Robert Martin
JC-U, 25-06-2014

MULTI-STAGE-CI SYSTEM WITH JENKINS IN THE EMBEDDED WORLD

BMW GROUP
BMW Car IT GmbH

AGENDA

- Some words about me
- Some questions to you
- SW development environment for embedded devices
- Why Multi-Stage-CI ?
- Multi-Stage-CI Overview
- Nightly Build versus Continuous Integration
- Automatic Integration, Flashing and Testing in HW
- Some recommendations

Some words about me

SOME WORDS ABOUT ME - PRIVATE

- My official Name: Robert Martin
- My Nickname: Robby
- My Age: 47 years

Hobby:
Hiking

- My Family:

Lara, 10 Simon, 12

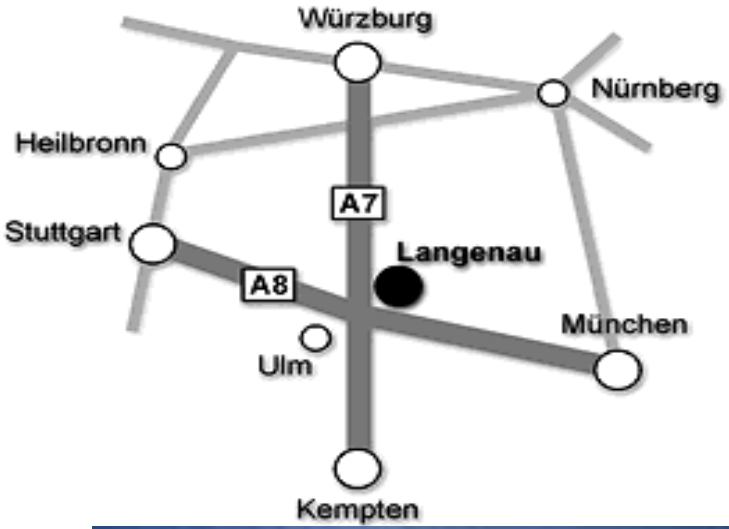
Mona, 7 Aaron, 7

My Wife Dunja, 43

Hobby: Organization of a music event once a year

SOME WORDS ABOUT ME - PRIVATE

My Home-Town: Langenau, 14 000 inhabitants, 20 km away from Ulm



Source: http://www.langenau.de/

SOME WORDS ABOUT ME - BUSINESS

- 1991 .. 1997 Alcatel
- 1998 .. 2000 Nokia
- 2001 .. 2006 Nokia
- 2007 .. 2009 Nokia
- 01/2010 .. 05/2011 Nokia – Mobile Phones S40 Platform
  - SW Project Leader to develop and roll-out Multi-Stage-Continuous Integration System for ca. 800 SW developers and SW test engineers
- 06/2011 .. 09/2012 Nokia – Mobile Phones Linux Platform
  - SW Project Leader to develop and roll-out Multi-Stage-Continuous Integration System for ca. 700 SW developers and SW test engineers
- 10/2012 .. Today BMW Car IT GmbH
  - SW Project Leader to develop and roll-out Multi-Stage-Continuous Integration System

Some questions to you

QUESTIONS TO YOU

1. Who is a SW developer ?
2. Who is a SW test engineer ?
3. Who is a SW integration engineer ?
4. Who is a SW project manager/SW Test manager/SW Release manager ?
5. Who is a line manger of a SW organization ?
6. Who is Jenkins/CI admin/.. ?

SW development environment for embedded devices

EMBEDDED DEVICES – CONSUMER ELECTRONIC

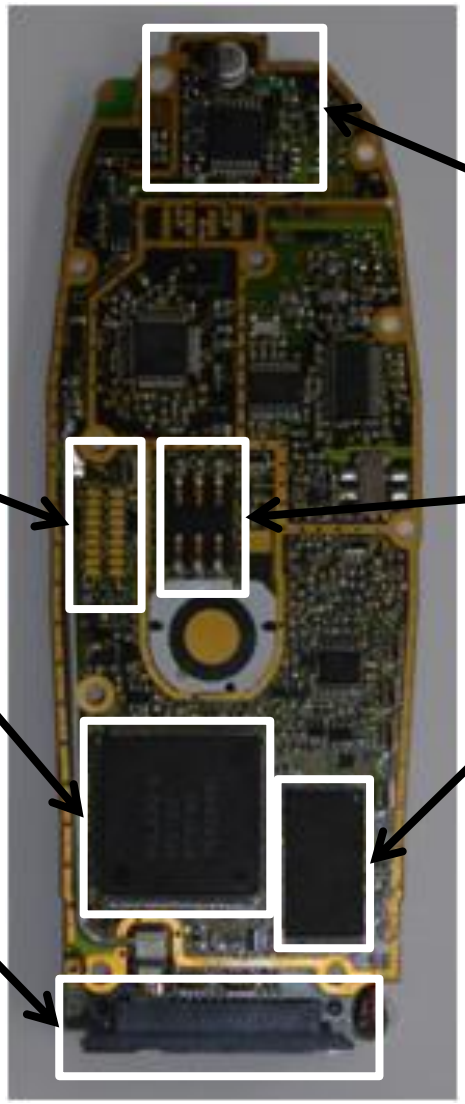
Our landline phone at home

Our old video recorder at home

Digital camera of my daughter

My old mobile phone

HARDWARE PARTS RELATED TO SOFTWARE – EXAMPLE MOBILE PHONE



Radio-Frequency area for GSM, UMTS, ..

