Starting and Scaling DevOps

by Gary Gruver

Chapter 1: DevOps and the Deployment Pipeline

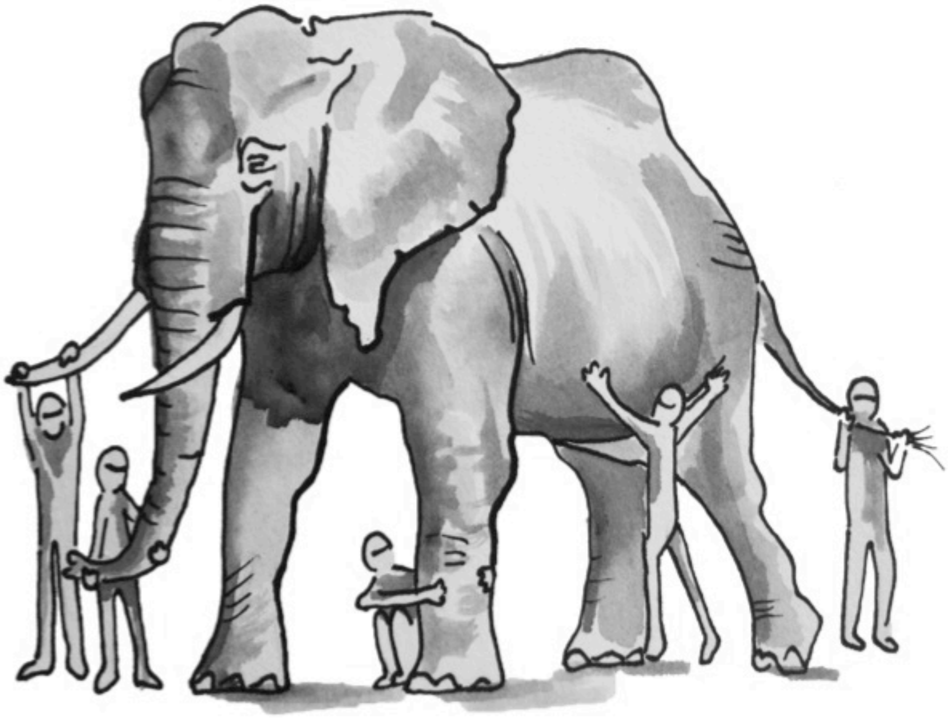
DevOps is a fundamental shift in how the industry is starting to manage their software and IT work. It is driven by the need for businesses to move more quickly and the realization that large software organizations are applying these DevOps principles to develop new software faster than anyone ever thought possible. Everywhere I go I run into people that want to *do* "DevOps" because of all the benefits they are hearing about but they are not sure exactly what DevOps is, where to start, or how to drive improvements over time. They and everyone in their organization are hearing a lot of different great ideas about DevOps but they struggle to get everyone to agree on a common definition and what changes they should make. In large organizations this lack of structure for aligning and implementing DevOps improvements impedes progress and leads to a lack of focus. This book is intended to help structure and align those improvements by providing a framework that large organizations can use to understand the DevOps principles in the context of their current development processes and to gain alignment across the organization for successful implementations.

Part of the issue with implementing DevOps principles and practices is that there are so many ideas out there about what DevOps is, and so many different ways to define it. The most consistent and comprehensive definition I have heard lately is from Gene Kim a co-author of *The Phoenix Project* and *The DevOps Handbook*. He is a great thought leader and evangelist for the DevOps movement. In order to get us all on the same page for our work here, we will use his definition of DevOps:

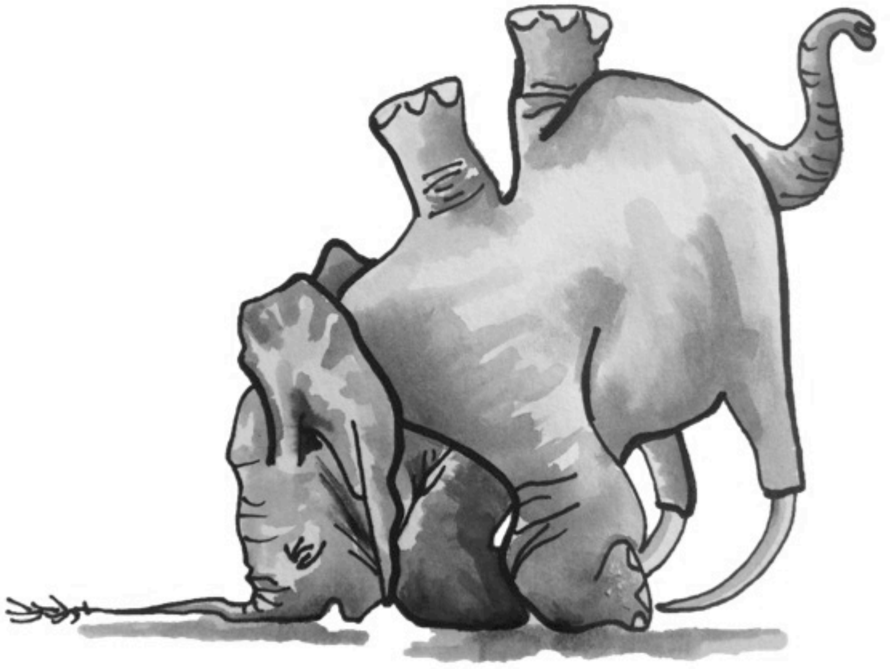
"DevOps should be defined by the outcomes. It is those set of cultural norms and technology practices that enable the fast flow of planned work from, among other things, development, through tests into operations while preserving world class reliability, operation and security. DevOps is not about what you do, but what your outcomes are. So many things that we associate with DevOps, such as communication and culture, fits underneath this very broad umbrella of beliefs and practices."

People have such different views of DevOps because what it takes to improve the quality and flow at every step from a business idea all the way out to working code in the customer's hands differs for different organizations. The DevOps principles designed to improve this process are a lot about implementing changes that help coordinate the work across teams. The movement started with leading edge companies that were fairly small, delivering code more frequently than anyone thought possible. DevOps was also very successful in large organizations like Amazon where they created architectures that enabled them to have small teams (10s of people) working independently. More recently DevOps has started being leveraged into large organizations with tightly coupled architectures that require coordinating the work across 100s of people. As it started scaling into these larger more complex organizations, the problem is that people started assuming the approaches for successfully coordinating the work across 10s of people would be the same and work as well for coordinating the work across 100s of people. The reality is that while the principles are the same for small and complex the implementations can and should be different.

Most large organizations don't have that context as they start their DevOps journey. They have different people in different roles that have gone to different conferences to learn about DevOps from presentations by companies with different complexity and different problems and have come back with different views of what DevOps means for them. It is like the five blind men describing the elephant. Each stakeholder gives a very accurate description of their section of the animal but the listener never gets a very good macro view of the elephant, so when they go to create their own elephant nobody can agree on where to start and they frequently want to implement ideas that worked well for teams of 10s, while in complex organizations that require coordinating the work of 100s. The intent of this book is to provide the overall view of the elephant to help large organizations have a common understanding of the concepts and provide a framework they can use to align the organization on where to start and how to improve their software development processes over time.



The reason this is important is that if you can't get people in a large organization aligned on what they are going to build and an approach for prioritizing improvement they are not very likely to deliver a DevOps implementation that will delivery the expected results. It will potentially have pieces and parts of the different things that the organization has heard about DevOps but it doesn't really help the organization deliver code on a more frequent basis while improving or maintaining all aspects of quality. It is like having the five blind men build and elephant based in their understanding of the animal. It may have all the right parts but it doesn't really look like or work like an elephant because they don't have a good macro view of the animal.



To clarify the macro view of DevOps we will look at how a business idea moves to development, where a developer writes code, through the creation of the environment to how code gets deployed, tested and passed into production where it is monitored. The process of moving from a business idea all the way out to the customer using a deployment pipeline was originally documented by Jez Humble and David Farley in their book *Continuous Delivery*. This book will leverage that framework extensively because I believe it represents the basic construct of DevOps. It captures the flow of business ideas to the customer and the quality gates that are required to maintain or improve quality.

It is my personal experience that creating and documenting, automating and optimizing deployment pipelines in large software/IT organizations is key to improving their efficiency and effectiveness. You already have in place something that you are using to get code through your organization from idea to production, which is your DP. But documenting that so everyone has a common view, then optimizing it based on the mapping is a key tool in this process that has yet to be exploited. The deployment pipeline defines and documents the flow of code through the system so that bottlenecks and waste and other inefficiencies can be identified and addressed using DevOps techniques. Improving it will require a lot of organizational change management but the DP will help everyone understand what processes are being changed at any one time including how to start working differently.

The deployment pipeline for a large organization with a tightly coupled architecture is a fairly complex concept to grasp. Therefore, we will start with the simplest example of a deployment pipeline with one developer. We will show the inefficiencies that can occur with one developer and highlight the DevOps approaches that were designed to address those issues. We will also show the metrics you can start collecting to help you understand the magnitude of your inefficiencies so you can align the organization on fixing the issues that will provide the biggest benefit.

Once the basic construct of the deployment pipeline is well understood, the next step is showing how the complexity changes as you start scaling the deployment pipeline from one developer to a team of developers. Having a team of developers working together on an application while keeping it close to release quality is a fundamental shift for most traditional organizations. It requires some different technical approaches by the developers but it also requires a big cultural shift of prioritizing keeping the code base stable over creating new features. This will be a big shift for most organizations but it is very important because if you can't get the developers to respond to the feedback from the deployment pipeline, then creating it will be of limited value.

The next big challenge large organizations have after they have had some success at the team level is how to scale DevOps across a large organization. They typically approach it by trying to get the rest of the organization to do what they did because of the benefits it provided. This overlooks the fact that the biggest barriers to adoption are not technical, but are instead organizational change management and getting people to work differently. The key to this adoption is helping the broader organization understand the principles, while providing as much flexibility as possible to allow them to develop and take ownership of their plans. In order to make this adoption of principles as flexible as possible, you should segment the work in large organizations into the smallest pieces possible to enable local control and ownership. For some organizations with loosely coupled architectures this will result in lots of small independent teams where you only have to coordinate the work across 10s of people. For other organizations with tightly coupled architectures that require large applications to be developed, qualified, and released together, you may require coordinating the work across 100s of people. It is important to start by grouping applications into these types because the things you do to coordinate the work across 10s of people will be different from the types of things you do to coordinate the work across 100s of people. While small teams will always be more efficient and deploy more frequently, the process of documenting, automating, and continually improving DPs is much more important for coordinating work across 100s because the inefficiencies across large organizations are much more pronounced.

Changing how a large organization works is going to take awhile and it is going to require changing how everyone both thinks about and does their actual work. A couple of things are important to consider when contemplating this type of organizational change: first, start where it provides the most benefit so you can build positive momentum and second find executives that are willing to lead the change and prioritize improvements that will optimize the DP instead of letting teams sub optimize their segment of the deployment pipeline.

Once the deployment pipeline is in place it provides a very good approach for transforming how you manage large and complex software projects. Instead of creating lots of management processes to track progress and align different groups, you use working code as the forcing function that aligns the organization. Requiring all the different development teams to integrate their code on a regular basis and ensure it is working with automated testing forces them to align their software designs without a lot of management overhead. Additionally, infrastructure as code forces a common definition of environments and deployment processes across development, QA, and operational teams and ensures consistency on the path to production, here again it is working code that helps to align these different groups.

Moving to infrastructure as code increases direct communication between Dev and Ops and this communication is key to the success of all sorts of cultural and structural shifts DevOps requires. People no longer log onto computers and make changes. Instead they work together on common scripts for making any changes to the infrastructure. This requires them at the minimum to document any changes they are making so everyone can see. And ideally it forces them to communicate directly about the changes they are making so they ensure those changes will work in every stage in the DP all the way out to production. Having to use common code and common tools forces the collaboration. And the effect that this collaboration has on efficiency cannot be underestimated. Since the teams are aligned by having to ensure their code works together on a daily basis, management processes do not need to be put in place to address those issues. SW is notoriously hard to track well with management processes. Getting status updates everywhere doesn’t work that well and takes a lot of overhead. It is more efficient if the teams resolve issues in real time. Additionally, it is much easier to track process using the deployment pipeline because instead of creating lots of different managerial updates everyone can track the progress of working code as it progresses down the pipeline.

This approach of a rigorous deployment pipeline with infrastructure as code and automated testing gating code progression is significantly different from the approach ITIL uses for configuration management. Where the ITIL processes were designed to ensure predictability and stability, the DevOps changes have been driven by the need to improve speed while maintaining stability. The biggest changes are around configuration management and approval processes. The ITIL approach has very strict manual processes for any changes that occur in the configuration of production. These changes are typically manually documented, manually approved in a change management tool, and then manually implemented. This approach helped for improving stability and consistency but slowed down flow by requiring lots of handoffs and manual processes. The DevOps approach of infrastructure as code with automated testing as gates in the deployment pipeline enables better control of configuration and more rigors in the approval process while dramatically improving speed. It does this by using the automated code that implements the configuration changes to be the same code that tracks the change. It also improves the rigors in the approval processes by requiring the person that traditionally approves the changes to document their criteria via automated tests instead of just using some arbitrary management decision for each change.

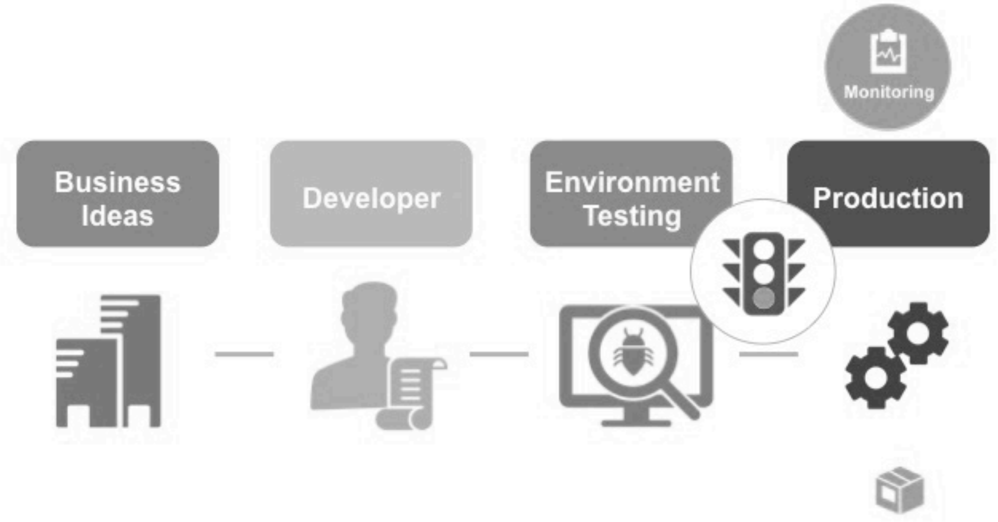
This approach provides some huge benefits for auditing and regulatory compliance. Where before the audit team would have to track the manual code changes, approval processes, and implementations in different tools it is now all automated and easily tracked in one place. It dramatically improves compliance because computers are much better than humans at ensuring the process is followed every time. It is also easier for auditing because all the changes are documented in a source control management tool that is designed for automatically tracking and documenting changes.

These changes are dramatically improving the effectiveness of large organizations because they improve the flow of value while maintaining stability. Most importantly though is that setting up and optimizing a deployment pipeline requires removing waste and inefficiencies that have existed in your organization for years. In order to improve the flow you will end up addressing lots of inefficiencies that occur in coordinating work across people. The productivity of individuals will be improved by better quality and faster feedback while they are writing code but the biggest benefits will come from addressing the issues coordinating the work within teams, across teams, and across organizations. It will require technical implementations and improvement but by far the biggest challenge is getting people to embrace the approaches and change how they work on a day-to-day business. These changes will be significant but the benefits will be dramatic.

Chapter 2: The Basic Deployment Pipeline

The deployment pipeline in a large organization can be a complex system to understand and improve. Therefore, it makes sense to start with a very basic view of the deployment pipeline, to break the problem down into its simplest construct and then show how it scales and becomes more complex when you use it across big, complex organizations. The most basic construct of the deployment pipeline is the flow of a business idea to development by one developer through a test environment into production. This defines how value flows through software/IT organizations, which is the first step to understanding bottlenecks and waste in the system. Some people might be tempted to start the deployment pipeline at the developer but I tend to take it back to the flow from the business idea because we should not overlook the amount of requirements inventory and inefficiencies that waterfall planning drives into most organizations.

