CompSci 401: Cloud Computing

Classic Software Engineering

Prof. Ítalo Cunha

昆山杜克大学
DUKE KUNSHAN UNIVERSITY

Software development

1. Identify need for a new piece of software
2. Software engineers design, develop, test, and deploy software
3. Users run or invoke the software as needed indefinitely

Software development in the real world

1. Identify need for a new piece of software
2. Software engineers design, develop, test, and deploy software
3. Users run or invoke the software as needed ~~indefinitely~~

- Operating system and frameworks evolve over time
  - Requires updates to software (e.g., Django 1 → 2 → 3 → 4)
- Software will have errors that require fixing
- Users ask for additional functionality and extensions

```
[/home]$ ls
vidarlo
[/home]$ cd ..
[/]$ cd etc
[/etc]$ ls
0.0.10.in-addr.arpa  csh.cshrc           gshadow-         logrotate.d      odbcinst.ini           rmt
adduser.conf         csh.login           gtk              lynx.cfg         openoffice             rpc
adjtime              csh.logout          host.conf        magic            opt                    screenrc
aliases              db.cache            hostname         mailcap          pam.conf               securetty
alternatives         debconf.conf        hosts            mailcap.order    pam.d                  security
apm                  debian_version      hosts.allow      mailname         passwd                 services
apt                  default             hosts.deny       mail.rc          passwd-                shadow