Access for emulator, real-time tracing, ..

SIM Card holder

Microcontroller incl. DSP, RAM, ..

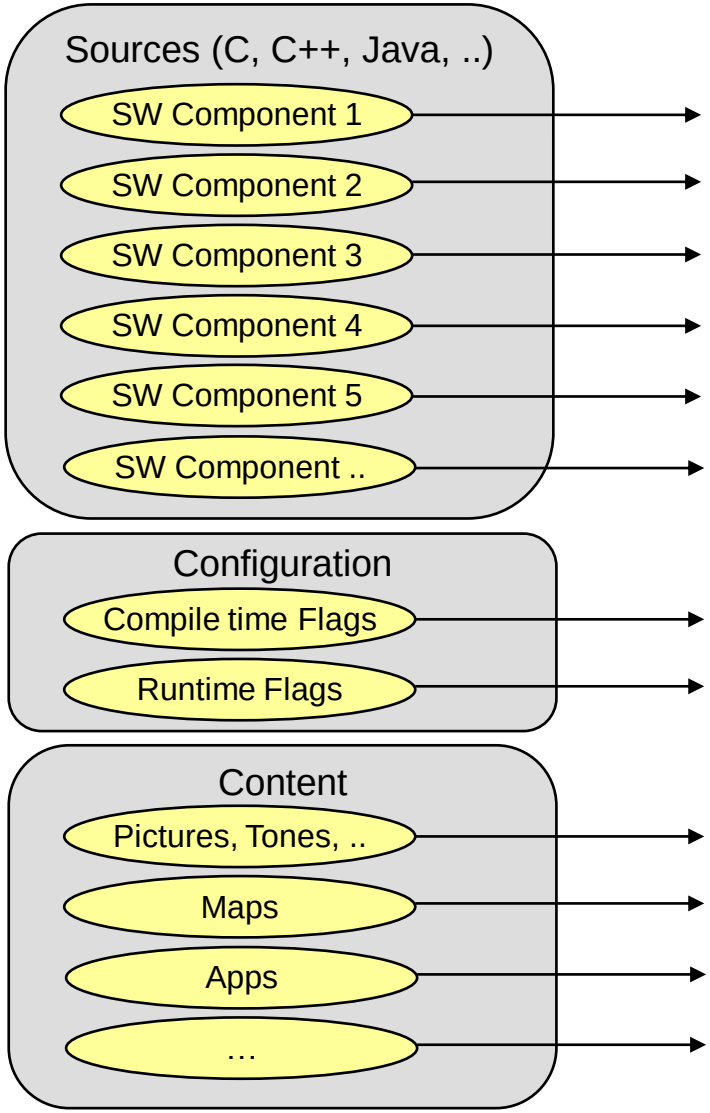
Flash-EEPROM

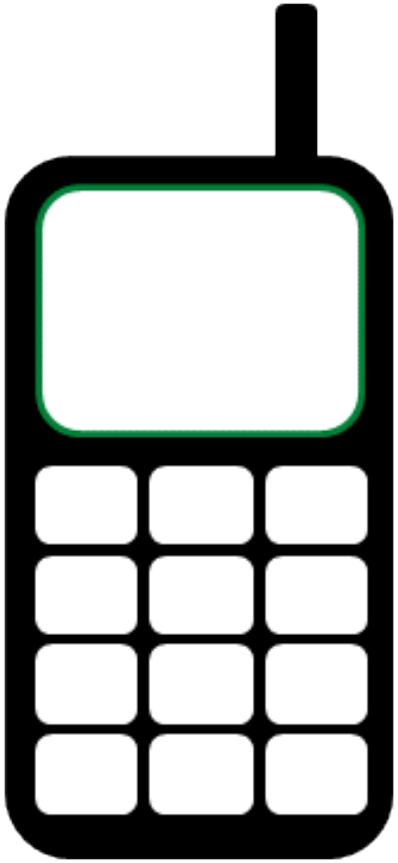
Connector for Flashing, PC connection, ..

plus hardware for Camera, USB, BT, WLAN, GPS, ..