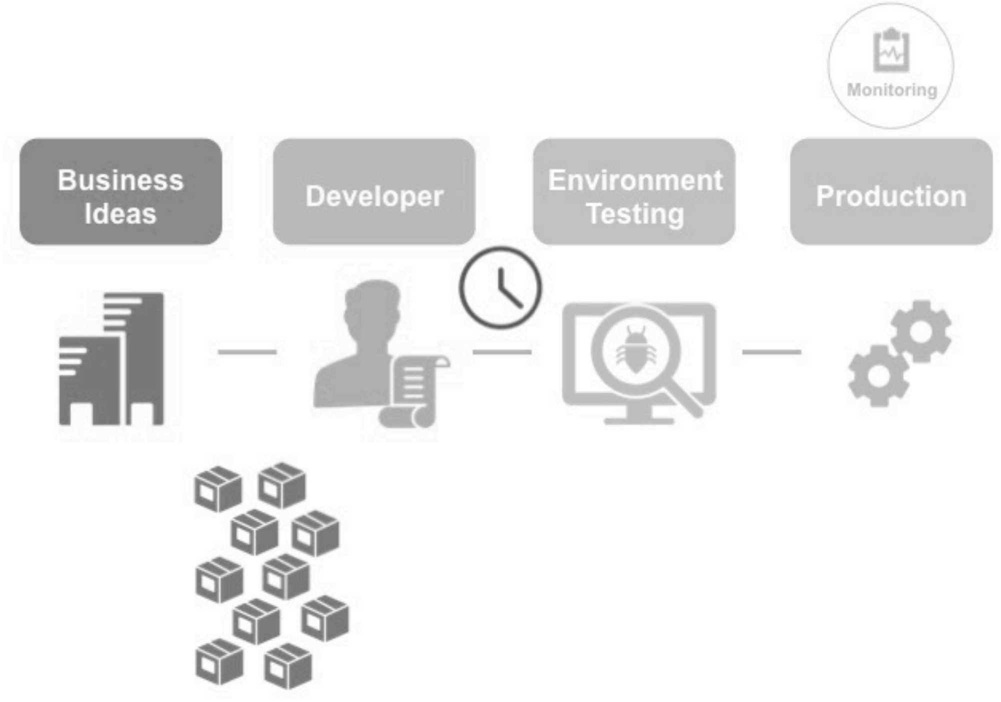
The first step in the pipeline is communicating the business idea to the developer so they can create the new feature. Then, once the new feature is ready the developer will need to tests it to ensure it is working as expected, that the new code has not broken any existing functionality, and that it has not introduced any security holes or impacted performance. This requires an environment that is representative of production. The code then needs to be deployed into the test environment and tested. Once the testing ensures the new code is working as expected and has not broken any other existing functionality it can be deployed into production, tested, and released. The final step is monitoring the application in production to ensure it is working as expected.



Requirements

The first step in the deployment pipeline is going from a business idea to work for the developer to create the new feature. This usually involves creating a requirement and planning the development to some extent. The first problem large organizations have with flow of value through their deployment pipeline is that they tend to use waterfall planning. They do this because they use waterfall planning for every other part of their business so they just apply the same processes to software. Software, however, is unlike anything else most organizations manage in three ways. First, it is much harder to plan accurately because everything you are asking your teams to do they are being asked to do it for the first time. Second, if software is developed correctly with a rigorous deployment pipeline is it relatively quick and inexpensive to change. Third, as an industry we are so poor at predicting our customer's usage that over 50% of all software developed is never used or does not meet its business intent. Because of these unique characteristics of SW if you use waterfall planning you end up locking in your most flexible and valuable asset to deliver features that won't ever be used or won't deliver the intended business results. You also use up a significant amount of your capacity planning instead of delivering real value to your business.

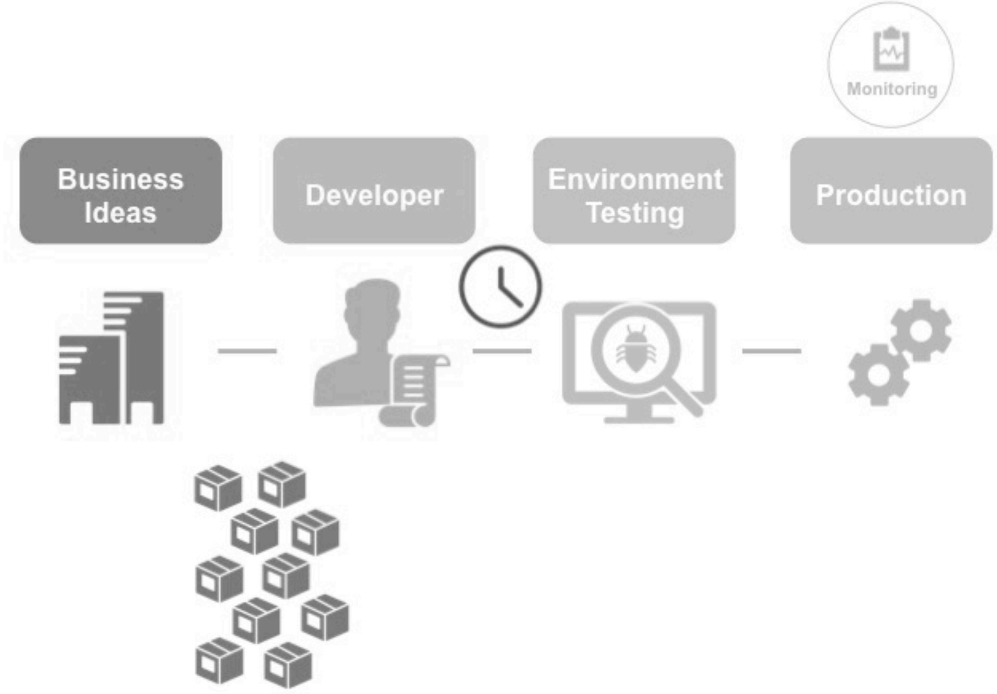
Organizations that use waterfall planning also tend to build up lots of requirements inventory in front of the developer. This inventory tends to slow down the flow of value and creates waste/inefficiencies in the process. As the Lean manufacturing efforts have clearly demonstrated, wherever you have excess inventory in the system it tends to drive waste in terms of rework and expediting. If the organization has invested in creating the requirements well ahead of when they are needed, then when the developer is ready to engage the requirement frequently needs to be updated to answer any questions the developer might have and/or updated to respond to changes in the market. This creates waste and rework in the system. The other challenge with having excess inventory of requirements in front of the developer is that as the marketplace evolves the priorities should also evolve. This leads to the organization having to reprioritize the requirements on a regular basis or in the worst case sticking to a committed plan and delivering features that are less likely to provide the expected business results. If these organizations let the planning process lock them into committed plans, it creates waste by delivering lower value features. If the organizations reprioritize a large inventory of requirements, they will likely at times deprioritize requirements that the organization has invested a lot of time and energy creating. Either way excess requirements inventory leads to waste.



Test Environment

The next step is getting an environment where the new feature can be deployed and tested. This job of providing environments typically belongs to operations so they frequently lead this effort. In small organizations using the cloud this can be very straightforward and easy. In large organizations using internal datacenters this can be a very complex and timely process that requires working through extensive procurement and approval processes with lengthy handoffs between different parts of the organization. Getting an environment can start with long procurement cycles and major operational projects just to coordinate the work across the different server, storage, networking, and firewall teams in operations. This is frequently one of the biggest pain points that cause organizations to start exploring DevOps.

There is one large organization that started their DevOps initiative by trying to understand how long it would take to get *Hello World!* up in an environment using their standard processes. They did this to understand where the biggest constraints were in their organization. They quit this experiment after 250 days even though they still did not have *Hello World!* up and running because they felt they had identified the biggest constraints. Next, they ran the same experiment in Amazon Web Services and showed it could be done in 2 hours. This experiment provided a good understanding of the issues in their organization and also provided a view of what was possible.

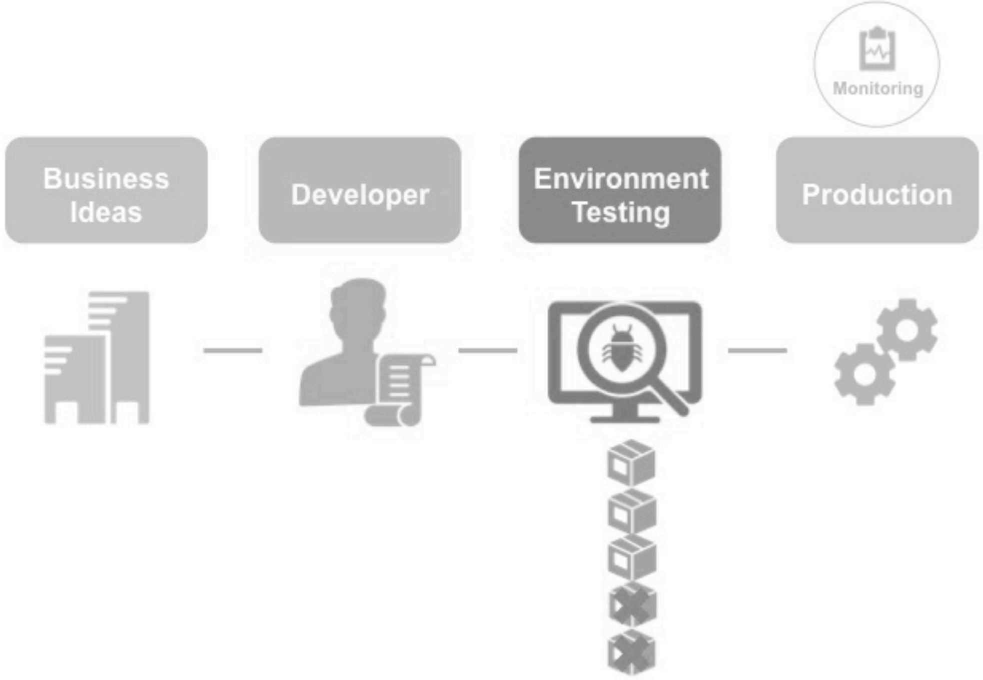


Testing and defect fixing

Once the environment is ready, the next step is deploying the code with the new feature into the test environment and ensuring it works as expected and does not break any existing functionality. This step should also ensure that any security or performance issues were not created by the new code. Three issues typically plague traditional organizations at this stage in their deployment pipeline: repeatability of test results; the time it takes to run the tests; and the time it takes to fix all the defects.

Repeatability of the results is a big source of inefficiencies for most organizations. They waste time and energy debugging and trying to find code issues that end up being problems with the environment, the code deployment, or even the testing process. This makes it extremely difficult to determine when the code is ready to flow into production and creates a lot of extra triaging effort for the organization. Large, complex, tightly coupled organizations frequently spend more time setting up and debugging these environments than they do writing code for the new capabilities.

This testing is typically done with expensive and time consuming manual tests that are not very repeatable. This is why it’s essential to automate your testing. The time it takes to run through a full cycle of manual testing delays the feedback to developers, which results in slow rework cycles, which reduces flow in the deployment pipeline. The time and expense of these manual test cycles also forces organizations to batch lots of new features together into major releases, which slows the flow of value and makes the triage process more difficult and inefficient.



The next challenge in this step is the time and effort it takes to get all the defects out of the code in the test environment and to get the applications up to production level quality. In the beginning the biggest constraint is the time it takes to run all the tests. When this takes weeks, the developers can typically keep up with fixing defects at the rate that testers are finding them. This changes once the organization moves to automation where all the testing can be run in hours. Then the bottleneck tends to move toward the developers ability to fix all the defects and get the code to production levels of quality.

Once an organization gets good at providing environments or is just adding features to an application that already has environments set up, getting production level quality is frequently one of the biggest challenges to release code on a more frequent basis. I have worked with organizations that have the release team leading large cross-organizational meetings to get applications tested, fixed, and ready for production. They meet everyday to review the testing progress to see when it will be done so they are ready to release to production. They track all the defects and fixes so they can make sure the current builds have production level quality.

Frequently you see them working late on a Friday night to get the build ready for offshore testing over the weekend only to find out Saturday morning that all the offshore teams were testing with the wrong code or a bad deployment, or the environment was misconfigured in some way. This process can drive a large amount of work into the system and is so painful that many batch very large, less frequent releases to limit the pain.

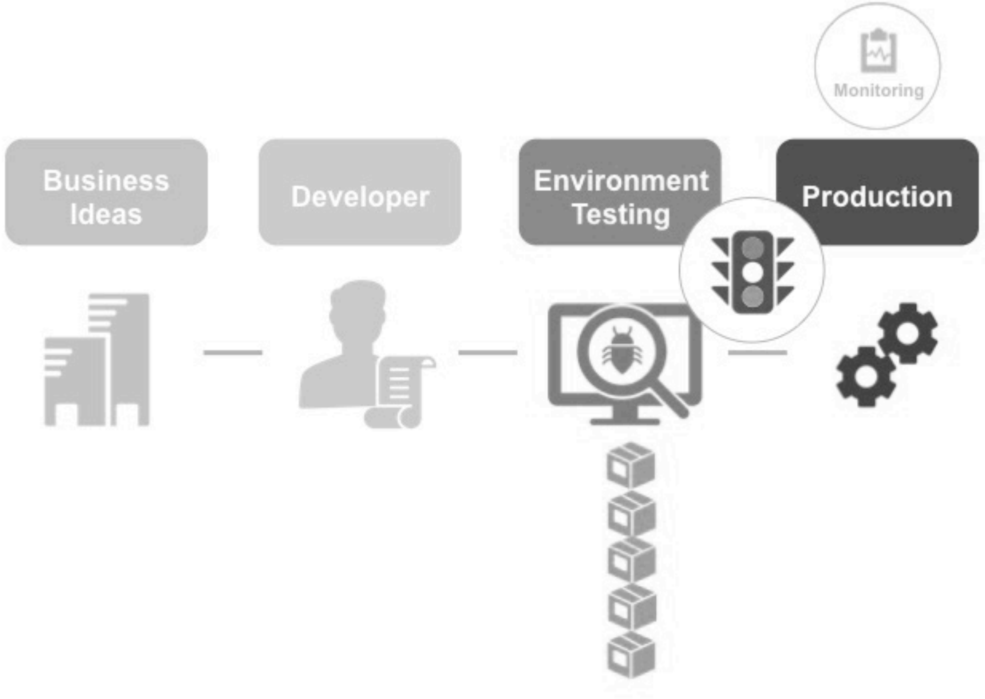
Production Deployment

The next step once all the code is ready, is deploying the code into production for testing and release to the customer. Production deployment is an Ops led effort, which is important because Ops doesn't always take the lead in DevOps transformations but when you use the construct of the deployment pipeline to illustrate how things work it becomes clear that Ops is essential to the transformation and should lead certain steps to increase efficiency in the process. It is during this step that organizations frequently struggle with seeing issues with the application for the first time during the release. It is often not clear if these issues are due to code, deployment, environments, testing, or something else altogether. Therefore, the deployment of large complex systems frequently requires large cross-organizational launch calls to support releases. Additionally, these deployment processes themselves can take lots of time and resources for manual implementations. The amount of time, effort, and angst associated with this process frequently pushes organizations into batching large amounts of change into less frequent releases.

Monitoring

Monitoring is typically another Ops led effort since they own the tools that are used to monitor production. Frequently the first place in the DP that monitoring is used is in production. This is problematic because when code is released to customers, Developers haven't been able to see potential problems clearly before the customer experience highlights it. If Ops works with Dev to move monitoring up the pipeline, potential problems are caught earlier before impacting the customer.

When code is finally released to the customers and monitored to ensure it is working as expected, then ideally there shouldn't be any new issues caught with monitoring in production if all the performance and security testing was complete with good coverage. This is frequently not the case in reality. For example, I was part of one large release into production where we had done extensive testing going through a rigorous release process only to have it immediately start crashing in production with an issue we had never seen before. Every time we pointed customer traffic to the new code base it would start running out of memory and crashing. After several tries and collecting some data we had to spend several hours rolling back to the old version of the applications. We knew where the defect existed but as we tried debugging the issues we couldn't reproduce it in our test environments. After a while we decided we couldn't learn any more until we deployed into production and used monitoring to help locate the issue. We deployed again and the monitoring showed we were running out of memory and crashing. This time the developers knew enough to collect more clues to help them identify the issue. It turns out a developer was fixing a bug that was not wrapping around a long line of text correctly. The command they used worked fine in all our testing but in production we realized that IE8 localized to Spanish had a defect that would turn this command into a floating point instead of an integer causing a stack overflow. This was such a unique corner case we would not have considered testing for it. Additionally, if we had considered it running all our testing on different browsers with different localizations would have become cost prohibitive. It is issues like this and others that remind us that the deployment pipeline is not complete until the new code is monitored in production and behaving as expected.



Chapter 3: Optimizing the Basic Deployment Pipeline

Setting up your deployment pipeline and increasing its throughput while maintaining or improving quality is a journey that takes time for most large organizations. This approach, though, will provide a systematic method for addressing inefficiencies in your software development processes and improving those processes over time. We will look at the different types of work, different types of waste, and different metrics for highlighting inefficiencies. We will start there because it is important to put the different DevOps concepts, metrics, and practices into perspective so you can start your improvements where they will provide the biggest benefits to start driving positive momentum for your transformation.

The technical and cultural shifts that need to be made will change how everyone works on a day-to-day basis. The goal is to get people to accept these cultural changes and embrace different ways of working. For example: As an operations person, I have always logged into a server to debug and fix issues on the fly. Now I can log on to debug but the fix is going to require updating and running the script. This is going to be slower at first and not natural to me, but the change means I and everyone else knows the exact state of the server with all changes under version control and can create new servers at will that are exactly the same. Short-term pain for long-term gain is going to be hard to get some to embrace, but this is the type of cultural change that is required to truly transform your development processes.

Additionally, there are lots of breakthroughs coming from the field of DevOps that will help you address issues that have been plaguing your organization for years that were not very visible while operating at a low cadence. When you do one deployment a month you don’t see the issues repeating enough to see a common cause that needs to be fixed. When you do a deployment a day you see the things that need fixing. When you are deploying monthly, manually, you can use brute force, which takes up a lot of time, a lot of energy, and creates a lot of frustration. When you deploy daily you can no longer use brute force. You need to automate to improve frequency and that automation allows you to fix the issues that are repeating.

As you look to address the inefficiencies, it is important to understand that there are three different kinds of work with software that require different approaches to eliminate waste and improve efficiency. First, there is new and unique work: new features, new applications, and new products that are the objective of the organization. Second, there is triage work to find the source of issues that need to be fixed. Many large complex organizations spend a significant amount of their time and resources just trying to localize problems. Third, there is repetitive work:

creating an environment, building, deploying, configuring databases, configuring firewalls, and testing.