asterisk             defoma              hotplug          manpath.config   perl                   shadow-
at.deny              deluser.conf        hotplug.d        mdadm            ppp                    shells
bakipkungfu          dhclient.conf       identd.conf      mediaprm         printcap               skel
bash.bashrc          dhclient-script     identd.key       mime.types       profile                squid
bash_completion      dictionaries-common inetd.conf       mkinitrd         protocols              ssh
bash_completion.d    discover.conf       init.d           modprobe.d       python2.3              sudoers
bind                 discover.conf-2.6   inittab          modules          raidtab                sysctl.conf
blkid.tab            discover.d          inputrc          modules.conf     rc0.d                  syslog.conf
blkid.tab.old        dpkg                ipkungfu         modules.conf.old rc1.d                  terminfo
calendar             emacs               issue            modutils         rc2.d                  timezone
chatscripts          emacs21             issue.net        motd             rc3.d                  ucf.conf
chkrootkit.conf      email-addresses     kernel-img.conf  mtab             rc4.d                  updatedb.conf
complete.tcsh        environment         ldap             mtools.conf      rc5.d                  vidarlo.net.hosts
console              exim4               ld.so.cache      Muttrc           rc6.d                  w3m
console-tools        fdmount.conf        ld.so.conf       mysql            rc.d                   wgetrc
cron.d               fonts               locale.alias     nanorc           rcS.d                  #wvdial.conf#
cron.daily           fstab               locale.gen       network          reportbug.conf         wvdial.conf
cron.hourly          groff               localtime        networks         resolvconf             wvdial.conf~
cron.monthly         group               logcheck         nsswitch.conf    resolv.conf            X11
crontab              group-              login.defs       ODBCDataSources  resolv.conf~           xpilot
cron.weekly          gshadow             logrotate.conf   odbc.ini         resolv.conf.pppd-backup
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adduser.conf         csh.login            gtk               lynx.cfg
adjtime              csh.logout           host.conf         magic
aliases              db.cache             hostname          mailcap
alternatives         debconf.conf         hosts             mailcap.or
apm                  debian_version       hosts.allow       mailname
apt                  default              hosts.deny        mail.rc
asterisk             defoma               hotplug           manpath.co
at.deny              deluser.conf         hotplug.d         mdadm
bakipkungfu          dhclient.conf        identd.conf       mediaprm
bash.bashrc          dhclient-script      identd.key        mime.types
