Introduction to DevOps

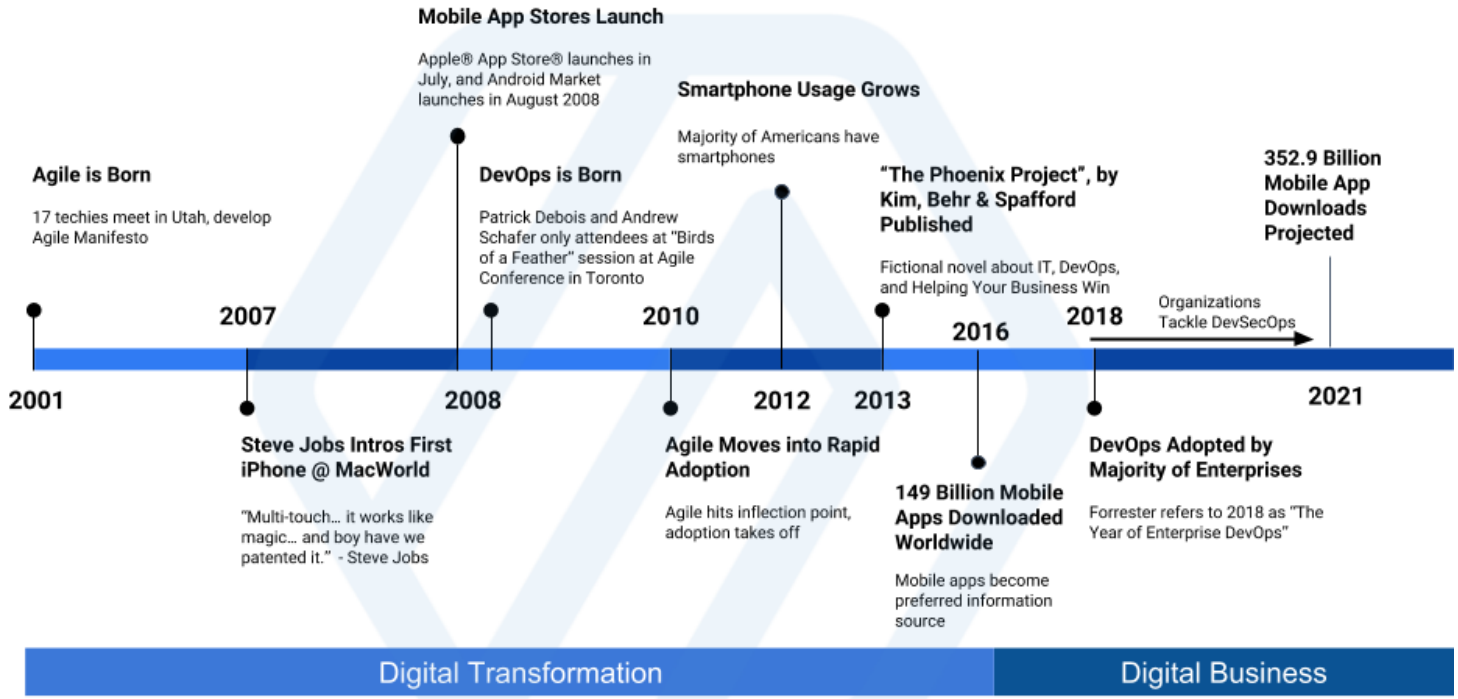
Lecture 2
Course: DevOps Engineering

Agenda

- Introduction to DevOps
- Motivations
- Technical solutions

Early history of DevOps

- DevOps was introduced in 2009, in a conference talk by some Fickr people
- Video of the talk: https://www.youtube.com/watch?v=LdOe18KhtT4



Software evolution

Let S_1 be a system in production.

Then an event ***e*** arrives. This event ***e*** could be (just to mention some):

- an idea for a new feature to add to S_1
- a problem found with S_1
- a competitive pressure, to change and improve S_1
- a desire for more efficiency of S_1
- a merger between two organizations using S_1 in different ways

In any case, the event ***e*** causes a requirement for either creating a new system S_2 or modifying S_1.

Remark: modifying S_1 is, by far, the most common response.

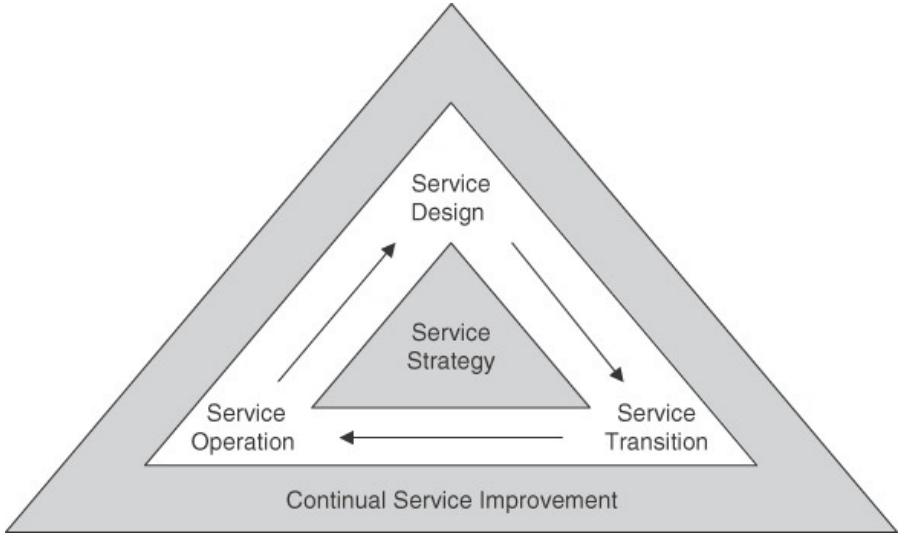
Requirements are developed in software

- The triggering of event ***e*** causes requirements to be generated
  - Requirements Engineering
    - Elicitation: capture the stakeholders needs
    - Analysis: refine stakeholders needs into “formal” product requirement specification
- “Formal” product requirement specification
  - Documents, Models (Waterfall/RUP)
  - User stories (Agile)
  - Orally (everywhere)
- Requirement specifications are divided and assigned to development teams

Remark: from now on, “requirement specification” = “requirement”

Operations (Ops)

- One characterization of Ops is given in the Information Technology Infrastructure Library (ITIL).
- ITIL acts as a coarse-grained job description for the operations staff.
- ITIL is based on the concept of “services,” and the job of Ops is to support the design, implementation, operation, and improvement of these services within the context of an business strategy
- An operations service can be the provisioning of hardware, the provisioning of software, or supporting various IT functions.
- Services provided by operations also include the specification and monitoring of service level agreements (SLAs), capacity planning, business continuity, and information security.



https://www.atlassian.com/itsm/itil

Event management in Ops

- Operators manage events throughout the services life cycle, which includes detecting events, monitoring a state of a service, and sequencing and categorizing events to determine the best course of action.
- Ops ensure that all operations run smoothly and that each event is handled in a timely manner with the appropriate response.

- There are three types of events:
  I. Information: Logs and reports such as basic status updates.
  II. Warning: Activities outside of the normal operations.
  III. Exception: Events that indicate something is wrong and services have been negatively impacted, such as a service network being down.

Main tasks of Ops (eg. In the cloud)

- Service management automation and integration
- Consolidated monitoring of cloud environment to get a single-pane view
- AI and Automation as a foundation layer
- Comprehensive ITIL-based operations framework
- Ability to integrate existing resources for deployment and support
- Manual and automated orchestration
- Integrated governance with quarterly audit and management reviews

https://www.coforge.com/services/cloud-and-infrastructure-management-services/cloud-services/cloud-operations

Over the wall development

Requirement is specified

Developers implement

Operators place in production

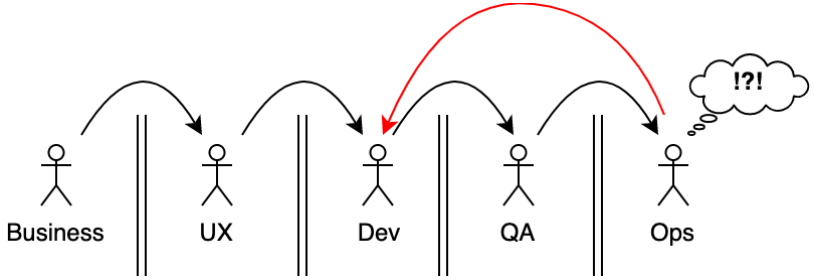
Time

Video: https://www.youtube.com/watch?v=Xrgk023l4lI

Developers organisation and work

- There are several (and different) development teams.
- Each dev(eloping) team gets its requirements.
- Developers on each dev team work on requirements.
- At some point the dev team feels they have satisfied the requirements they have been assigned.
- Their code is complete –> their job is done.

