacy IT operations practices around configuration management and monitoring (Tivoli) when I first met Luke Kanies (the founder of Puppet Labs). Luke was giving a presentation on Puppet at an O'Reilly open source conference on configuration management (CM).

At first I was just hanging out at the back of the room killing time and thinking, “What could this twenty-year-old tell me about configuration management?” After all, I had literally been working my entire life at some of the largest enterprises in the world, helping them architect CM and other operations management solutions. However, about five minutes into his session, I moved up to the first row and realized everything I had been doing for the last twenty years was wrong. Luke was describing what I now call second generation CM.

After his session I had an opportunity to sit down and have coffee with him. I was totally sold on what we now call infrastructure as code. However, while we met for coffee, Luke started going even further, explaining his ideas. He started telling me he believed that operations was going to have to start behaving like software developers. They were going to have to keep their configurations in source control and adopt CI/CD delivery patterns for their workflow. Being the old IT Operations person at the time, I think I replied to him with something like, “That idea is going to sink like Led Zeppelin with Ops folk.” (I was clearly wrong.)

Then about a year later in 2009 at another O'Reilly conference, Velocity, I saw Andrew Clay Shafer give a presentation on Agile Infrastructure. In his presentation, Andrew showed this iconic picture of a wall between developers and operations with a metaphorical depiction of work being thrown over the wall. He coined this “the wall of confusion.” The ideas he expressed in that presentation codified what Luke was trying to tell me a year earlier. That was the light bulb for me. Later that year, I was the only American invited to the original DevOpsDays in Ghent. By the time that event was over, this thing we call DevOps was clearly in my blood.

Clearly, the co-authors of this book all came to a similar epiphany, even if they came there from very different directions. But there is now an overwhelming weight of evidence that the problems described above happen almost everywhere, and that the solutions associated with DevOps are nearly universally applicable.

The goal of writing this book is to describe how to replicate the DevOps transformations we've been a part of or have observed, as well as dispel many of the myths of why DevOps won't work in certain situations. Below are some of the most common myths we hear about DevOps.

Myth—DevOps is Only for Startups: While DevOps practices have been pioneered by the web-scale, Internet “unicorn” companies such as Google, Amazon, Netflix, and Etsy, each of these organizations has, at some point in their history, risked going out of business because of the problems associated with more traditional “horse” organizations: highly dangerous code releases that were prone to catastrophic failure, inability to release features fast enough to beat the competition, compliance concerns, an inability to scale, high levels of distrust between Development and Operations, and so forth.

However, each of these organizations was able to transform their architecture, technical practices, and culture to create the amazing outcomes that we associate with DevOps. As Dr. Branden Williams, an information security executive, quipped, “Let there be no more talk of DevOps unicorns or horses but only thoroughbreds and horses heading to the glue factory.”

Myth—DevOps Replaces Agile: DevOps principles and practices are compatible with Agile, with many observing that DevOps is a logical continuation of the Agile journey that started in 2001. Agile often serves as an effective enabler of DevOps, because of its focus on small teams continually delivering high quality code to customers.

Many DevOps practices emerge if we continue to manage our work beyond the goal of “potentially shippable code” at the end of each iteration, extending it to having our code always in a deployable state, with developers checking into trunk daily, and that we demonstrate our features in production-like environments.

Myth—DevOps is incompatible with ITIL: Many view DevOps as a backlash to ITIL or ITSM (IT Service Management), which was originally published in 1989. ITIL has broadly influenced multiple generations of Ops practitioners, including one of the co-authors, and is an ever-evolving library of practices intended to codify the processes and practices that underpin world-class IT Operations, spanning service strategy, design, and support.

DevOps practices can be made compatible with ITIL process. However, to support the shorter lead times and higher deployment frequencies associated with DevOps, many areas of the ITIL processes become fully automated, solving many problems associated with the configuration and release management processes (e.g., keeping the configuration management database and definitive software libraries up to date). And because DevOps requires fast detection and recovery when service incidents occur, the ITIL disciplines of service design, incident, and problem management remain as relevant as ever.

Myth—DevOps is Incompatible with Information Security and Compliance: The absence of traditional controls (e.g., segregation of duty, change approval processes, manual security reviews at the end of the project) may dismay information security and compliance professionals.

However, that doesn’t mean that DevOps organizations don’t have effective controls. Instead of security and compliance activities only being performed at the end of the project, controls are integrated into every stage of daily work in the software development life cycle, resulting in better quality, security, and compliance outcomes.

Myth—DevOps Means Eliminating IT Operations, or “NoOps:” Many misinterpret DevOps as the complete elimination of the IT Operations function. However, this is rarely the case. While the nature of IT Operations work may change, it remains as important as ever. IT Operations collaborates far earlier in the software life cycle with Development, who continues to work with IT Operations long after the code has been deployed into production.

Instead of IT Operations doing manual work that comes from work tickets, it enables developer productivity through APIs and self-serviced platforms that create environments, test and deploy code, monitor and display production telemetry, and so forth. By doing this, IT Operations become more like Development (as do QA and Infosec), engaged in product development, where the product is the platform that developers use to safely, quickly, and securely test, deploy, and run their IT services in production.

Myth—DevOps is Just “Infrastructure as Code” or Automation: While many of the DevOps patterns shown in this book require automation, DevOps also requires cultural norms and an architecture that allows for the shared goals to be achieved throughout the IT value stream. This goes far beyond just automation. As Christopher Little, a technology executive and one of the earliest chroniclers of DevOps, wrote, “DevOps isn’t about automation, just as astronomy isn’t about telescopes.”

Myth—DevOps is Only for Open Source Software: Although many DevOps success stories take place in organizations using software such as the LAMP stack (Linux, Apache, MySQL, PHP), achieving DevOps outcomes is independent of the technology

being used. Successes have been achieved with applications written in Microsoft.NET, COBOL, and mainframe assembly code, as well as with SAP and even embedded systems (e.g., HP LaserJet firmware).

SPREADING THE AHA! MOMENT

Each of the authors has been inspired by the amazing innovations happening in the DevOps community and the outcomes they are creating: they are creating safe systems of work, and enabling small teams to quickly and independently develop and validate code that can be safely deployed to customers. Given our belief that DevOps is a manifestation of creating dynamic, learning organizations that continually reinforce high-trust cultural norms, it is inevitable that these organizations will continue to innovate and win in the marketplace.

It is our sincere hope that *The DevOps Handbook* will serve as a valuable resource for many people in different ways: a guide for planning and executing DevOps transformations, a set of case studies to research and learn from, a chronicle of the history of DevOps, a means to create a coalition that spans Product Owners, Architecture, Development, QA, IT Operations, and Information Security to achieve common goals, a way to get the highest levels of leadership support for DevOps initiatives, as well as a moral imperative to change the way we manage technology organizations to enable better effectiveness and efficiency, as well as enabling a happier and more humane work environment, helping everyone become lifelong learners—this

not only helps everyone achieve their highest goals as human beings, but also helps their organizations win.

Figures

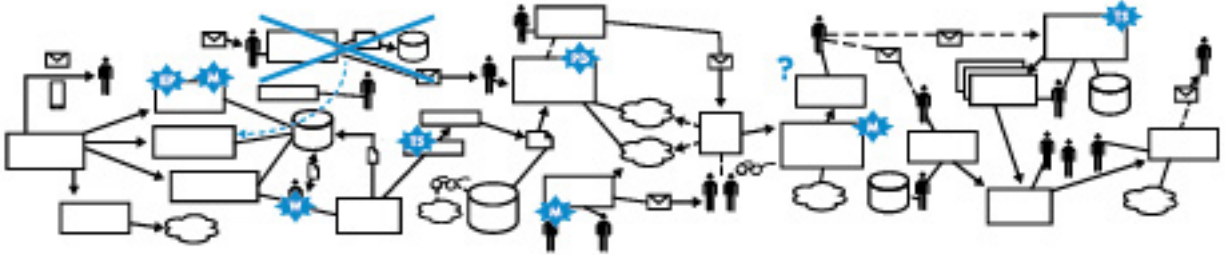


Figure 1: A technology value stream with a deployment lead time of three months (Source: Damon Edwards, "DevOps Kaizen," 2015.)