bash_completion      dictionaries-common  inetd.conf        mkinitrd
bash_completion.d    discover.conf        init.d            modprobe.d
bind                 discover.conf-2.6    inittab           modules
blkid.tab            discover.d           inputrc           modules.co
blkid.tab.old        dpkg                 ipkungfu          modules.co
calendar             emacs                issue             modutils
chatscripts          emacs21              issue.net         motd
chkrootkit.conf      email-addresses      kernel-img.conf   mtab
complete.tcsh        environment          ldap              mtools.con
console              exim4                ld.so.cache       Muttrc
console-tools        fdmount.conf         ld.so.conf        mysql
cron.d               fonts                locale.alias      nanorc
cron.daily           fstab                locale.gen        network
cron.hourly          groff                localtime         networks
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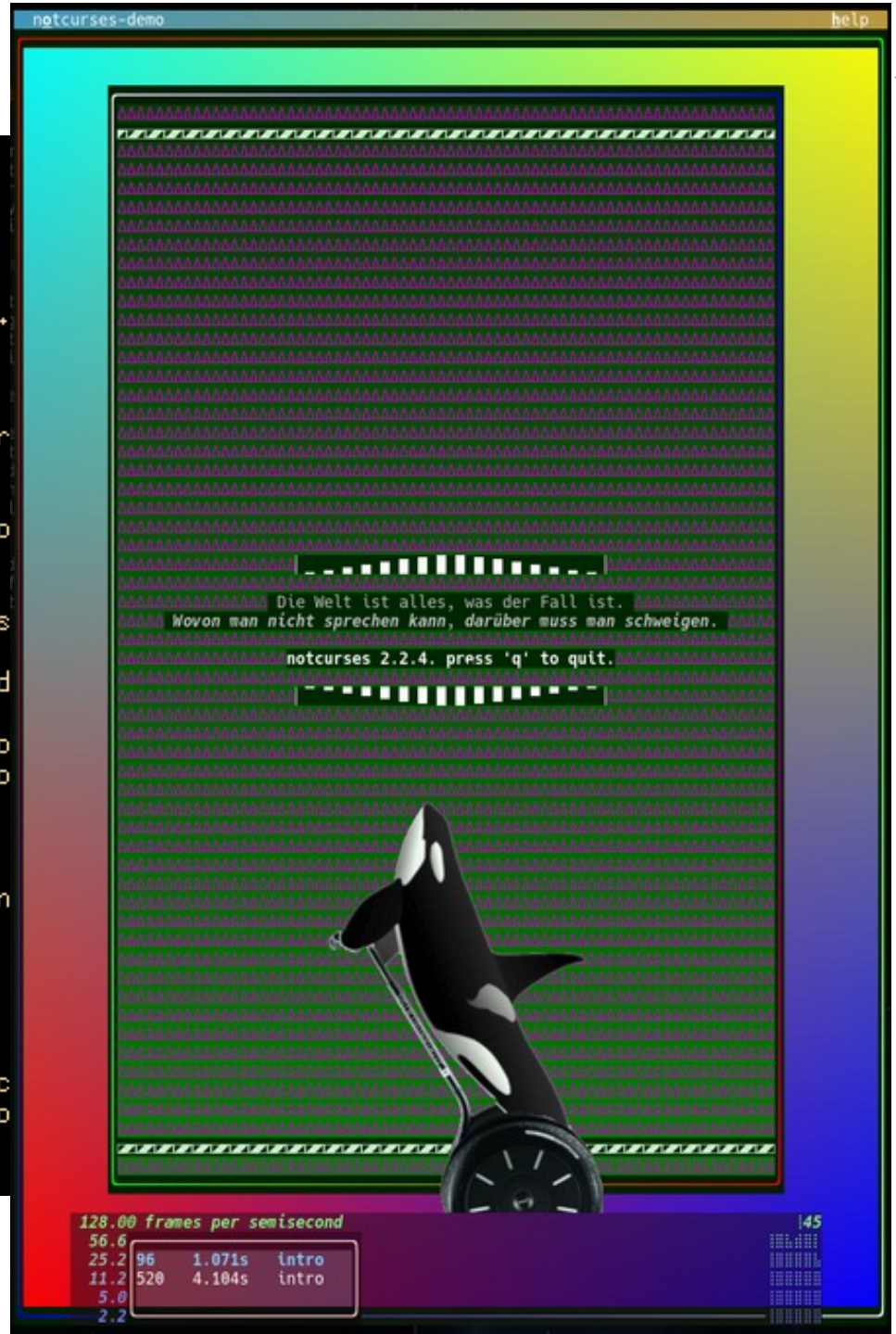
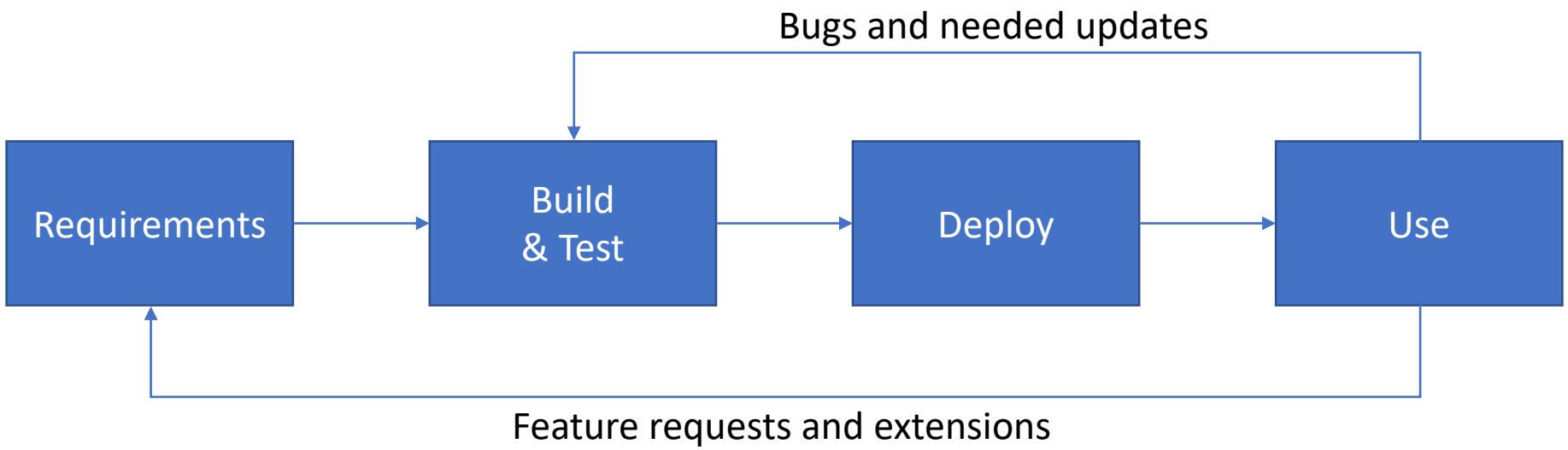


Software development cycle



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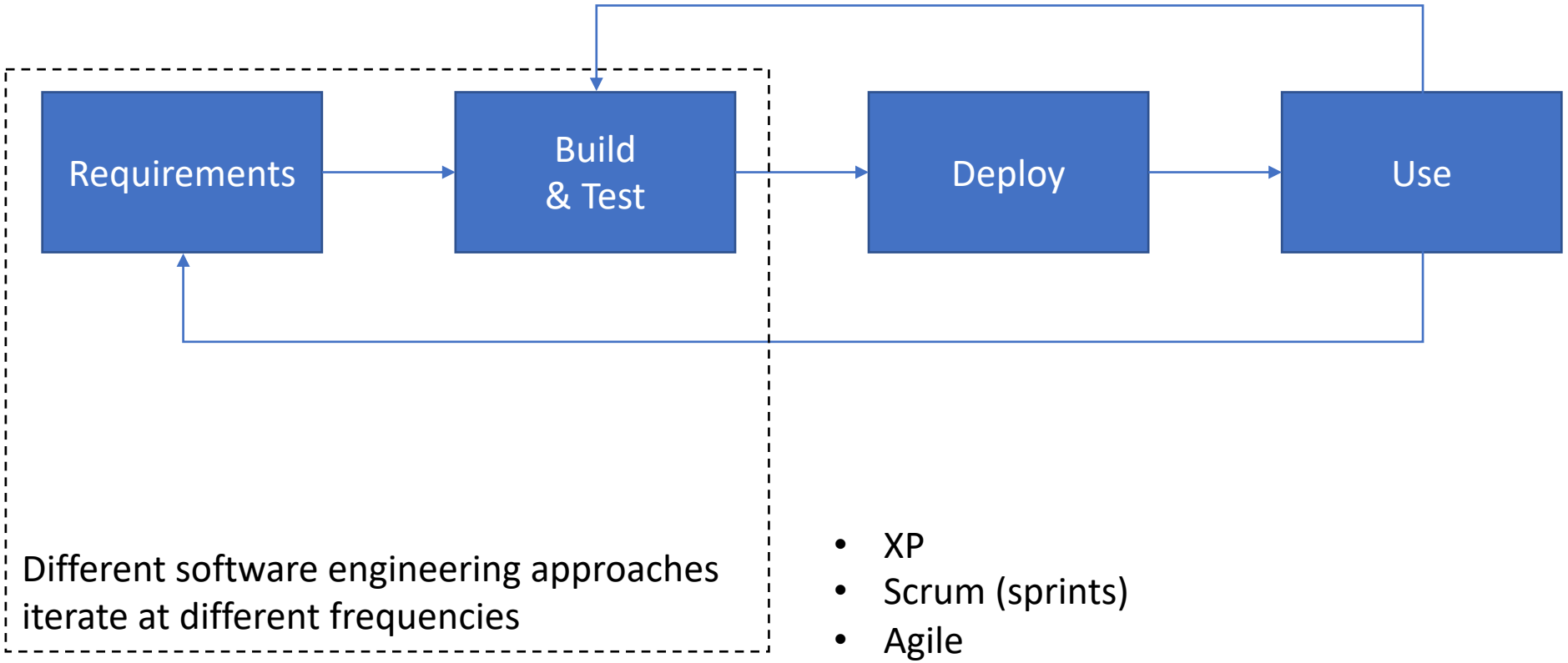
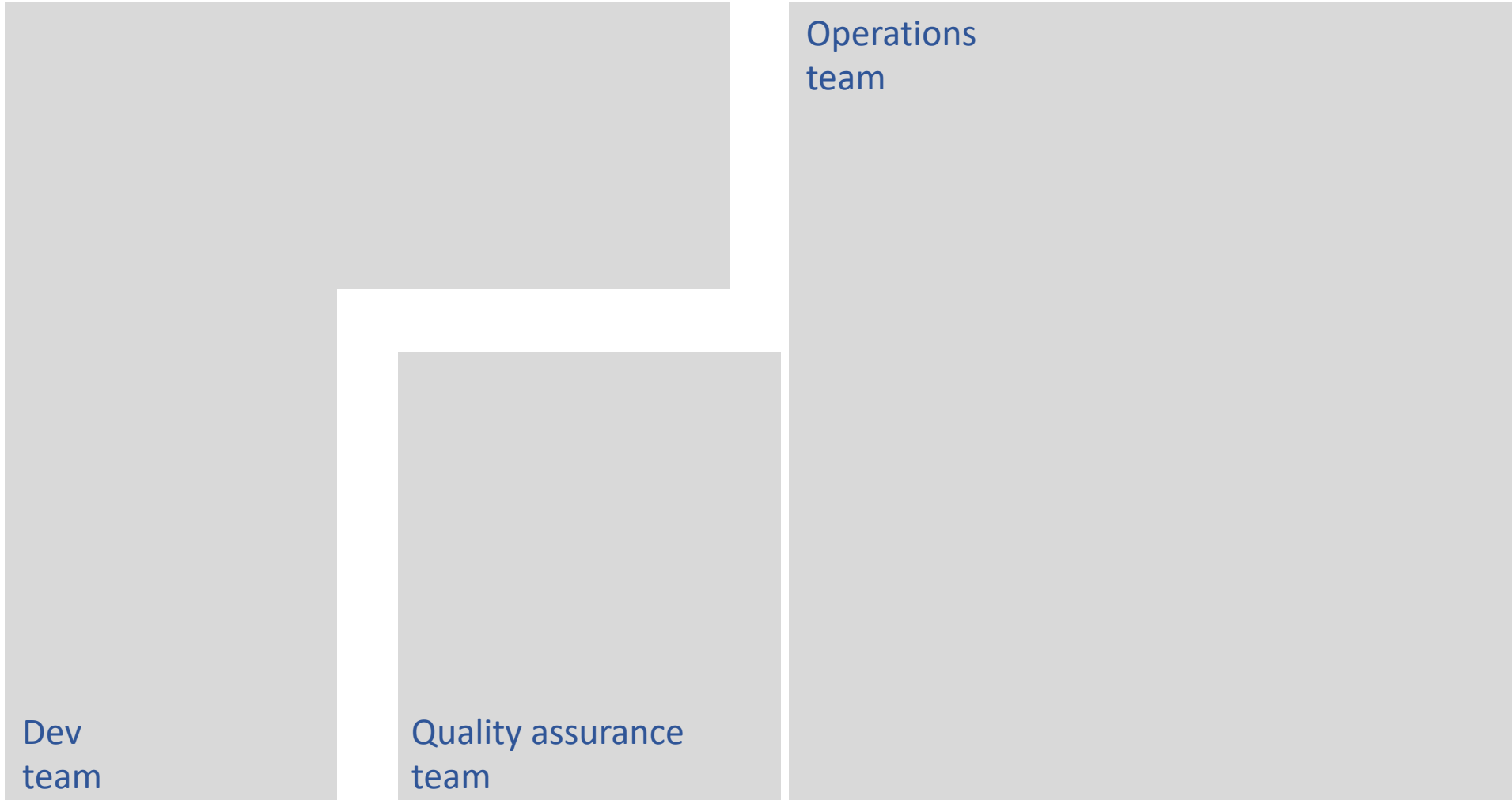


- XP
- Scrum (sprints)
- Agile

Large projects and teams



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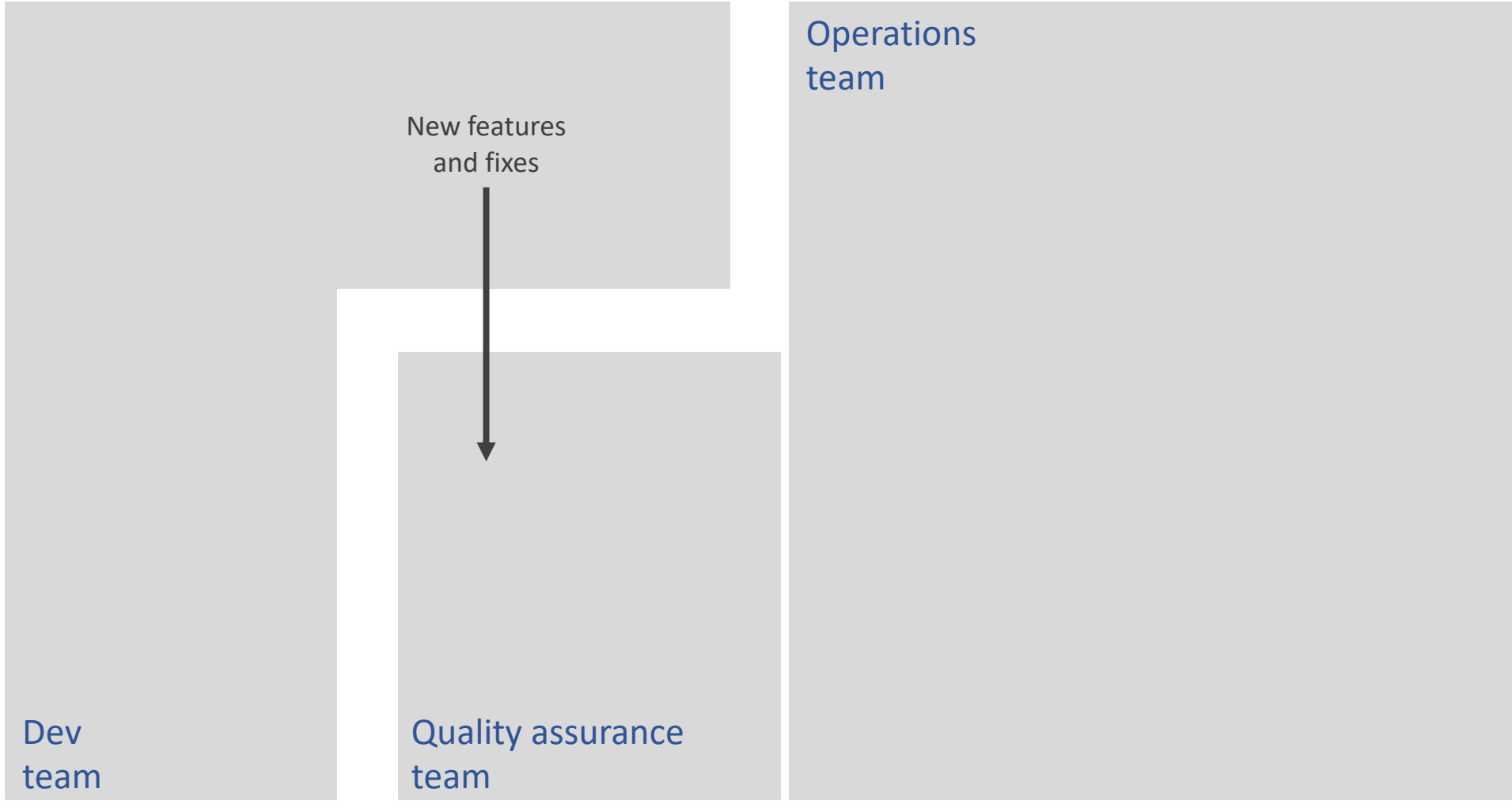

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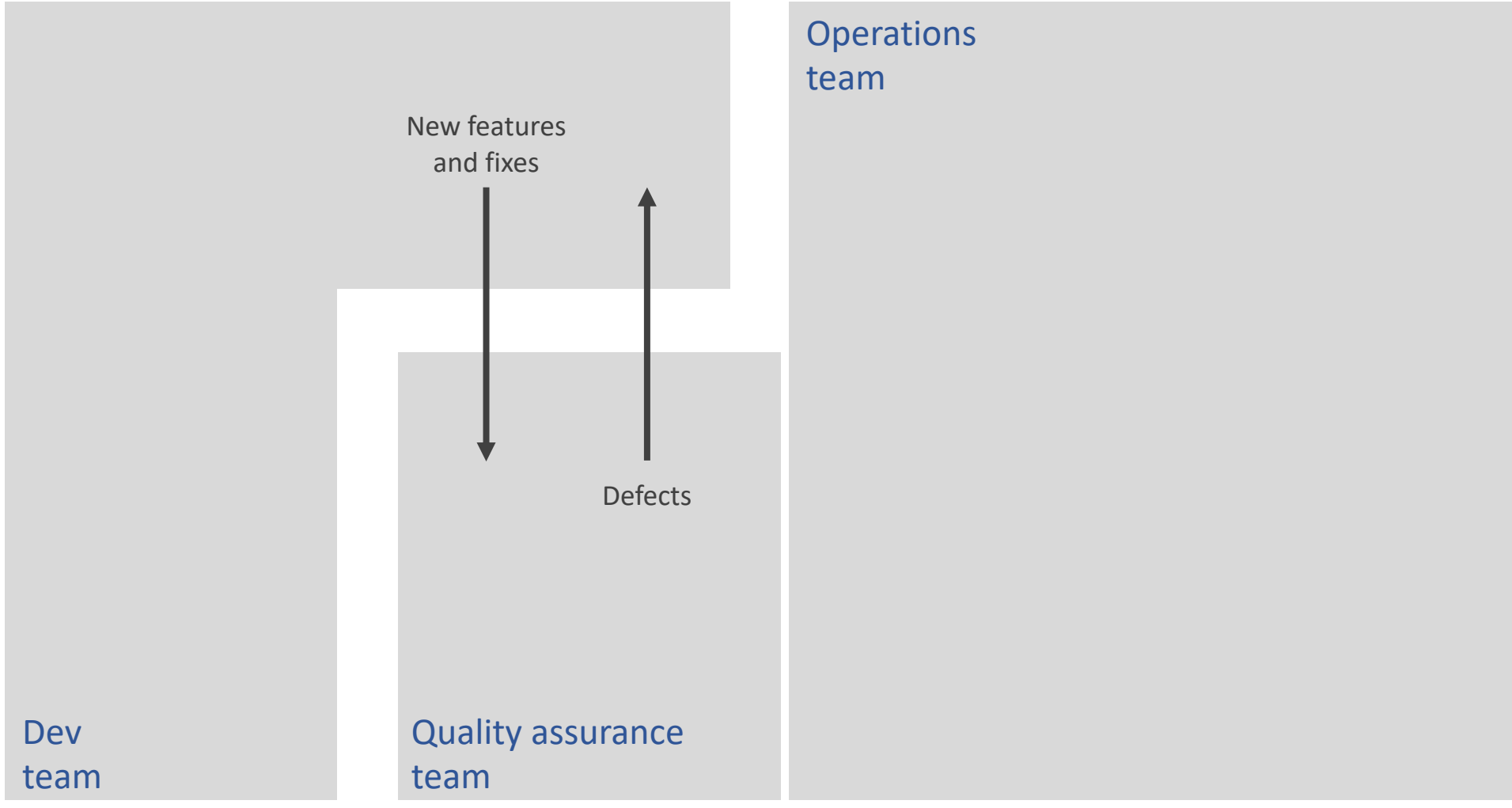