The wall of confusion



- refers to the phenomena that occur when one group in a value stream approaches their job as complete when they've passed it onto the next group.
- The canonical example is when developers throw their code "over the wall" to their ops colleagues and don't pay attention to what must be done to actually get the software they've written into a deployable state
- This often causes the ops team to struggle with getting the software actually deployed, and can lead to significant delays in releases and raised the risk of defects and other problems
- This phenomenon is not limited to development and IT operations

https://levelup.gitconnected.com/the-wall-of-confusion-623057a4dd26

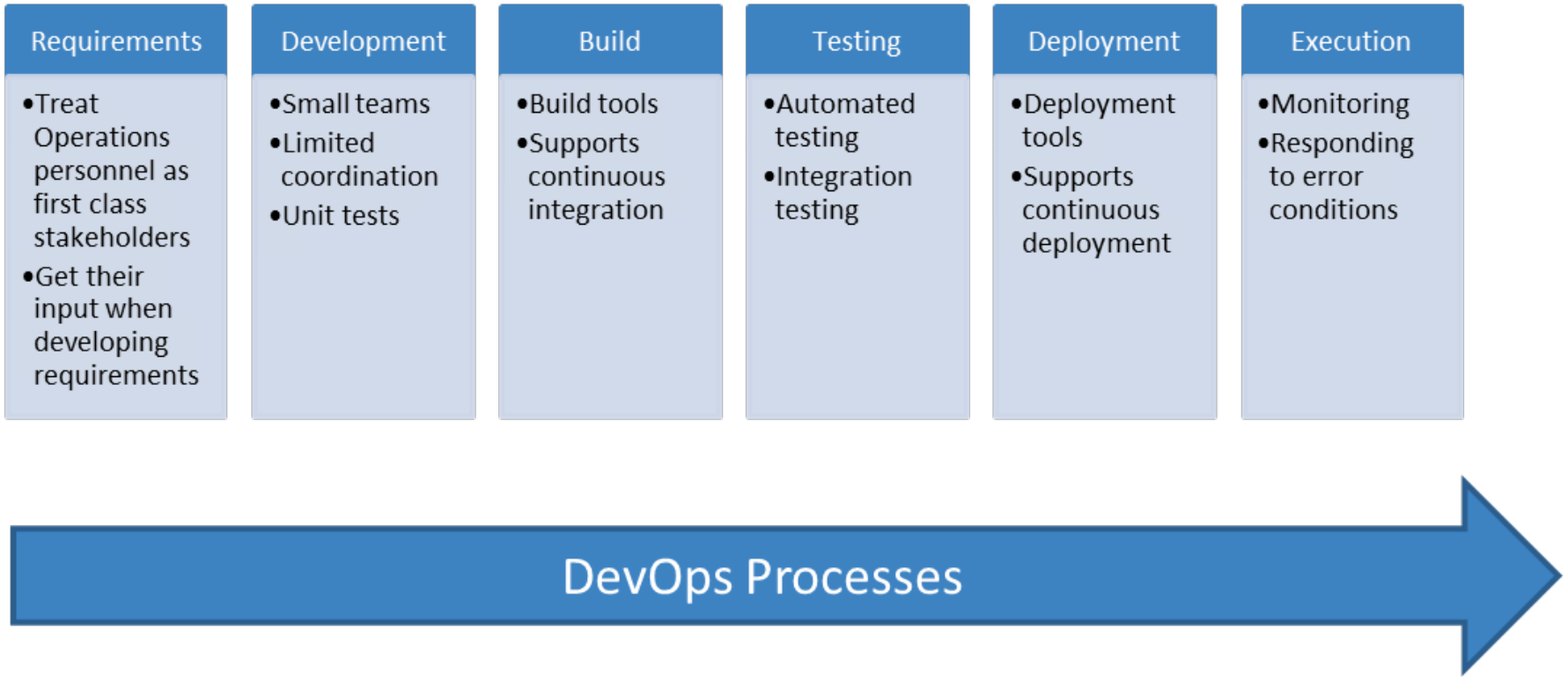
What is wrong?

- Code Complete ≠ Code in Production

- Between the completion of the code and the placing of the code into production there is a step called: Deployment

- Deploying completed code can be **very time consuming** because of concern about errors that could occur.

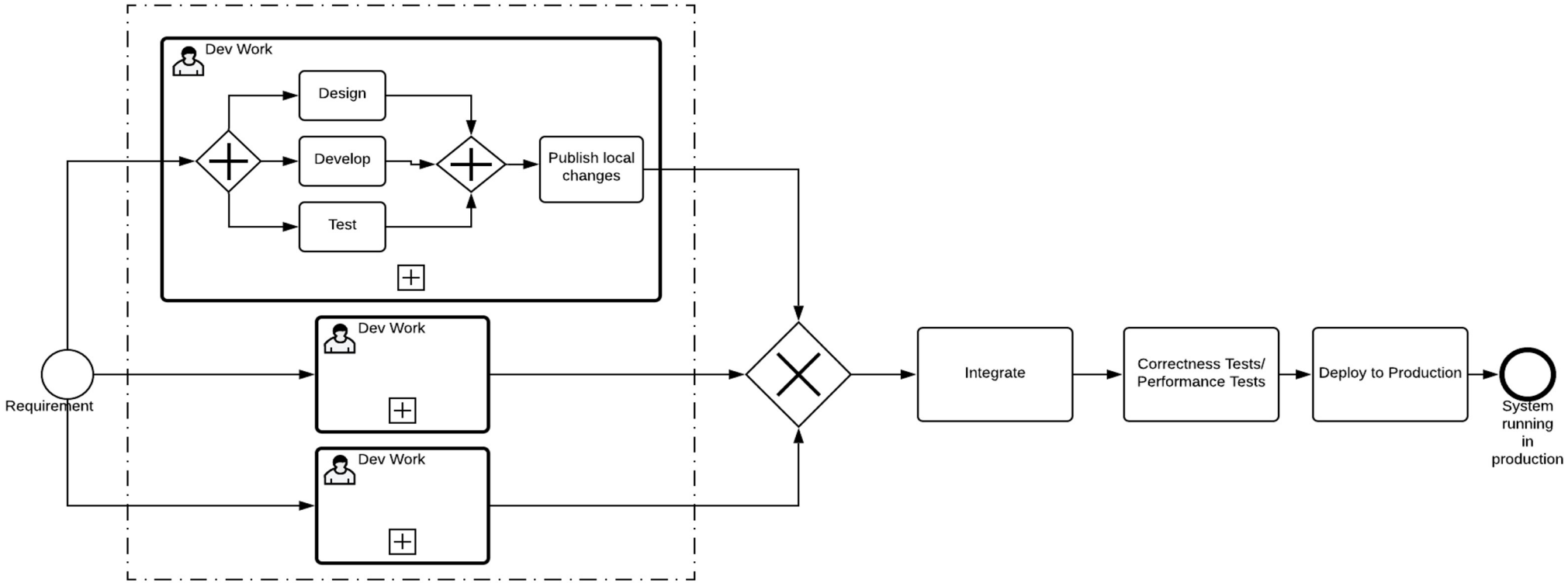
operations personnel are first class stakeholders



Multi-team development workflow

- You **design, develop** and **test** your code in isolation.
- Your code is **integrated** with code developed by other team mates or teams to see if *an executable* can be constructed.
- The built system is **tested** for correctness.
- The built system is **tested** for performance and other qualities.
- The built system is placed into **production**.

Multi-team development workflow (BPMN 2.0)



http://www.bpmn.org/

Software Development Life Cycle (SDLC) multiteam

- SDLC: it is a series of **phases** that provide a common understanding of the software building process.
- SDLC Examples (*)
  - Waterfall
  - V-Shape
  - Prototyping
  - Spiral
  - Iterative and Incremental (eg. RUP)
  - Agile

What is the SDLC that corresponds to a multi-team development workflow?

(*) from https://melsatar.blog/2012/03/15/software-development-life-cycle-models-and-methodologies/.

Iterative and Incremental - multiteam

Pros

- Produces business value **early** in the development lifecycle.
- Better use of **scarce** resources through proper increment definition.
- Can accommodate some **change requests** between increments.
- More focused on **customer value** than the linear approaches.
- We can detect **project issues** and changes earlier.

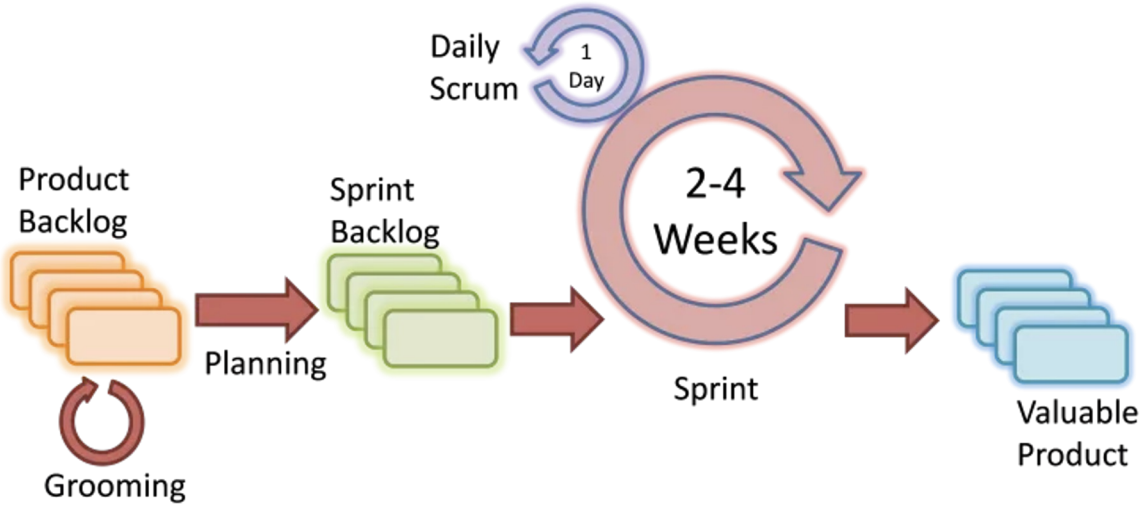
Cons

- Requires **heavy documentation**.
- Follows a defined **set of processes**.
- Defines increments based on function and feature dependencies.
- Requires more **customer involvement** than the linear approaches.
- **Partitioning** the functions and features might be problematic.
- **Integration** between the iterations can be an issue if it is not considered during the development and project planning.

Agile

Pros

- Decrease the **time required** to make use of some system features.
- Face to face communication and continuous inputs from **customer representative** leaves no space for guesswork.
- The end result is the **high-quality** software in the **least possible time** duration and satisfied customer.