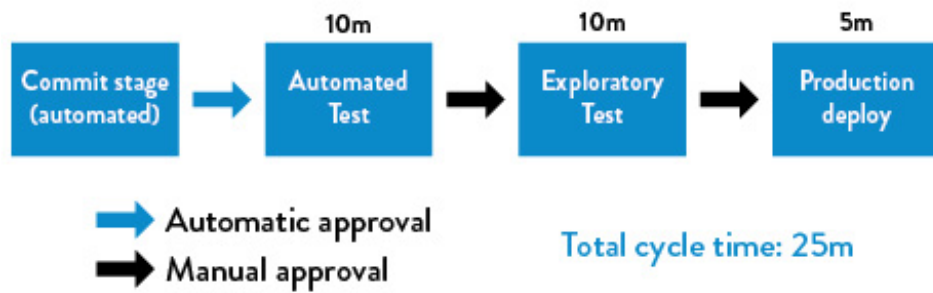


Figure 2: A technology value stream with a lead time of minutes

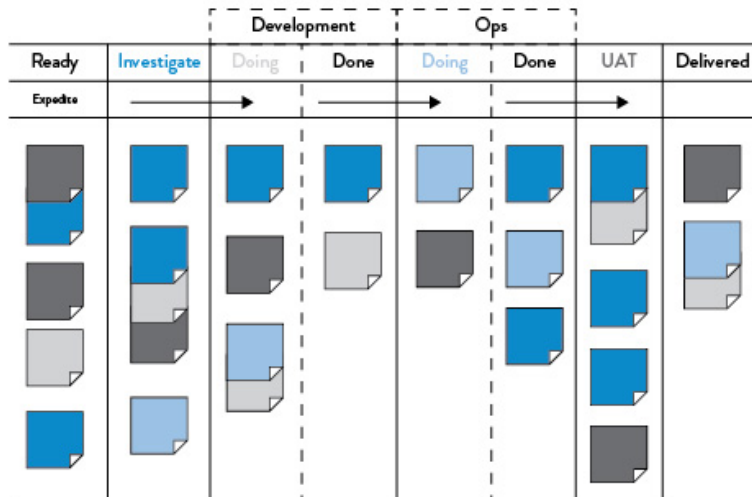


Figure 3: An example kanban board, spanning Requirements, Dev, Test, Staging, and In Production (Source: David J. Andersen and Dominica DeGrandis, Kanban for ITOps, training materials for workshop, 2012.)

Ideal vs. Non-Ideal Testing Pyramids

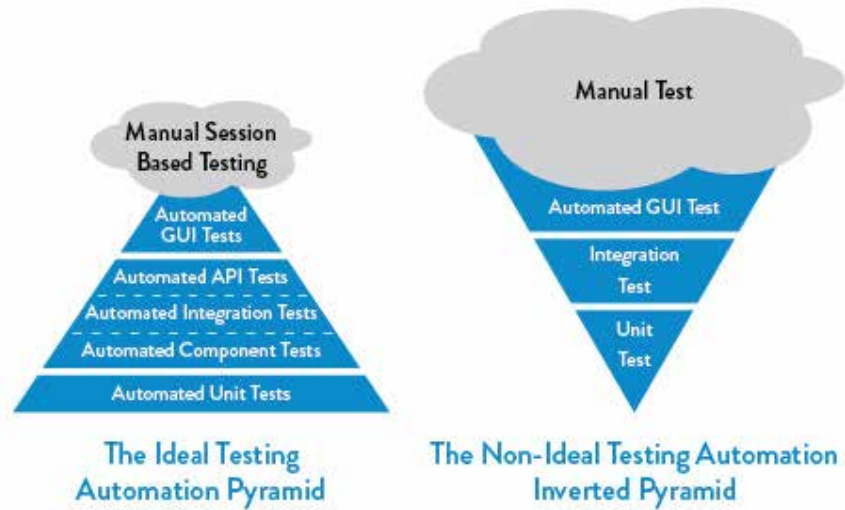


Figure 4: The ideal and non-ideal automated testing pyramids (Source: Martin Fowler, "TestPyramid.")

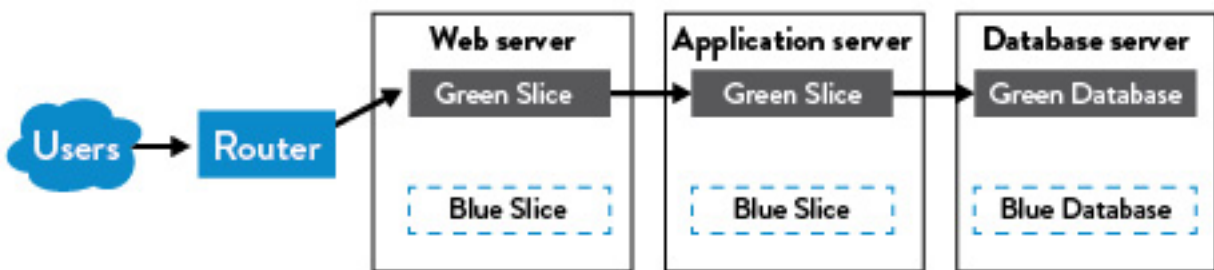


Figure 5: Blue-green deployment patterns (Source: Humble and North, Continuous Delivery, 261.)

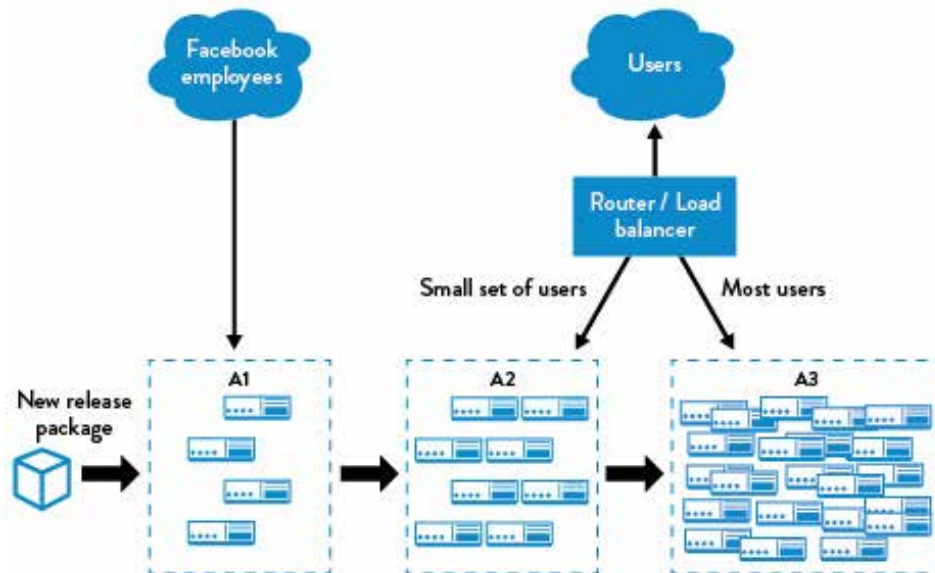


Figure 6: The canary release pattern (Source: Humble and Farley, Continuous Delivery, 263.)

| | Pros | Cons |
|--|---|--|
| Monolithic v1 (All functionality in one application) | <ul style="list-style-type: none"> • Simple at first • Low inter-process latencies • Single codebase, one deployment unit • Resource-efficient at small scales | <ul style="list-style-type: none"> • Coordination overhead increases as team grows • Poor enforcement of modularity • Poor scaling • All-or-nothing deploy (downtime, failures) • Long build times |
| Monolithic v2 (Sets of monolithic tiers: "front end presentation," "application server," "database layer") | <ul style="list-style-type: none"> • Simple at first • Join queries are easy • Single schema, deployment • Resource-efficient at small scales | <ul style="list-style-type: none"> • Tendency for increased coupling over time • Poor scaling and redundancy (all or nothing, vertical only) • Difficult to tune properly • All-or-nothing schema management |
| Microservice (Modular, independent, graph relationship vs. tiers, isolated persistence) | <ul style="list-style-type: none"> • Each unit is simple • Independent scaling and performance • Independent testing and deployment • Can optimally tune performance (caching, replication, etc.) | <ul style="list-style-type: none"> • Many cooperating units • Many small repos • Requires more sophisticated tooling and dependency management • Network latencies |

Figure 7: Architectural archetypes (Source: Shoup, "From the Monolith to Micro-services.")