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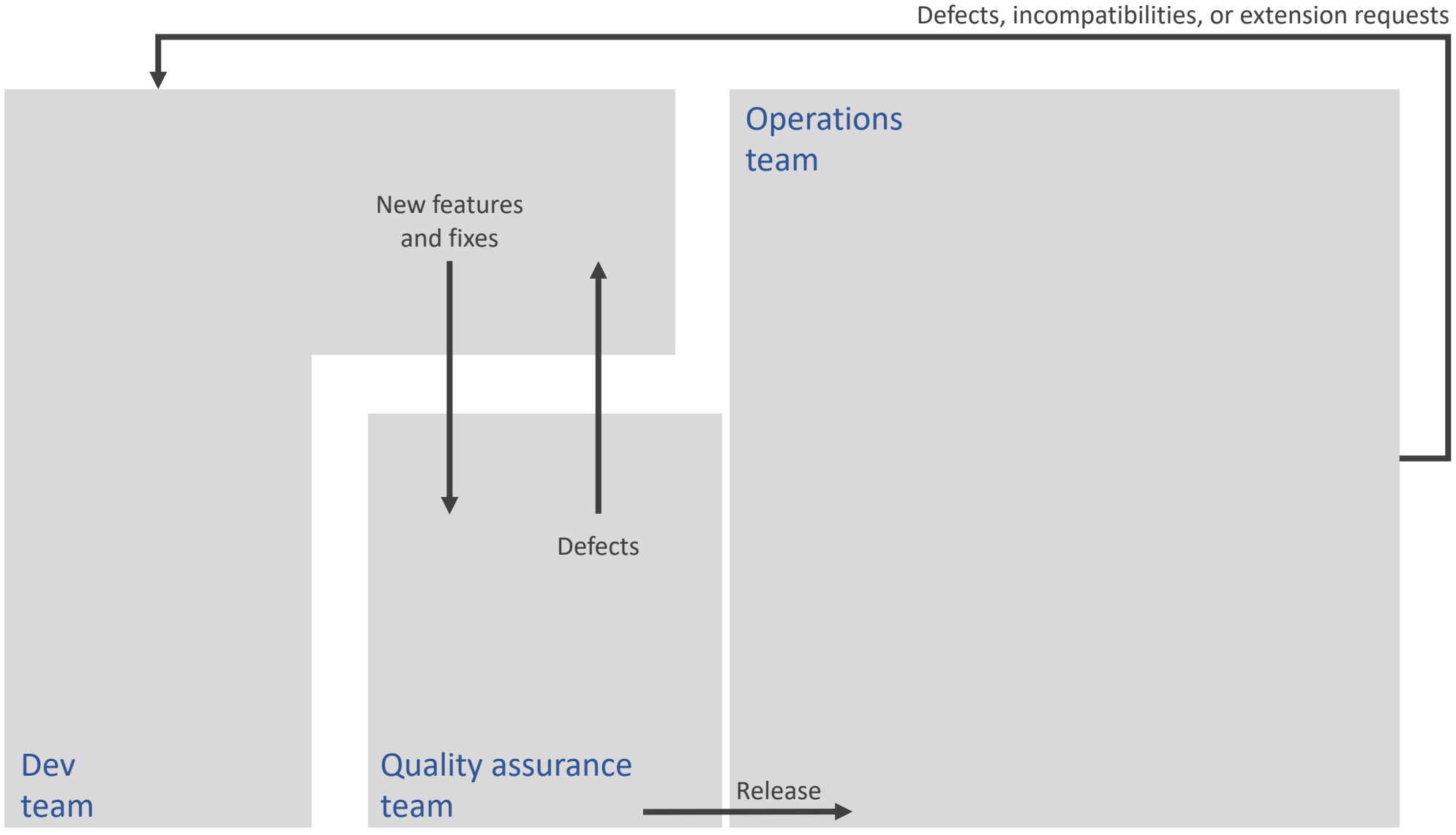

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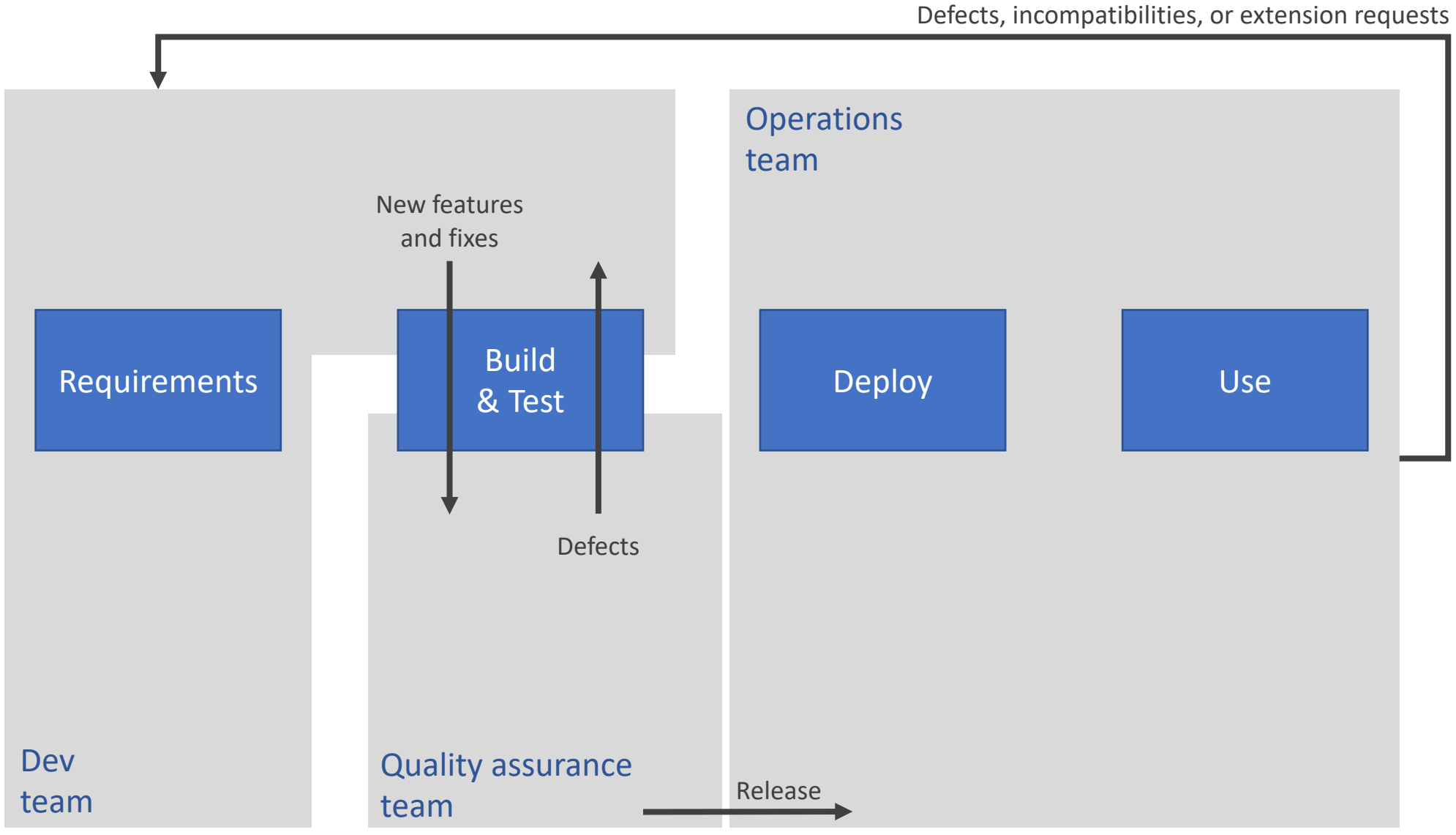

Conflicting interests

- More features
- Ship *yesterday*
- Latest libraries and frameworks
- Unlimited resources

Dev team

Quality assurance team

- Stable libraries and frameworks
- Lightweight code, resource constraints
- Zero errors

Operations team

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DevOps

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DevOps paradigm

- A culture/organizational approach to software development
- Join development, QA, and operation teams
- An extension to agile methods
  - Relies heavily on automation and orchestration

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  - Relies heavily on automation and orchestration

- If operations requires a serverless application can coordinate with developers to build stateless code
- Operations can inform developers a preferred/desirable microservice approach, including how to modularize/size

DevOps requirements

- Automation and orchestration
  - Continuous integration to automate building and testing
    - Version management to separate development code from production code
    - Small software modules to compartmentalize testing
    - Extensive testing to ensure software quality (e.g., test-driven development)