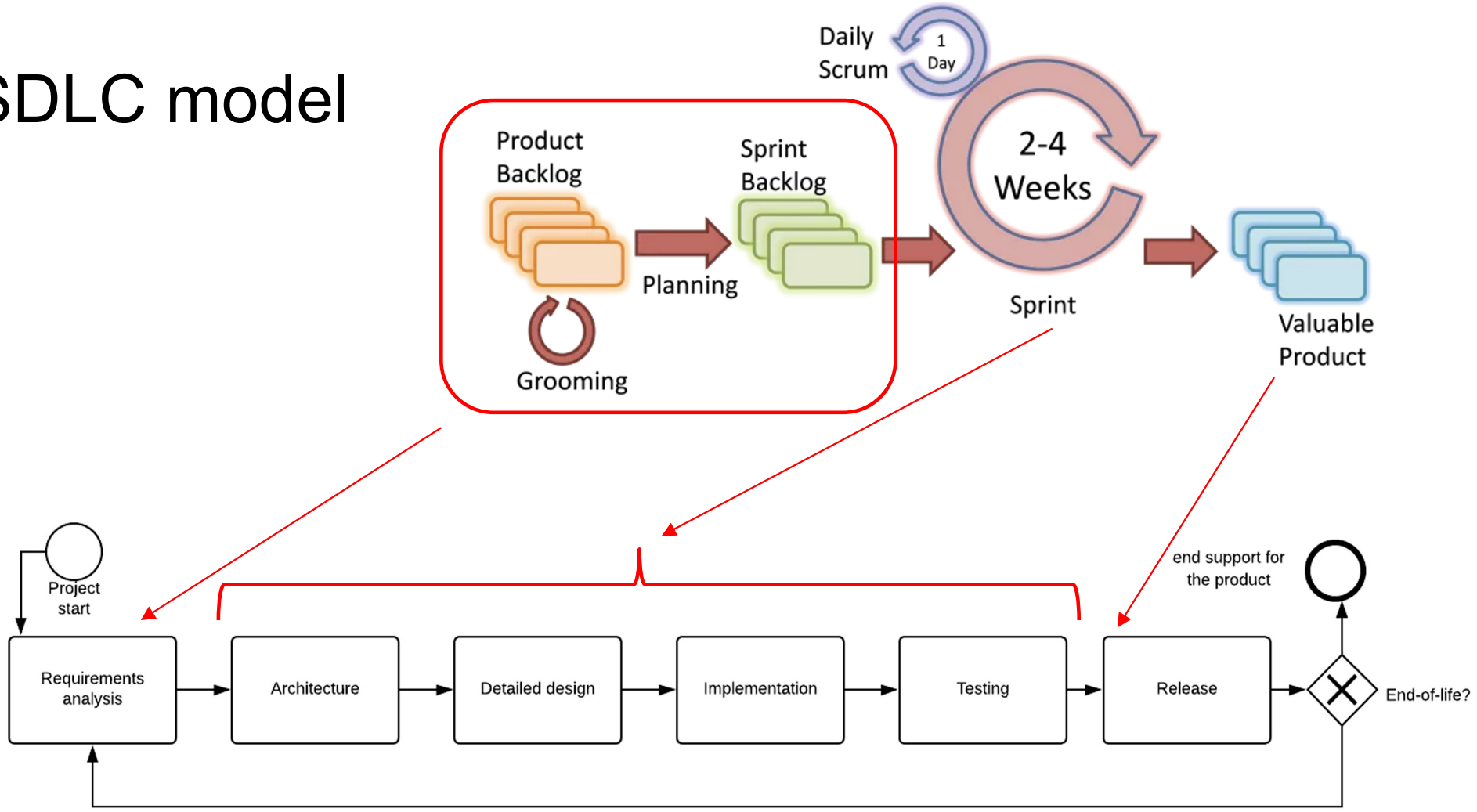


Cons

- **Scalability. (*)**
- The ability and collaboration of the **customer** to express user needs.
- **Documentation** is done at later stages.
- Reduce the usability of **components**.
- Needs **special skills** for the team.

(*) Read Agile at Scale

SDLC model

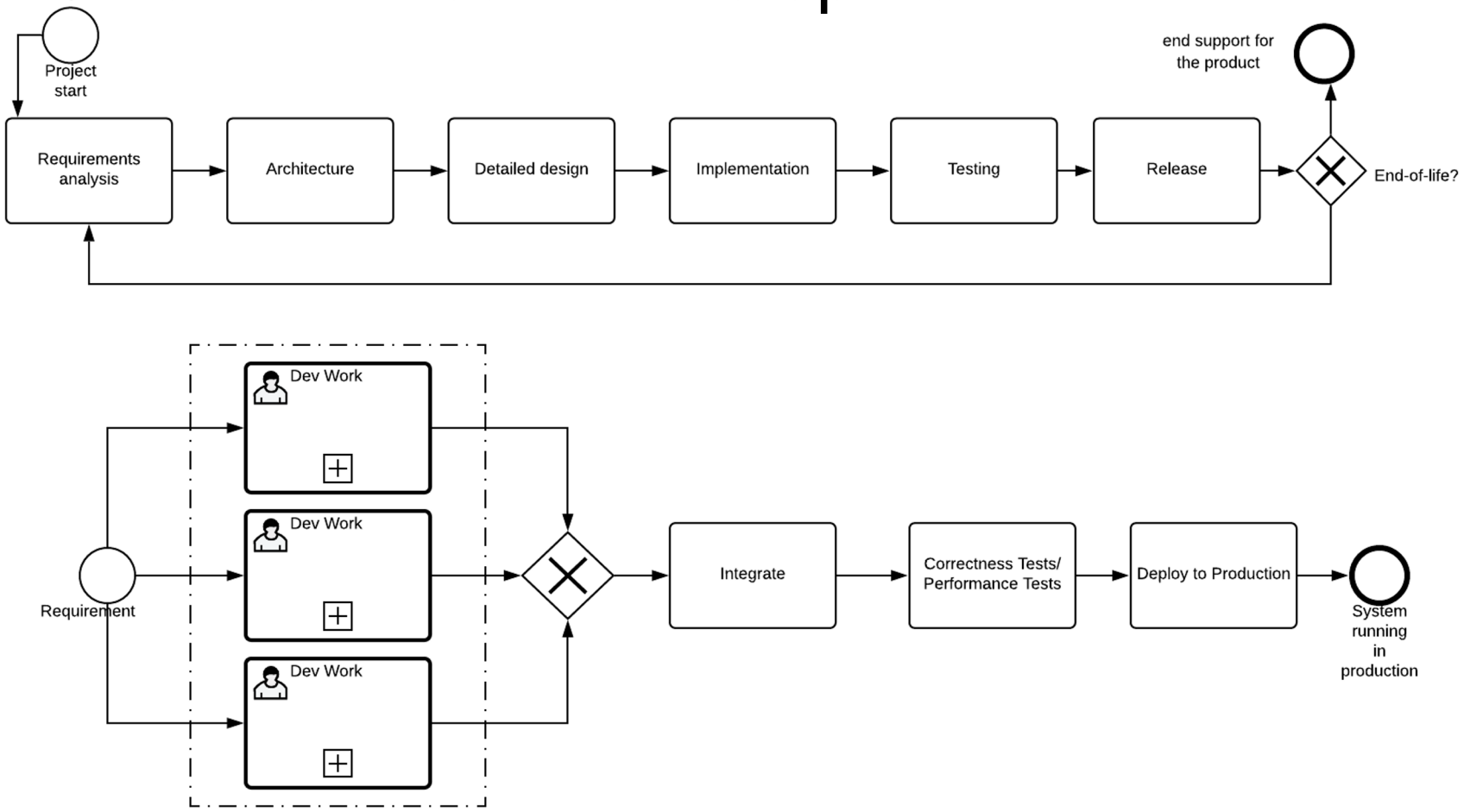


Video: https://www.youtube.com/watch?v=i-QyW8D3ei0

Boundary objects

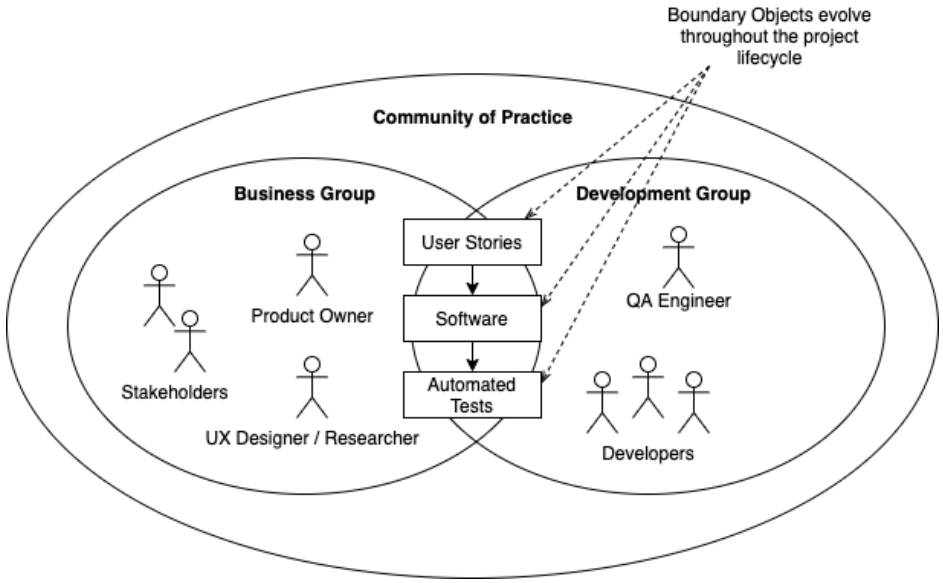
- These are objects which sit at the boundary of your system. Any object which takes input from or produces output to another system — regardless if that system is a User, the internet or a database — can be classified as a boundary object.
- These boundary objects are responsible for translating information into and out of our system.
- Example: in order to take User commands, we would need the boundary object to translate a keyboard input (like a spacebar) into a recognizable domain event (such as a character jump).