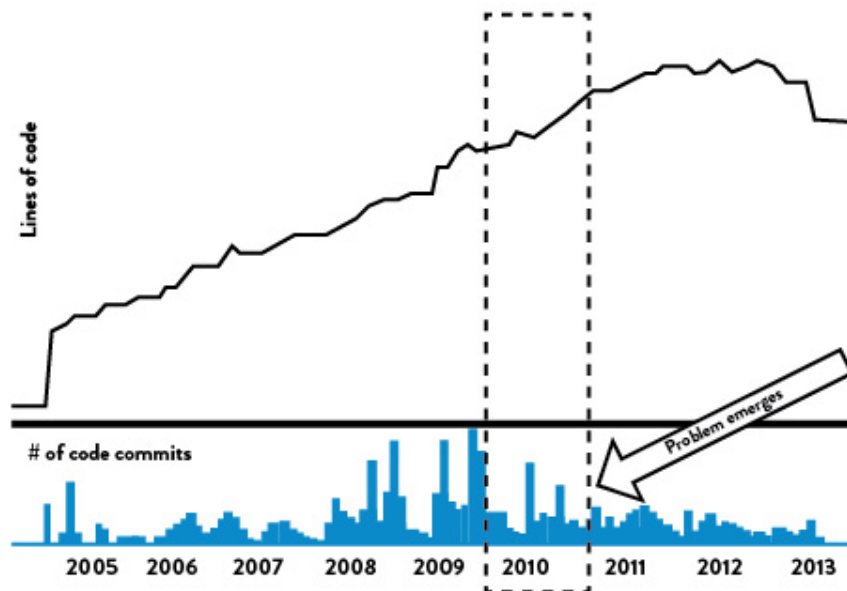


Figure 8: Blackboard Learn code repository: before Building Blocks (Source: "DOES14 - David Ashman - Blackboard Learn - Keep Your Head in the Clouds," YouTube video, 30:43, posted by DevOps Enterprise Summit 2014, October 28, 2014, <https://www.youtube.com/watch?v=SSmixnMpsI4>.)

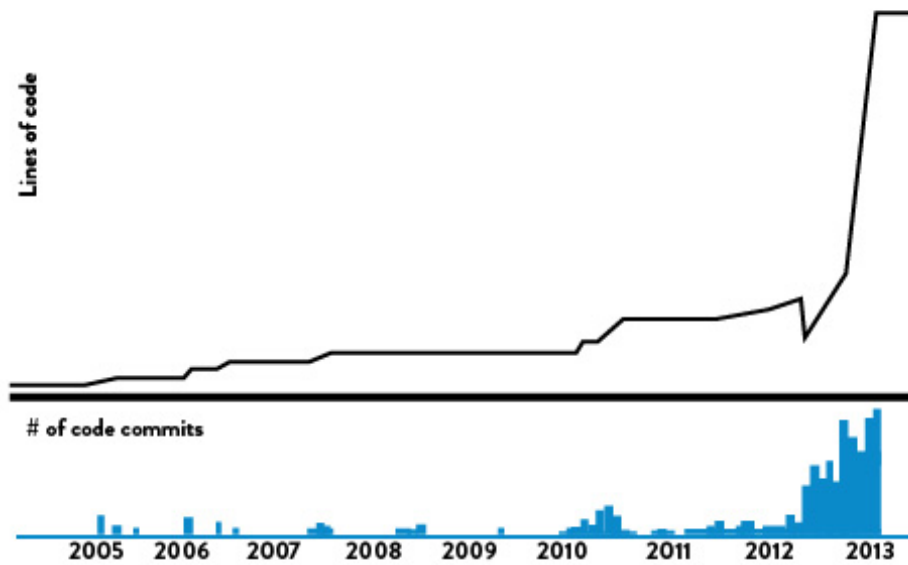


Figure 9: Blackboard Learn code repository: after Building Blocks (Source: “DOES14 - David Ashman - Blackboard Learn - Keep Your Head in the Clouds.” YouTube video, 30:43, posted by DevOps Enterprise Summit 2014, October 28, 2014, <https://www.youtube.com/watch?v=SSmixnMpsI4>.)

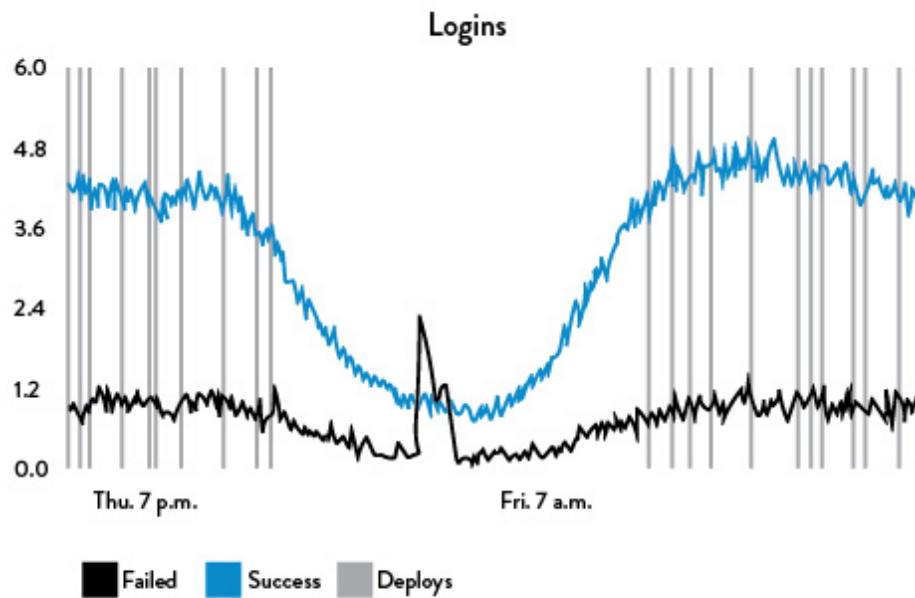


Figure 10: One line of code to generate telemetry using StatsD and Graphite at Etsy (Source: Ian Malpass, “Measure Anything, Measure Everything.”)

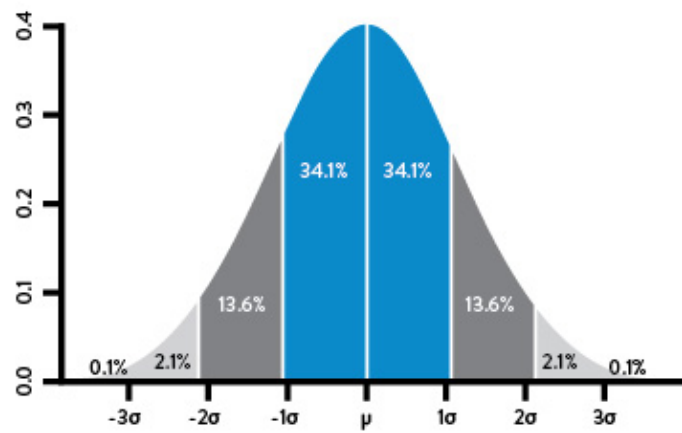


Figure 11: Standard deviations (σ) & mean (μ) with Gaussian distribution
(Source: Wikipedia's "Normal Distribution" entry, https://en.wikipedia.org/wiki/Normal_distribution.)