Important note:
Picture is just showing an example

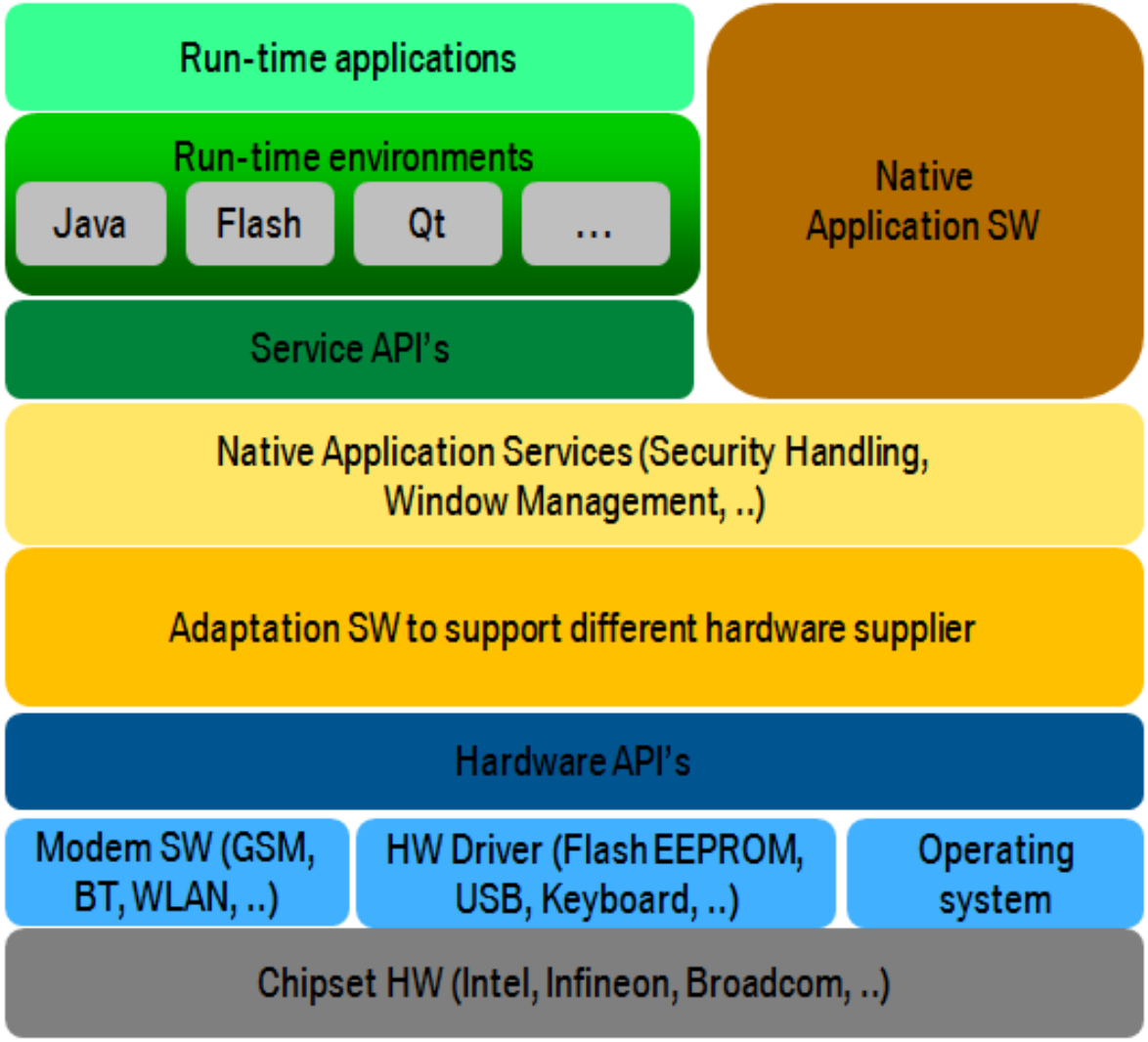
WHAT SOFTWARE RELEVANT PARTS ARE NEEDED FOR YOUR PRODUCT – EXAMPLE MOBILE PHONE ?





Important note:
Picture is just showing an example

SW ARCHITECTURE – EXAMPLE MOBILE PHONE



Important note:
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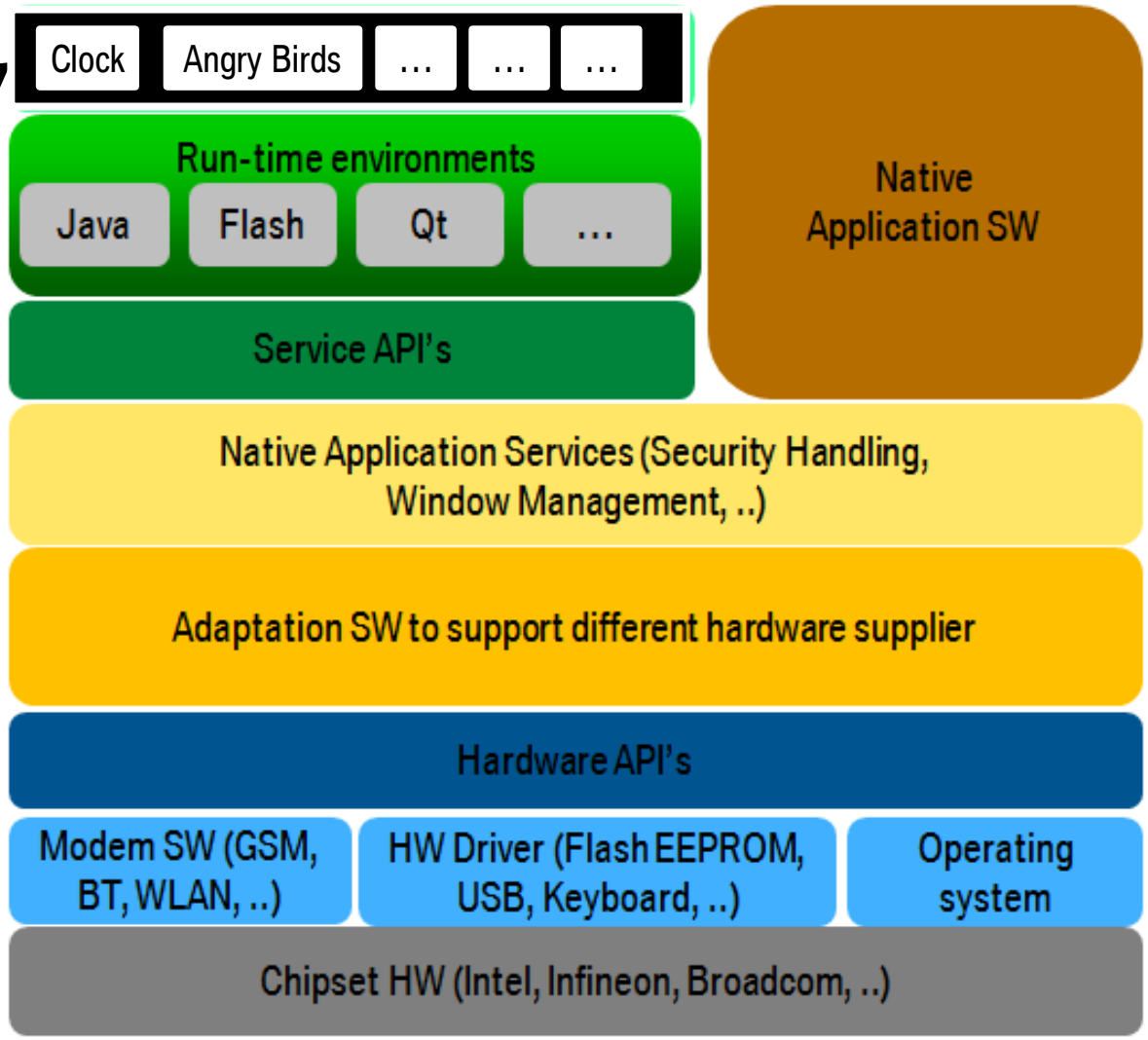
WHERE ARE THE APPS RUNNING ?