SDLC vs. Multi-team development



Boundary objects

- In earlier stages of the project, a rapid prototype (or wireframes) might be the boundary object. In later stages, it might be automated tests.
- Agile User Stories are a popular example of boundary objects. Kanban cards are another example of boundary objects.
- Both are small enough to let to follow the work through the system, but can also contain deeper layers of information in the form of Gherkins, diagrams, mockups, discussions, decisions, and any other relevant information needed to get the work done.



https://levelup.gitconnected.com/the-wall-of-confusion-623057a4dd26

What can go wrong?

- Wrong version deployed
- Deployment takes too long
- Bugs are fixed too slowly
- Source of bug is not identified soon enough
- Bugs are reported to the wrong team
  - Is it a network issue?
  - Not enough capacity on the server?
  - Software configuration error?
  - A bug in the code?
  - User error?

What can go wrong? – Integration

- Not all portions of the system are available
  - Portions developed by other teams
  - Portions developed by 3rd party
  - Names and signatures of methods from other software are inconsistent
- Sequencing errors
  - Other teams do not follow the contract with your code in terms of sequence of method calls
- Version incompatibility
  - Your team assumed version A of 3rd party software but the build downloads version B

What can go wrong? – Integration (2)

- Data problems
  - Database data is not refreshed for each test
  - Data does not flow correctly to your code
- Configuration problems
  - Configuration parameter settings for code developed by different teams is incompatible
  - Configuration parameters are not specified
  - External services are not reachable for security or configuration reasons
- ...

What can go wrong? – Performance / Acceptance Test

- Configuration problems
  - External services not available because of lack of permissions
  - Inconsistent configuration settings
  - Leaking into production environment
- Data problems
  - Database is not representative of production database
  - Stale database after tests
- ...

What can go wrong? – Production

- Configuration problems
  - Requires authentication and authorization
  - Inconsistent configurations
- Performance problems
  - Under actual load, system may not have adequate performance
- Logical problems
  - May require new version to be rolled back
  - Database may have been corrupted
- ...

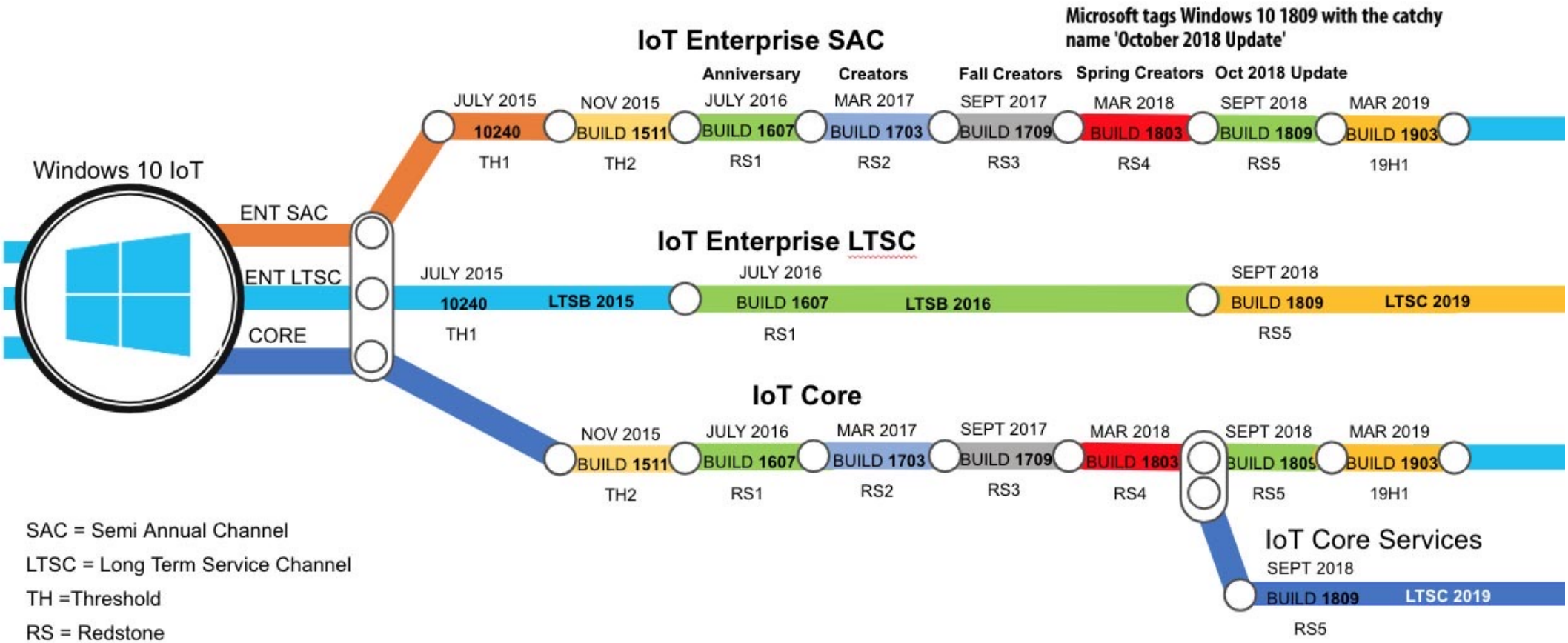
While you look into the problem, time is passing

- Every error must either be **corrected** or **prevented**.
- Preventing errors can be done through some combination of:
  - Software Development Process
  - System Architecture
  - Tooling
  - Coordination among teams.
- Coordination **takes time**.
- Correcting errors **takes time**.

How much time?

- Historically, for complex software products (eg. Office or Windows) releases are scheduled for once a quarter, or once a year to give time to coordinate and adequately test.
- This means there may be **months delay** before a new concept or feature is added to a system.
- **This delay has become more and more unacceptable.**
  - Internet companies deploy **multiple times a day**
    - Amazon had a new release to production every **11.6 seconds** in May of 2011.
      - Velocity 2011: Jon Jenkins, "Velocity Culture". Jump to min 10:00 to go straight to the point.

Windows 10 IoT Road Map 2019



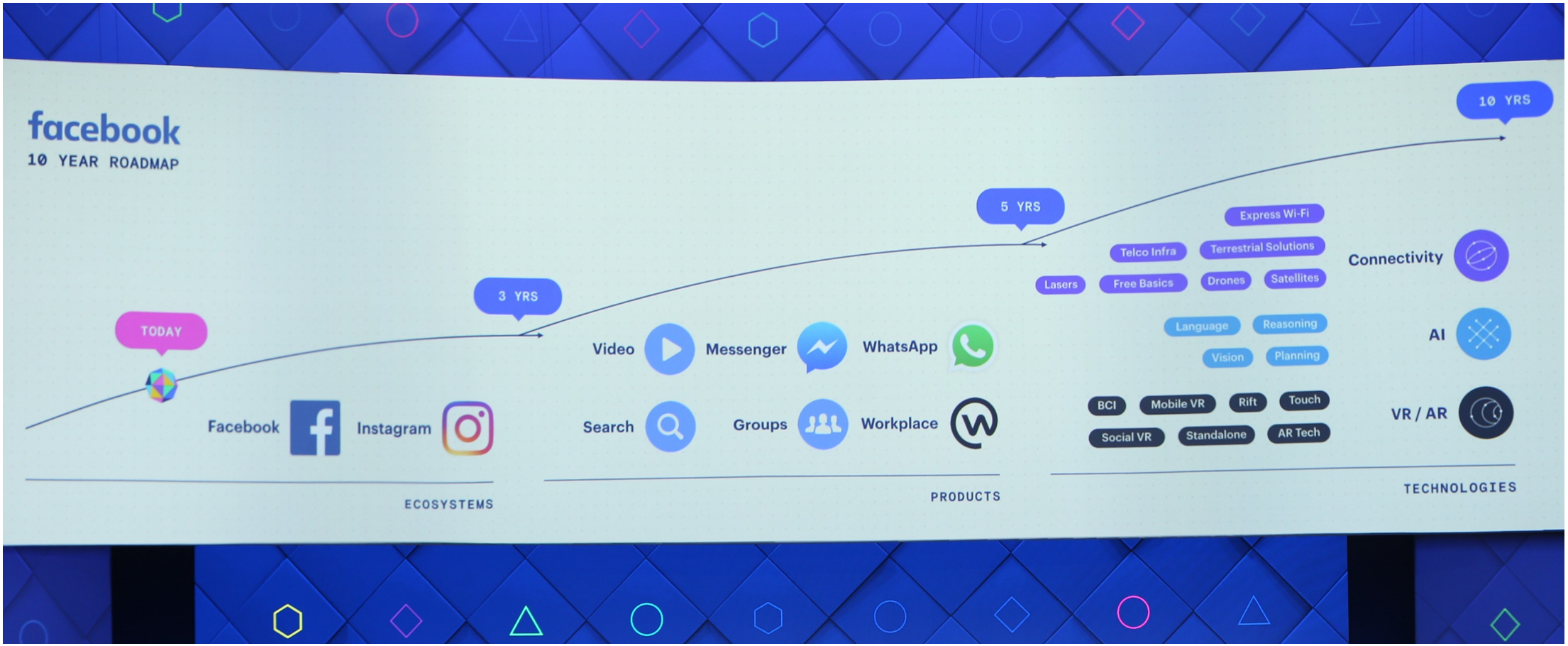
SAC = Semi Annual Channel

LTSC = Long Term Service Channel

TH =Threshold

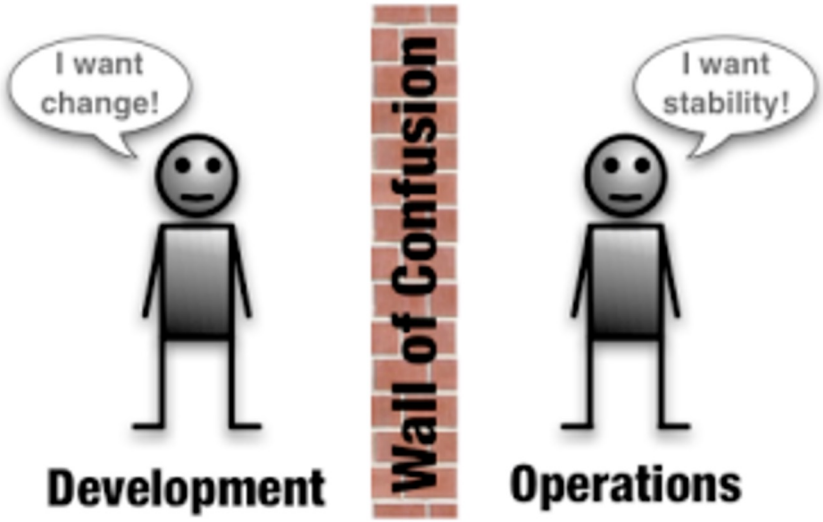
RS = Redstone

Facebook roadmap (Zuckerberg 2016)



Problem

- Velocity of new releases (Dev)
  - The businesses want to get valuable new software to keep increasing revenue
    - Pressure over developers.
- Ensuring quality of service (Ops)
  - If there is no requirement for quality, then releasing that the system being released is usable.
    - Ops see any change as a risk.