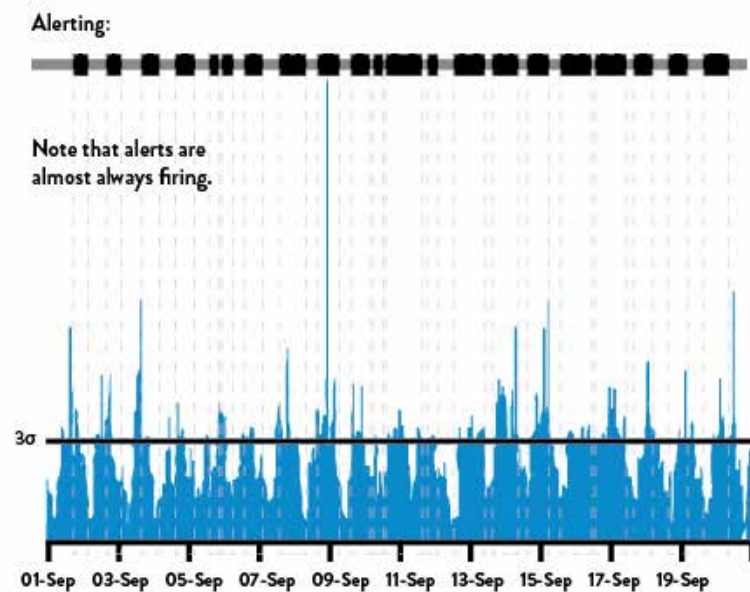


Figure 12: Downloads per minute: over-alerting when using "3 standard deviation" rule (Source: Dr. Toufic Boubez, "Simple math for anomaly detection.")

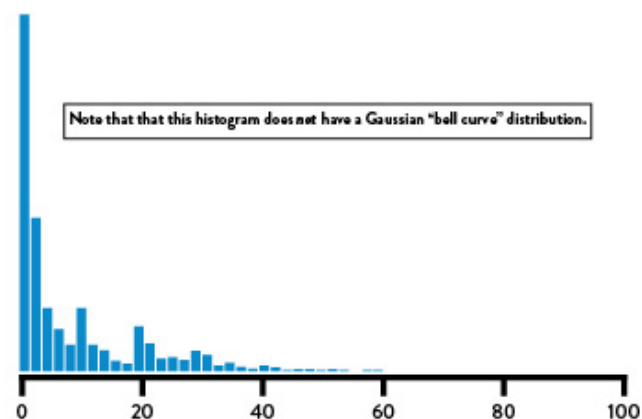


Figure 13: Downloads per minute: histogram of data showing non-Gaussian distribution (Source: Dr. Toufic Boubez, "Simple math for anomaly detection.")

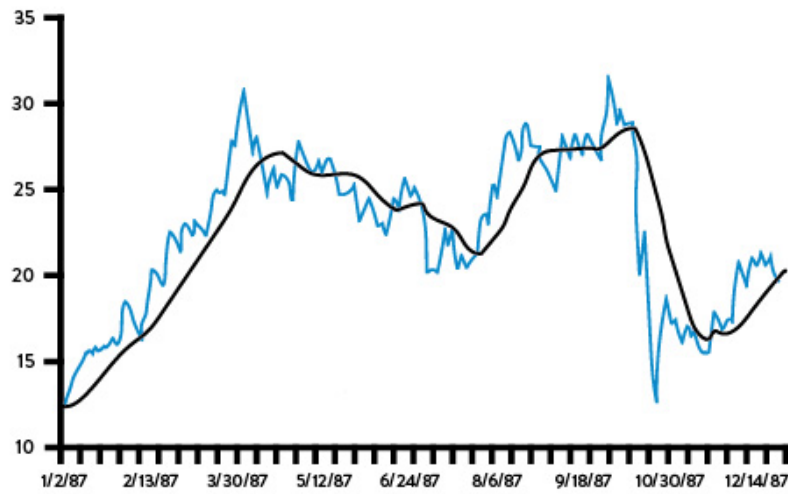


Figure 14: Autodesk share price and thirty day moving average filter (Source: Jacobson, Yuan, Joshi, "Scryer: Netflix's Predictive Auto Scaling Engine.")

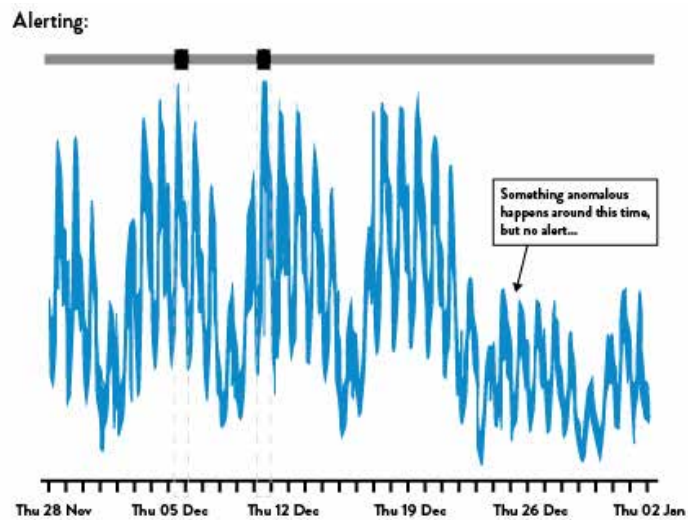


Figure 15: Transaction volume: under-alerting using "3 standard deviation" rule (Source: Dr. Toufic Boubez, "Simple math for anomaly detection.")

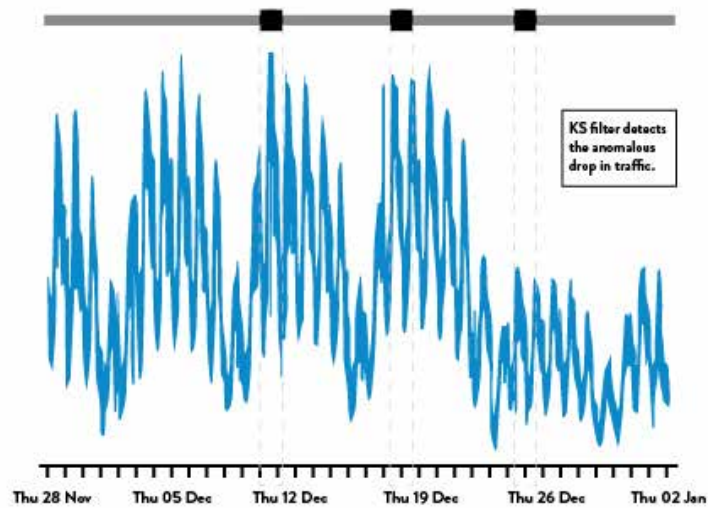


Figure 16: Transaction volume: using Kolmogorov-Smirnov test to alert on anomalies (Source: Dr. Toufic Boubez, "Simple math for anomaly detection.")

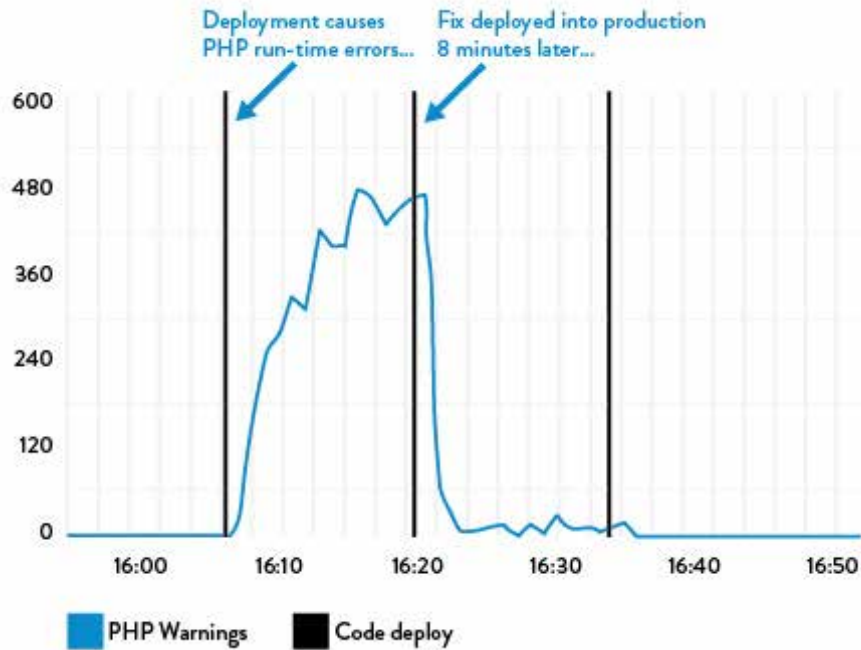


Figure 17: Deployment to Etsy.com causes PHP run-time warnings and is quickly fixed (Source: Mike Brittain, “Tracking Every Release.”)