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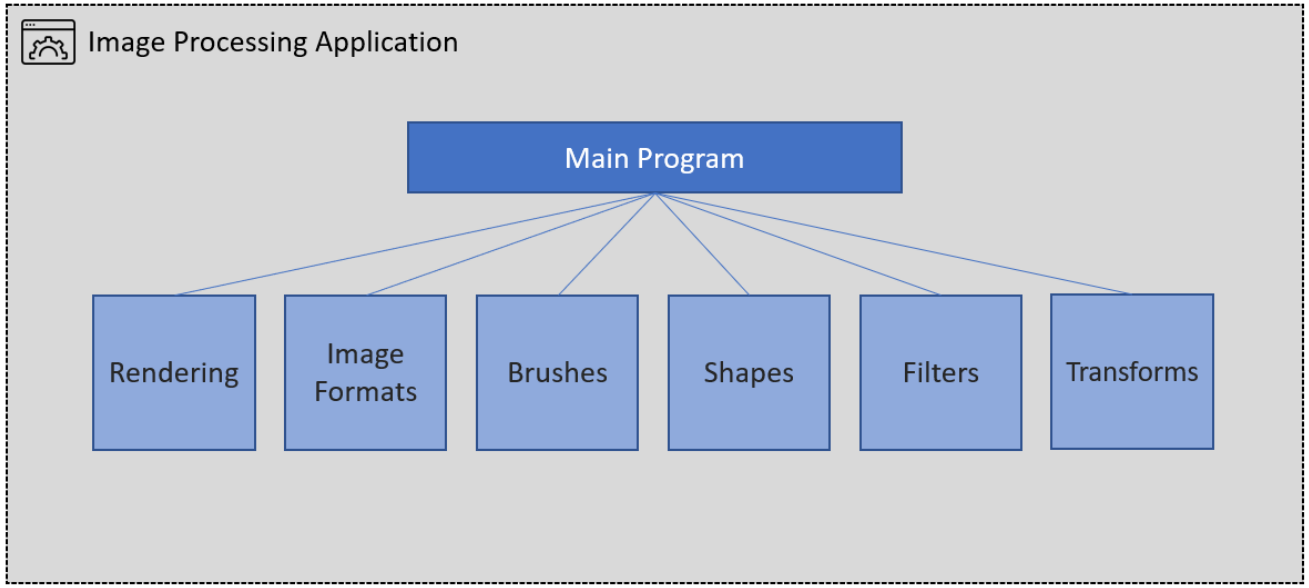

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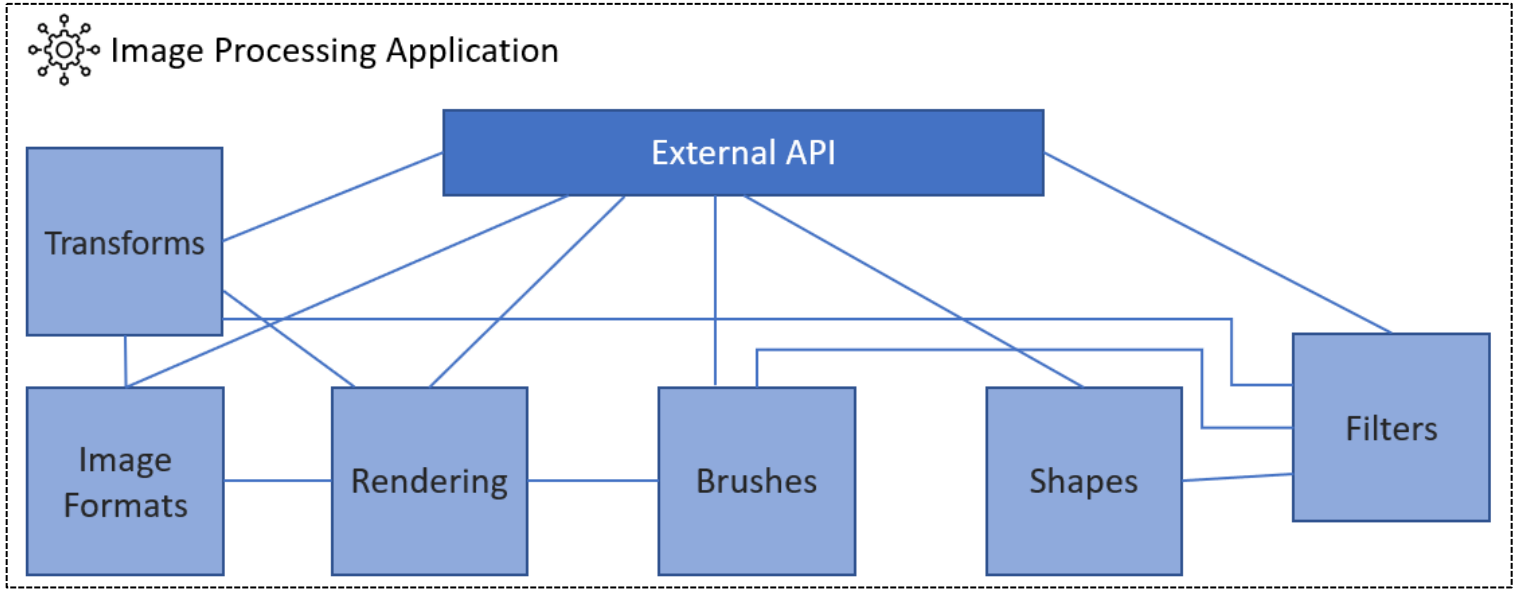

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  - Continuous delivery to automate software deployment

Classic software releases and updates

- Package software
- Pick “low risk” time to deploy
  - Maintenance window
  - Warn users of possible unavailability
- Possibly bring the application offline to swap versions

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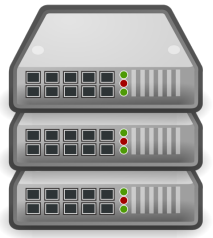

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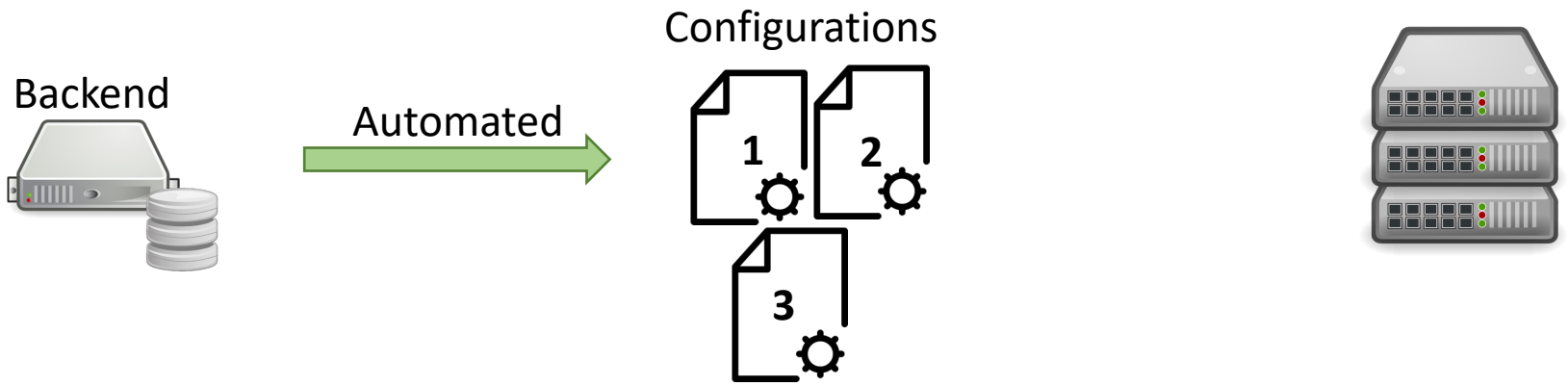

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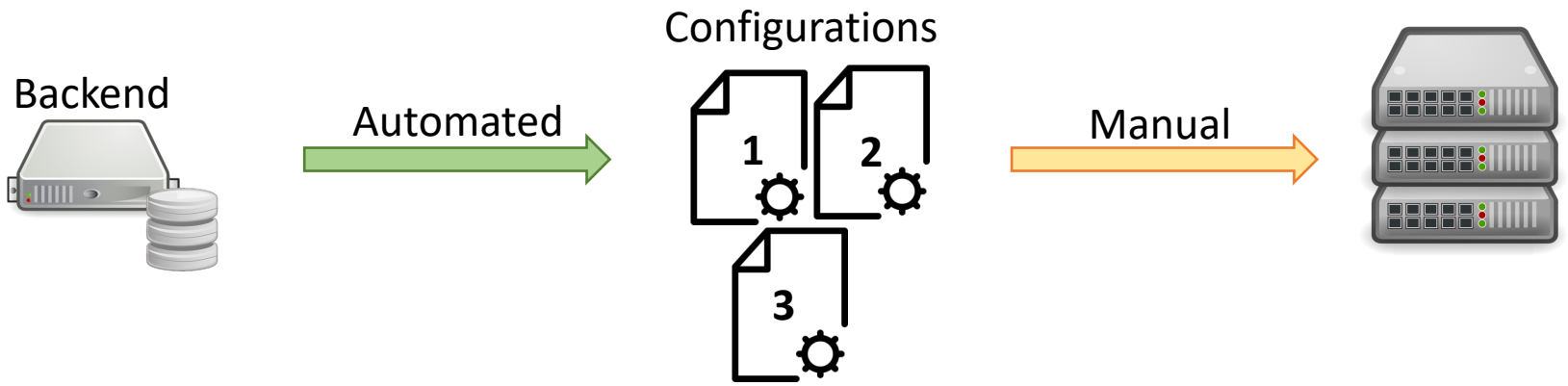

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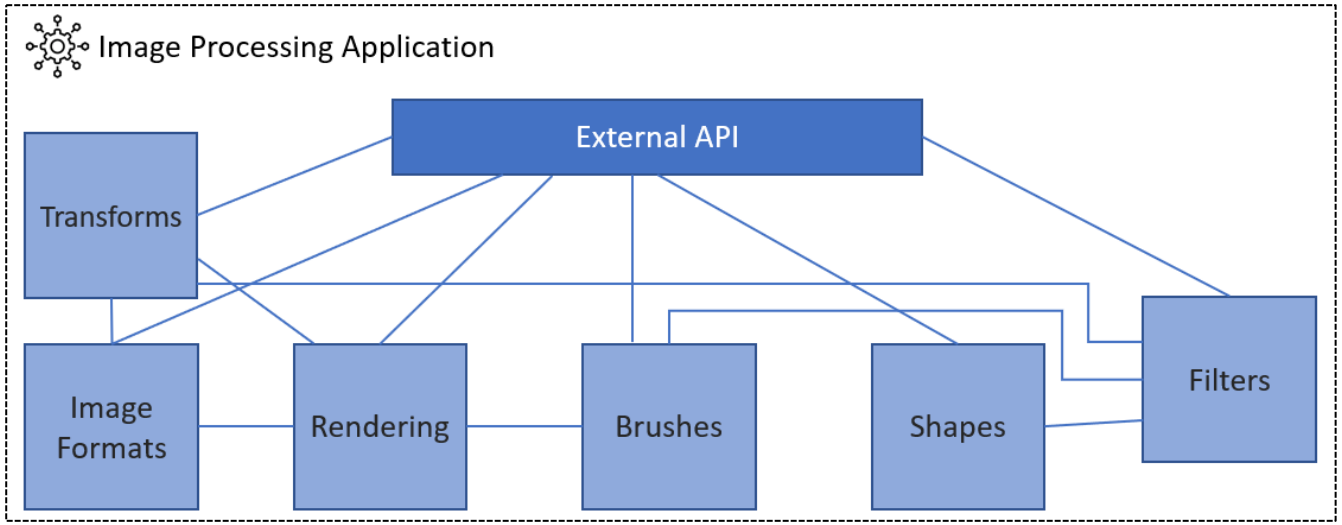
- Not a good fit for cloud environments
  - Large/global user base implies there is no “low risk” time to deploy
  - In a microservice architecture, other services depend on the updated service
  - Stopping a microservice for a release may be impossible

CI/CD to deploy updates rapidly

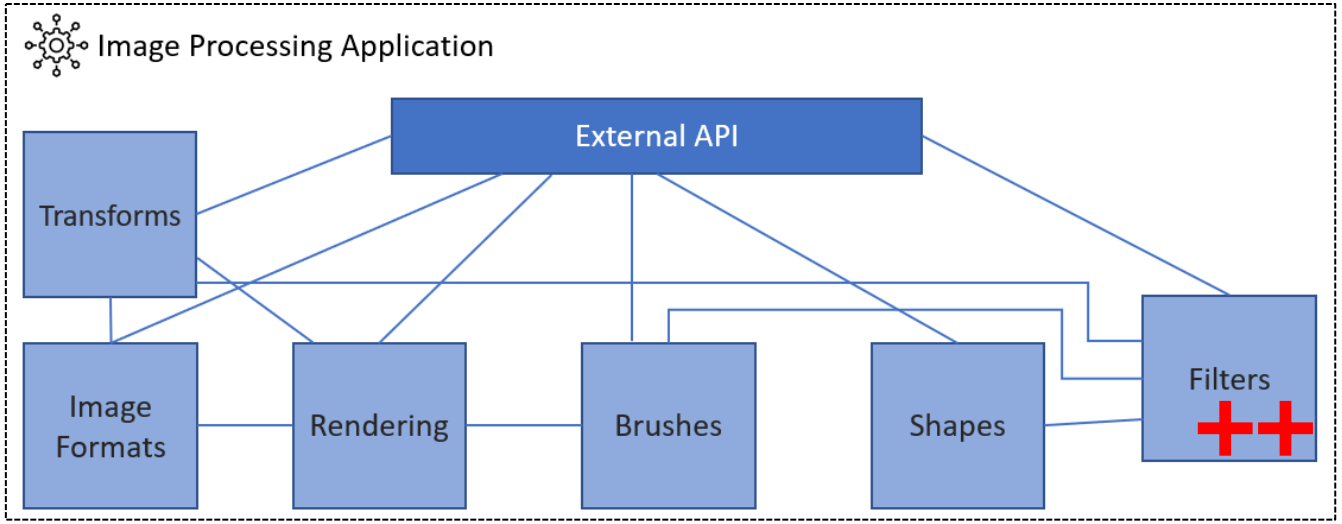
- Smaller modules and extensive testing improve software quality
  - Less errors in production
- Rollout
  - Containers running old version can continue running during upgrade
    - Can finish serving ongoing requests
  - Containers running new version spawn and are monitored closely for errors