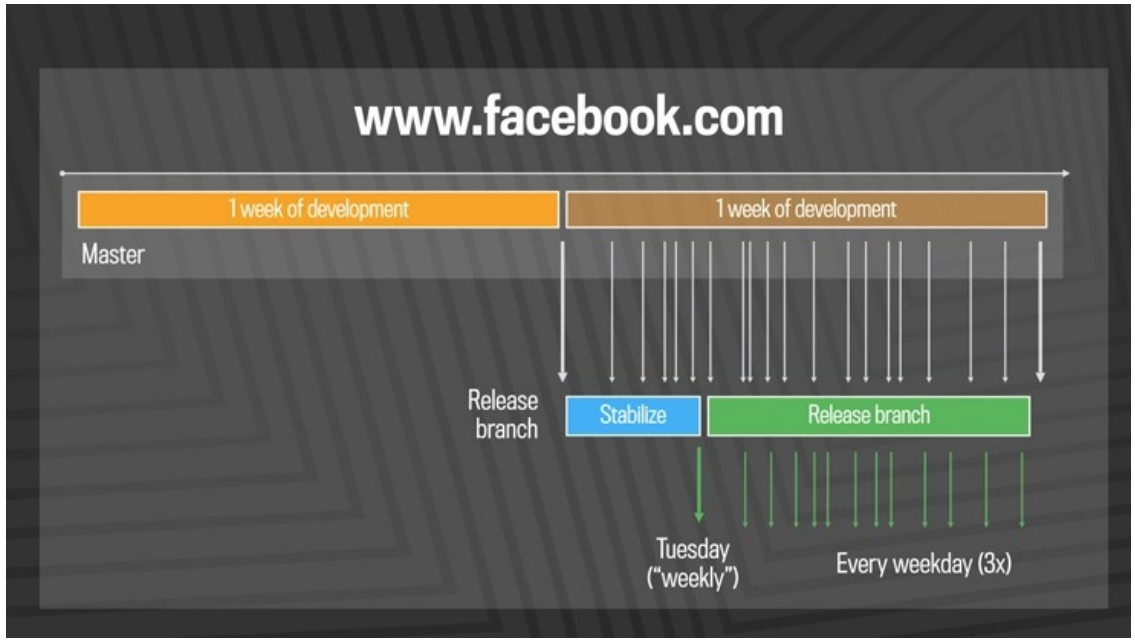
What can we do?

see “Balance Velocity and Risk by Having DevOps Teams Earn Leaner Processes” (2018)

Facebook till 2016

The approach «synchronize and stabilize» over a development cycle of 2 weeks worked well until 2016

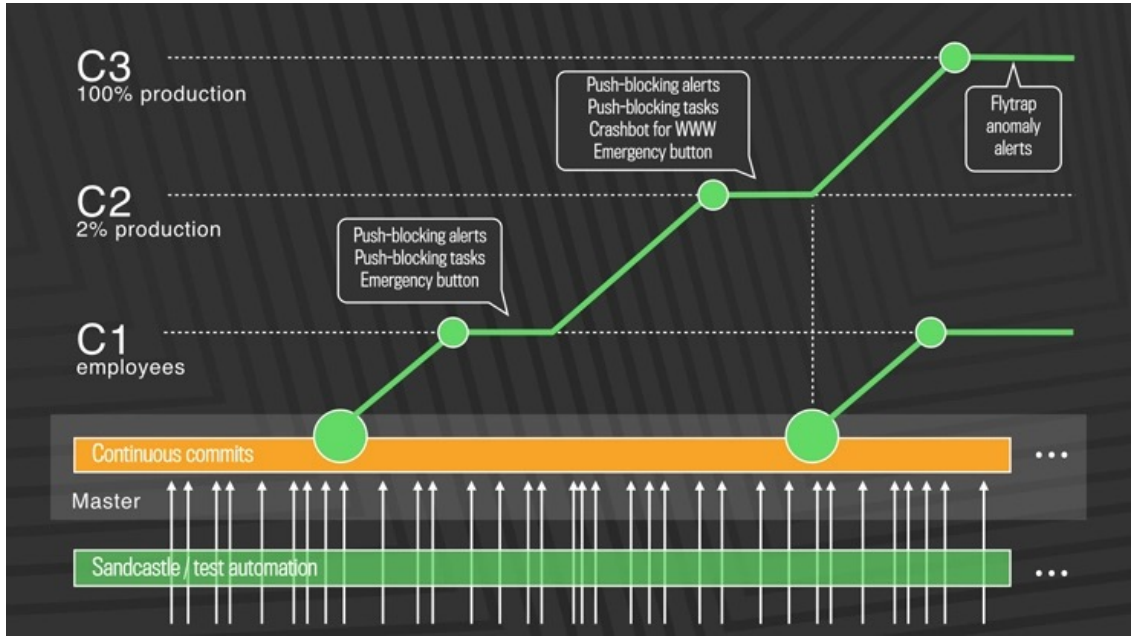
as they added more engineers, they got more done — the [rate of code delivery scaled] with the size of the team.
But it took a lot of human effort in the form of release engineers, in addition to the tools and automated systems in place, to drive the daily and weekly pushes
They understood that batching up larger and larger chunks of code for delivery would not continue to scale as the team kept growing.



https://engineering.fb.com/2017/08/31/web/rapid-release-at-massive-scale/

Facebook after 2016

the code velocity at Facebook required to develop a system that pushes tens to hundreds of diffs every few hours.
The changes that get made in this quasi-continuous delivery mode are generally small and incremental, and very few will have a visible effect on the actual user experience.
Each release is rolled out to 100 percent of production in a tiered fashion over a few hours, so they can stop the push if found any problems



https://engineering.fb.com/2017/08/31/web/rapid-release-at-massive-scale/

What is DevOps?

- No standard definition of DevOps until 2021.
  - “DevOps is a cultural movement” [2]
  - “DevOps is interaction between development and operations personnel” [4]
  - “DevOps is …” -> see [3] for a long list of definitions

- A standard definition of DevOps has been issued in 2021:
    - IEEE Standard Initiative Working group created in 2016. [6]
    - The final standard IEEE Std 2675-2021 [9]

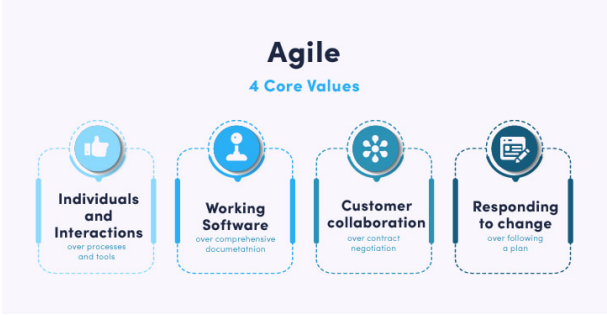
IEEE Standard 2675-2021 DevOps

Contents

DevOps definition from the IEEE standard 2675

- *Set of principles and practices which enable better communication and collaboration between relevant stakeholders for the purpose of specifying, developing, and operating software and systems products and services, and continuous improvements in all aspects of the life cycle* [9]

- Principles and the related cultural background (agile, lean) are included in the definition (DevOps is a social construct)



DevOps definition - for us:

- *“DevOps is a set of **practices** intended to **reduce the time** between committing a change to a system and the change being placed into normal production, **while ensuring high quality**.”* [1]
- Goal oriented definition
- DevOps practices involve developers and operators’ processes, architectures, and tools.
- These processes, architectures, tools are aimed at:
  - Preventing errors
  - Speeding up the detection and correction of errors

Four relevant times (implied by our definition)

*"DevOps is a set of practices intended to reduce the time between **committing** a change to a system and the change being **placed into normal production**, while ensuring high quality."*