Since the new and unique work isn't repetitive tasks, it can't be optimized the way you would a manufacturing process. In manufacturing the product being built is constant so you can make process changes and measure the output to see if there was an improvement. With the new and unique part of software you can't do that because you are changing both the product and the process at the same time. Therefore, you don't know if the improvement was due to the process change or just a different outcome based on processing a different type or size of requirement. Instead the focus here should be on increasing the feedback so that people working on these new capabilities don't waste time and energy on things that won't work with changes other people are making, won't work in production, or don't meet the needs of the customer. Providing fast, high-quality feedback helps to minimize this waste. It starts with feedback in a production-like environment with their latest code working with everyone's else's latest code to ensure real-time resolution of those issues. Then, ideally, the feedback comes from the customer with code in production as soon as possible. Validating with the customer is done to address the fact that 50% of new software features are never used or do not meet their business intent. Removing this waste requires getting new features to the customers as fast as possible to enable finding which of the 50% are not meeting their business objective so the organization can quit wasting time on those efforts.

In large software organizations, triaging and localizing the source of the issue can consume a large amount of effort. Minimizing waste in this area requires minimizing the amount of triage required and then designing processes and approaches that localize the source of issues as quick as possible when triage is required. DevOps approaches work to minimize the amount of triage required by automating repetitive tasks for consistency. The DevOps approaches are also designed to improve the efficiency of the triage process by moving to smaller batch sizes with fewer changes needing to be investigated as potential sources of the issue.

The waste with repetitive work is different. DevOps moves to automate these repetitive tasks for three reasons. First, it addresses the obvious waste of doing something manually that could be automated. This also enables the tasks to be run more frequently, which helps with batch sizes and thus the triage process. Second, it dramatically reduces the time associated with these manual tasks so that the feedback cycles are much shorter, which helps to reduce the waste for new and unique work. Third, because the automated tasks are much more repetitive it reduces the amount of triage required to find manual mistakes or inconsistencies across environments.

DevOps practices are designed to help address these sources of waste, but with so many different places that need to be improved in large organizations it is important to understand where to start. The first step is documenting the current deployment pipeline and starting to collect data to help target the bottlenecks in flow and the biggest sources of waste. We will walk through each step of the deployment pipeline. We will review metrics to collect to help you understand the magnitude of issues you have at each stage. Then, we will describe the DevOps approaches people have found effective for addressing the waste at that stage. Finally we will highlight the cultural changes that are required to get people to accept working differently.

This approach should help illustrate why so many different people have different definitions of DevOps. It really depends what part of the elephant they are seeing. For any given organization the constraint to flow may be the planning/requirements process, the development process, obtaining consistent environments, the testing process, or deploying code. Your view of the constraint also potentially depends on your role in the organization. While everything you are hearing about DevOps is typically valid, you can't simply copy it because it might not make sense for your organization. One organization's bottleneck is not another organization's bottleneck!

Requirement/Planning

Here we are talking about new and unique work, not repetitive work, so fixing it requires fast feedback and a focus on end-to-end cycle time for ultimate customer feedback.

For organizations trying to better understand the waste in the planning and requirements part of their deployment pipeline it is important to understand the data showing the inefficiencies. It may not be possible to collect all the data at first but don't wait to start improvements because you can't get it all at once. As with all the metrics we describe, get as much data as you can to target issues and start your continuous improvement process. It is more important to start improving than it is to get a perfect view of your current issues. Ideally though you would want to know the following:

- What percentage of the organizations capacity is spent on documenting requirements and planning?
- Amount of requirements inventory waiting for development roughly in terms of days of supply.
- What percentages of the requirements are reworked after originally defined?
- What percentages of the delivered features are being used by the customers and are achieving the expected business results?

Optimizing this part of the deployment pipeline requires moving to a just-in-time approach to documenting and decomposing requirements only to the level required to support the required business decisions while limiting the commitment of long-term deliveries to a subset of the overall capacity. The focus here is to limit the amount of inventory of requirements as much as possible. Ideally this would wait until the developer is ready to start working on the requirement before investing in defining the feature. This approach minimizes waste because effort is not exerted until you know for sure it is going to be developed. It also enables quick responsiveness to changes in the market because great new ideas don't have to wait in line behind all the features that were previously defined.

While this is the ideal situation, it is not always possible because organizations frequently need a longer-range view of when things might happen to support different business decisions. For example do I need to ramp up hiring to meet schedule or should I build the manufacturing line because a product is going to be ready for a launch. The problem is that most organizations create way more requirements inventory a long way into the future than is needed to support their business decisions. They want to know exactly what features will be ready when using waterfall planning because that is what they do for every other part of the business. The problem is that this approach drives a lot of waste into the system and locks in to a committed plan what should be your most flexible asset. Additionally, most organizations push their software teams to commit to 100+% of their capacity so they are not able to respond to changes in the market place or discoveries during development. This is a significant source of waste in a lot of organizations.

We have worked with one organization that moved to a more just-in-time approach for requirements and that has transformed their planning processes from taking 25% or more of their capacity to less than 5%. They eliminated waste and freed up 20% of the capacity of their organization to focus on creating value for the business. It also improves the speed of value through the system because new ideas can move quickly into development if they are the highest priority instead of waiting in queue behind a lot of lower-priority ideas that were previously planned.

This move is a big cultural change for most organizations. It requires software/IT and business executives to think differently about how they manage software. They really need to change their perspective from optimizing the system for accuracy in plans to optimizing it for throughput of value for the customer. They need to be clear about the business decisions they need to support and work with the organization to limit the investment in requirements just to the level of detail required to support those decisions.

Environments

For many organizations, like the one described in chapter 2, the time it takes for operations to create an environment for testing is one of the lengthiest steps in the deployment pipeline. Additionally, the consistency between this testing environment and production is so lacking that it requires finding and fixing a whole new set of issues at each stage of testing in the deployment pipeline. Creating these environments is one of the main repetitive tasks that is easy to document, automate and put under revision control. The objective here is to be able to quickly create environments that provide consistent results across the deployment pipeline. This is done through a movement to infrastructure as code, which has the additional advantage of documenting everything about the environments so it is easier for different parts of the organization to track and collaborate on changes.

To better understand the impact environment issues are having on your deployment pipeline it would be helpful to have the following data:

- Time from environment request to delivery
- How frequently new environments are required
- % of defects associated with code vs. environment vs. deployment vs. database vs. other at each stage in the deployment pipeline

One of the biggest improvements coming out of the DevOps movement is around the speed and consistency of environments, deployments, and databases. This started with *Continuous Delivery* by Jez Humble and David Farley. They showed the value of infrastructure as code where all parts of the environment are treated with the same rigor and controls as the application code. The process of automating the infrastructure and putting it under version control has some key advantages. First, is that the automation ensures consistency across different stages and different servers in the deployment pipeline. Second, the automation supports the increased frequency that is required to drive to smaller batch sizes and more frequent deployments. Third it provides working code that is a well-documented definition of the environments that everyone can collaborate on when changes are required to support new features.

Technical solutions in this space are quickly evolving because organizations are seeing how getting control of their environments provides so many benefits. Smart engineers around the World are constantly inventing new ways to make this easier and to improve its speed. Cloud capabilities whether internal or external tend to help a lot with speed and consistency. New scripting capabilities from Chef, Puppet, Ansible, and others helps with getting all the changes in scripts under source control management. There are also breakthroughs with containers that are helping with speed and consistency. The "how" in this space is evolving quickly because of the benefits the solutions are providing but the "what" is a lot more consistent. For environments you don't want the speed of provisioning to be a bottleneck in your deployment pipeline. You need to be able to ensure consistency of the environment, deployment process, and data across different stages of your deployment pipeline. You need to be able to qualify infrastructure code changes efficiently so your infrastructure can move as quickly as your applications. Additionally, you need to be able to quickly and efficiently track everything that changes from one build and environments to the next.

Forcing Dev and Ops to collaborate on these scripts for the entire DP is essential. The environments across different stages of the DP are frequently different sizes and shapes so often no one person understands how a configuration change in development stage should be implemented in every stage through production. If you are going to change the infrastructure code it has to work for every stage. If you don't know how it should work in those stages it forces necessary discussions. If you are changing it and breaking other stages without telling anyone, the SCM will find you out and the people managing the DP will provide appropriate feedback. Working together on this code is what forces the alignment between Dev and Ops. Before this change, Dev would tend to make a change to fix their environment so their code would work but they wouldn't bother to tell anyone or let people know that for their new feature to work something will have to change in production. It was release engineering's job to try and figure out everything that had changed and how to get it working in production. With the shift to infrastructure as code it is everyone's responsibility to work together and clearly document in working automation code all of the changes.

This shift to infrastructure as code also has a big impact on the ITIL and auditing processes. Instead of the ITIL processes of documenting configuration of a change manually in a ticket it is all documented in code that is under revision control in a source control management tool SCM. The SCM is designed to make it easy to track any and all changes automatically. You can look at any server and see exactly what was changed by who and when. Combine this with automated testing that can tell you when it started failing and you can quickly get to the change that caused the problem. This localization gets easier when the cycle time between tests limits this to a few changes to look through.

Right now this triage process takes a long time to sort through clues to find the change that caused the problem. It is hard to tell if it is a code, environment, deploy, data, or test problem and currently the only thing under control for most organizations is code. CD changed that and put everything under version control that is tracked. This eliminates server-to-server variability and enables version control of everything else. This means that the process for making the change and documenting the change are the same thing so you don't have to look at the documentation of the change in one tool to see what was approved and then validate that it was really done in the other tool. You also don't have to look at everything that was done in one tool and then go to the other tool to ensure it was documented. This is what they do during auditing. The other thing done during auditing is tracking to ensure everyone is following the manual processes every time – something that humans do very poorly but computers do very well. So when all this is automated it meets the ITIL test of tracking all changes and it makes auditing very easy. The problem is that the way DevOps is currently described to process and auditing teams makes them dig in their heels and block changes when instead they should be championing those changes. To avoid this resistance to the these cultural changes, it is important to help auditing understand the benefits it will provide and include them in defining how the process will work so it will be easier for them to audit and they know where to look for the data they require.

Using infrastructure as code across the deployment pipeline also has the benefit of forcing cultural alignment between development and operations. When development and operations are using different tools and processes for creating environments, deploying code into those environments, and managing databases, they tend to find lots of issues releasing new code into production. This can lead to lots of animosity between development and operations. As they start using the same tools, and more specifically the same code, you find that making that code work in all the different stages of the deployment pipeline forces them to collaborate much more closely. They need to understand each other's needs and the differences between the different stages much better. They also need to agree that any changes to the production environments start at the beginning of the deployment pipeline and propagate through the system just like the application code. Over time you find that this working code is the forcing function that starts the cultural alignment between development, operations, and all the organizations in between. This is a big change for most large organizations. It requires that people quit logging into servers and making manual changes. It requires an investment in creating automation for the infrastructure. It also requires everyone to be using common tools, communicating about any infrastructure changes that are required, and documenting the changes with automated scripts. It requires much better communication across the different silos than exists in most organizations.

Organizations doing embedded development typically have a unique challenge with environments because the firmware/software systems are being developed in parallel with the actual product so there is no product available for early testing. Additionally, even when the product is available it is frequently difficult to fully automate the testing in the final product. These organizations need to invest in simulators to enable them to test the software portions of their code as frequently and cheaply as possible. They need to find or create a clean architectural interface between the software parts of their code and the low-level embedded firmware parts. Code is then written that can simulate this interface running on a blade server so they can test the software code without the final product. The same principle holds true for the low-level embedded firmware but this testing frequently requires validating the interactions of this code with the custom hardware in the product. For this testing they need to create emulators that support testing of the hardware and firmware together without the rest of the product.

This investment in simulators and emulators is a big cultural shift for most embedded organizations. They never have invested to create these capabilities and just do big bang integrations late in the product lifecycle that don't go well. Additionally, those that have created simulators or emulators have not invested in continually improving these capabilities to ensure they can catch more and more of the defects over time. These organizations need to make the cultural shift to more frequent test cycles just like any other DevOps organization but they can't do that if they don't have test environments the can trust for finding code issues. If the organization is not committed to maintaining and improving these environments, the organization tends to loose trust and quit using them. If this happens you are missing a key tool for transforming how you do embedded software and firmware development.

Testing

The testing, debug, and defect fixing stage of the deployment pipeline is a big source of inefficiencies for lots of organizations. To understand the magnitude of the problem for your deployment pipeline it would be helpful to have the following data:

- The time it takes to run the full set of testing
- The repeatability of the testing (false failures).
- The time it takes the release branch to meet production quality
- Approval times
- Batch sizes or release frequency

The time it takes for testing is frequently one of the biggest bottlenecks to flow in organizations starting on the DevOps journey. They depend on slow-running manual tests to find defects and support their release decisions. Removing or reducing this bottleneck is going to require moving to automated testing. This automated testing should include all aspects of testing required to release code into production: regression, new functionality, security, and performance. The operations group should also work to add monitoring or other operational concerns to these testing environments to ensure issues are found and feedback is given to developers while they are writing code so they can learn and improve. Automating all the testing to run within hours instead of days and weeks is going to be a big change for most organizations. The tests need to be reliable and provide consistent results if they are going to be used for gating code. You should run them over and over again in random order against the same code to make sure they provide the same result each time. Make sure the test automation framework is designed so the tests are maintainable and triageable. You are going to be running and maintaining 1,000s of automated tests running daily and if you don't think through how this is going to work at scale you will end up dying under the weight of the test automation instead of reaping its benefits. This requires a well-designed automation framework that is going to require close collaboration between development and QA.

Make sure the tests are designed to make the triage process more efficient. It isn't efficient from a triage perspective if the system tests are finding lots of environment or deployment issues. If this happens, you should start designing specific post deployment tests to find and localize these issues quickly. Then once the post deployment tests are in place make sure they are passing and the environments are correct before starting any system testing. The approach improves the triage efficiency by separating code and infrastructure issues with the design of the testing process.

Automated testing and responding to feedback is going to be a big cultural shift for most organizations. The testing process is going to have to move from manually knowing how to test the applications to using leading-edge programming skills to automate testing of the application. These are skills that don't always exist in organizations that have traditionally done manual testing. Therefore, the development organization and the test organization are going to have to collaborate to design the test framework. The development organization is going to have to modify how they write code so that automated testing will be stable and maintainable. And probably the biggest change is to have the developers respond to test failures and keeping build stability as their top priority.

This will be a big shift for most organizations. If you can't get this shift to happen, it probably doesn't make sense to invest in building out complex deployment pipelines that won't be used. The purpose of the automated testing is not to reduce the cost of testing, it is to enable the tests to be run on a more frequent basis to provide feedback to developers in order to reduce waste in new and unique work. If they are not responding to this feedback, then it is not helping. Therefore, it is important to start this cultural shift as soon as possible. Don't write a bunch of automated tests before you start using them to gate code. Write a few automated build acceptance tests that define a very minimal level of stability. Make sure everyone understands that keeping those tests passing on every build is job one. Watch this process very carefully. If it is primarily finding test issues, review and redesign your test framework. If it is primarily finding infrastructure issues, start designing post deployment tests to ensure stability before running any system test looking for code issues. If it is primarily finding code issues, then you are on the right track and ready to start the cultural transformation of having the developers responding to feedback from the deployment pipeline. This process moving to automated tests gating code is going to be a big cultural shift but it is probably one of the most important steps in changing how software is developed.

Testing more frequently on smaller batches of changes makes triage and debug much easier and more efficient. The developer receives feedback while they are writing the code and engaged in that part of the design instead of weeks later when they have moved on to something else. This makes it much easier for them to learn from their mistakes and improve instead of just getting beat up for something they don't even remember doing. Additionally, there are fewer changes in the code base between the failure and the last time it passed so you can quickly localize the potential sources of the problem.

The focus for automated testing really needs to be on increasing the frequency of testing and ensuring the organization is quickly responding to failures. This should be the first step for two reasons. First it starts getting developers to ensure the code they are writing is not breaking existing functionality. Second, and most importantly, it ensures that your test framework is maintainable and triagable before you waste time writing tests that won't work over the long term.

I worked with one organization that was very proud of the fact that they had written over 1000 automated tests that they were running at the end of each release cycle. I pointed out that this was good but to see the most value they should start using them in the deployment pipeline every day, gating builds where the developers were required to keep the builds green. They should also make sure they started with the best, most stable tests because if the red builds were frequently due to test issues instead of code issues then the developers would get upset and disengage from the process. They spent several weeks trying to find reliable tests out of over 1000 available. In the end they found out that they had to throw out all the existing tests because they were not stable, maintainable, or triagable. Don't make this same mistake! Start using your test automation as soon as possible. Have the first few tests gating code on your deployment pipeline, then once you know you have a stable test framework start adding more tests over time.

Once you have good test automation in place that is running in hours instead of days or weeks the next step to enabling more frequent releases is getting and keeping trunk much closer to production-level quality. If you let lots of defects build up on trunk while you are waiting for the next batch release, then the bottleneck in your deployment pipeline will be the amount of time and energy it takes to fix all the defects required before releasing into production. The reality is that to do continuous deployment, trunk has to be kept at production levels of quality all the time. This is a long way off for most organizations but the benefit of keeping trunk closer to production-level quality is worth the effort. It enables more frequent smaller releases because there is not as big an effort to stabilize a release branch before going into production. It also helps with the localization of issues because it is easier to identify changes in quality when new code is integrated. Lastly while you may still have some manual testing in place it ensures that your testers are as productive as possible working on a stable build. This might not be your bottleneck if you start with a lot of manual testing because the developers can fix defects as quickly as the testers can find them. This though starts to change as you add more automated tests. Watch for this shift and be ready to move your focus as the bottleneck changes over time.