Apps are running usually in the runtime environment
-> Dependent on the selected architecture of the manufacturer (Nokia, Samsung, Apple, LG, ..)



Important note:
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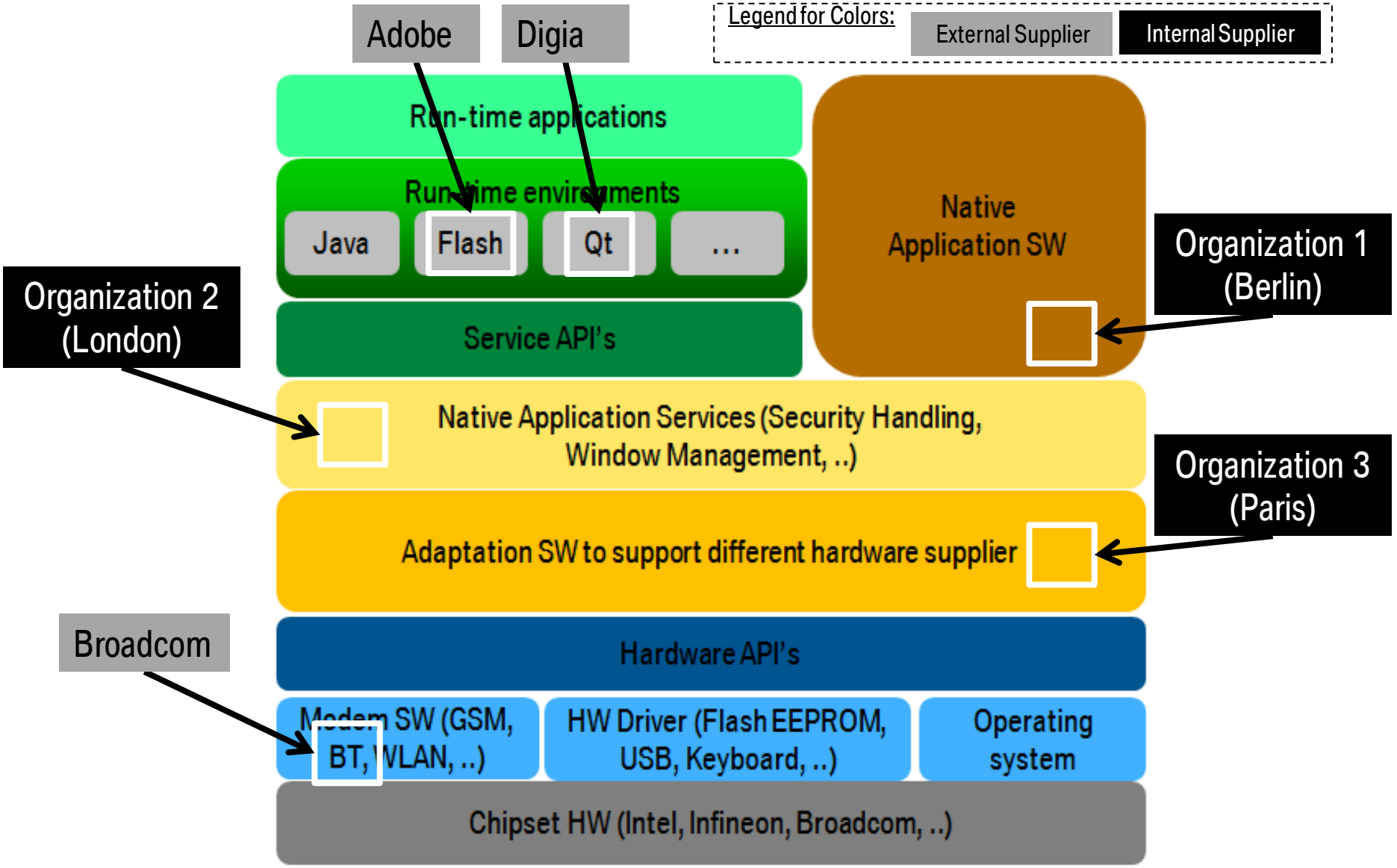
WHO DELIVERS THE SOFTWARE FOR YOUR PRODUCT ?