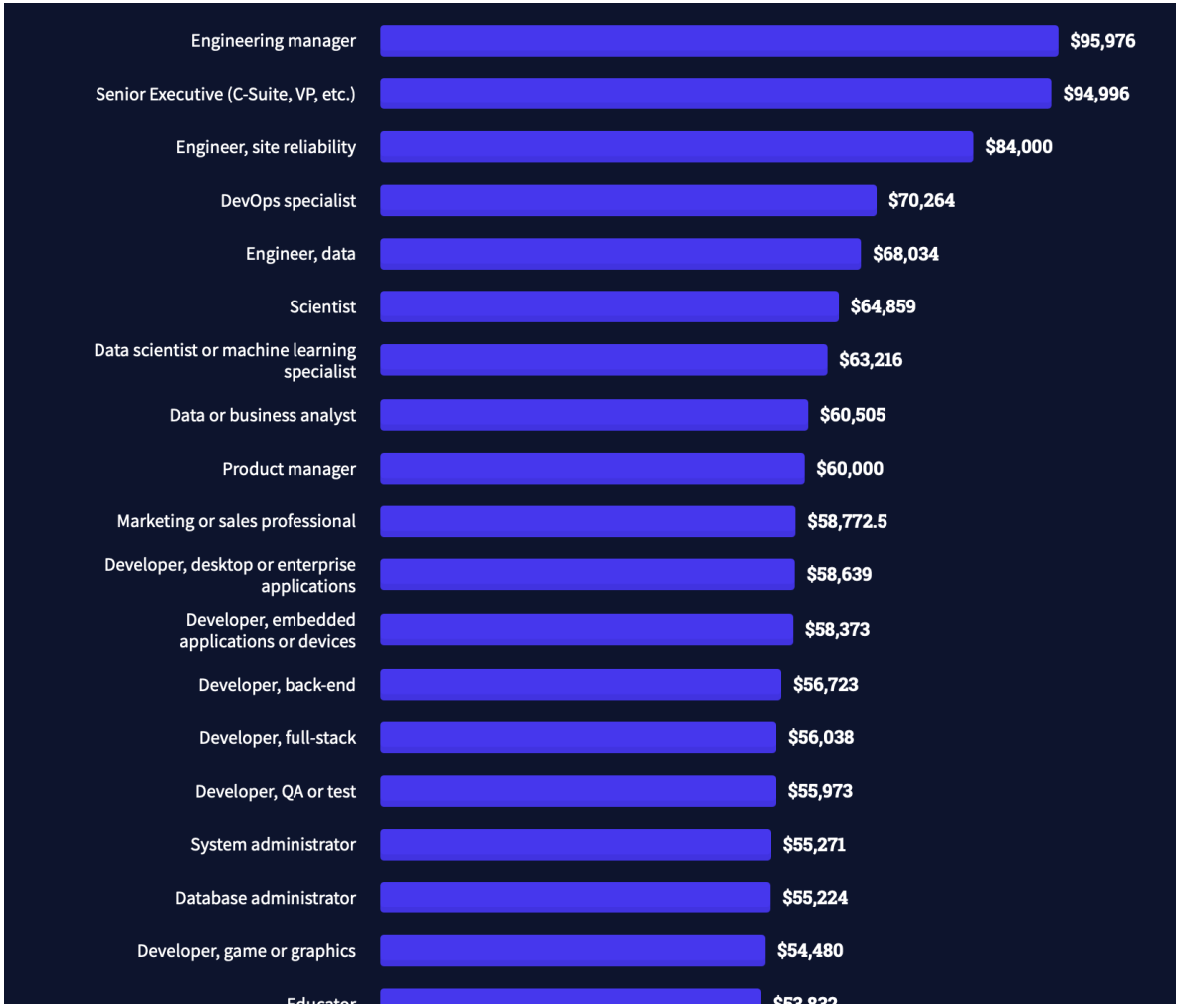
1. **(P1) Pre-commit**: The time during which a developer has sole, private access to the code.
2. **(P2) Commit-Deployment**: The time during which the code is being built, tested against other portions of the system and being prepared for deployment.
3. **(P3) Probation**: The time between the code being placed in production (or production-like) and the developers/operators having confidence in its quality.
4. **(P4) Normal production**: The time after the developers/operators have confidence that the quality is equal to other portions of the production system.

Team structures & Roles

- Size
  - “Two pizza rule”
- Structure
  - DevOps department
  - DevOps team
  - NoOps (i.e. individual)
- Roles
  - Developer
  - Service owner (i.e. service interface)
  - Reliability engineer (i.e. firefighter)
  - Gatekeeper (aka release engineer/coordinator)
  - DevOps Engineer (dev/support the DevOps environment)

Reading: [1] (pp 13-14), [4], and [5] (pp 9-12)

Today's job offers (or why it's good to know about DevOps)



Salary by Developer Type,
in **2021**,
in the **world**,
in **USD**

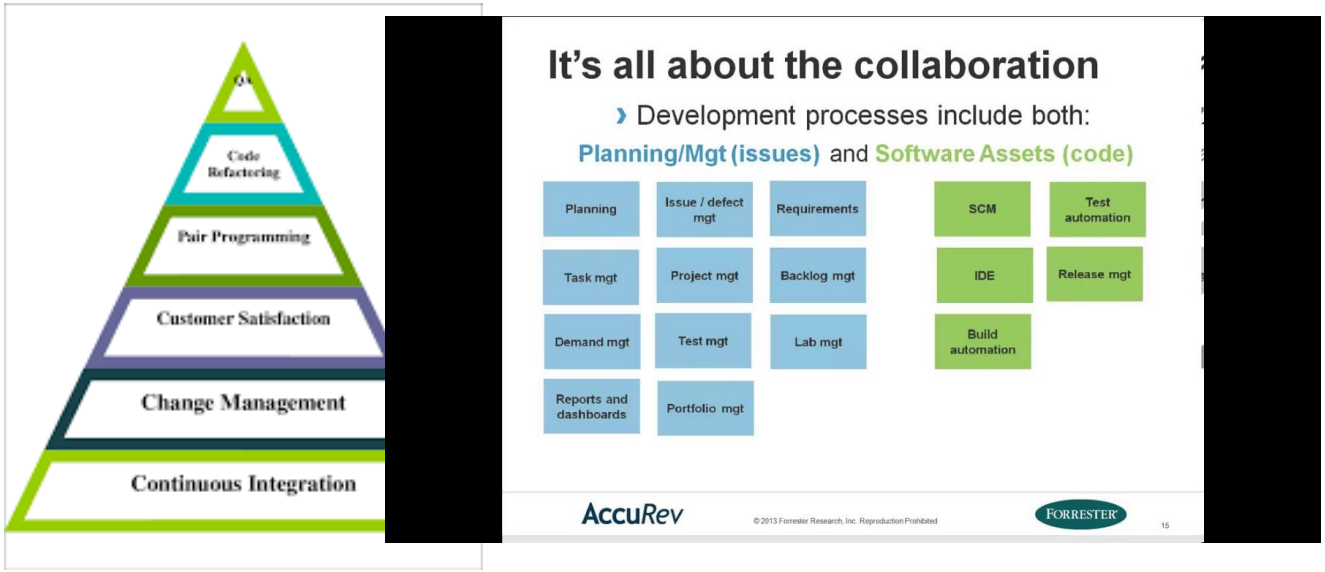
Source: Stack Overflow Survey

More implications coming from the definition

- *“DevOps is a set of **practices** intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality.”* [1]
- What is a practice?
  - Def (*): **action** rather than thought or ideas**.**
    - In software development [7, page 89], a practice is:
      - “*an activity or mode of working*”
      - It MUST be
        - performed regularly (activity)
        - enforced systematically (mode of working)
          - otherwise, it’s only a nice technique
    - A practice is implied by a **principle**.

(*) Cambridge Dictionary

Agile best practices: examples



More implications coming from the definition (cnt'd)

- What is a principle?
  - Def (*): a basic idea or rule that explains or controls how something happens or works.
    - In software development [7, page 49], a principle is:
      - "*A methodological rule that expresses a general view of how software should be developed*".
      - It MUST be
        - abstract: it is a generic rule.
        - falsifiable: it may make sense to disagree with the principle.
- Examples:
  - Principle: "Spend less than you make"
  - Practice:
    - "Put 10% of your earnings every month in your savings account"
    - "Any time you save a little cash, transfer it into your savings account".

(*) Cambridge Dictionary

Agile principles

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference for the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development.The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the art of maximizing the amount of work not done—is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly

DevOps principles

- P1. Establish close collaboration between software Development and Operations teams.
- P2. Treat Operations as first class citizens for the requirements analysis activity.
- **P3. Automate the "*DevOps environment*" as much as possible.**
- **P4. Include a deployment pipeline in your "*DevOps environment*".**
- **P5. Make and publish measurements.**
- **P6. Keep everything version controlled.**
- **P7. Do not deliver low quality artifacts.**
- P8. Ensure and enhance team spirit.
- P9. Maximize compatibility between Development and Operations tools.
- P10. Ensure incremental improvement.

Reading: [3] chapter 2

DevOps environment: represents the collections of services and resources that allow not only the particular system to work properly, but also those required by the organisation to succeed in making such a system and, eventually, achieve its release.

Reading: [8] pages 277-279.

(Focused) DevOps principles

- **P3. Automate the "*DevOps environment*" as much as possible:**
  - Automate as much as possible the setup of the *parts* that compose the DevOps environment, and the execution of the *processes it supports*. This leads to garner efficiencies with process speed, consistency and auditability, and above all, it allows to make the (re)creation process less error-prone by reducing manual interventions.

- **P4. Include a deployment pipeline in your "*DevOps environment*":**
  - A deployment pipeline is a model that describes the process of getting software (whether code, configuration files, database schemes or data) from a main repository into the hands of its expected users. A DevOps environment implements a deployment pipeline.

(Focused) DevOps principles (cnt’d)

- **P5. Make and publish measurements.**
  - Define and track meaningful metrics. Their semantics should be transparent. The collected data should be accessible to all, capable of being visualised, and drive the feedback loop.

- **P6. Keep everything version controlled.**
  - Everything you need to build, test, deploy, and release the system under development should be kept in some form of versioned storage. The relevant version of every asset should be identifiable for any given build.

- **P7. Do not deliver low quality artifacts.**
  - Write automated tests at multiple levels (unit, component, acceptance) and run them every time a change is made to the system under development, its configuration files, or the environment and software stack where it runs. Everybody on the team (developer, operators, devops engineers) is responsible for the quality of the application at all times.

DevOps practices

- Pr1. Continuous planning.
- Pr2. Continuous feedback loop.
- Pr3. Performance metrics measurement.
- Pr4. Automated dashboards and monitoring tools.
- Pr5. Continuous monitoring.
- **Pr6. Continuous integration.**
- **Pr7. Continuous deployment.**
- **Pr8. Continuous delivery.**
- **Pr9. Configuration management for code and**
- **infrastructure.**
- Pr10. Change management.
- **Pr11. Automated testing.**
- **Pr12. Continuous testing.**
- Pr13. Process standardization.
- **Pr14. Infrastructure as code.**
- Pr15. Stakeholder participation in defining
- requirements.
- Pr16. Continuous improvement.
- Pr17. Code ownership.
- Pr18. Constant, seamless communication.
- Pr19. Cross-functional teams.
- Pr20. Blameless postmortems.
- Pr21. Shared responsibilities, goals, values as
- well as mutual respect and trust.
- Pr22. Automated Deployment.
- **Pr23. Automated Code Review.**

Reading: [3] chapter 2.