This transition to a more stable trunk is a journey that is going to take some time. Start with a small set of tests that will define the minimal level of stability that you will ever allow in your organization. These are your build acceptance tests. If these fail due to a change, then job one is fixing those test failures as quickly as possible. Even better, you should automatically block that change from reaching trunk. Then over time, work to improve the minimal level of stability allowed on trunk by farming your BAT tests. Have your QA organization help identify issues they frequently find in builds that impact their ability to test effectively. Create an automated test to catch this real-time. Add it to the BAT set and never do any manual testing on a build until the all the automated tests are passing. Look for major defects that are getting past the current BAT tests and add a test to fill the hole. Look for long running BAT tests that are not finding defects and remove them so you have time to add more valuable tests. This is a constant process of farming the BAT test that moves trunk closer to release quality over time.

If you are going to release more frequently with smaller batches, this shift to keeping trunk stable and closer to release quality is required and is also going to be a big shift for most organizations. Developers will need to bring code in without breaking existing functionality and not exposing their code to customers until it is done and ready for release. Typically, organizations release by creating a release branch where they finalize and stabilize the code. Every project that is going to be in a release needs to have their code on trunk when the release branches. This code is typically brought in with the new features exposed to the customer ready for final integration testing. For lots of organizations the day they release branch is the most unstable day for trunk because developers are bringing in last minute features that are not ready and have not been tested with the rest of the latest code. This is especially true for projects the business wants really badly. These projects tend to come in with the worst quality, which means every other project on the release has to wait until the really bad project is ready before the release branch can go to production. This type of behavior tends to lead to longer release branches and less frequent releases. To address this, the organization needs to start changing their definition of done. The code can and should be brought in but not exposed to the customer until it meets the new definition of done. If the organization is going to move to releasing more frequently the new definition of done needs to change to include the following: all the stories are signed off, the automated testing is in place and passing, and there are no known open defects. This will be a big cultural shift that will take some time.

The final step in this stage of the deployment pipeline is the approval for moving into production. For some organizations that are tightly regulated this requires getting manual approval by someone in the management chain, which can take up to days at times. For organizations that are well down the path to continuous deployment this can be the biggest bottleneck for the flow of code. To remove this bottleneck, highly regulated organizations move to have the manager that was doing the manual approval work with testers to document their approval criteria with automated tests. For less regulated environments having the developer take ownership and responsibility for quickly resolving any issues found in productions can eliminate the management approval process.

There are lots of changes that can help improve the flow at this stage of the deployment pipeline. The key is to make sure you are prioritizing improvements that will do the most to improve the flow. So, start with the bottleneck and fix it then identify and fix the next bottleneck. This is the key to improving flow. If your test cycle is taking 6 weeks to run and your management approval takes a day, it does not make any sense to take on the political battle of convincing your organization that DevOps means we need to let developers push code into production. If, on the other hand, testing takes hours, your trunk is always at production levels of quality, and your management approval takes days then it makes sense to address the approval barriers that are slowing down the flow of code. It is important to understand the capabilities of your organizations and the current bottlenecks before prioritizing the improvements.

Production feedback

The next step in the basic deployment pipeline is release into production. Ideally you would have found and fixed all the issues in the test stage and this is a fairly automated and simple process. Realistically, this is not the case for most organizations. To better understand the source and magnitude of the issues at this stage it is helpful to look at the following metrics:

- The time and effort required to deploy and release into production
- The number of issues found during release and their source (Code, environment, deployment, test, data, etc…)

If you are going to release code into production with smaller more frequent releases, you can't have a long drawn out release process requiring lots of resources. Many organizations start with teams of operations people deploying into a datacenter with run books and manual processes. This takes a lot effort and is often plagued with manual errors and inconsistencies. DevOps addresses this by automating the release process as the final step in the deployment pipeline. The process has been exercised and perfected during earlier stages in the deployment pipeline and production is just the last repeat of the process. This automation ensures consistency and greatly reduces the amount of time and people required for release.

The next big challenge a lot of organizations have during the release process is that they are finding issues during the release process that they never discovered earlier in the deployment pipeline. It is important to understand the source of these issues so the team can start addressing the reasons they were not caught before release into production. As much as possible you should be using the same tools, processes, and scripts in the test environment as in the production environment. The test environment is frequently a smaller version of production so it is not exact but as much as possible you should work to abstract those differences out of the common code that that defines the environment, deploy the code, and configure the database. If you are finding a lot of issues associated with these pieces start automating these processes and architect for as much common code across the deployment pipeline as possible. Also once you have this automation in place any patches for production should start at the front end of the pipeline and flow through the process just like the application code.

Organizations with large complex deployments also frequently struggle with the triage process during the launch call. A test will fail but it is hard to tell if it is due to an environment, deployment, database, code, or test issue. The automated testing in the deployment process should be designed to help in this triage process. Instead of configuring the environments, deploying the code, configuring the database, and then running and debugging system tests. Create post deployment automated tests that can be run after the environments are configured to make sure they are correct server by server. Do the same thing for the deployment and database. Then after you have proven those steps executed correctly you can run the system tests to find any code issues that were not caught earlier in the deployment pipeline. This structured DevOps approach really helps to streamline the triage process during code deployment and helps localize hard to find intermittent issues that only happen when a system test happens to hit the one server where the issue exists.

Making these deployments into production work smoothly requires these technical changes but mostly it requires everyone in the deployment pipeline working together to optimize the system. This is why the deployment pipeline is an essential part of DevOps transformations. If operations continually sees issues during deployment they need to work to design feedback mechanisms upstream in the deployment pipeline so the issues are found and fixed during the testing process. If there are infrastructure issues found during deployment, operation teams need to work with the development teams to understand why the infrastructure as code approaches did not find and resolve these issues earlier in the deployment pipeline. Additionally, the operations team should be working with the test organization to ensure post deployment tests are created to improve the efficiency and effectiveness of the triage process. These are all very different ways of working that these teams need to embrace over time if the DevOps transformation is going to be successful.

Monitoring

The final step is monitoring the code to make sure it is working as expected in production. The primary metric to monitor here is:

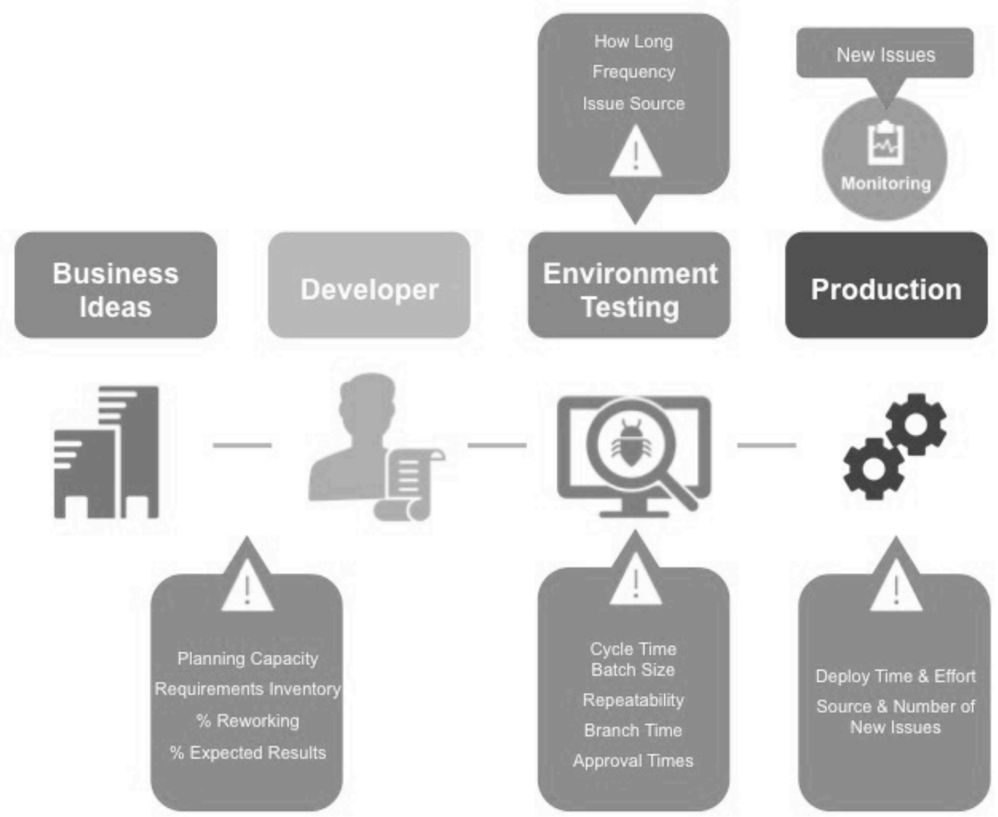
- Issues found in production

Some organizations are so busy fighting issues in production that they are not able to focus on creating new capabilities. Addressing production quality issues can be the biggest challenge for these organizations. In these situations it is important to shift the discovery of these issues to earlier in the pipeline. The operational organization needs to work with the development organization to ensure their concerns and issues are being tested for and addressed earlier in the pipeline. This includes adding tests to address their concerns and adding monitoring that is catching issues in production to the test environments. As discussed in the release section it also requires getting common tools and scripts for environments, deployments, and databases cross the entire deployment pipeline.

Implementing all these changes can help ensure you are catching most issues before launching into production. It does not necessarily help with the IE8 issue with Spanish localization discussed in chapter 2. For this case it would have just been too costly and time consuming to test every browser in ever localization for every test case. Instead the other significant change that website or SaaS type organizations that have complete control over their deployment processes tend to implement is to separating deployment from release by using tools like feature toggles and canary releases. This enables the code to be released into production without being accessible by the customer. This is done due to the realization that no matter how much you invest in testing you still might not find everything. Additionally, the push to find everything can drive the testing cost and cycle times out of control. Instead these organizations use a combination of automated testing in their deployment pipeline and canary releases in production. Once the feature makes it through their deployment pipeline instead of releasing it to everyone at once they do a canary release by giving access to a small percentage of customers and monitoring the performance to see if it is behaving as expected before releasing it to the entire customer base. This is not a license to avoid testing earlier in the pipeline but it does enables organizations to limit the impact on the business for unforeseen issues while taking a pragmatic approach to their automated testing.

Getting Started

This simple construct of a deployment pipeline with a single developer does a good job of introducing the concepts and shows how the DevOps changes can help to improve flow. The metrics are also very useful for targeting where to start improving the pipeline. It is important to start this work with the bottleneck and/or the biggest source of waste because transforming your development and deployment processes is going to take some time and you want to start seeing the benefits of these changes as soon as possible. This can only occur if you start by focusing on the biggest issues for your organization. The metrics are intended to help identify these bottlenecks and waste to gain a common understanding of the issues across your organization so you can get everyone aligned on investing in the improvements that will add the most value out of the gate.

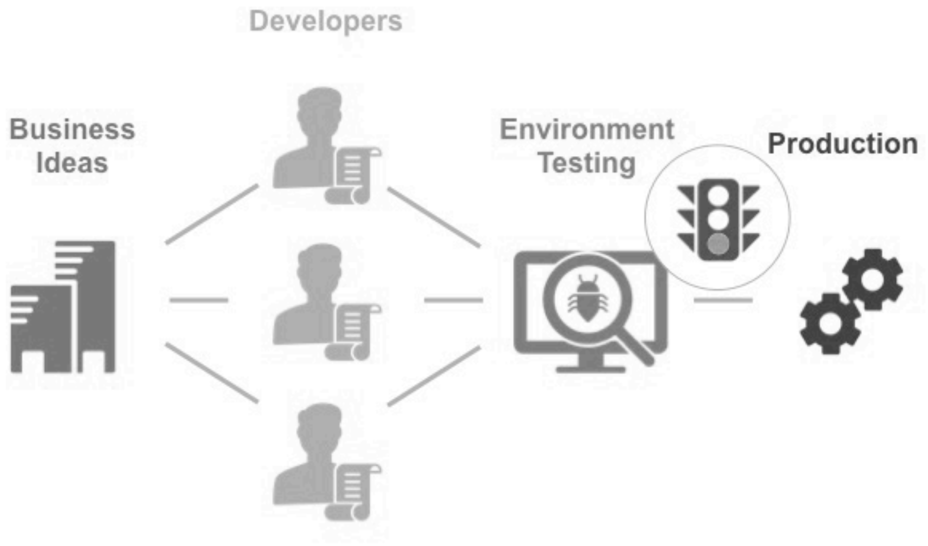

How Long
Frequency
Issue Source
New Issues
Monitoring
Business Ideas
Developer
Environment Testing
Production
Planning Capacity
Requirements Inventory
% Reworking
% Expected Results
Cycle Time
Batch Size
Repeatability
Branch Time
Approval Times
Deploy Time & Effort
Source & Number of New Issues

Chapter 4: Scaling to a Team with Continuous Integration

Continuous Integration is the first step in the deployment pipeline if you have more than one developer. This is the first thing that changes with the deployment pipeline when you start scaling beyond one developer to a team of developers and drives lots of changes in behavior. All the different developers bring their code together and make sure it is working here. You need to make green builds job one and develop in a way that allows you to bring code in without breaking trunk. This is a big change for developers used to traditional methods but it provides huge advantages. Before you have done it you can't imagine that it would ever work and once you have done it this way you can't imagine working any other way. The challenge is ensuring the cultural changes occur and the teams are embracing this new way of working.

The first step in scaling the deployment pipeline is broadening the flow of work from one developer to a team working on an application. The big change here is associated with distributing the development across members in the team and then integrating all their changes to ensure it all works together, meets the business expectations, and does not break existing functionality. This requires improving the communication with the business and across team members, which is usually accomplished with Scrum practices. It also requires implementing continuous integration as the first step towards delivering code in the deployment pipeline.

Scaling to CI



To understand the impact of this additional complexity on top of the basic deployment pipeline it is helpful to understand the following additional metrics:

- Number of green builds a day and % green in continuous integration
- Percent of features requiring rework before acceptance by the business
- Amount of effort required to integrate code from different developers to complete a working feature

These last two metrics are a big source of waste that the agile scrum process is designed to address. Scrum makes all the different developers on a team and the business lead have a quick meeting every morning. This helps to ensure the developers create what the business wants and ensures the developers are talking about how all their code is going to work together. If these two metrics are your biggest issues then by all means start with scrum. If not, maybe start somewhere else. As we talked about in “Leading the Transformation”, how the teams work is the second order effect. How the teams come together to deliver value is the first order effect. The deployment pipeline is the forcing function that aligns the team. Then stage 1+ are the forcing function that aligns across teams. This merge and integration of the code early and often is what helps to minimize rework waste.

If when scaling the deployment pipeline to a team the last two metrics stand out as your biggest sources of waste, then bringing in an Agile coach to work with the team should be one of your highest priorities. The scrum process and daily standups are designed to improve the alignment with the business and across team members. There is lots of great material from the Agile community to help with these improvements so it won't be repeated here. The point, however, is to put those changes and improvements in perspective as part of the broader deployment pipeline so organizations understand the waste being targeted with those improvements and the magnitude of those issues within the broader perspective of the flow of value through the organization.

If instead the first metric or others from chapter 3 stand out as the biggest issues when scaling the pipeline across a team it probably make sense to focus on those. From a development perspective having continuous integration in the deployment pipeline drives significant changes in how developers need to work on a day-to-day basis. Continuous Integration is used is to quickly find and resolve issues where different developers on the team are making changes that won't work together or won't work in production. It requires the developers to make keeping the build green as job one and the operation people to ensure the issues they are concerned about are represented with automated tests in the CI environment. It also requires developers to be checking in their code to trunk on a regular basis instead of allowing it to stay out on branches and in dedicated environments. This is a big cultural change for most organizations and a completely different way of working, but it is probably the most foundational piece of DevOps and the deployment pipeline. If you can't get the organization to make the shift to integrating code on trunk and keeping it stable you are going to be limited in your ability to improve the flow and release more frequently.

It also requires a significantly different approach to development to enable bringing in new code without breaking the existing functionality. In the past the team would work together on a dedicated branch coordinating changes across the application, services layer, and database then when everything was together and working it would be merged to trunk.

This front end branching enabled the teams to develop and make sure everything could work together without breaking trunk. The problem is that once all the changes were ready you had to merge this big batch of changes with all the other changes that occurred on trunk since the branch was created. This merge process can tend to be difficult and delay the discovery of code on the different branches that would not work together. It also drives inefficiencies in the development process because it allows developers to keep working on code separately that won't work together and requires duplication of effort on both branches.

Therefore, there is a strong drive to move away from branching in your deployment pipeline. This requires new approaches for the development team. Instead of coordinating changes across the application and services layer the team needs to move to versioning the services so the application and services layer can independently bring changes to trunk without breaking the build. Instead of modifying a service to support the new feature add version 2 of the service that supports the new feature on trunk. Then the application can bring in the new code when it is ready and call the version of the code it needs for the feature. The test framework should be able to test both the new feature and the old feature on trunk at the same time while the old feature is toggled on in the trunk environment. Then after the testing on the new feature is passing and using the new version of the service then trunk can toggle from the old feature to the new feature and the old version of the service can be deprecated. A similar approach needs to be taken for database changes using the techniques described by Scott Ambler and Sadalage Pramod in their book Refactoring Databases. There are lots of reasons development teams will give for why they must branch but you should understand that all these issues have been solved by other organizations to enable them to optimize flow in their deployment pipeline. Getting developers to make these changes is going to require technical solutions but mostly it is about leading the cultural changes of getting them to work differently on a day-to-day basis.