    - Eventual migration if no errors occur

Sandbox trial



Production version

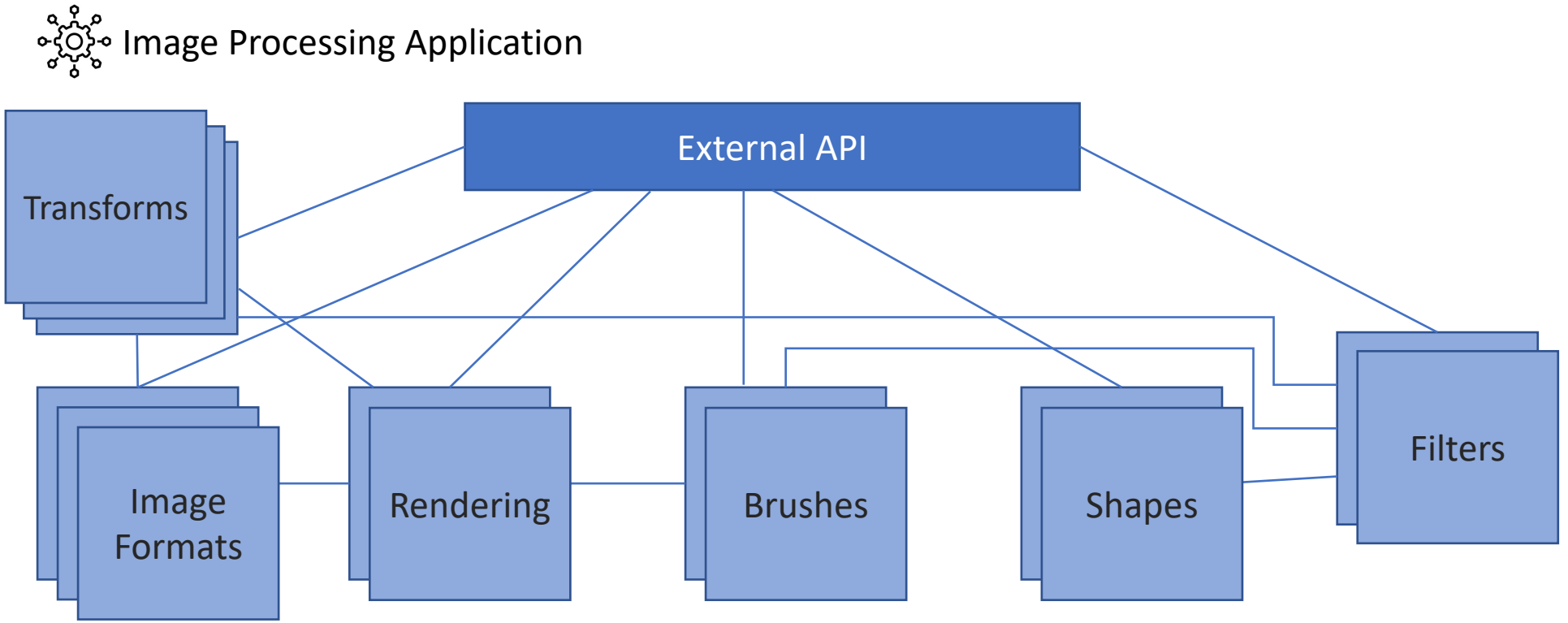
- Unchanged



Sandbox trial

- With updates
- Does not impact production version
- May not catch all errors due to isolation
  - Different users and infrastructure
- High cost

Canary deployment



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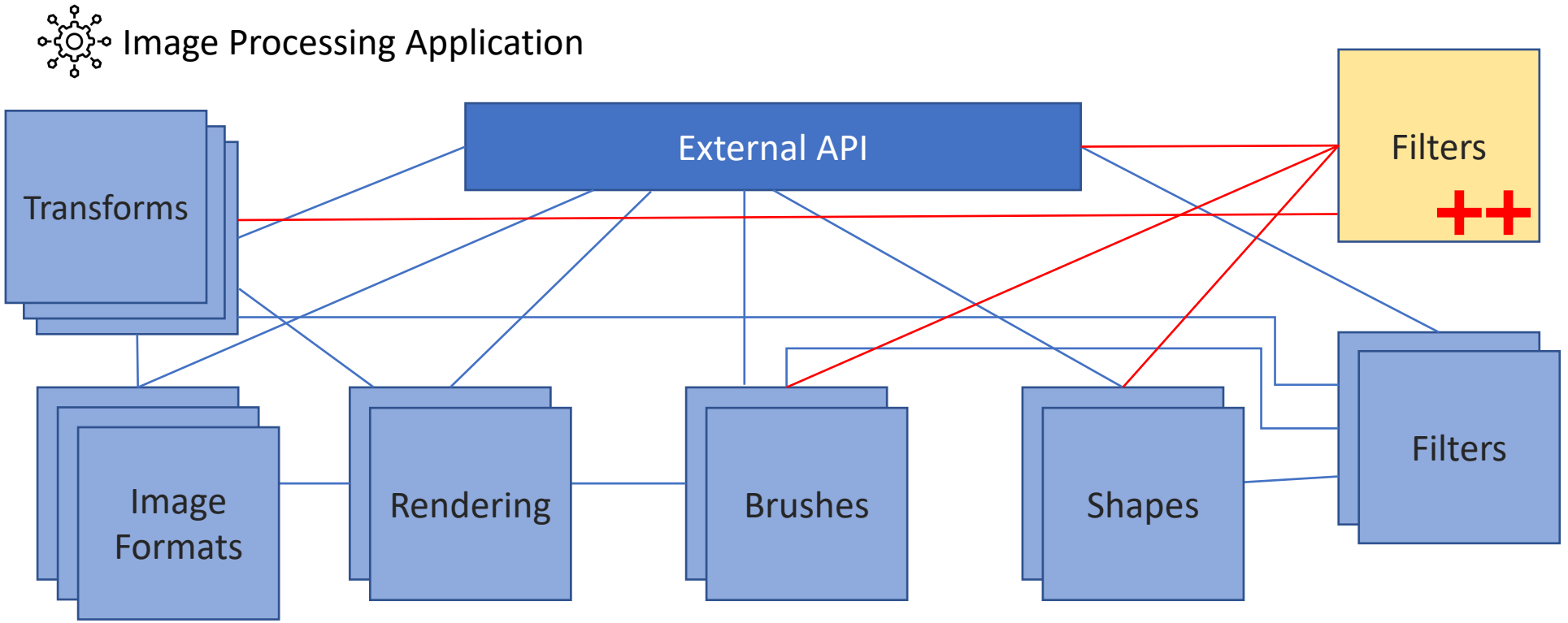

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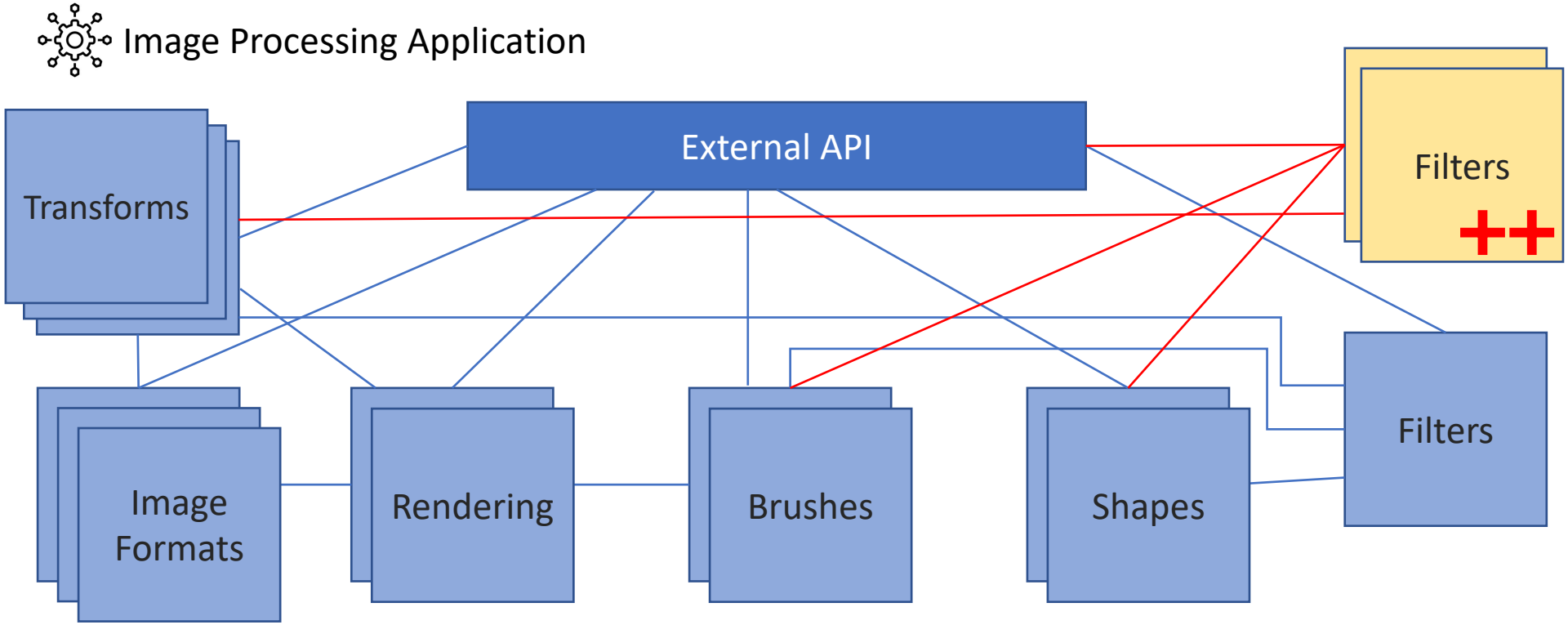

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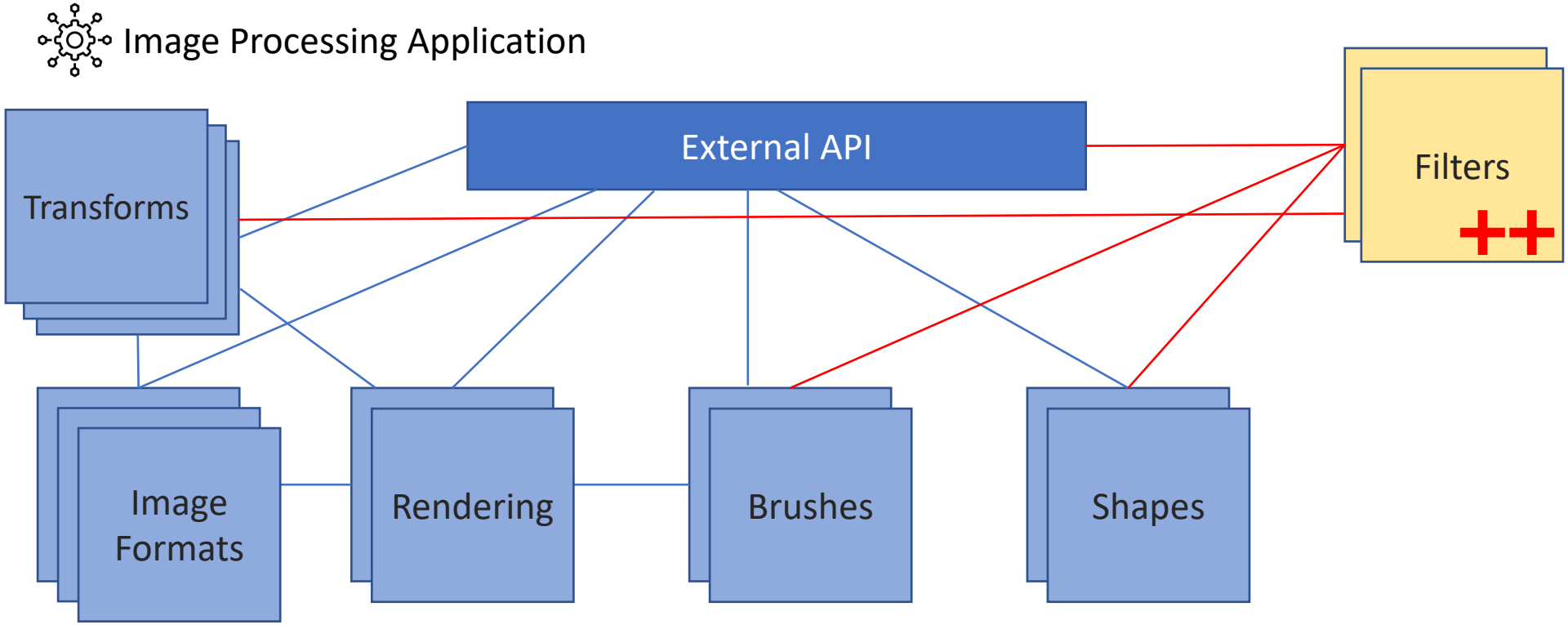

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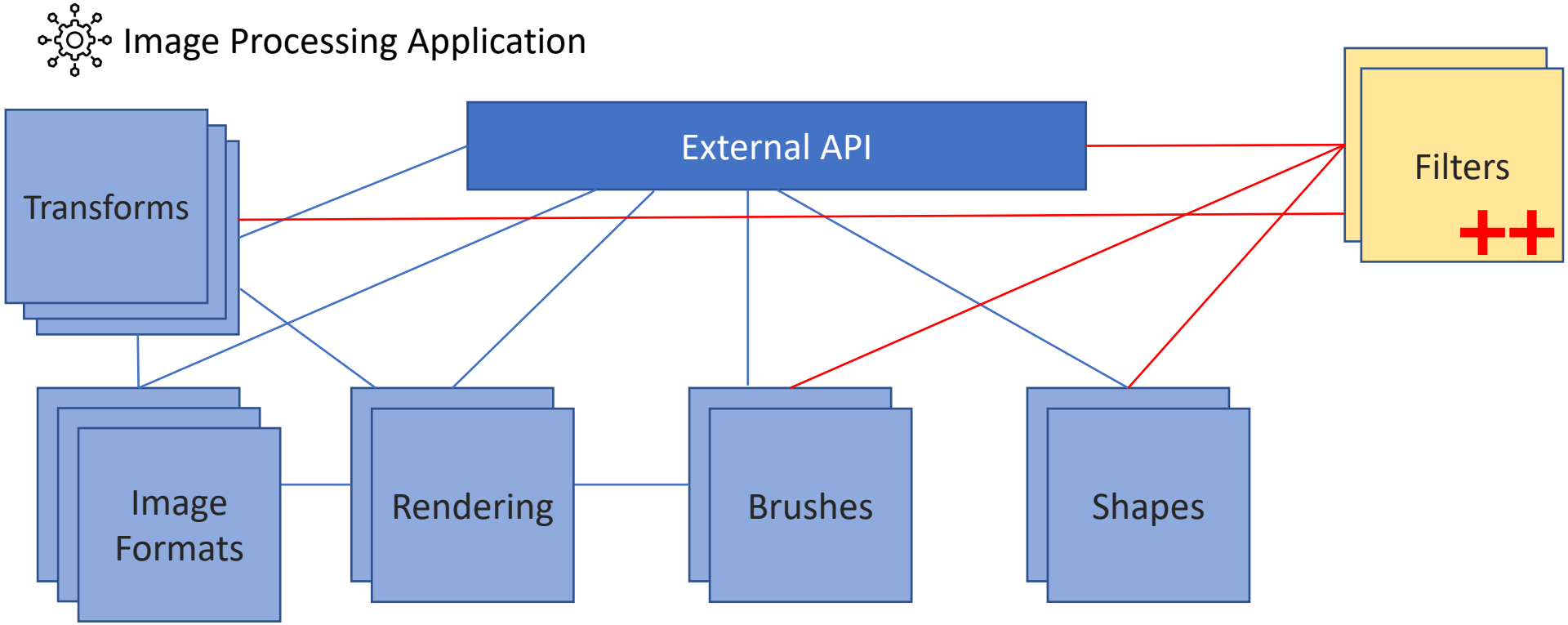
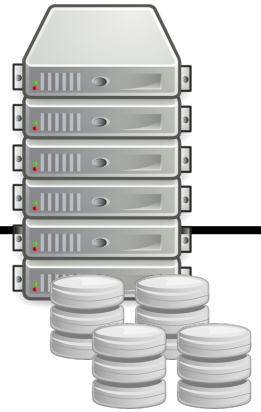
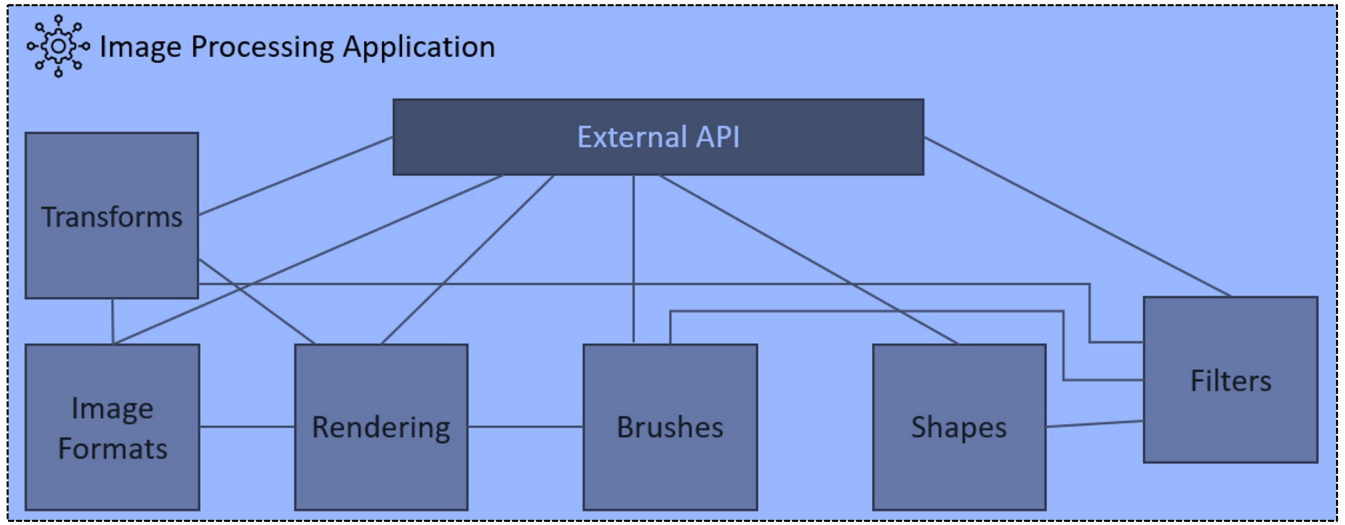
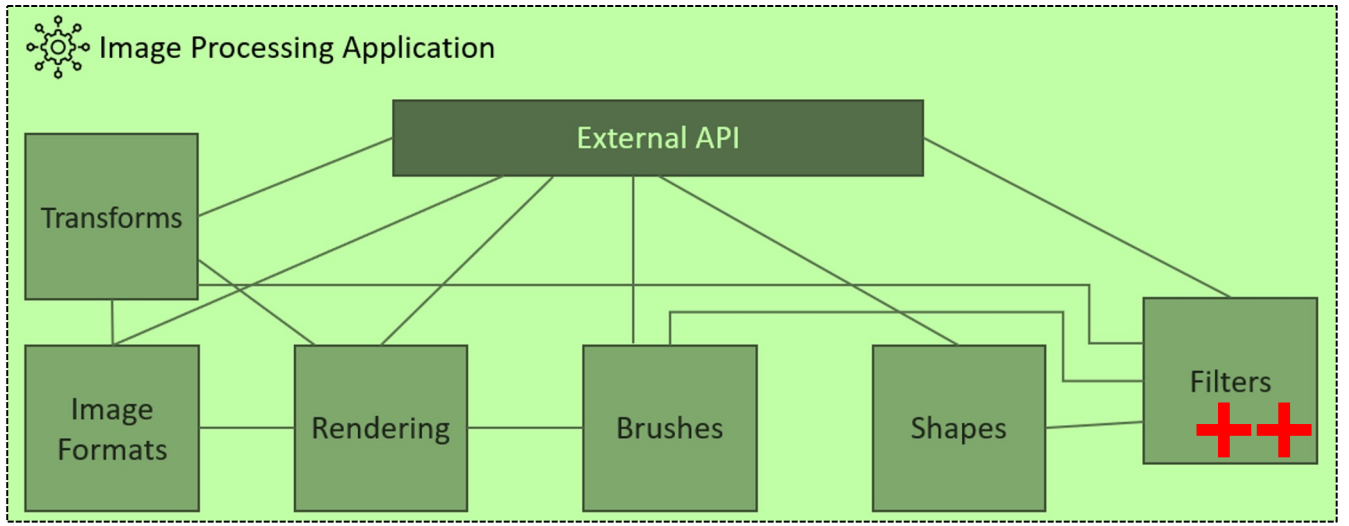


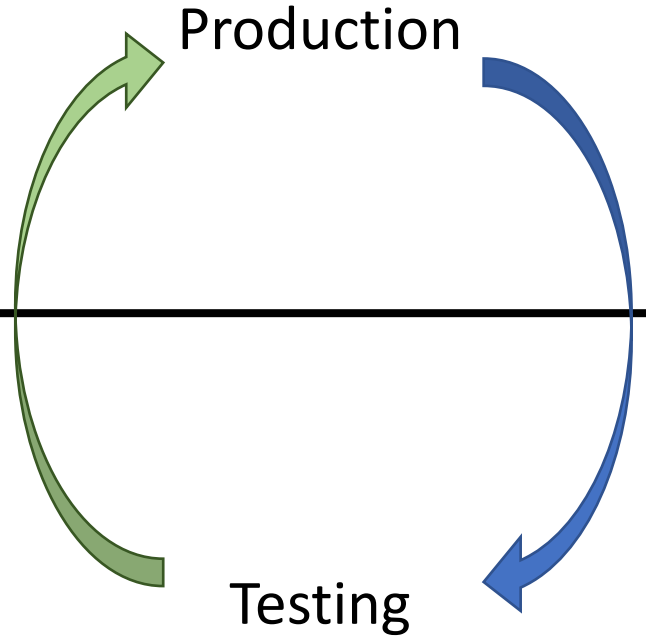
Blue-green deployment

Production infrastructure



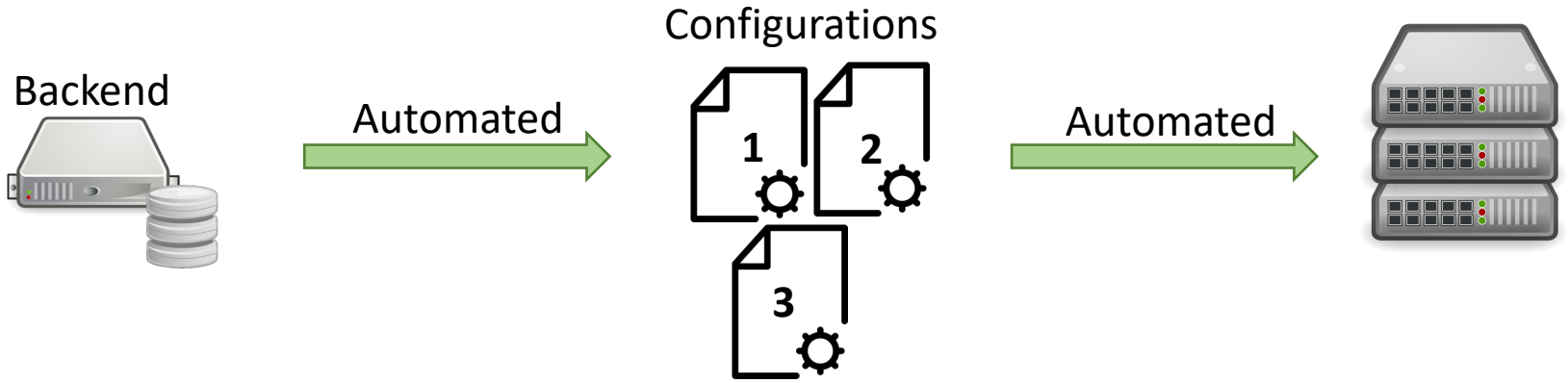






Modern software releases and updates

- Generate configurations
- Have configurations pushed automatically
  - For example, periodically push configurations every night
- Monitor router and traffic behavior
- Automatically roll back if errors occur



Difficult aspects of DevOps

- Culture shift
  - Teams have to collaborate more closely or merge
  - Realignment of incentives and rewards
- Extensive automation and orchestration
  - Initial setup costs, maintenance overhead
- Higher risk from rapid development
  - Despite tests and rollout/rollbacks, failures may occur more often