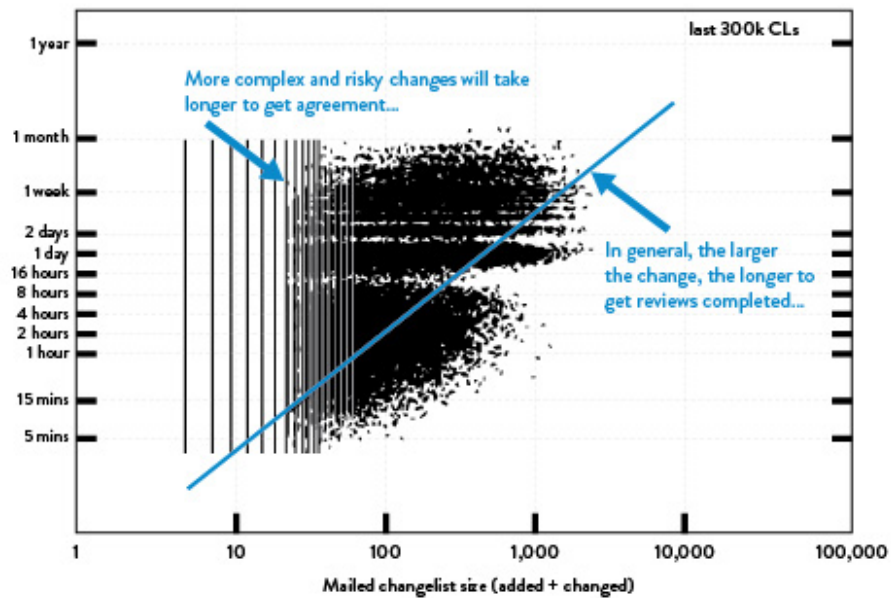


Figure 18: Size of change vs. lead time for reviews at Google (Source: Ashish Kumar, “Development at the Speed and Scale of Google,” presentation at QCon, San Francisco, CA, 2010, https://qconsf.com/sf2010/dl/qcon-sanfran-2010/slides/AshishKumar_Developing-ProductsattheSpeedandScaleofGoogle.pdf.)

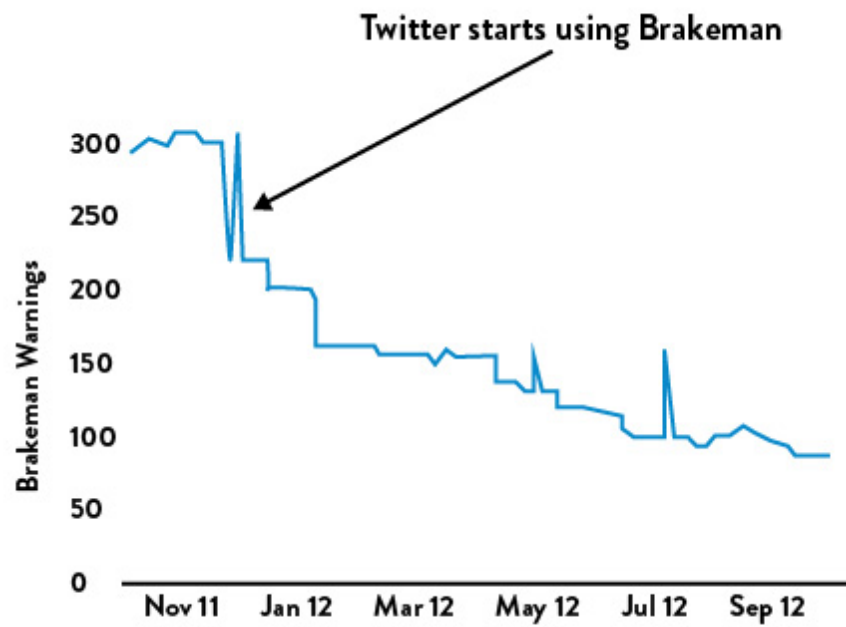


Figure 19: Number of Brakeman security vulnerabilities detected

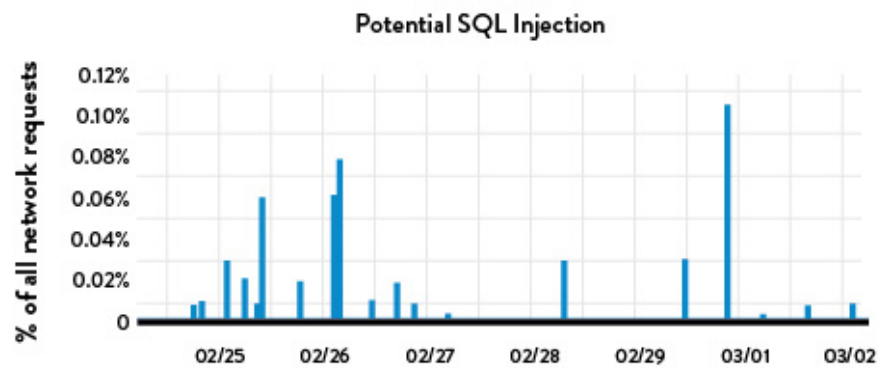


Figure 20: Developers would see SQL injection attempts in Graphite at Etsy (Source: "DevOpsSec: Applying DevOps Principles to Security, DevOpsDays Austin 2012," SlideShare.net, posted by Nick Galbreath, April 12, 2012, <http://www.slideshare.net/nickgsuperstar/devopssec-apply-devops-principles-to-security>.)

Appendices

APPENDIX 1 THE CONVERGENCE OF DEVOPS

We believe that DevOps is benefiting from an incredible convergence of management movements, which are all mutually reinforcing and can help create a powerful coalition to transform how organizations develop and deliver IT products and services.

John Willis named this “the Convergence of DevOps.” The various elements of this convergence are described below in approximate chronological order. (Note that these descriptions are not intended to be an exhaustive description, but merely enough to show the progression of thinking and the rather improbable connections that led to DevOps.)

THE LEAN MOVEMENT

The Lean Movement started in the 1980s as an attempt to codify the Toyota Production System with the popularization of techniques such as Value Stream Mapping, kanban boards, and Total Productive Maintenance.

Two major tenets of Lean were the deeply held belief that lead time (i.e., the time required to convert raw materials into finished goods) was the best predictor of quality, customer satisfaction, and employee happiness; and that one of the best predictors of short lead times was small batch sizes, with the theoretical ideal being “single piece flow” (i.e., “1x1” flow: inventory of 1, batch size of 1).

Lean principles focus on creating value for the customer—thinking systematically, creating constancy of purpose, embracing scientific thinking, creating flow and pull (versus push), assuring quality at the source, leading with humility, and respecting every individual.

THE AGILE MOVEMENT

Started in 2001, the Agile Manifesto was created by seventeen of the leading thinkers in software development, with the goal of turning lightweight methods such as DP and DSDM into a wider movement that could take on heavyweight software development processes such as waterfall development and methodologies such as the Rational Unified Process.

A key principle was to “deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.” Two other principles focus on the need for small, self-motivated teams, working in a high-trust management model and an emphasis on small batch sizes. Agile is also associated with a set of tools and practices such as Scrum, Standups, and so on.

THE VELOCITY CONFERENCE MOVEMENT

Started in 2007, the Velocity Conference was created by Steve Souders, John Allspaw, and Jesse Robbins to provide a home for the IT Operations and Web Performance tribe. At the Velocity 2009 conference, John Allspaw and Paul Hammond gave the seminal “10 Deploys per Day: Dev and Ops Cooperation at Flickr.”

THE AGILE INFRASTRUCTURE MOVEMENT

At the 2008 Agile Toronto conference, Patrick Dubois and Andrew Schafer held a “birds of a feather” session on applying Agile principles to infrastructure as opposed to application code. They rapidly gained a following of like-minded thinkers, including John Willis. Later, Dubois was so excited by Allspaw and Hammond’s “10 Deploys per Day: Dev and Ops Cooperation at Flickr” presentation that he created the first DevOpsDays in Ghent, Belgium, in 2009, coining the word “DevOps.”