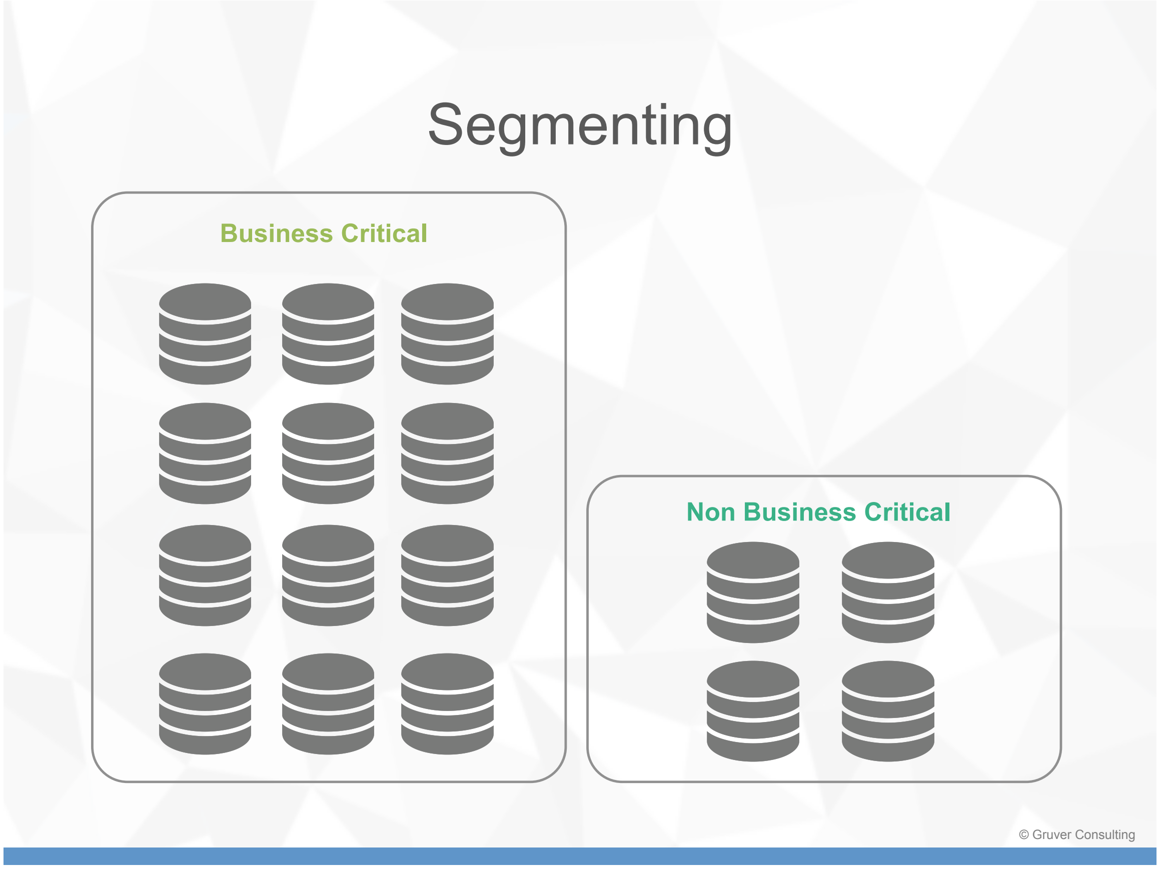
Chapter 5: Scaling Beyond a Team

Most large organizations start DevOps with a small prototype. They work to improve part of a deployment pipeline or a full deployment pipeline for a smaller application. They see all the advantages it provides for that team and decide that they would see much bigger benefits if they scaled it across the entire organization. They approach it with the mentality of how do they get everyone to do DevOps the way they did it because of the success they saw. They try to create a company-wide centralized plan for the change. This approach, however, overlooks organizational change management, which is the biggest challenge. When driving change, it is harder to get people to comply with your wishes than it is to help them create and own their plans, which ultimately will make those plans successful. Additionally, the challenges that they are facing with their deployment pipeline are frequently very different from the challenges found in the prototype and, thus, require different solutions.

It is much easier to get people to own leading the cultural changes when the plans are their own and they have flexibility to prioritize the improvements that will help their business the most. Instead of getting lost in the rituals of DevOps, which happened in a lot of Agile transformations, the focus needs to be on helping them learn how to apply the principles. Forcing them to change and do things simply because they are being told to doesn't work. At HP we were very focused on the principles and gave the teams as much flexibility as possible in terms of how they worked. They had the ownership and made their approaches successful. I am seeing the same thing happening with DevOps. A bottom up approach has some success so they want to scale by telling everyone to do it that way (rituals instead of principles). Teaching them the principles and helping them create a plan that will make their own work successful is the way to go. Providing a framework that traditional organizations can use to create their plan and align the organization under the plan is essential. That and allowing people to say no to changes they are hearing about that were designed for coordinating work of 10s of people that won't work well for coordinating the work of 100s. Right now everyone is hearing about different DevOps ideas. They are all good but nobody is putting them in context. Most importantly there needs to be differentiation between what applies to 10 people versus what applies to 1000s.

The first step for large organizations is segmenting the problem down into smaller more manageable pieces with local ownership and focusing on areas where the changes can add the most value. Changing how a large organization works is hard enough without making it bigger and more complex than is required. The more developers and operational people that have to work together, the more complicated it gets. Therefore, you should break out different parts that don't have to be developed, tested, and deployed as a unit because the architecture is tightly coupled. For example, in retail where companies are trying to create common experiences at every customer interface, creating the capability to buy online and pick up in store requires coordinating the work across large, tightly coupled systems. It impacts the Website, and mobile teams for ordering. It goes through credit and inventory systems that are typically on legacy systems. Then it goes through the point of sales systems and tools for the stores. These systems are so tightly coupled that moving to buy online and pick up in store requires coordinating the dev, test, and deploy across all those systems. In this case that is one DP. The HR system was not coupled, so it should be treated as a separate deployment pipeline. The purchasing and ordering systems are not coupled so they could also be a different DP.

Segmenting the problem down into as many independent DPs as possible is the first step so you can define and optimize the DP for each one separately. The next step is to determine which DPs are worth the investment to optimize. If the applications in the DP are not core to how you compete and are not being updated much it is probably not worth the investment.



Segmenting

Business Critical

Non Business Critical

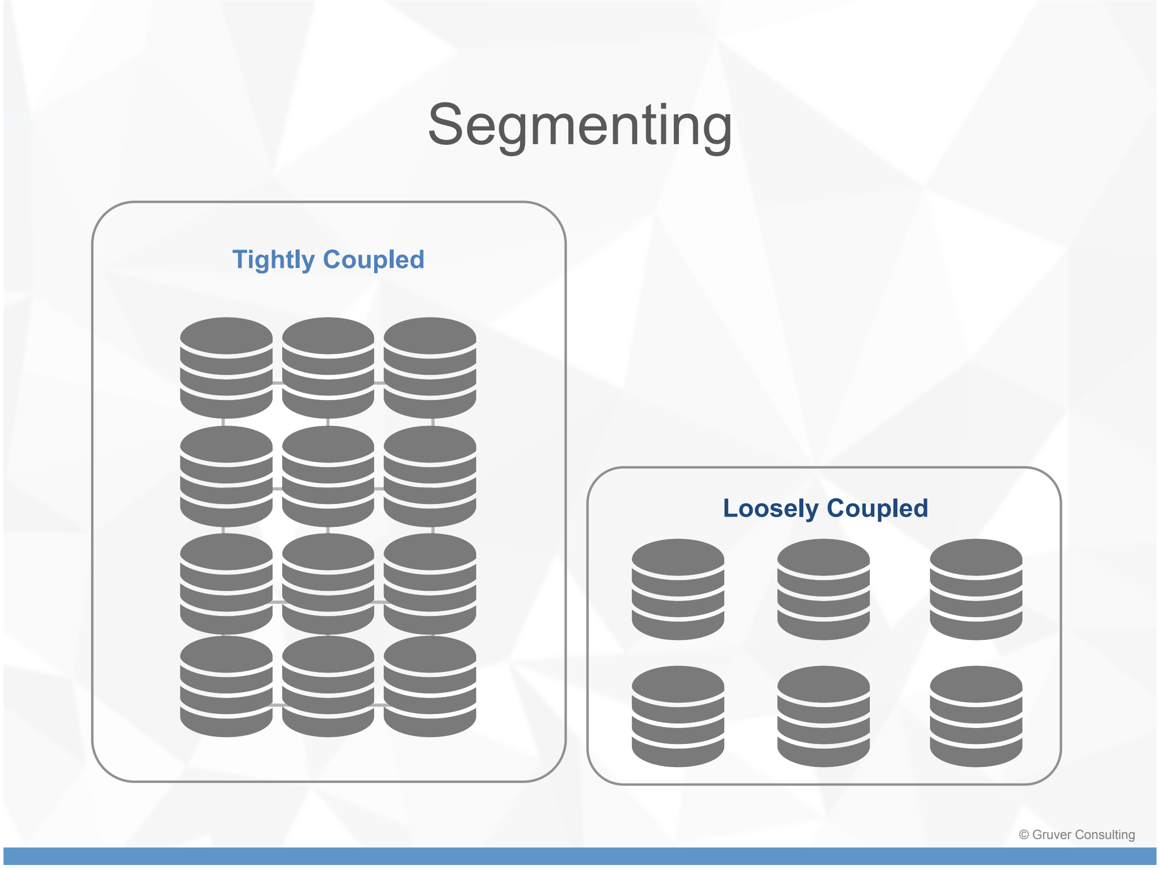
© Gruver Consulting

Next, if the applications are worth the investment it becomes essential, given the complications, to make the DP as small as possible for a few reasons. Coordinating less people is easier than coordinating more, especially in SW. Different DPs will have different sources of waste and cycle time. This process will take some time so you want to start where you see the biggest benefits for your effort to get positive momentum. Most importantly, since this is all about getting people to change how they are working on a daily basis you want people taking ownership for making their ideas successful. If the leaders of that deployment pipeline have the latitude to prioritizing the things that will benefit their DP the most, then they will make their ideas successful and they are likely to fix their biggest issues. If this deployment pipeline can be simplified down to small teams of 5-20 people, you can handle the complexity one way because people can wrap their mind around the complete system and take ownership.

If the smallest the DP can get is 1000s of people, then you have to take different approaches. DevOps thinking spends so much time hearing about the improvements from small teams that the differences between approaches aren't well appreciated. DevOps thinking tends to look at this from the perspectives of small teams and from the bottom up. As an executive trying to change large tightly-coupled systems, I have a different view of the world. Ideally everyone should architect for small independent teams because they will always be more efficient but the reality is that it is hard and takes time so you probably need to improve the process while you are waiting for re-architecture efforts by optimizing the current deployment pipelines.

DevOps forces the coordination across lots of different people: different devs, devs plus qa plus security, and ops. A DP can help small teams significantly but the opportunities for improvement are much larger for larger teams. And if you try to use the same processes for 1,000s of people that work well for 10s of people it doesn't always work well. Since many DevOps thinkers have not led a transformation at scale it is understandable that they don't appreciate the differences. Additionally, most of the people leading the DevOps movement are from new, leading-edge companies that have architectures that enable them to work independently. They don't understand what it takes to coordinate the work of 100-1000s or the benefit that it can provide. Instead of asking these organizations to behave like loosely-coupled organizations, we should be talking about the complex systems they have and helping them figure out how to deliver code on a more frequent basis while maintaining all aspects of quality. They need a framework for understanding what they should be doing to get everyone in a large organization on the same page. Telling them that what they need to do is have Dev push code to production at will is doing them a disservice. Telling them they need to solve problems with 1000s of people the same way you solve them for 10 people is wrong. Dealing with large complex systems requires a different approach and if done well the opportunities for improvements are much bigger because the inefficiencies associated with developing code across more people is much larger.

Scaling across a large organization requires segmenting the DPs into these two different types because the approaches taken will be significantly different in these efforts. The first group is applications where fairly small teams can independently develop, qualify, and deploy code where they don't have to share significant code with other groups. Think micro-services or Amazon 2 pizza teams. The second group is larger applications or groups of applications where larger groups of people need to work together to develop, qualify, and deploy code because of tight coupling in the architecture. This group probably needs to include code that is common and needs to be shared across groups. Ideally, every application would fit in the first loosely-coupled architectural grouping since smaller, less complex things are easier to manage and improve. The reality for most large traditional organizations, however, is that a lot of the code architecture is tightly coupled or needs to be shared and you can't ignore that complexity.

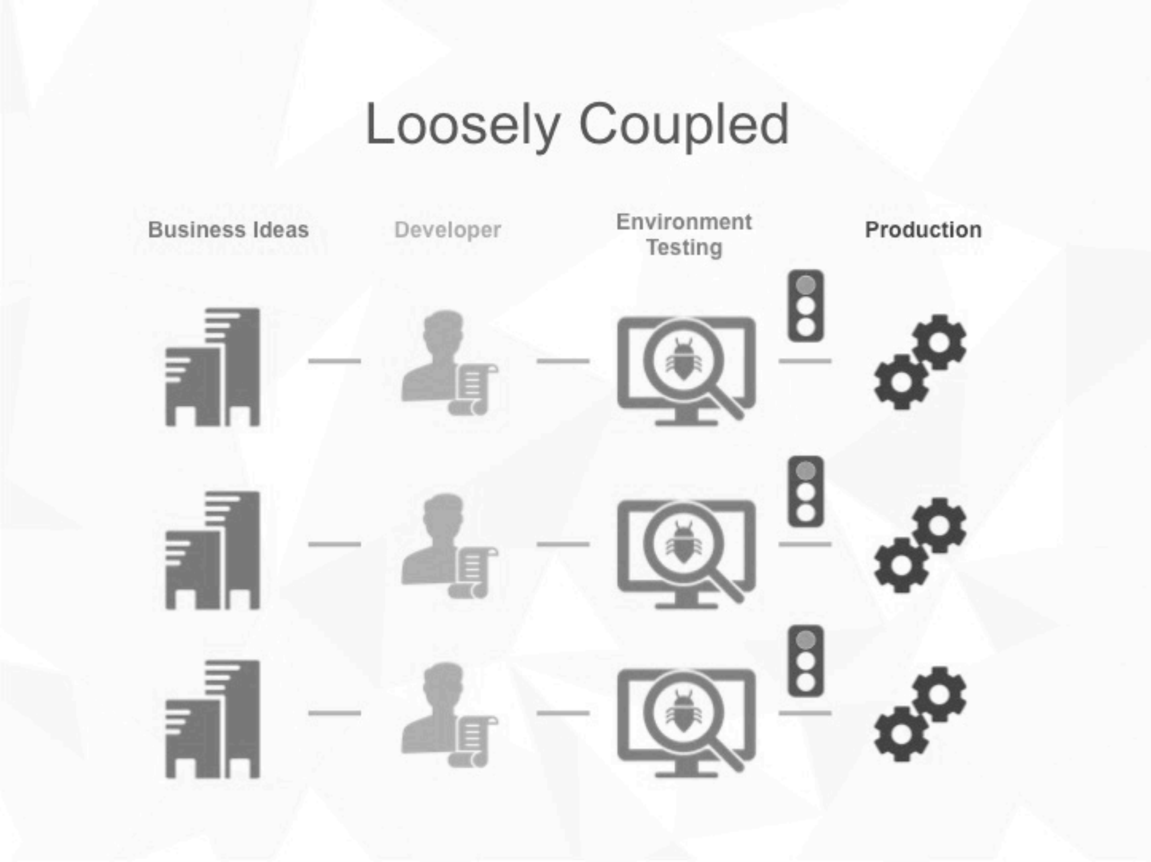


Given this complexity, the next step is to take the applications that are tightly couple and form them into the groups that have to be developed, qualified, and deployed as a system. Next examine each of the groupings to see if there are fairly easy architectural changes that you can make that enable you to break the system into two smaller, more manageable chunks. This is an important step before starting to optimize the deployment pipelines because managing and improving smaller systems is much less complex than the larger ones, and it enables more localized ownership to make it successful.

Breaking the problem down into smaller more manageable chunks is going to be challenging for organizations with tightly coupled legacy architectures. It is also going to be difficult for very large organizations that share a common core set of code across lots of businesses. In these cases you are going to have to find a pragmatic approach that can help simplify and segment the problem as much as possible. If you have a very large tightly-coupled architecture can you start with a smaller component in the system? If you have common code leveraged across lots of very large businesses can you create a plan for that common code and how it is delivered to the businesses instead of lumping all the businesses into a common plan? It is going to be hard to change a large organization. Therefore, it is going to be important to simplify and segment wherever possible. Once you have identified the large, tightly-coupled systems that are key to the business and can't be broken down any smaller it is time to start setting up and optimizing the deployment pipeline. The first step is to identify the cross-organizational executives that will lead the transformation clarifying the objectives of the transformation.

Chapter 6: Scaling with Loosely-Coupled Architectures

Scaling DevOps in large organizations with loosely-coupled architecture is more about propagating the teams and approaches in parallel across the organization as depicted in the graphic below. These organizations should focus on the cultural changes at the team level, the removal of barriers, and the placing of any guardrails for the team. As much as possible you want the team to feel ownership and responsibility all the way from the business idea to working code in production that meets the need. You want to remove barriers by providing capabilities on demand that will support the needs of the teams and help break down cross-organizational barriers. These teams should be allowed as much flexibility as possible in determining how they meet those objectives so they take ownership for the success. In large organizations, especially, it frequently makes sense to have some commonality. It is important to be clear about where and why these common guardrails may exist.



Cultural

The nice thing about having an architecture that enables small teams to work independently is that they can learn, adapt and respond quicker than large, complex tightly-coupled systems. They are also typically close enough to all the work going on with the team that they can understand and respond to most issues. In these cases you are trying to reinforce and support team ownership for the success of the project and extend it all the way out to working code in production. This requires integrating quality, security, performance, and operational perspectives into the development team and breaking down the silos between different organizations.