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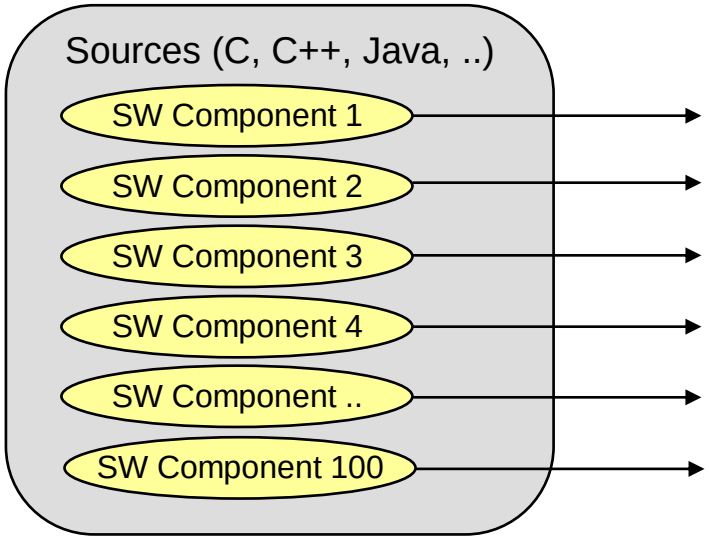
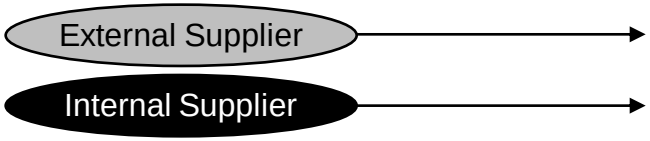
WORKING ASSUMPTION FOR TODAY´S PRESENTATION

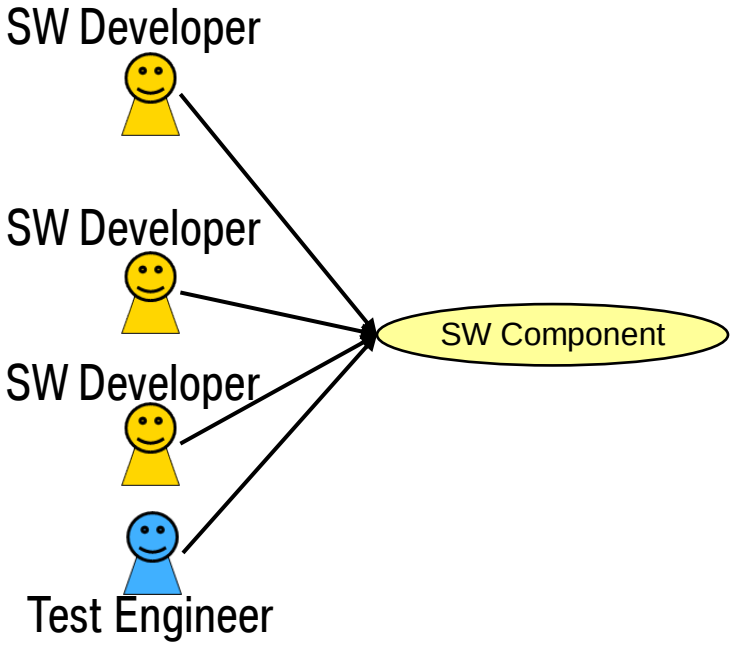
We need 100 different SW components for our product