- System-wide failures instead of module failures
  - DevOps performs extensive tests of small modules,
    but global or cascading failures may occur in production

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Site Reliability Engineering

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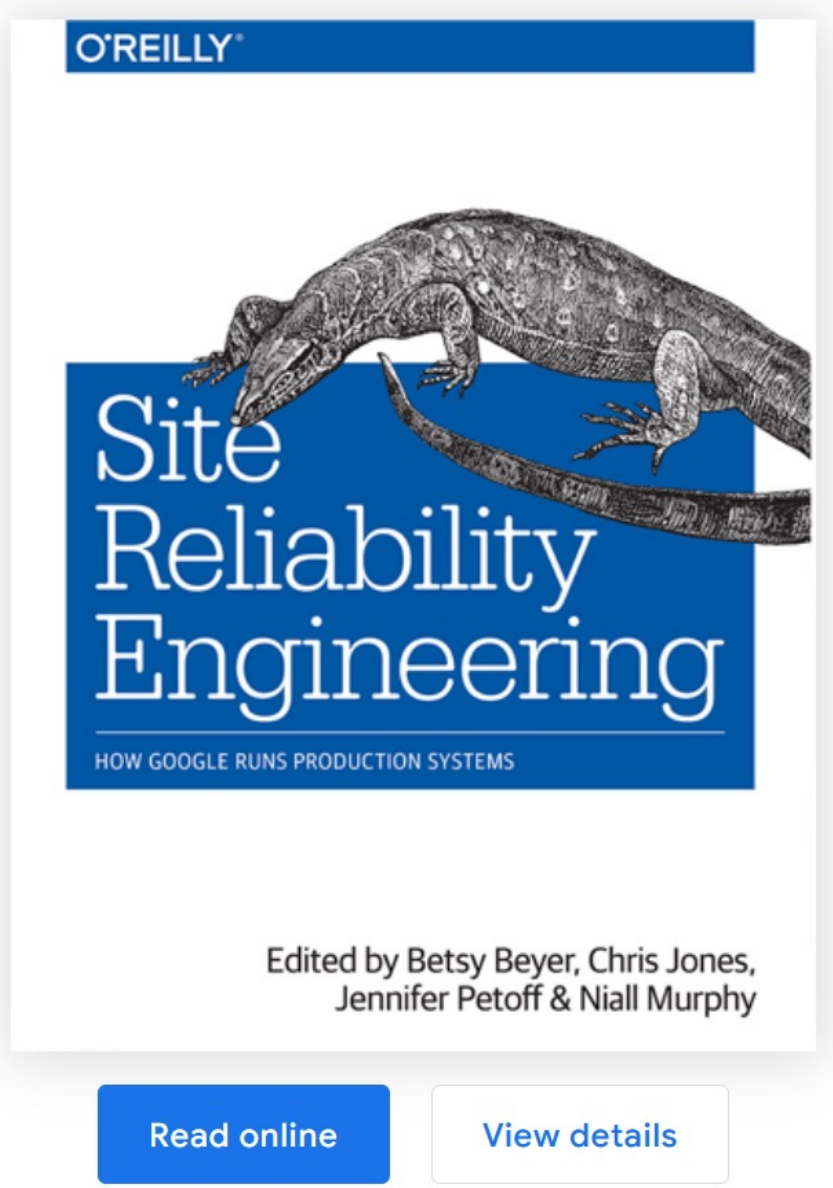
Site Reliability Engineering

- Systems management within Google
- Very similar to DevOps



SRE at Google

- SRE team members are software developers
- 50% cap on “ops” tasks
- At least 50% on development
- SREs build automation solutions
  - Or “automatic” systems that can run and repair themselves

Continued focus on engineering

- 50% of the time on development work
- Operational load above 50% redirected to development teams
- 1-2 incidents per 8-12h shift
  - Gives engineers time to dig deep and write post-mortem reports
  - Avoids pager fatigue

Error budgets and change velocity

- Most services aim for less than 100% availability
  - 99.99% availability is *much* easier to achieve than 100%
  - And the difference between the two might not be perceptible by users
- Allows teams to implement and deploy changes quickly
  - Provided the service is above the availability target
- Improve robustness if availability is below target

Emergency response

- Humans add latency
- Automate emergency response as much as possible
  - Progressive rollouts and automated rollbacks
- Playbooks for dealing with issues