THE CONTINUOUS DELIVERY MOVEMENT

Building upon the Development discipline of continuous build, test, and integration, Jez Humble and David Farley extended the concept of continuous delivery, which included a “deployment pipeline” to ensure that code and infrastructure are always in a deployable state and that all code checked in to trunk is deployed into production.

This idea was first presented at Agile 2006 and was also independently developed by Tim Fitz in a blog post titled “Continuous Deployment.”

THE TOYOTA KATA MOVEMENT

In 2009, Mike Rother wrote *Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results*, which described learnings over his twenty-year journey to understand and codify the causal mechanisms of the Toyota Production System. *Toyota Kata* describes the “unseen managerial routines and thinking that lie behind Toyota’s success with continuous improvement and adaptation... and how other companies develop similar routines and thinking in their organizations.”

His conclusion was that the Lean community missed the most important practice of all, which he described as the Improvement Kata. He explains that every organization has work routines, and the critical factor in Toyota was making improvement work habitual, and building it into the daily work of everyone in the organization. The Toyota Kata institutes an iterative, incremental, scientific approach to problem-solving in the pursuit of a shared organizational true north.

THE LEAN STARTUP MOVEMENT

In 2011, Eric Ries wrote *The Lean Startup: How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, codifying his lessons learned at IMVU, a Silicon Valley startup, which built upon the work of Steve Blank in *The Four Steps to the Epiphany* as well as continuous deployment techniques. Eric Ries also codified related practices and terms including Minimum Viable Product, the build-measure-learn cycle, and many continuous deployment technical patterns.

THE LEAN UX MOVEMENT

In 2013, Jeff Gothelf wrote *Lean UX: Applying Lean Principles to Improve User Experience*, which codified how to improve the “fuzzy front end” and explained how product owners can frame business hypotheses, experiment, and gain confidence in those business hypotheses before investing time and resources in the resulting features. By adding Lean UX, we now have the tools to fully optimize the flow between business hypotheses, feature development, testing, deployment, and service delivery to the customer.

THE RUGGED COMPUTING MOVEMENT

In 2011, Joshua Corman, David Rice, and Jeff Williams examined the apparent futility of securing applications and environments late in the life cycle. In response, they created a philosophy called “Rugged Computing,” which attempts to frame the non-functional requirements of stability, scalability, availability, survivability, sustainability, security, supportability, manageability, and defensibility.

Because of the potential for high release rates, DevOps can put incredible pressure on QA and Infosec, because when deploy rates go from monthly or quarterly to hundreds or thousands daily, no longer are two week turnaround times from Infosec or QA tenable. The Rugged Computing movement posited that the current approach to fighting the vulnerable industrial complex being employed by most information security programs is hopeless.

APPENDIX 2 THEORY OF CONSTRAINTS AND CORE, CHRONIC CONFLICTS

The Theory of Constraints body of knowledge extensively discusses the use of creating core conflict clouds (often referred to as “C³”). Here is the conflict cloud for IT:

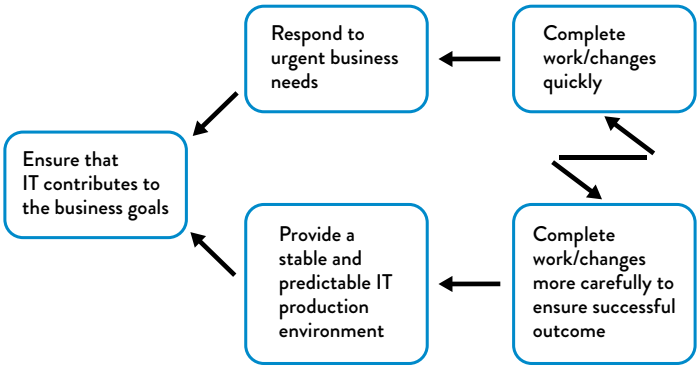


Figure 46: The core, chronic conflict facing every IT organization

During the 1980s, there was a very well-known core, chronic conflict in manufacturing. Every plant manager had two valid business goals: protect sales and reduce costs. The problem was that in order to protect sales, sales management was incentivized to increase inventory to ensure that it was always possible to fulfill customer demand.

On the other hand, in order to reduce cost, production management was incentivized to decrease inventory to ensure that money was not tied up in work in progress that wasn’t immediately shippable to the customer in the form of fulfilled sales.

They were able to break the conflict by adopting Lean principles, such as reducing batch sizes, reducing work in process, and shortening and amplifying feedback loops. This resulted in dramatic increases in plant productivity, product quality, and customer satisfaction.

The principles behind DevOps work patterns are the same as those that transformed manufacturing, allowing us to optimize the IT value stream, converting business needs into capabilities and services that provide value for our customers.

APPENDIX 3 TABULAR FORM OF DOWNWARD SPIRAL

The columnar form of the downward spiral depicted in *The Phoenix Project* is shown below:

Table 4: The Downward Spiral

| IT Operations sees... | Development sees... |
|--|--|
| Fragile applications are prone to failure | Fragile applications are prone to failure |
| Long time required to figure out which bit got flipped | More urgent, date-driven projects put into the queue |
| Detective control is a salesperson | Even more fragile code (less secure) put into production |
| Too much time required to restore service | More releases have increasingly turbulent installs |
| Too much firefighting and unplanned work | Release cycles lengthen to amortize cost of deployments |
| Urgent security rework and remediation | Failing bigger deployments more difficult to diagnose |

| | |
|--|---|
| Planned project work cannot be completed | Most senior and constrained IT Operations resources have less time to fix underlying process problems |
| Frustrated customers leave | Ever increasing backlog of work that could help the business win |
| Market share goes down | Ever increasing amount of tension between IT Operations, Development, Design |
| Business misses Wall Street commitments | |
| Business makes even larger promises to Wall Street | |

APPENDIX 4 THE DANGERS OF HANDOFFS AND QUEUES

The problem with high amounts of queue time is exacerbated when there are many handoffs, because that is where queues are created. Figure 47 shows wait time as a function of how busy a resource at a work center is. The asymptotic curve shows why a “simple 30 minute change” often takes weeks to complete—specific engineers and work centers often become problematic bottlenecks when they operate at high utilization. As a work center approaches 100% utilization, any work required from it will languish in queues and won’t be worked on without someone expediting/escalating.

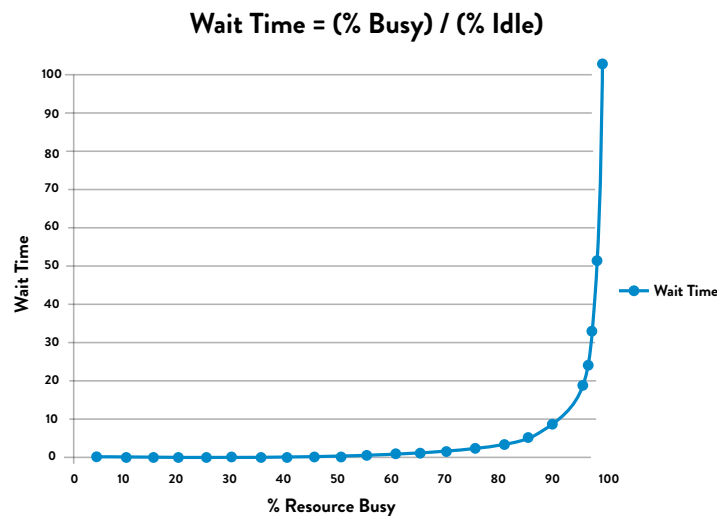


Figure 47: Queue size and wait times as function of percent utilization (Source: Kim, Behr, and Spafford, *The Phoenix Project*, ePub edition, 557.)

In figure 47, the x-axis is the percent busy for a given resource at a work center, and the y-axis is the approximate wait time (or, more precisely stated, the queue length). What the shape of the line shows is that as resource utilization goes past 80%, wait time goes through the roof.