SW is delivered by external and internal suppliers



Each SW component is developed by 3 SW developers and 1 test engineer



Important note:
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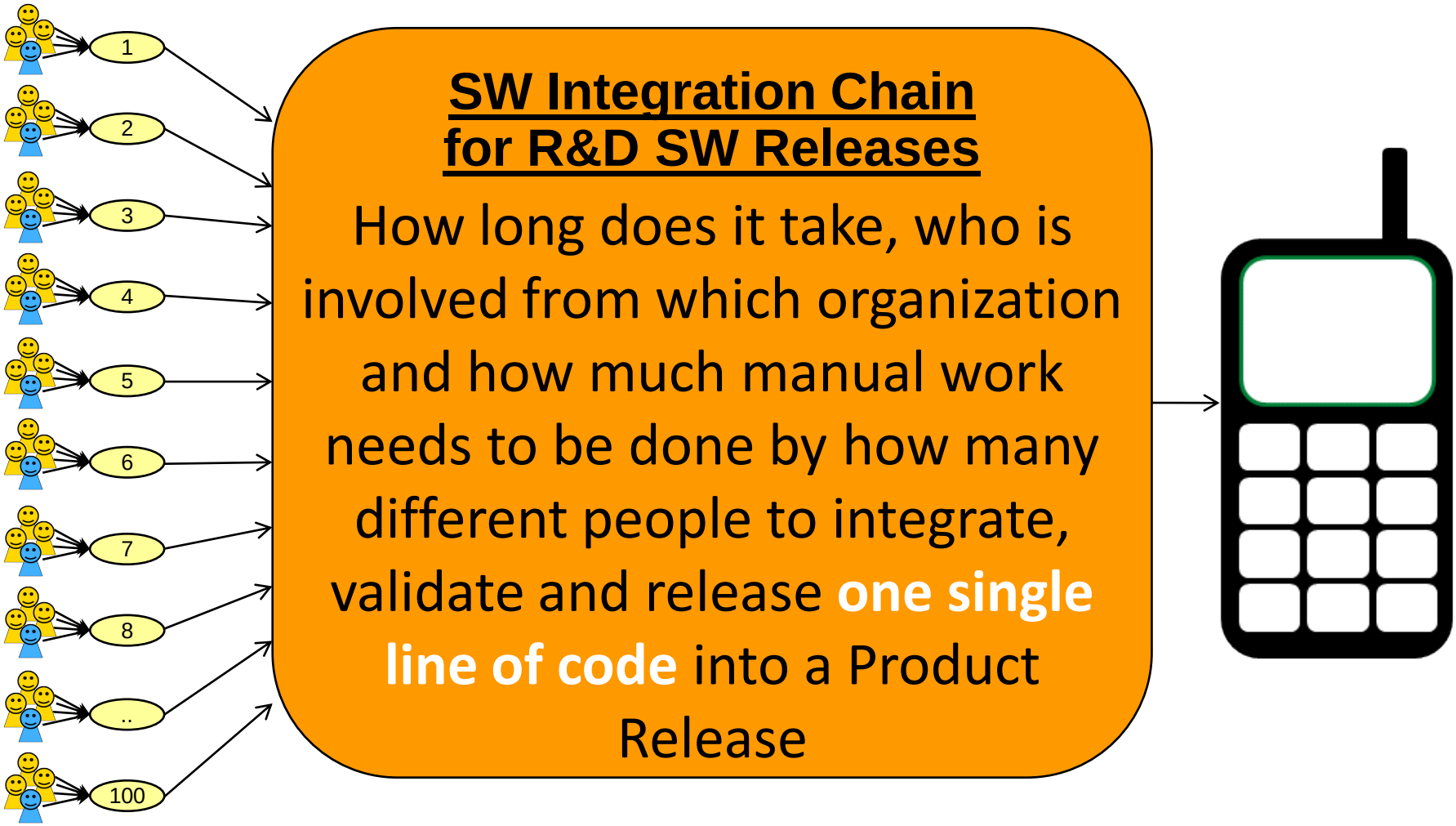
HOW IS SW INTEGRATION ORGANIZED ?

ONE KEY QUESTION FOR A SW COMPANY ?



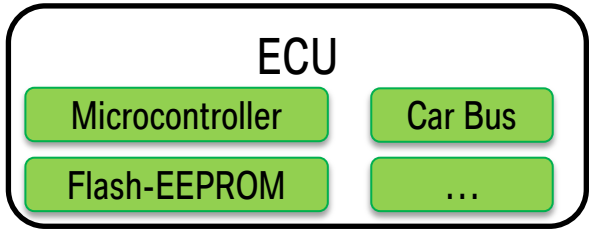
EMBEDDED DEVICES – HARDWARE COSTS

Product	Consumer End Price in EURO	HW Costs for Prototype during development	Comments
Digital Camera	250	800	
Landline phone	120	350	
Mobile Phone – Entry Market	55 .. 85	550	
Mobile Phone – High End	500 .. 800	1500	e.g. iPhone
BMW X5	> 45 000	> ???	dependent on the selected features like engine, active cruise control, ..