(Focused) Practices

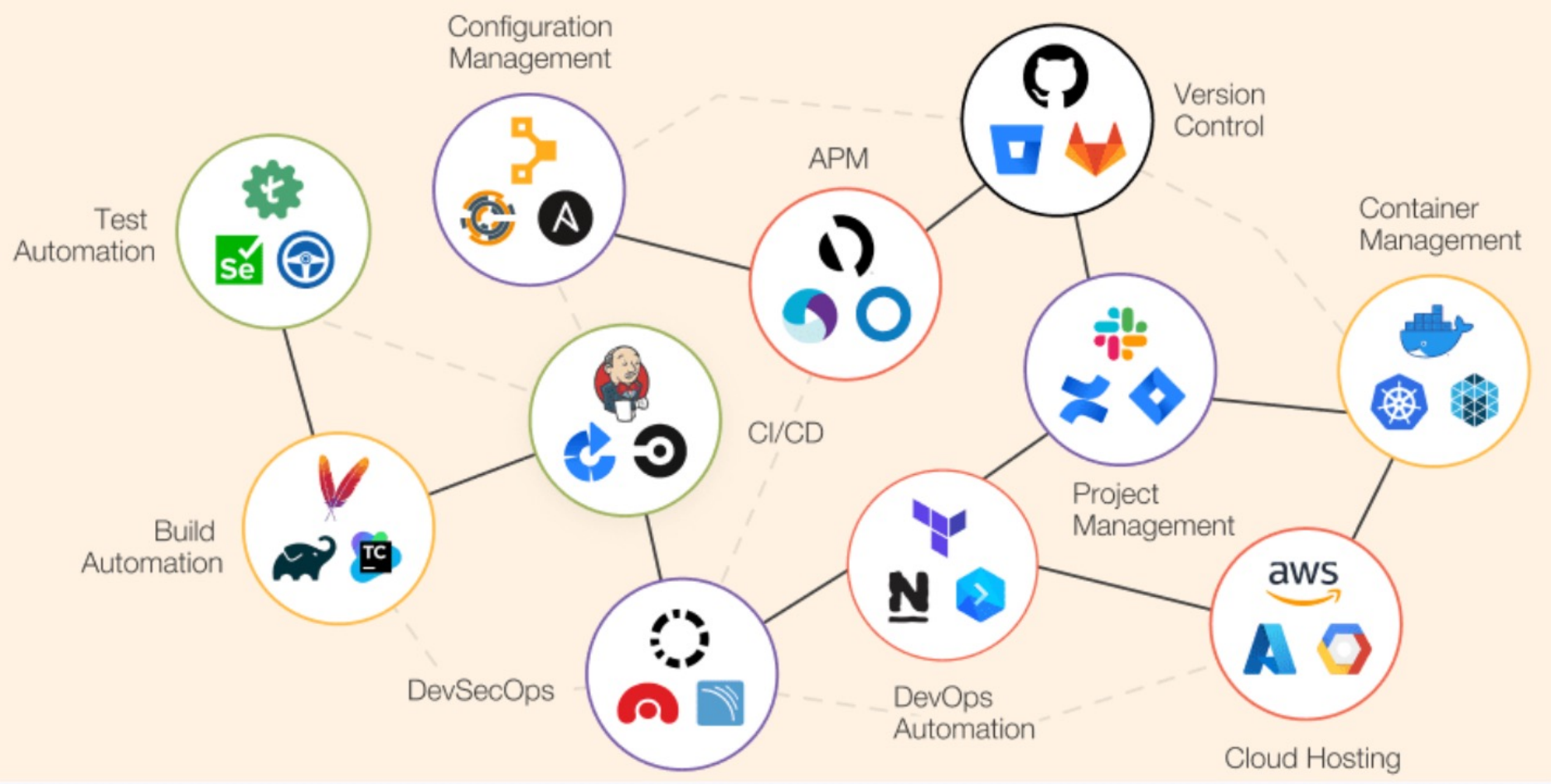
Practice	Description
Pr6. Continuous integration	CI is the **process** of automating the build and testing of code every time a team member commits changes to version control.
Pr7. Continuous deployment	CD is the **process** to automate the steps aimed at deploying the system generated by the CI process into production, without any human interaction.
Pr8. Continuous delivery	CDe is the same **process** than CD, but (only) the deployment into production requires human intervention.
Pr9. Configuration management for code and infrastructure	Rely on configuration parameters to **adapt** how the SUD behaves and moves through various environments on their way to production, as well as easying the **setup** of the environments.
Pr11. Automated testing	**Write** test cases such that they can be executed using a tool that does not require any manual intervention to reach the end of the test case execution.
Pr12. Continuous testing	It is the **process** of executing automated test cases as part of the CI, CD or CDe pipeline.
Pr14. Infrastructure as code	**Manage** the DevOps environment parts (networks, virtual machines, load balancers, proxies, storage) using descriptive models that can be read, write, maintain and *use* in the same way as source code.
Pr23. Automated code review	It is the **process** to verify the source code adheres to a predefined set of rules or best practices using an automated tool. The Automated Code Review is trig-gered during the Continuous Integration as soon as the developers check-in the code.

Principles and practices mapping

Practice	Principle				
	P3	P4	P5	P6	P7
Pr6. Continuous integration	X	X		X	
Pr7. Continuous deployment	X	X			
Pr8. Continuous delivery	X	X		X	
Pr9. Configuration management for code and infrastructure	X			X	
Pr11. Automated testing	X				X
Pr12. Continuous testing.	X	X			X
Pr14. Infrastructure as code	X			X	
Pr23. Automated code review	X				X

https://www.simform.com/blog/devops-tools/

DevOps categories of tools



DevOps metrics

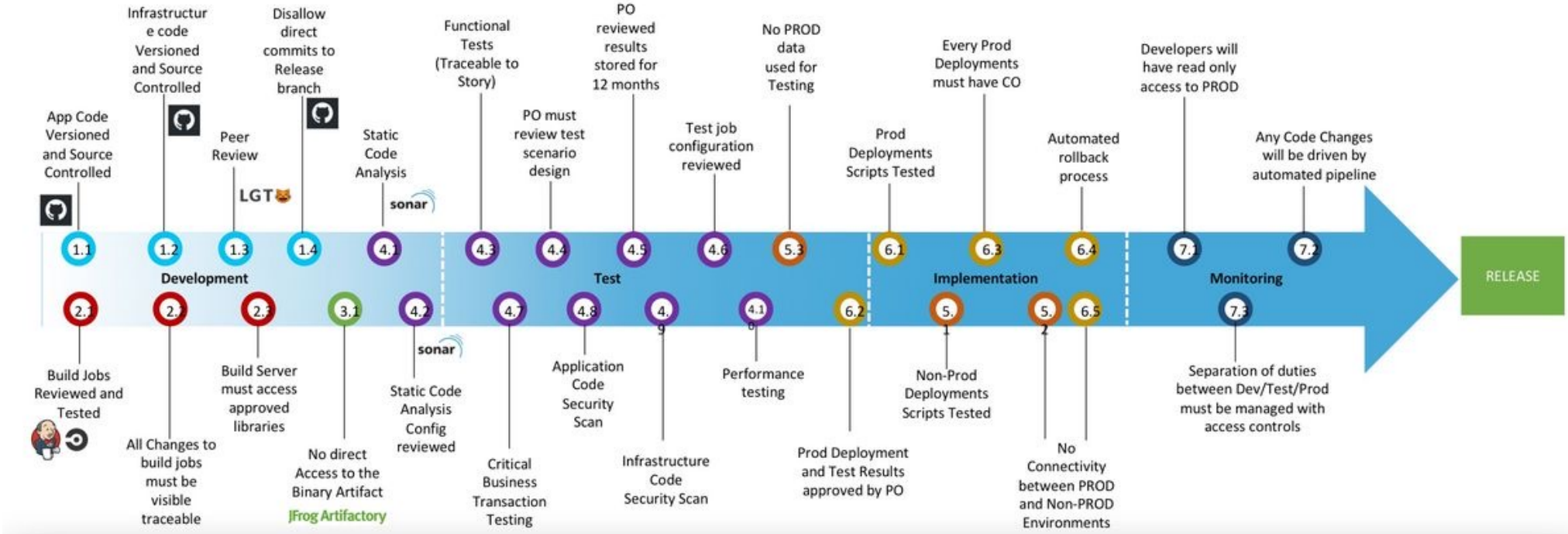
DevOps success is measured in many ways, depending on the type of team and their objectives. However, all effective teams pay attention to these key metrics:

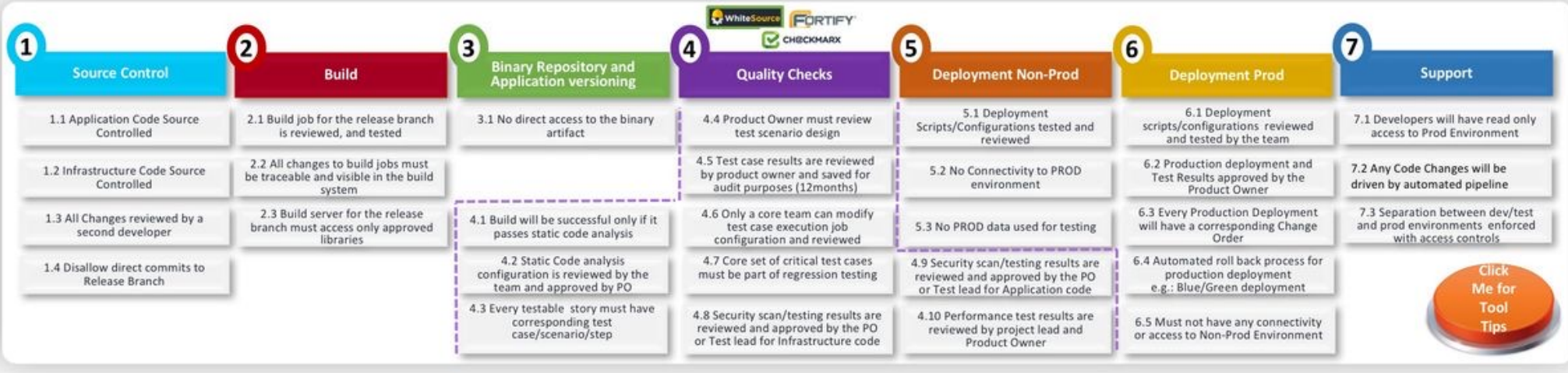
- **Deployment frequency**: How often software is successfully released to 'production'
- **Lead time for changes**: The amount of time it takes a commit to get into production
- **Change failure rate**: The percentage of deployments that cause a failure in production
- **Time to restore service:** How long it takes an organization to recover from failures in production

These are sometimes referred to as DORA metrics, after Google's DevOps Research & Assessment team, who first popularized them.