In *The Phoenix Project*, here’s how Bill and his team realized the devastating consequences of this property on lead times for the commitments they were making to the project management office:

I tell them about what Erik told me at MRP-8, about how wait times depend upon resource utilization. “The wait time is the ‘percentage of time busy’ divided by the ‘percentage of time idle.’ In other words, if a resource is fifty percent busy, then it’s fifty percent idle. The wait time is fifty percent divided by fifty percent, so one unit of time. Let’s call it one hour.

So, on average, our task would wait in the queue for one hour before it gets worked.

“On the other hand, if a resource is ninety percent busy, the wait time is “ninety percent divided by ten percent”, or nine hours. In other words, our task would wait in queue nine times longer than if the resource were fifty percent idle.”

I conclude, “So... For the Phoenix task, assuming we have seven handoffs, and that each of those resources is busy ninety percent of the time, the tasks would spend in queue a total of nine hours times the seven steps...”

“What? Sixty-three hours, just in queue time?” Wes says, incredulously. “That’s impossible!”

Patty says with a smirk, “Oh, of course. Because it’s only thirty seconds of typing, right?”

Bill and team realize that their “simple 30 minute task” actually requires seven handoffs (e.g., server team, networking team, database team, virtualization team, and, of course, Brent, the ‘rockstar’ engineer).

Assuming that all work centers were 90% busy, the figure shows us that the average wait time at each work center is nine hours—and because the work had to go through seven work centers, the total wait time is seven times that: sixty-three hours.

In other words, the total % of *value added time* (sometimes known as process time) was only 0.16% of the total lead time (thirty minutes divided by sixty-three hours). That means that for 99.8% of our total lead time, the work was simply sitting in queue, waiting to be worked on.

APPENDIX 5 MYTHS OF INDUSTRIAL SAFETY

Decades of research into complex systems shows that countermeasures are based on several myths. In “Some Myths about Industrial Safety,” by Denis Besnard and Erik Hollnagel, they are summarized as such:

- **Myth 1:** “Human error is the largest single cause of accidents and incidents.”
- **Myth 2:** “Systems will be safe if people comply with the procedures they have been given.”
- **Myth 3:** “Safety can be improved by barriers and protection; more layers of protection results in higher safety.”
- **Myth 4:** “Accident analysis can identify the root cause (the ‘truth’) of why the accident happened.”
- **Myth 5:** “Accident investigation is the logical and rational identification of causes based on facts.”
- **Myth 6:** “Safety always has the highest priority and will never be compromised.”

The differences between what is myth and what is true are shown below:

Table 5: Two Stories

| Myth | Reality |
|--|---|
| Human error is seen as the cause of failure. | Human error is seen as the effect of systemic vulnerabilities deeper inside the organization. |
| Saying what people should have done is a satisfying way to describe failure. | Saying what people should have done doesn’t explain why it made sense for them to do what they did. |
| Telling people to be more careful will make the problem go away. | Only by constantly seeking out their vulnerabilities can organizations enhance safety. |

APPENDIX 6 THE TOYOTA ANDON CORD

Many ask how can any work be completed if the Andon cord is being pulled over five thousand times per day? To be precise, not every Andon cord pull results in stopping the entire assembly line. Rather, when the Andon cord is pulled, the team leader overseeing the specified work center has fifty seconds to resolve the problem. If the problem has not been resolved by the time the fifty seconds is up, the partially assembled vehicle will cross a physically drawn line on the floor, and the assembly line will be stopped.

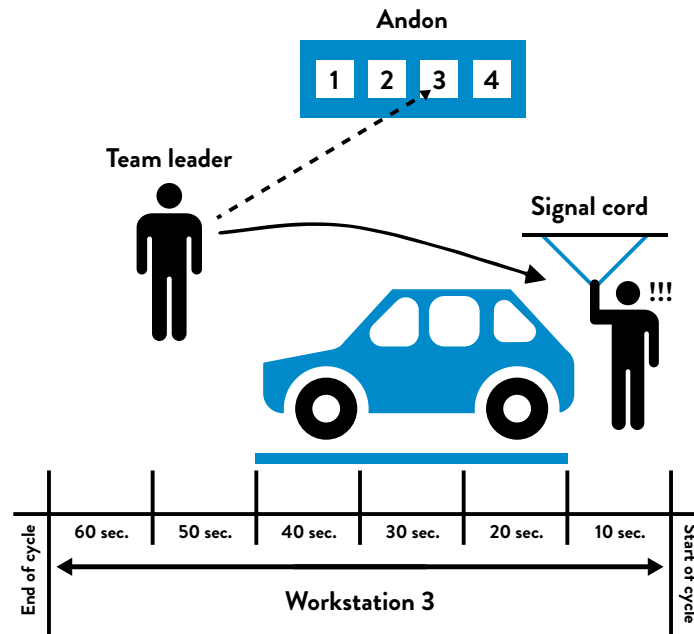


Figure 48: The Toyota Andon cord

APPENDIX 7 COTS SOFTWARE

Currently, in order to get complex COTS (commercial off-the-shelf) software (e.g., SAP, IBM WebSphere, Oracle WebLogic) into version control, we may have to eliminate the use of graphical point-and-click vendor installer tools. To do that, we need to discover what the vendor installer is doing, and we may need to do an install on a clean server image, diff the file system, and put those added files into version control. Files that don't vary by environment are put into one place ("base install"), while environment-specific files are put into their own directory ("test" or "production"). By doing this, software install operations become merely a version control operation, enabling better visibility, repeatability, and speed.

We may also have to transform any application configuration settings so that they are in version control. For instance, we may transform application configurations that are stored in a database into XML files and vice versa.

APPENDIX 8 POST-MORTEM MEETINGS

A sample agenda of the post-mortem meeting is shown below:

- An initial statement will be made by the meeting leader or facilitator to reinforce that this meeting is a blameless post-mortem and that we will not focus on past events or speculate on "would haves" or "could haves." Facilitators might read the "Retrospective Prime Directive" from the website Retrospective.com.

Furthermore, the facilitator will remind everyone that any countermeasures must be assigned to someone, and

if the corrective action does not warrant being a top priority when the meeting is over, then it is not a corrective action. (This is to prevent the meeting from generating a list of good ideas that are never implemented.)

- Those at the meeting will reach an agreement on the complete timeline of the incident, including when and who detected the issue, how it was discovered (e.g., automated monitoring, manual detection, customer notified us), when service was satisfactorily restored, and so forth. We will also integrate into the timeline all external communications during the incident.

When we use the word “timeline,” it may evoke the image of a linear set of steps of how we gained an understanding of the problem and eventually fixed it. In reality, especially in complex systems, there will likely be many events that contributed to the accident, and many troubleshooting paths and actions will have been taken in an effort to fix it. In this activity, we seek to chronicle all of these events and the perspectives of the actors and establish hypotheses concerning cause and effect where possible.

- The team will create a list of all the factors which contributed to the incident, both human and technical. They may then sort them into categories, such as ‘design decision,’ ‘remediation,’ ‘discovering there was a problem,’ and so forth. The team will use techniques such as brainstorming and the ‘infinite hows’ to drill down on contributing factors they deem particularly important to discover deeper levels of contributing factors. All perspectives should be included and respected—nobody should be permitted to argue with or deny the reality of a contributing factor somebody else has identified. It’s important for the post-mortem facilitator to ensure that sufficient time is spent on this activity, and that the team doesn’t try and engage in convergent behavior such as trying to identify one or more ‘root causes.’
- Those at the meeting will reach an agreement on the list of corrective actions that will be made top priorities after the meeting. Assembling this list will require brainstorming and choosing the best potential actions to either prevent the issue from occurring or enable faster detection or recovery. Other ways to improve the systems may also be included.

Our goal is to identify the smallest number of incremental steps to achieve the desired outcomes, as opposed to “big bang” changes, which not only take longer to implement, but delay the improvements we need.

We will also generate a separate list of lower priority ideas and assign an owner. If similar problems occur in the future, these ideas may serve as the foundation for crafting future countermeasures.

- Those at the meeting will reach an agreement on the incident metrics and their organizational impact. For example, we may choose to measure our incidents by the following metrics:
 - ▶ **Event severity:** How severe was this issue? This directly relates to the impact on the service and our customers.
 - ▶ **Total downtime:** How long were customers unable to use the service to any degree?
 - ▶ **Time to detect:** How long did it take for us or our systems to know there was a problem?
 - ▶ **Time to resolve:** How long after we knew there was a problem did it take for us to restore service?