Important note:
The values for the costs in the table are estimated costs

EMBEDDED DEVICES – AUTOMOTIVE INDUSTRY

ECU = Electronic Control Unit



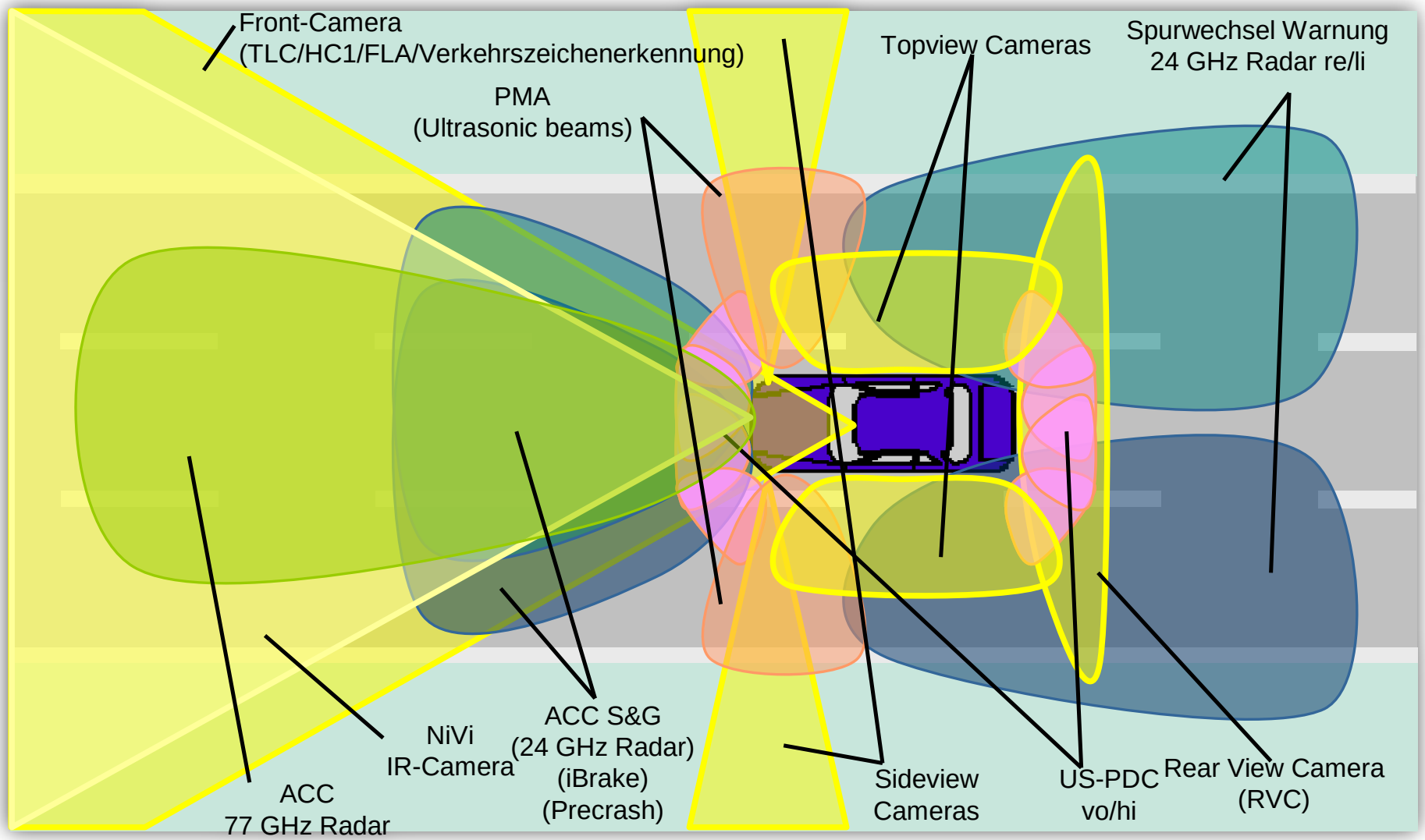
Many different ECUs for different purposes in one car for

- Engine Control
- Airbag Detection
- Active Cruise Control
- Radar Sensors
- Camera Sensors
- Navigation
- …

EMBEDDED DEVICES – AUTOMOTIVE INDUSTRY

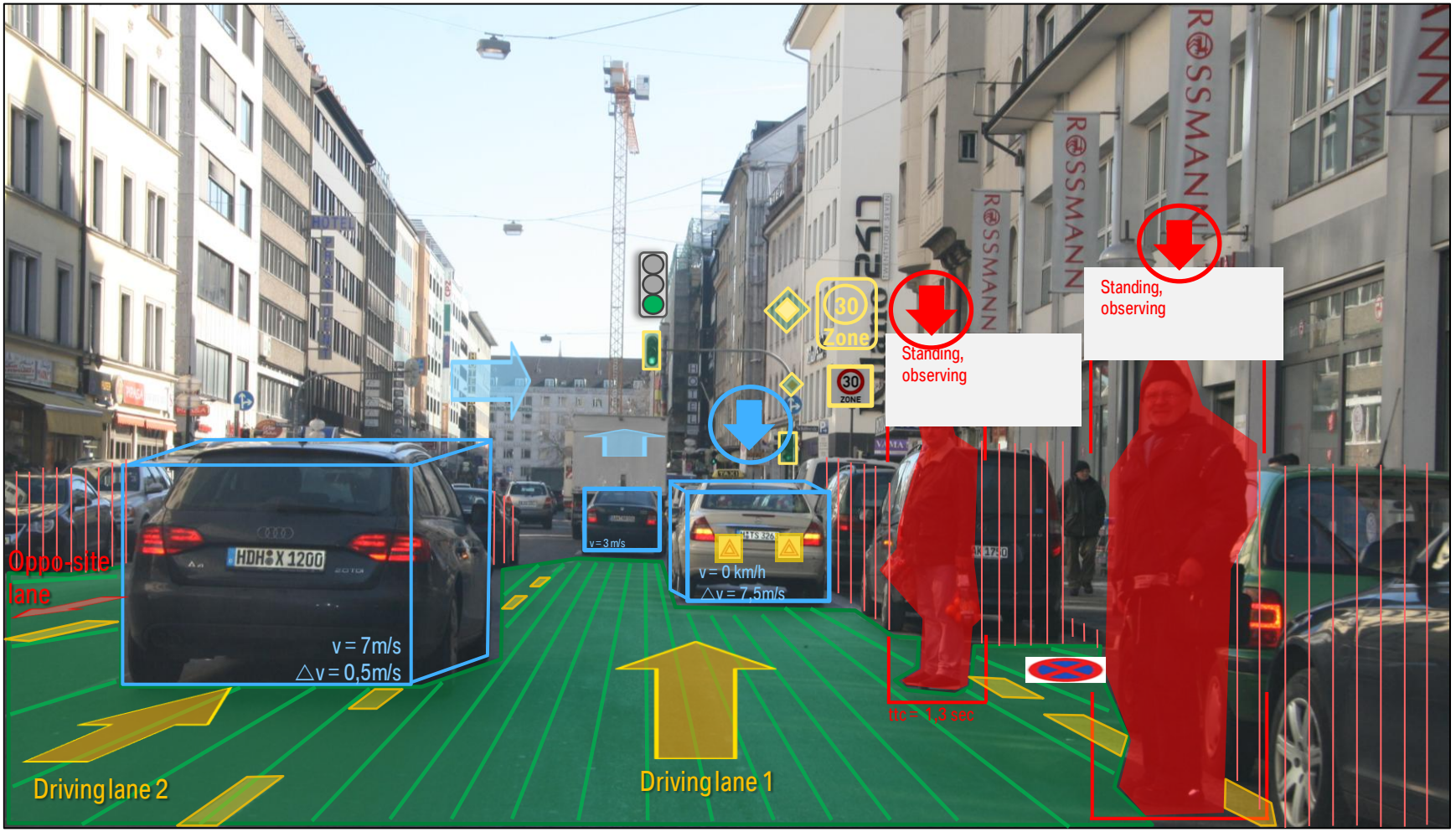
Important note:
Picture is just showing the principle