It is helpful in these situations to reinforce the ownership by having everyone on the team take turns wearing the pager for off shift support rather than having separate operational support. There is nothing like needing to personally get up at 2:00 AM to make you think through whether the new feature is ready to release into production on a Friday afternoon. And there is nothing like having to work through production issues to help you understand how to write code that will work in production and how to provide the monitoring in the code that will make it easier to debug production issues. This is at the core of the "you build it you run it" mentality at Amazon, Google, and other large, fast moving organizations. This is also behind the 2 pizza team rules at Amazon where they work to keep teams and services small enough that the team members can understand the system and have that personal level of ownership. This cultural end-to-end view of the product is at the core of these teams learning and adapting, which enables them to move faster. To support this learning you need to create a blameless culture where people feel comfortable sharing failures so everyone can learn from the mistakes.

The ability of these small independent teams to move fast and learn is at the core of the movement to micro services. There are other architectural approaches that enable small teams to work independently but this is the most popular one at the moment. The idea is to encapsulate everything required for the service to run in a micro service that can be updated independently without breaking the broader application. It is so much easier for these small, independent teams to move fast that wherever possible you should make the architectural changes to support this approach.

Barriers

The other important aspect to enabling these teams to move fast is to start removing barriers that would slow down and frustrate them. Focus on providing them with the resources they need and removing the bureaucracy that exists in most large organizations. These teams should not have to wait on slow-moving central organizations to provide them with what they need. They also should not have to go through slow-moving approval processes.

There is nothing more demoralizing for these small, fast-moving teams than having to wait to get an environment for testing a new feature or to wait for an environment in production where they can deploy the code. Success in these situations really requires being able to provide environments with cloud like efficiencies on demand for testing and production. Teams also need to have access in test environments to the production monitoring capabilities so they can ensure the application is ready and has the appropriate monitoring working for debug of production issues. The infrastructure needs to easily support canary releases so they can experiment quickly without putting the entire customer base at risk. The leadership team needs to work to ensure the infrastructure and tools are in place to support the teams so they can focus on delivering business value.

The leadership team also needs to help by removing bureaucracy and organizational barriers that exist in most large traditional organizations. The change resistance boards that exist in organizations, which don't really understand the changes the teams are implementing, need to be replaced with more efficient processes. The barriers and division of responsibilities across development, QA, security, and operations need to be knocked down to enable efficient collaboration. Processes that were put in place for a command and control approach need to be redesigned or eliminated to support the culture of empowerment and accountability at the team level.

Guardrails

While moving quickly with empowered teams is important for organizations with loosely coupled architectures, it might not be possible or practical to give them complete independence. As you start scaling these teams across the organization it will be important for everyone to understand where they have independence and where they need to use common tools or share common processes.

For example, in tightly regulated industries if you are going to remove bureaucratic processes like the change approval board, you need to ensure there are some auditable standards for moving changes into production. Do you require the previous approver with separation of duties to codify their approval criteria in automated tests that enables auditable release criteria with the speed these small fast moving teams require? Do you require canary releases to less then x% of customers to run for y time before complete release into production? Leaders are going to have to help drive these types of changes because they are big, cross-organizational changes not successfully driven at the team level. That said, once the changes are in place the teams will have to work within the guidelines defined if the organization is going to pass the audits required for regulatory approval.

There are other places where the teams might want to take advantage of the efficiencies of working in a large organization. For example, do you want to empower every team to pick their own tools for scripting environments and deployments or do you want to have a common approach and more common environments to enable efficiencies and leverage across the organization. This is a more difficult decision because it walks the line between empowerment and efficiencies. Ideally, this wouldn't be a hard and fast rule. Instead, infrastructure and capabilities would be put in place to make using the common tools and approach the path of least resistance so teams naturally pick them if they meet their needs.

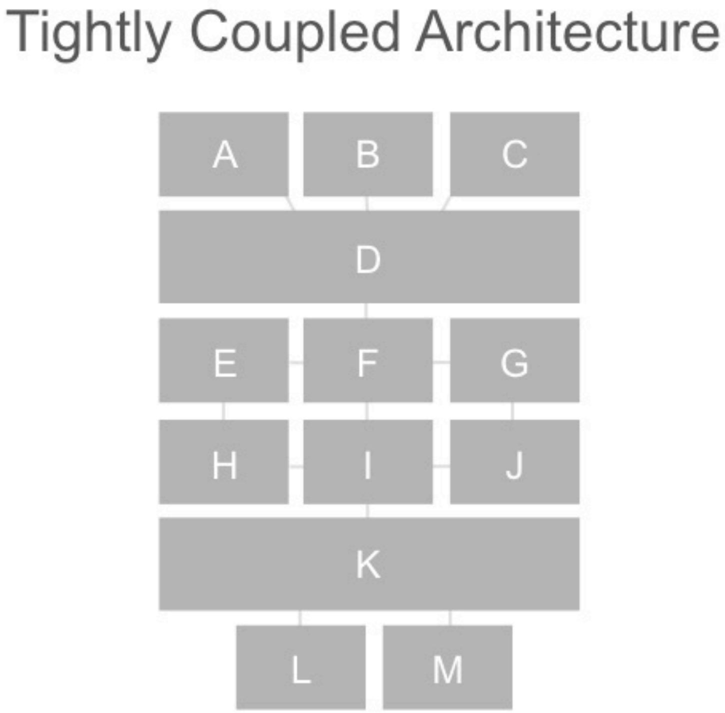
For practical reasons, large organizations may need to consider other commonalities across teams to enable efficiencies in procurement and the ability to look across the organization. For example, all the code at Google is in one SCM tool where anyone can checkout and look at the code at anytime. Teams do not have a choice over using that tool or making their code available. This takes away from the team's independence in some respects but as a company they decided that the tradeoff was worth the advantage of having everyone on one tool that enabled collaboration across the company. Organizations may or may not want to consider similar commonality for looking at demand in business requirements across teams. This commonality can be driven by the ability to work across teams or it may be driven by the costs of buying tools and the efficiencies of enterprise licenses.

There is a lot of value in empowering the teams so they own the success of their approach. There are also valid reasons for driving some level of consistency across large organizations. As organizations start scaling these small, fast-moving teams it is important for the leadership teams to think through these issues and be clear about what if any guardrails they are going to require.

Chapter 7: Documenting the Deployment Pipeline for Tightly-Coupled Architectures

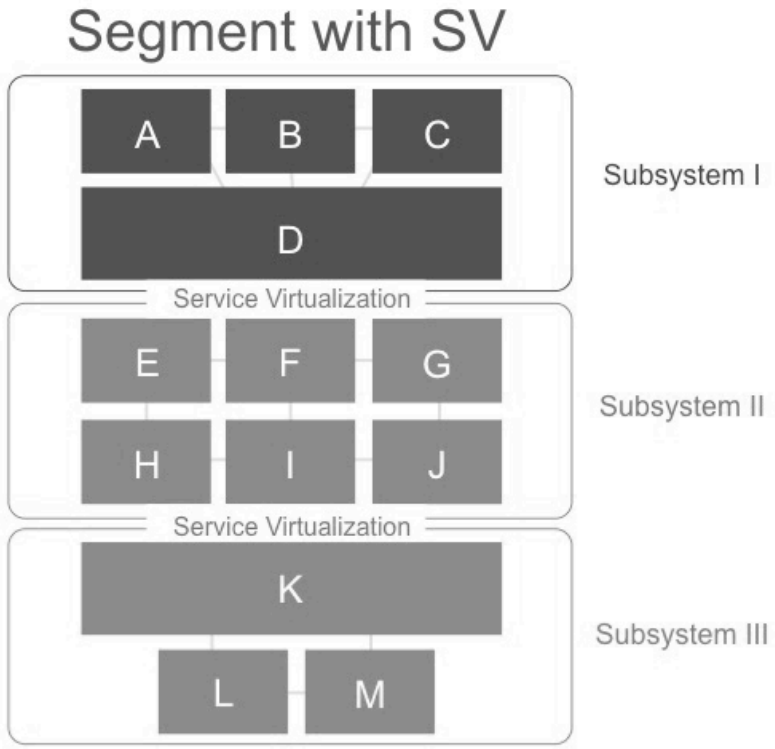
Documenting the DP for tightly-coupled architectures is an important concept and what all of this book's chapters have been leading up to. We have built the foundation and put everything into context so you can determine how to handle the complexity of large systems. For tightly-couple architectures that require 100s-1000s of engineers to coordinate the development, qualification, and deployment of code, the deployment pipeline gets more complex. One way to try to work with this complexity is to have one big continuous integration process on the front end of the pipeline where everyone checks in and does multiple builds a day. With that many developers integrating into one build process, however, a complex enterprise system can take a long time to deploy, and automated testing for everything on that complex of an environment is not very practical. It results in builds with changes from too many developers, which makes it challenging to localize the issues during the triage process and hard to keep green. So it is important when designing complex deployment pipelines to break the design down into more manageable pieces. This can be done by increasing the build frequency, reducing the test time by running a subset automated testing defined as BAT (build acceptance testing), and using service virtualization to break the system into smaller more manageable pieces. Once you have these smaller, more manageable pieces you take the basic construct of CI and expand it into the integration of stable subsystems that build up into the enterprise system with appropriate automated quality gates.

The first step of designing the deployment pipeline for a large, complex, tightly-coupled system is to draw up the architecture with all the applications showing the couplings and interfaces. If you can build, deploy, and run a reasonable set of BAT tests on the system frequently enough to have a small enough number of changes that triage is efficient, then you should use one large CI process for the entire system.



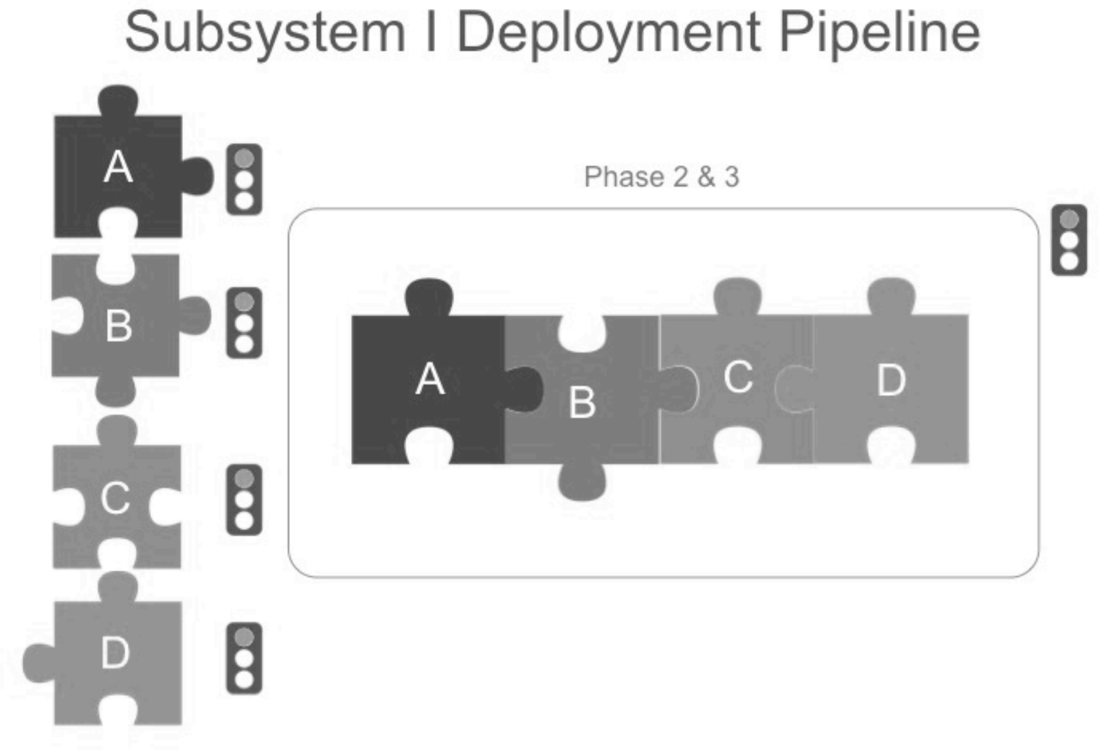
Tightly Coupled Architecture

If you can’t build frequently enough to keep the number of commits small, which is typical of large complex enterprise systems, think about how to break this up into smaller, more manageable pieces. Look for clean interfaces where it would be easy to mock the interface with service virtualization. Ideally you would not need this step at all because maintaining the service virtualization is going to take some effort. Therefore, you should avoid the step where possible by just using build frequency to localize the offending code but when the build time of this complex system takes too long or there are just so many developers working on the system that you have over ~20 commits per build it probably makes sense to break it up into smaller subsystems that you will keep stable for integration. When breaking it down, look for opportunities to reduce the number of commits per build where there are natural organizational and architectural interfaces.



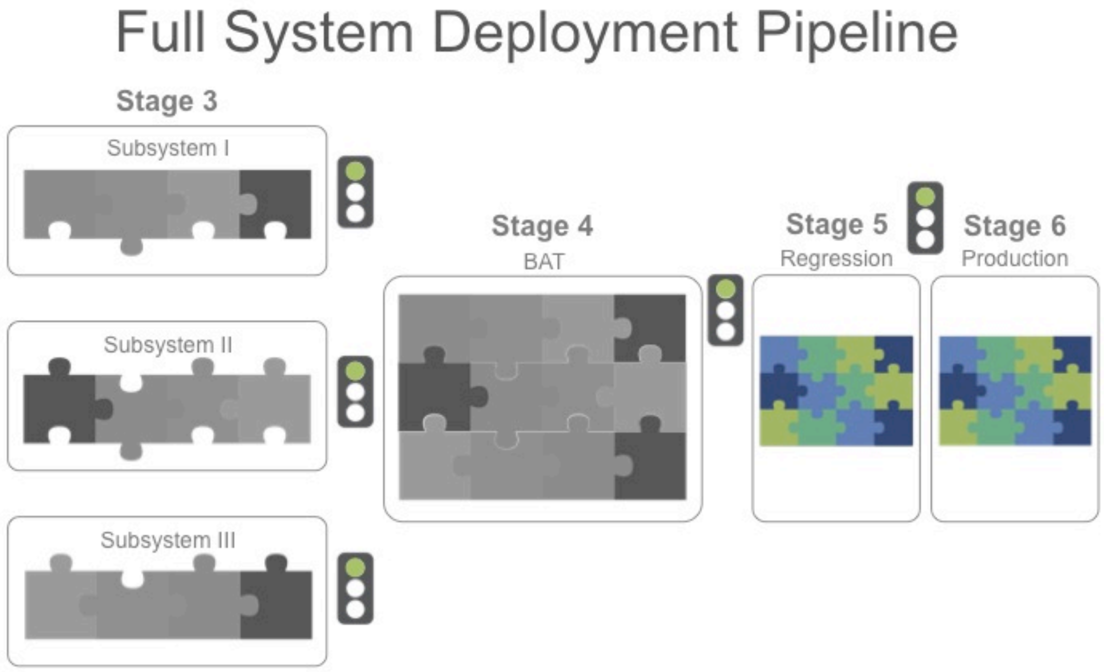
Once these subsystems that can be optimized based on build frequency are defined, you need to define the deployment pipeline for building each of them. This should start with continuous integration Stage 1 of the DP for each application and with each team owning a component with a quality gate for keeping major issues out of the subsystem build. This gate at each stage will be defined by a subset of tests called "build acceptance tests" that will define the minimal level of stability that you will ever allow in the system.

Next the deployment pipeline should take the latest green builds out of each of the components and build those into a subsystem with automated subsystem BAT testing running against the service virtualization as many times a day as possible. Stage 2 of the DP is really continuous integration of the subsets of continuous integration that have to work together.



Subsystem I Deployment Pipeline

Keeping this code base up and running with green builds at this subsystem level should be the top priority for everyone in this part of the organization. Creating subsystems around natural organizational boundaries where possible helps by providing clarity in responsibilities for keeping these subsystems stable. Having BAT gates at each stage helps keep the large systems as stable as possible while localizing the ownership for fixing issues to the teams that created the problem. These subsystems are then built and tested in the full system without virtualization as frequently as possible. This is ideally how code should flow through your system. It is nice to start with the end point in mind.



Next, understand how your current deployment pipeline works. You may not call it a deployment pipeline but there is a process for how you build up, test, and release these large enterprise systems. It is important for the organization to understand how that works before you start making improvements. From a similar perspective, starting at the developer committing code what are the steps for building up and testing this system. Draw it up on a wall and get people together to review it for accuracy. This will have a lot more complexity than the simple construct described in Chapters 2 and 3 but the concepts are similar. Once you have completed this map you have a first pass at your deployment pipeline. Now you are ready for Chapter 8, where we will start optimizing the complex deployment pipelines described here.

Chapter 8: Optimizing Complex Deployment Pipelines

Everything up until this point has given us the context we need to optimize complex deployment pipelines. We understand the basic framework of the DP with metrics for one developer and how DevOps practices address those issues. We have covered how development needs to change how they work to make CI work. We have segmented down to the big, complex, hard-to-solve problems. We have acknowledged that loosely-couple architectures are best and a lot of what you are hearing about DevOps mostly applies to them. And we have an early view of complex deployment pipelines. Now we are ready to deal with the complexity of large, tightly-coupled systems. It is time to get everyone to agree on the biggest issues so we can start making improvements. It is this macro view of the elephant that starts getting the organizational alignment you need to move forward in a coordinated fashion.

DevOps helps to improve the productivity of software organizations because it starts to address the inefficiencies between people, teams, and organizations. It also helps improve the effectiveness of individuals by improving the quality and frequency of feedback. The biggest opportunities for improvement, though, are across the organization, which is more important for large, complex deployment pipelines. It also helps for small, independent teams as discussed in chapter 6, but since there are less people coordinating work for these organizations the impact of the improvements on productivity will be less dramatic. These smaller teams will always be more nimble and able to deploy more frequently because they are dealing with less complex systems, which is why wherever possible you should re-architect for independence. That said, the biggest inefficiencies in most large organizations exist in the large, complex, tightly-coupled systems that require coordination across large numbers of people from the business all the way out to operations.