Bethany Macri from Etsy observed, “Blamelessness in a post-mortem does not mean that no one takes responsibility. It means that we want to find out what the circumstances were that allowed the person making the change or who introduced the problem to do this. What was the larger environment....The idea is that by removing blame, you remove fear, and by removing fear, you get honesty.”

APPENDIX 9 THE SIMIAN ARMY

After the 2011 AWS EAST Outage, Netflix had numerous discussions about engineering their systems to automatically deal with failure. These discussions have evolved into a service called “Chaos Monkey.”

Since then, Chaos Monkey has evolved into a whole family of tools, known internally as the “Netflix Simian Army,” to simulate increasingly catastrophic levels of failures:

- **Chaos Gorilla:** simulates the failure of an entire AWS availability zone
- **Chaos Kong:** simulates failure of entire AWS regions, such as North America or Europe

Other member of the Simian Army now include:

- **Latency Monkey:** induces artificial delays or downtime in their RESTful client-server communication layer to simulate service degradation and ensure that dependent services respond appropriately
- **Conformity Monkey:** finds and shuts down AWS instances that don’t adhere to best-practices (e.g., when instances don’t belong to an auto-scaling group or when there is no escalation engineer email address listed in the service catalog)
- **Doctor Monkey:** taps into health checks that run on each instance and finds unhealthy instances and proactively shuts them down if owners don’t fix the root cause in time
- **Janitor Monkey:** ensures that their cloud environment is running free of clutter and waste; searches for unused resources and disposes of them
- **Security Monkey:** an extension of Conformity Monkey; finds and terminates instances with security violations or vulnerabilities, such as improperly configured AWS security groups

APPENDIX 10 TRANSPARENT UPTIME

Lenny Rachitsky wrote about the benefits of what he called “transparent uptime:”

1. Your support costs go down as your users are able to self-identify system wide problems without calling or emailing your support department. Users will no longer have to guess whether their issues are local or global, and can more quickly get to the root of the problem before complaining to you.
2. You are better able to communicate with your users during downtime events, taking advantage of the broadcast nature of the Internet versus the one-to-one nature of email and the phone. You spend less time communicating the same thing over and over and more time resolving the issue.
3. You create a single and obvious place for your users to come to when they are experiencing downtime. You save your users’ time currently spent searching forums, Twitter, or your blog.
4. Trust is the cornerstone of any successful SaaS adoption. Your customers are betting their business and their livelihoods on your service or platform. Both current and prospective customers require confidence in your service. Both need to know they won’t be left in the dark, alone and uninformed, when you run into trouble. Real time insight into unexpected events is the best way to build this trust. Keeping them in the dark and alone is no longer an option.
5. It’s only a matter of time before every serious SaaS provider will be offering a public health dashboard. Your users will demand it.

Additional Resources

- Many of the common problems faced by IT organizations are discussed in the first half of the book *The Phoenix Project: A Novel about IT, DevOps, and Helping Your Business Win* by Gene Kim, Kevin Behr, and George Spafford.
- This video shows a speech Paul O'Neill gave on his tenure as CEO of Alcoa, including the investigation he took part in after a teenage worker was killed at one of Alcoa's plants: https://www.youtube.com/watch?v=tC2ucDs_XJY.
- For more on value stream mapping, see *Value Stream Mapping: How to Visualize Work and Align Leadership for Organizational Transformation* by Karen Martin and Mike Osterling.
- For more on ORMs, visit Stack Overflow: <http://stackoverflow.com/questions/1279613/what-is-an-orm-and-where-can-i-learn-more-about-it>.
- An excellent primer on many agile development rituals and how to use them in IT Operations work can be found in a series of posts written on the Agile Admin blog: <http://theagileadmin.com/2011/02/21/scrum-for-operations-what-is-scrum/>.
- For more information on architecting for fast builds, see Daniel Worthington-Bodart's blog post "Crazy Fast Build Times (or When 10 Seconds Starts to Make You Nervous):" <http://dan.bodar.com/2012/02/28/crazy-fast-build-times-or-when-10-seconds-starts-to-make-you-nervous/>.
- For more details on performance testing at Facebook, along with some detailed information on Facebook's release process, check out Chuck Rossi's presentation "The Facebook Release Process:" <http://www.infoq.com/presentations/Facebook-Release-Process>.
- Many more variants of dark launching can be found in chapter 8 of *The Practice of Cloud System Administration: Designing and Operating Large Distributed Systems, Volume 2* by Thomas A. Limoncelli, Strata R. Chalup, and Christina J. Hogan.
- There is an excellent technical discussion of feature toggles here: <http://martinfowler.com/articles/feature-toggles.html>.
- Releases are discussed in more detail in *The Practice of Cloud System Administration: Designing and Operating Large Distributed Systems, Volume 2* by Thomas A. Limoncelli, Strata R. Chalup, and Christina J. Hogan; *Continuous Delivery: Reliable Software Releases Through Build, Test, and Deployment Automation* by Jez Humble and David Farley; and *Release It! Design and Deploy Production-Ready Software* by Michael T. Nygard.
- A description of the circuit breaker pattern can be found here: <http://martinfowler.com/bliki/CircuitBreaker.html>.
- For more on the cost of delay see *The Principles of Product Development Flow: Second Generation Lean Product Development* by Donald G. Reinertsen.

- A further discussion on staying ahead of failures for the Amazon S3 service can be found here: https://qcon.sf.com/sf2010/dl/qcon-sanfran-2009/slides/JasonMcHugh_AmazonS3ArchitectingForResiliencyInTheFaceOfFailures.pdf.
- For an excellent guide on conducting user research, see *Lean UX: Applying Lean Principles to Improve User Experience* by Jeff Gothelf and Josh Seiden.
- Which Test Won? is a site that displays hundreds of real-life A/B tests and asks the viewer to guess which variant performed better, reinforcing the key that unless we actually test, we're merely guessing. Visit it here: <http://whichtestwon.com/>.
- A list of architectural patterns can be found in *Release It! Design and Deploy Production-Ready Software* by Michael T. Nygard.
- An example of published Chef post-mortem meeting notes can be found here: <https://www.chef.io/blog/2014/08/14/cookbook-dependency-api-postmortem/>. A video of the meeting can be found here: <https://www.youtube.com/watch?v=Rmi1Tn5oWfI>.
- A current schedule of upcoming DevOpsDays can be found on the DevOpsDays website: <http://www.devopsdays.org/>. Instructions on organizing a new DevOpsDays can be found on the DevOpsDay Organizing Guide page: <http://www.devopsdays.org/pages/organizing/>.
- More on using tools to manage secrets can be found in Noah Kantrowitz's post "Secrets Management and Chef" on his blog: <https://coderanger.net/chef-secrets/>.
- James Wickett and Gareth Rushgrove have put all their examples of secure pipelines on the GitHub website: <https://github.com/secure-pipeline>.
- The National Vulnerability Database website and XML data feeds can be found at: <https://nvd.nist.gov/>.
- A concrete scenario involving integration between Puppet and ThoughtWorks' Go and Mingle (a project management application) can be found in a Puppet Labs blog post by Andrew Cunningham and Andrew Myers and edited by Jez Humble: <https://puppetlabs.com/blog/a-deployment-pipeline-for-infrastructure>.
- Preparing and passing compliance audits is further explored in Jason Chan's 2015 presentation "SEC310: Splitting the Check on Compliance and Security: Keeping Developers and Auditors Happy in the Cloud:" https://www.youtube.com/watch?v=IoOO_K4v12Y&feature=youtu.be.
- The story of how application configuration settings were transformed by Jez Humble and David Farley for Oracle WebLogic was described in the book *Continuous Delivery: Reliable Software Releases Through Build, Test, and Deployment Automation*. Mirco Hering described a more generic approach to this process here: <http://notafactory-anymore.com/2015/10/19/devops-for-systems-of-record-a-new-hope-preview-of-does-talk/>.
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