DevOps anywhere?

- Domain
  - Trade-off between “time-to-market” vs. “risks that something goes wrong”
  - High level of safety and regulations
    - Financial
    - Automotive
      - Anyway, something may go wrong: see Subaru
      - Others may try: see Tesla’s over-the-air update
    - Aerospace
- Product
  - Monolithic architecture
  - Technical debt
- Resources & Costs
  - DevOps Engineer > Devs > Ops (see again Stack Overflow Survey on salaries)

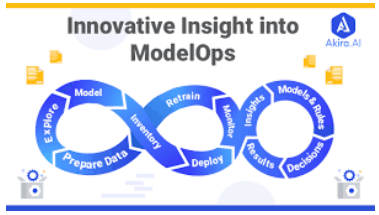


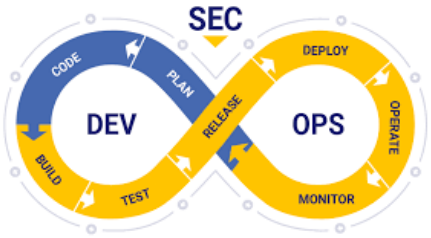


https://www.infoq.com/news/2017/06/does-financial-industry/

DevOps variants

- DevSecOps security as code
- AIOps Artificial intelligence for IT Operations
- MLOps deploy and maintain ML models in production reliably and efficiently
- DataOps continuous improvement in data pipelines and analytics
- WebOps deployment, operation, maintenance, tuning, and repair of web-based applications and systems

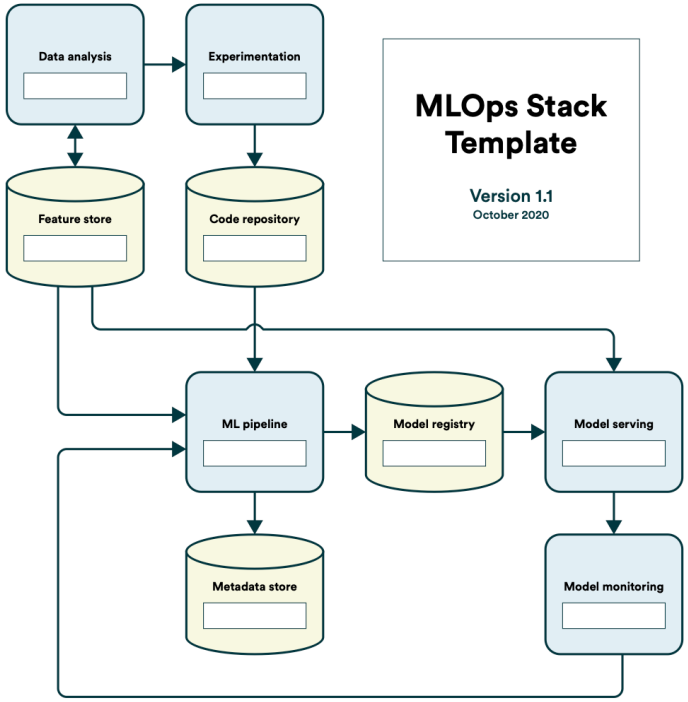




DevSecOps

DevSecOps is a practice that incorporates application and infrastructure security into **Agile** and **DevOps**
It addresses security concerns when they arise - which is when they are most accessible, quickest, and least costly to resolve (and before they are put into production).
Additionally, DevSecOps shifts the duty for application and infrastructure security from a security team to a shared responsibility for the development, security, and IT operations teams

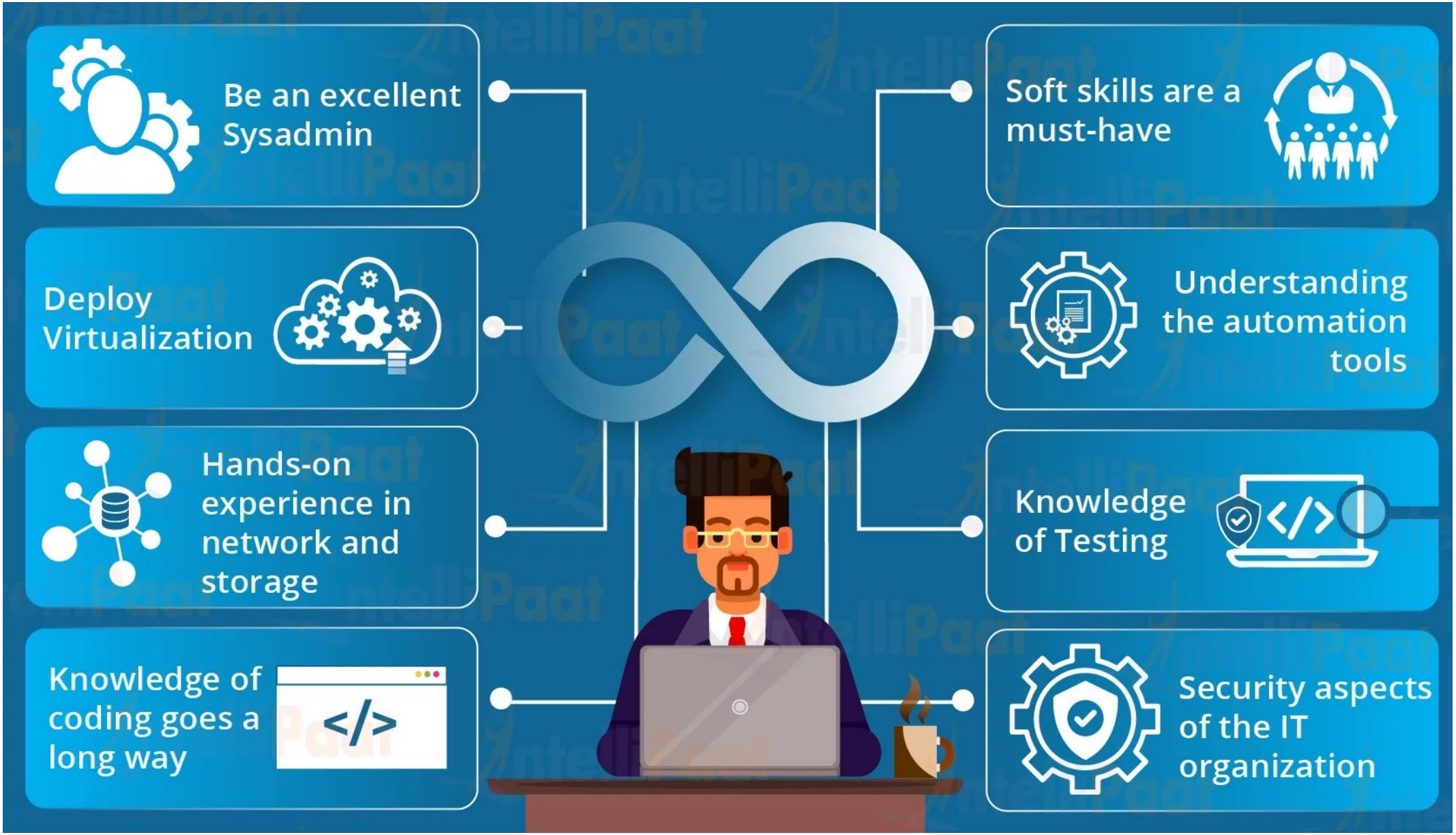
https://blog.packagecloud.io/ten-must-have-devsecops-tools/



Component	Requirements	Tooling
Data analysis		
Experimentation		
Feature store		
Code repository		
ML pipeline		
Metadata store		
Model registry		
Model serving		
Model monitoring		

https://ml-ops.org/content/state-of-mlops

MLOps Setup Components	Tools
Data Analysis	Python, Pandas
Source Control	Git
Test & Build Services	PyTest & Make
Deployment Services	Git, DVC
Model & Dataset Registry	DVC[aws s3]
Feature Store	Project code library
ML Metadata Store	DVC
ML Pipeline Orchestrator	DVC & Make



https://www.kovair.com/blog/role-and-responsibilities-of-a-devops-engineer/

Conclusions

- Software systems are more and more complex, with lot of components
- DevOps represents a change in IT culture, focusing on rapid IT service delivery through the adoption of agile, lean practices in the context of a system-oriented approach.
- DevOps emphasizes people (and culture), and it seeks to improve collaboration between operations and development teams.
- DevOps implementations utilize technology — especially automation tools that can leverage an increasingly programmable and dynamic infrastructure from a life cycle perspective.

Related issues

- Site Reliability Engineering
- Platform Engineering
- Continuous architecture
- Observability Engineering

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Questions?