Waste in large organizations

As we are trying to improve the frequency of release with quality (DevOps) in large organizations, we need to reduce cycle-time, remove duplicate work, and eliminate waste so things can move more quickly. It helps to understand the types of work and inefficiencies you are trying to address to help facilitate this quickness.

Product owners responsible for representing the needs of the business can experience a lot of waste in the deployment pipeline. They spend time documenting requirements that are misunderstood by the development and test organizations. They spend time documenting requirements that the development teams are never able to implement. They work on features that the customers won't use or don't meet the need of the business. They spend time prioritizing and re-prioritizing features that never get developed. They waste time trying to sign off on features in test environments where the code was not correctly deployed or where the environment is unstable.

Developers waste time working on new features that do not meet the expectations of the business. They waste time creating code that does not work with features being created by others. They waste time building new code on top of recently-created defects because of slow feedback from testing. They waste time creating features that will never be used because it takes too long to get the MVP in front of customers. They waste time triaging defects that were thought to be code that end up being issues with data, environments, and deployments. They end up debugging and fixing the same defect more than once because all the right fixes are not correctly committed to all the right branches. They waste time localizing issues among 100s of changes to find out the defects was with some else's code and not their own.

The testing process wastes time creating and executing tests that were not designed like the business or the developer had in mind. The QA organization wastes time and energy testing on a build that has the wrong version of code, is in an environment that is not configured correctly, or is unstable for other reasons. This leads to wasted effort documenting defects that are not repeatable, which leads to ongoing debates between the development and QA organizations. The QA organization spends a lot of time testing the same code and finding the same defects on two different branches of the code.

The release team wastes time trying to find all the right versions of the code, the proper definition of the environments, and getting all the right data in place to support testing. In fact, lots of organizations spend more time and effort getting the big complex enterprise environments up and ready for testing than they do actually writing the code. They find out tests fail because one group overwrote the data another group needed for testing. They find out tests fail because the developer did not let them know they needed a patch in the OS, or a firewall opened to support the new features. These types of waste and inefficiencies can make it very difficult to release code, which leads to infrequent releases and large batch sizes.

Operations is the last stage in the deployment pipeline but it can also be a large source of waste. If there are lots of defects being released into production they end up spending most of their time just firefighting. If development teams are not communicating well the changes they are making or providing instrumentation in their code for efficient debug it is very hard to keep the applications up and running.

Executive Lead Continuous Improvement

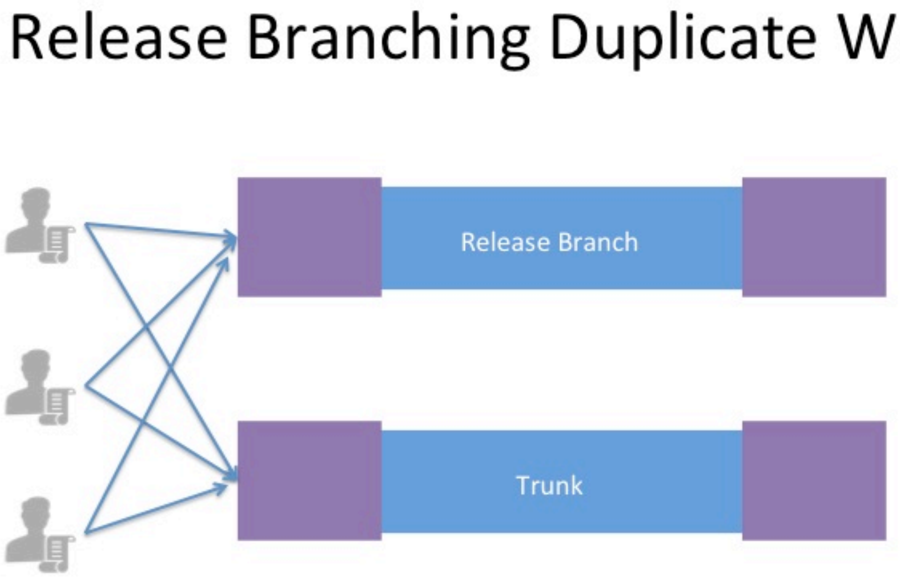
Addressing these inefficiencies and getting the organization focused on improving the biggest issues in the deployment pipeline requires looking across the system and prioritizing improvements. The challenge is getting the organization to agree on the biggest sources of waste so you can start a focused continuous improvement process. This needs to be led by the executives because they have a view across the DP and they have ability to muster the resources and align the organization on agreed improvements. This effort needs to be led by a person or group of people that are chartered to own the process. Because it requires looking across different groups in the organization, this tends to be an executive or team of executives that come together to lead the transformation. They need to be able to prioritize improvements across the teams that will add the most value. They also need to ensure everyone is supporting the changes the team has decided to implement.

This can't be an executive directed initiative because the executives don't have a good feel for the issues until they spend time out in the organization getting a better feel for the issues in the system. It needs to be more of an executive lead approach initiative where they are spending time out in the organization understanding issues, prioritizing improvements, and helping to remove barriers. For more details see *Leading the Transformation* by Gary Gruver and Tommy Mouser.

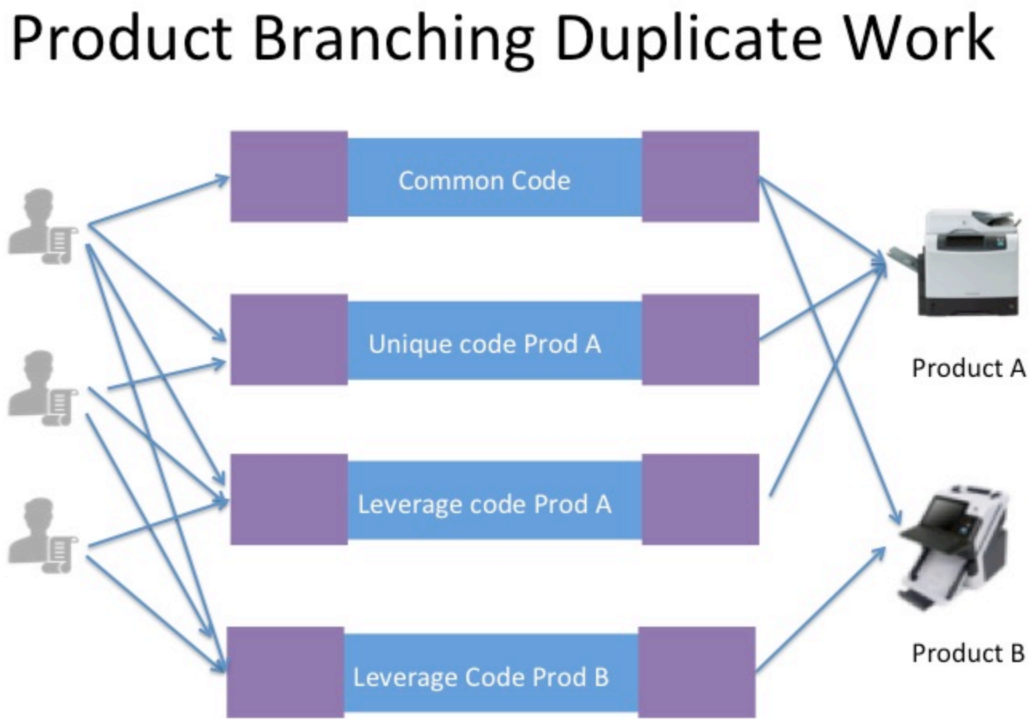
The first step in leading the transformation is getting the technical and managerial team together to gain a common understanding of the biggest sources of waste and inefficiencies in the system (a common view of the elephant). This analysis should be done for each DP by the people responsible for working on those applications. The team needs to start with the architecture and work through the process defined in chapter 7 to document a common understanding of how the DP works. Next we will walk through the metrics the team should work to capture for the DP to give everyone a common understanding of the biggest sources of waste and inefficiencies that should be addressed. The goal of this exercise is to agree on the objectives for the first monthly iteration. The intent is to identify tangible work that the team feels like can and should be completed in the next 30 days, work that will help the organization the most. There are four types of metrics in addition to the ones reviewed in chapter 3 that are important to these more complex DP that we will describe next. The team should populate their deployment pipeline and discuss the issues before agreeing on the objectives for the first month. Again, don't worry about getting the metrics perfect or accurate to three significant digits. The goal here is to provide enough metrics that the organization can agree on the biggest sources of waste, which show them where to start the continuous improvement process.

Mapping waste associated with Duplicate work

The first step in identifying waste and opportunities for improvement in the deployment pipeline is looking for duplication of work. Start looking for duplicate work in branching because duplicate work here is probably one of the biggest wastes. This usually happens with different branches of code where you are either duplicating the entire deployment pipeline or significant portions of it. This can be due to branching during the release process where you isolate to drive to production-level stability or for product organizations to support a variety of products. Either way it forces duplication of work in the system. Developers need to ensure they are committing the correct code to the branches where it is required and not to the ones where it isn't. Testing needs to occur on both branches which can be really problematic if there is any manual testing left in the system. Additionally branching drives duplicate efforts in debugging and triaging defects. Therefore, branches should be seen as a source of waste if they are very long lived and require a significant amount of effort to support. In the beginning they usually exist for a reason but as you start working to improve your development and deployment processes you look to address those reasons so the duplicate work associated with branches can be minimized.


Release Branching Duplicate Work

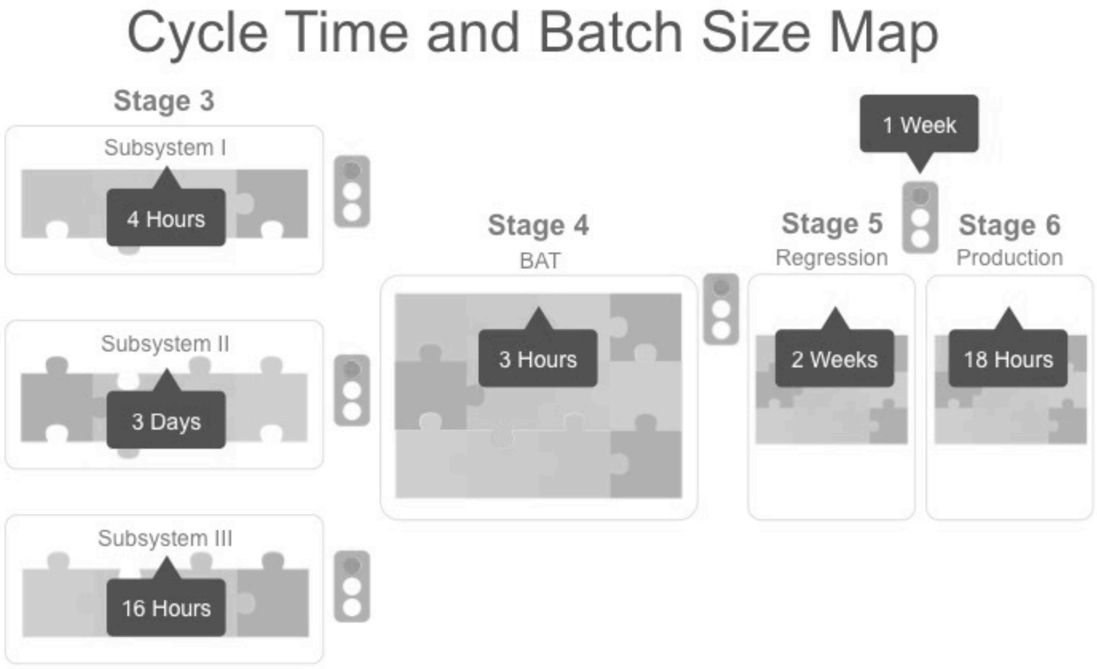
The other place that branching and duplication of work tends to occur is in product development organizations with embedded firmware. Here duplication of work is associated with getting the code up and running and qualified on the different products that frequently have hardware differences. To minimize this waste it is important to either minimize the hardware variability or architecturally isolate these differences from as much of the common code as possible. The architecture should be designed to have small components that are unique for specific products to deal with the hardware differences and should be minimized as much as possible. Components that are common but need to behave differently for different products that need to leverage code should not be branched where possible because of the duplication of work. For these components, instead of embedding all the product differences in the component there should be a file that contains the product differences in one place that is referenced by the component code. Lastly there is platform code that should be common across all the products that should not have to branch.



Cycle-time and batch sizes Metrics

The next step in analyzing the deployment pipeline is to evaluate it for cycle-time and batch sizes. DevOps is all about more frequency, which cycle-time and batch sizes help create. Shorter cycle-time and smaller batch sizes help with rework waste from slow feedback and batch sizes also help with triage efficiency. Cycle-time and batch sizes are typically driven by repetitive work or fixing defects before release. You should start the automation of repetitive work where it will have the most benefit for cycle-time. Cycle-time is important because it drives feedback times to minimize the amount of work on features that customers won't use, that won't work with other code, or that won't work in production. The reduction in cycle-time minimizes the time different groups across the deployment pipeline invest in things that won't work together. They can then identify the issues and ensure those issues are addressed as soon as possible.

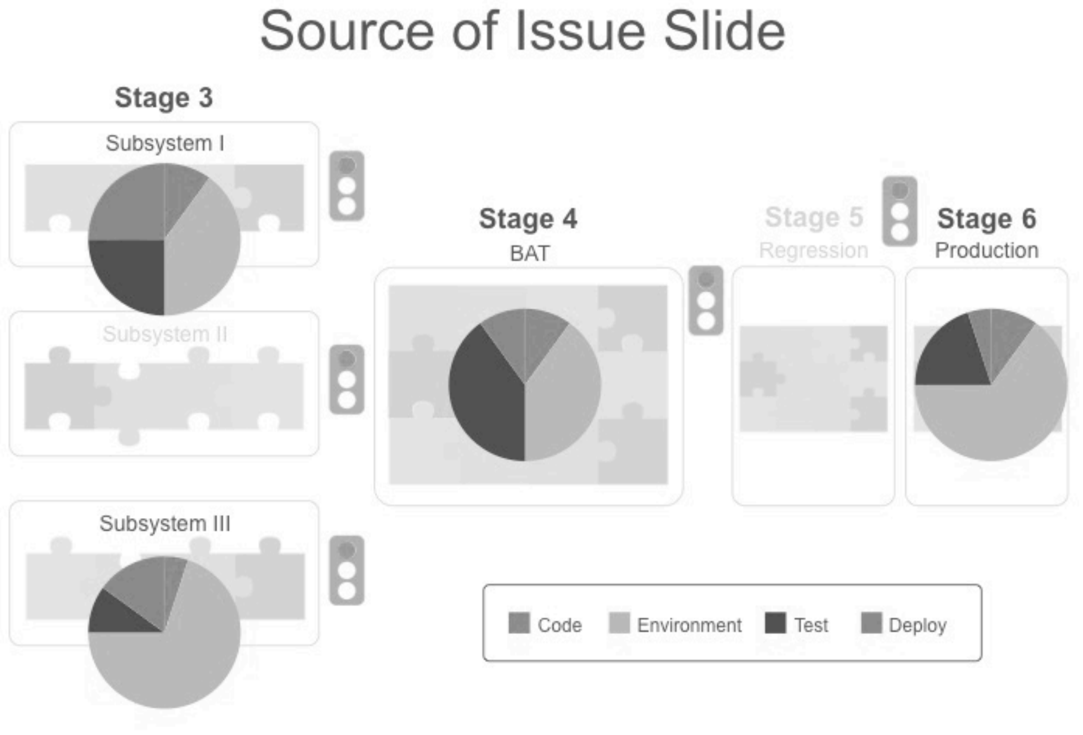
The reduction in cycle-time will also help to reduce the batch size, which makes triage in large, complex systems simpler because there are fewer changes since the last time the tests were passing. To reduce cycle-time you are going to have to automate long running manual processes, like testing, and manual processes done frequently, like deployments. Automating these repetitive tasks is required to reduce the cycle-time but is also required to make small batch sizes with simpler triage affordable. It has the added benefit of eliminating errors that frequently occur with manual processes. When you focus on reducing cycle-time with smaller batches it also forces you to fix issues that have been plaguing your organization for years. When you were not building, deploying, testing, or releasing as frequently, your organization could not see the issues as repetitive and they were just muscling their way through the issues every time. As you start increasing the frequency, this is not possible. You have to start understanding and addressing these issues and fixing them with automation where possible.



This example of a cycle-time map, while simplified to major subsystems, does help to target major bottlenecks. The stage 4 is taking 3 hours which is pretty good but subsystem II is stuck at 3 days with 1 day to deploy and 2 days to test. This would be a good target for improving cycle-time with some deployment and test automation. Additionally, if the deployment into production is taking a large group of people 18 hours you are not going to want to release more frequently until those issues are addressed.

Type of Issues map

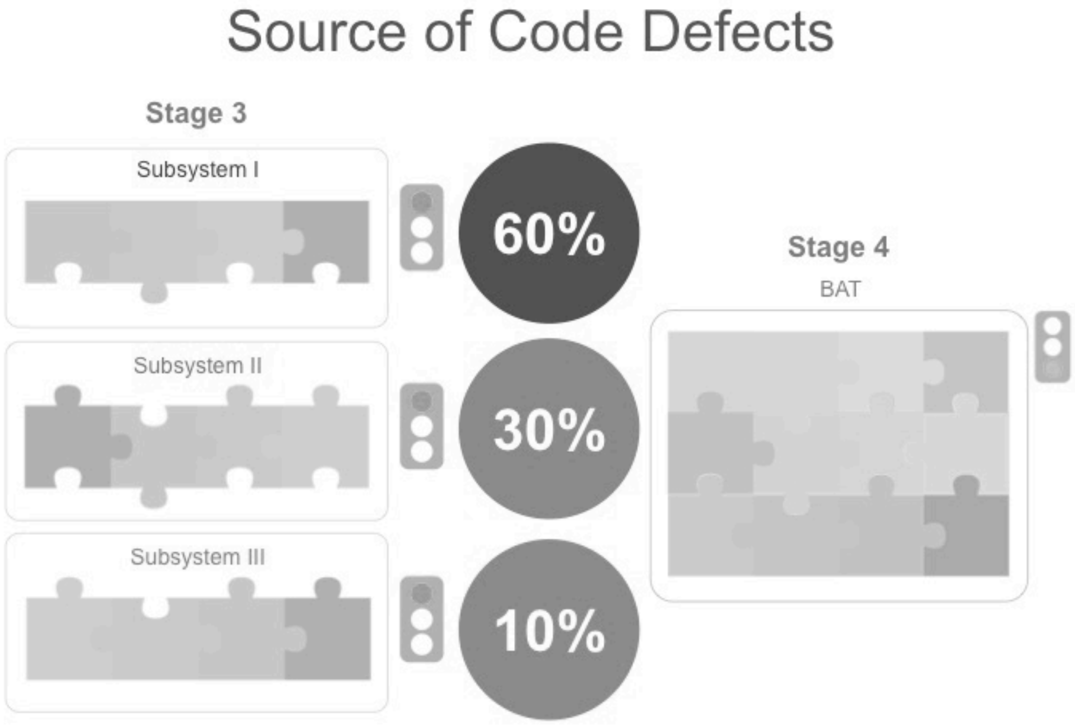
The next view we want of the DP is the kind of issues we are seeing at each stage because the type of issues will define what we start fixing first. With this map we are really trying to separate the new/unique work issues from issues caused by repetitive work, because the solution for these types of issues will be different. Additionally, we want to understand the source of the repetitive issues so we know what to prioritize fixing. The errors in repetitive work are addressed with automation, which also helps with cycle time. To understand which repetitive work in the DP that should be prioritized for fixing you should look at the cycle-time and type of issues map to determine where to start. Additionally, if a significant portion of your issues are non-code related you are going to want to automate your testing in ways that will make your triage process more efficient. Instead of just building an environment, deploying code, configuring data, and then running system tests, start using post deployment validation steps at the end of each step to ensure it was completed successfully and is ready for code testing. Then, when you run the system tests you can find code issues instead of starting a long, drawn out triage process across code, environments, deployments and data.



This example of the source of issues map shows that code is not a significant part of the problem. In this case, if you were to start your DevOps journey by gating code for your developers you would not be very successful. The developers would start by responding to all the failures but once they spent time debugging and realized that the issues weren't very often associated with their code they would disengage from responding to the feedback and your transformation would falter. Instead, in this example the team should focus on automating their environments and getting those definitions under version control so the DP is not being overwhelmed by those issues. Next they would need to address the consistency of the test automation because if these tests can't be used as a reliable gate for catching code issues they are not very helpful.

Mapping sources of Code issues:

Code issues are new and unique work. The key here to removing waste is in minimizing the time working on code that does not work together, does not work in production, and does not meet the business intent. You want to find these issues as quickly as possible to minimize waste. You also want to minimize the impact of these defects on the rest of the system. This is done by reducing cycle-time and gating defects from impacting the stability of the system. The cycle-time map will be used to drive feedback frequency. The sources of code issues will help you understand how to prioritize creating or improving code gates. The quality gates are really important to improving efficiencies in large complex systems. These gates push the ownership for triaging and solving the issues to people who created the problem and, more importantly, it improves the stability of the larger complex system so it is easier to triage. You should start with the subsystem that is leading to the most code defects and create a code gate for that application or subsystem. Start at the last integration point before production and work your way backwards creating gates and making the system more stable.



This example of the source of code defects shows that the majority of the defects in stage 4 are coming from subsystem I. It would be nice to automate the testing and gates for every subsystem from the start but that is just not realistic for most organizations. This mapping shows that you should prioritize investments in automated testing and improving the gates for subsystem I because it is causing the most issues. Next, move onto subsystem II when you have the bandwidth or it becomes the next biggest source of issues. It is this process of prioritizing test automation and gates for continuous improvements that provides code that is more stable on an ongoing basis and is closer to release quality for more frequent releases.

This new and unique work for SW will always be code but for embedded systems this gating is potentially new HW/FW subsystems that are not ready for product integration. Here it is important to create gates in your product development life cycle to ensure these subsystems are ready before committing to using new HW on the platform. This requires a longer-range view of the DP, but the basic principle of gating instabilities from impacting the broader system apply.

The other big source of inefficiencies in the time to find code issues is front-end branching. This is where different teams take a branch to create new capabilities. They work on the branches until the new features are ready and stable and then they integrate them on trunk. The problem with this way of working is that different teams on different branches don't see the interactions between the new code they are each creating until it is merged to trunk. As we discussed in chapter 4 this is a big cultural change for most organizations but it is also a big source of waste in most big, complex systems.

Putting it all together

These graphics and metrics show additional complexities that are important to think about with tightly coupled systems but the graphics are simple because they are created to fit into a book. Ideally, you would want your team to have their entire DP mapped out on the wall and that includes as many of the metrics from this chapter and chapter 3 as possible. It is this macro view of the elephant that you can use to get your organization aligned on where to start. Have the team review the mapping of all the metrics on your DP and see if you can get everyone to agree on the biggest issues and where to start.

When you are working on this alignment, it is very important to ensure that you have a repeatable process for gating code. The following questions are formulated to help you on that path. For each stage in the deployment pipeline do you have a stable environment for gating code? Are the automated tests reliable, maintainable, and triagable? Can you run all the tests multiple times in random order and get the same answer? Can you redeploy the same code and run the same tests and get the same answer? If not, do you need to start by focusing on the test and or environment/deployment issues? Are there certain applications that cause most of the defects in the enterprise system integration? Should you look at gating those applications first? How long does it take to build each stage of the pipeline? How long does it take to test each stage of the deployment pipeline? What is the source of defects at each stage in the deployment pipeline? In chapter 3 we talked about capturing the source of issues based on code, environment, deployment, data, or tests. In more complex systems like this with integration points it is important to understand the source of the code defects in terms of the contributing subsystem. This becomes really important in large complex organizations. Getting everything about environments, deployments, tests, and databases (repetitive work) automated is going to take time. You want dev and ops starting the automation where you are seeing the most issues or longest cycle times across the DP. If your big issues are code, you work on gates with test automation at integration points starting with the source with the most code issues. If your biggest issues are repetitive tasks, you start with automation where it adds the most value in terms of repeatability and speed.

This process is going to take some time and be a journey for the organization. It is important to get everyone aligned so you are going through the journey as a team. There will be missteps and mistakes along the way but if it is the team's plan they will own making it successful. The important part is getting them to agree on where to start and being willing to engage with the team on the journey. I would recommend against planning this effort too far into the future because everyone is going to learn so much about what needs to be changed. As I work with organizations, they frequently find what they felt was the biggest issue was just the first layer of the onion. In these cases, if they had created a long-range plan for improvement, it would have required a complete rework of the plan when they discovered the next layer of the onion. Instead, up front, work to get agreement across the business that you will invest X% of your capacity for these improvement efforts then get started with the continuous improvement process using your map of the deployment pipeline as the guide.

Chapter 9: Practices for tightly versus loosely coupled Architectures

First, I want to acknowledge that everything you are hearing about DevOps practices are correct, but lots of it really best applies if you have 10-20 person problems. The perspective you have on DevOps and how to improve flow in your organization is going to depend largely on the size of the organization and the coupling in your architecture. If you have a small organization or an architecture that enables small teams to independently develop, qualify, and release code then it is going to drive your view of DevOps and how you improve flow through the system. If, on the other hand, you have a large organization with a tightly coupled architecture that requires coordinating development, qualification and deployment across 100s to 1000s of people you are going to have a completely different perspective on how to design and optimize your deployment pipeline. We have covered a lot of the differences so far at a macro level. The differences are profound enough, that it makes sense here to review the biggest differences, why they exist, and why understanding them is important to your organization.

Saying that DevOps requires developers to push code into production without any approvals is a classic example of where understanding how DevOps is used in loosely-coupled architectures and applying that to tightly-coupled architectures is not the best practice. In organizations with loosely-coupled architectures, in a small team one person can understand the entire application and fix it quickly if it fails in deployment. They also test in hours and have trunk at production-level quality. For them, waiting for the approval is the long lead-time item. For most enterprises starting DevOps, the approval time is so far down the parato chart that it is hard to see why you would even bother. Current DevOps thinking says that in order to do DevOps, developers must be able to push into production. This flies in the face of ITIL with separation of duties and it is a nightmare to audit for regulated groups. People hear this and say "well if that is DevOps I can't do DevOps because I am regulated". Besides, when the ITIL process people or auditors hear this they will throw up all sorts of roadblocks." So, now DevOps thinking is fighting an industry battle to get people to agree that separation of duties is not a requirement for regulatory so that enterprises can do DevOps. This is a misguided fight. It misses the point.

DevOps thinkers are getting so caught up in this debate that they are ignoring the 6 weeks it takes to test the code and get it production ready. There are so many other things these organizations can be doing to remove waste and increase the frequency of deployments without taking on this political battle that won't provide much benefit. The large, tightly-coupled organizations would be better served by mapping their complex deployment pipelines and working to address the waste and inefficiencies that exist in their organization instead of saying they must do X to be doing DevOps.

Additionally, in small teams when the developers are pushing code into production the likelihood that someone else is pushing in conflicting code changes at the same time they are is fairly low. If there are 100s of developers working on a tightly-coupled system who can independently deploy code whenever they like, the likelihood of finding issues in production goes way up. Therefore, it does not make sense to have developers pushing directly into production. Instead, in large systems the developers should check code into the SCM once they feel it is ready, and they have done all the right level of pre-testing. After that, the DP is automatically kicked off with the continuous integration process. The DP then moves this code together with all the other changes through each stage of the DP. If a quality gate fails then the developers in that batch need to respond and react to the failure but they are not responsible for deploying the code into production. The deployment into production is the job of the automated DP. This is very different from loosely coupled systems where developers independently push into production but it is required when you are trying to coordinate the work across 100s instead of 10s.

You should also consider another difference for environment availability for the complex deployment pipeline. In the basic construct, you are concerned about how long it takes to provide a developer an environment for testing before pushing code into production. You need environments on demand so developers are not waiting and can validate their changes easily so they catch their own defects. This requires an environment. In large complex systems once developers think it is ready instead of pushing into production, they should just commit code to the SCM. The DP pipeline then monitors the SCM for changes and kicks off builds that flow through the deployment pipeline. This creates an additional need for environments to support the DP. You need the ability to setup up these environments easily, but once this is set up, it is not really an environment-on- demand situation. It needs to be rebuilt on a regular basis with the latest definition of infrastructure as code but the demand of DP environments should not be that variable.

The tools processes and approaches from development into and through the DP should be consistent as possible without any discontinuities. This is something else that is important for more complex DP. In the more complex situation there are two different needs for environments. The first need is having an easy-to-get-to place for the developer to validate their change before committing the code. These are environments available to the developer that can quickly be spun up and down. The second need is that environments are necessary to support each stage in the deployment pipeline. These environments are part of the deployment pipeline. These are to be used by the pipeline automation based on the CI process monitoring the SCM. The developer never really deploys directly to these environments, they just check in code and that kicks off the automation that deploys, tests, gates, and progresses code all the way into production. This may help to address the concern some large organization have that DevOps means giving production-level access to developers and letting them commit code. With a well-defined deployment pipeline that is not the case. The pipeline deploys into product as long as the code meets all the gating requirements defined in terms of automated tests by the current approvers.

This automated DP pipeline can also cover the concerns with the approval process when that starts becoming the bottleneck that tends to be more important in large complex organizations. In this case instead of removing the separation of duty and all of those concerns, simply have the person responsible for the approval process describe the criteria they use for approval so you can create an automated test to represent their signoff. This approach has a few advantages. First it forces more rigor into a somewhat arbitrary "management approval" process; they have to be clear about the criteria. Second, this approval process is documented in the SCM with an automated test so everyone can see and suggest modifications if required. Third, it is fast and automated by the DP so nobody is waiting around for manual approvals.

Another difference is having developers wear pagers, and not having a DevOps team, as being a key practice. This works well for small teams because when the developer is paged out, the service they are supporting is small enough that they probably know what to fix or at least who to call to get help. It is also easy for that small team to add some operations perspective to the groups to figure out how to own their service end to end. This is not the case when you have 100s to 1000s of people working in a tightly-coupled system. If a developer is paged out to fix a problem, the likelihood that it is due to code they know anything about is pretty low. It may create some empathy for what operations is dealing with but they aren't very likely to be in a position to help. Additionally, adding an operations person to the scrum team in a tightly-coupled system may help with environments or a simple CI process, but they are not likely to design, create, maintain, and optimize a large complex DP. This is going to take more of a structured effort. It could be led by operations, development, QA, release, or a DevOps team but someone is going to have to play that role.

For tightly-coupled organizations it is more important to build up stable enterprise systems using a well structured DP with good quality gates. Before the transformation many of these organizations spend lots of time and effort setting up very complex Enterprise test environments where they do the majority of their testing. These large test environments can be very expensive and hard to manage so they are not a very efficient approach for finding defects. For these organizations it is much more important to push the majority of testing and defect fixing down into smaller less complex test environments with quality gates to keep defects out of the bigger more complex environments. This helps to reduce the cost and complexity of the testing. It also helps with the triage process because the issues are localized to the subsystem or application that created and needs to fix the issue. These types of issues really don't apply to loosely-coupled organizations where the DP does not have to pass through these complex test environments.

Lastly, in large, tightly-couple systems the automated system testing becomes much more important. With loosely coupled systems quick running unit tests can frequently find most of the issues. With tightly-coupled systems, by definition that is not the case. It requires creating effective system tests that can quickly find the unknown consequences of a change. It is also really important that these system tests and the framework are maintainable and triagable if the DP is going to be effective.

The general DevOps principles are the same for large and small DPs. It is all about how to improve the frequency of deployment while maintaining all aspects of quality, which requires coordinating work across people. As outlined here, however, the practices that you use for coordinating the work across 10s of people versus 100s of people though can and should be different.

Chapter 10: The Impact of Moving to DevOps in Larger More Complex Organizations

Once all the changes we have discussed in this book are in place, they can have a dramatic effect on how the business works. They impact how we manage the software development, how we run the ITIL process, and how we do auditing.

Large software projects are hard to manage. It is difficult to coordinate the designs and work across different developments team that have code that has to work together. Traditional organizations put lots of meetings and checkpoints in place to coordinate this work. This is especially important if the development organization is geographically dispersed and even worse if they are different contractors working on the code. The inefficiencies and waste associated with trying to understand and coordinate this work can be huge. Once you have a well-structure rigorous DP in place you will find that the working code is the forcing function that aligns and coordinates all this work. The teams and different contractors all need to be checking in their code on a regular basis to ensure it all works together and they are responsible for resolving those issues real-time if they are going to make it through the quality gates. You will find with the deployment pipeline that working code is the forcing function that aligns all these different development teams. The same thing happens when all the different organizations from development through operations are using infrastructure as code to coordinate their work. That working code becomes the forcing function that gives those teams a common objective of keeping the code working in a production-like environment. The other big change is that holding big meetings, or scrum of scrum meetings, become less important because everyone can watch the working code progress down the deployment pipeline.

The area where there are big changes with the ITIL processes are for configuration management. With ITIL, any changes to production configurations were manually documented in change management tracking tools, manually approved by management, and then manually implemented. With a rigorous deployment pipeline all that tracking, documenting, and implementation is all automated and the changes are tracked in the source control management tool, that is designed for tracking changes. The implementation uses this documented automation code to make any changes, ensuring what we said was going to happen actually happened like we said it would. Additionally it requires that approval processes that used to be arbitrary management decisions are documented with automated tests that support more repeatable and rigorous criteria for release.

This fundamental shift to a deployment pipeline provides significant improvements in the auditing and compliance processes required for most organizations. Before Auditing required working through a sampling of change tickets to see if the appropriate people approved the change before it went into production and that the change implemented was actually what was approved. This is what happens before creating a rigorous deployment pipeline. It requires auditing a small sample of the change requests to ensure everyone in the organization followed the process and manually going through different systems to pull data to show the process was followed. After the automated deployment pipeline is in place and everything is automatically documented, it is much easier to ensure that the process was correctly followed for every change. This approach really takes advantage of what computers do very well, which is to repeat the same thing over every time the same way. The automation may initially be wrong but once you get it fixed you can count on it being done the same way every time, which is something very difficult to get humans to manually implement. The changes and criteria for approval are also automatically documented in the SCM tool where it is very easy for the auditors to see exactly who changed what and when. It is a huge improvement for both the efficiency and effectiveness of auditing but it is also a big change. Therefore, it is important to include the auditors early in the process. Help them understand how this is going to help them do their job better and include them in the process so they can help define what data they need and where it will be kept. This is about organizational change management with the auditors also so it important to include them in the plans so they will own making their ideas successful.

Moving to DevOps for large, tightly-coupled organizations is a big job. It requires addressing waste and inefficiencies that have existed in your organization for years. The DP with the framework and metrics provided, though, provide a systematic approach for getting everyone one the same page for optimizing the entire system. The DevOps practices provide techniques for addressing the waste to improve the deployment frequency while maintaining all aspects of quality. The principles are the same across large and small teams but the practices can and should be different.

In large complex systems it is important for the executives to pull the technical and managerial leaders for a DP together to get everyone to agree on where there are the biggest opportunities for improvement. They need to kick-start and lead the ongoing continuous improvement process. By following this process and using the DP framework provided by Jez Humble and David Farley they can align the organization on a common plan that will result in a high performing DevOps elephant.