EXAMPLE: DATA FROM VARIOUS SENSORS FUSED TO ONE COMMON ENVIRONMENT MODEL.



Source: Gentner, BMW

ENVIRONMENT MODEL IN THE CLOUD: INTERPRETATION OF COMPLEX TRAFFIC SITUATIONS.



Source: Gentner, BMW

HOW MUCH SOFTWARE IS IN A FULLY-EQUIPPED MODERN BMW CAR?

a. < 50 million lines of code

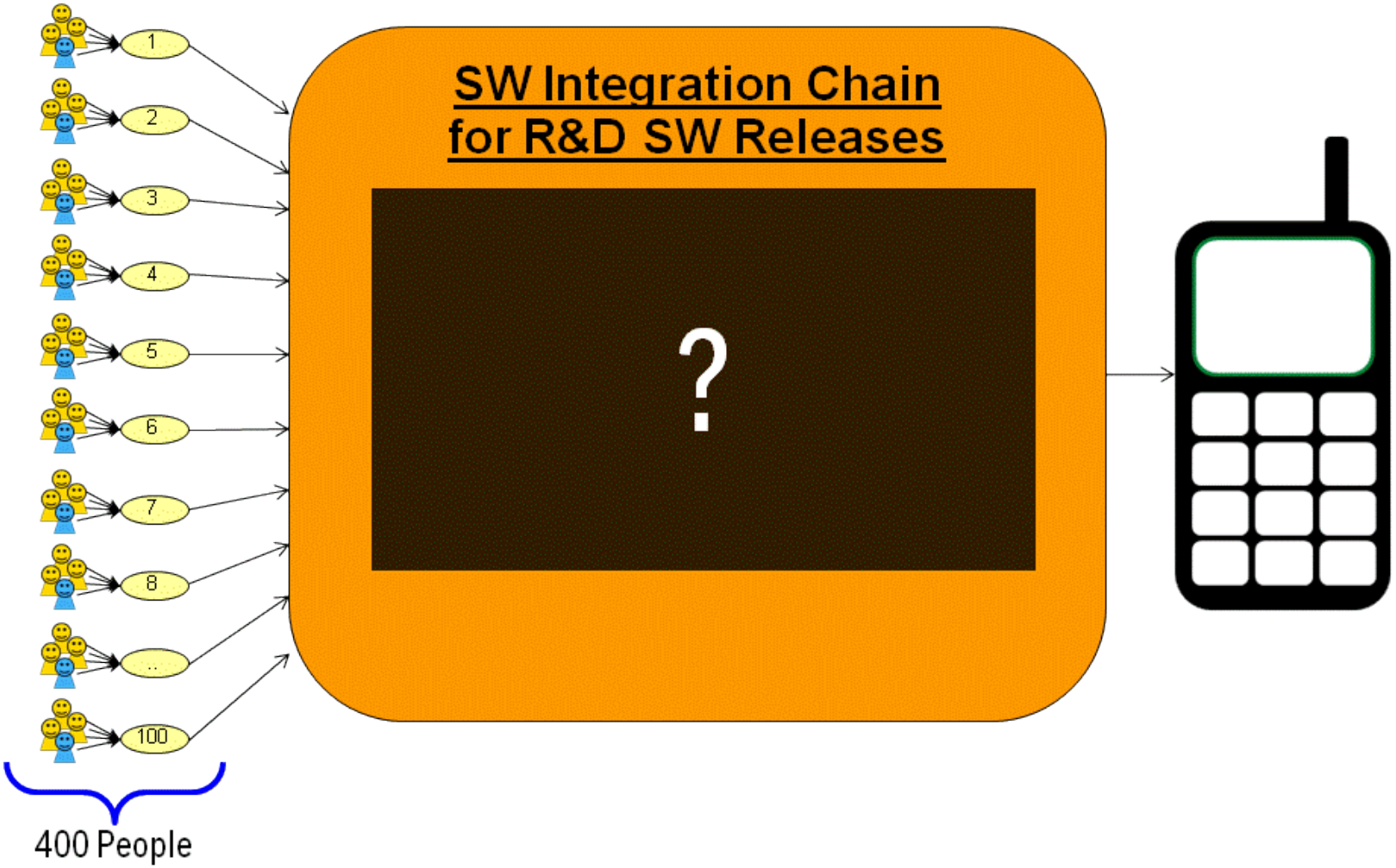
b. 50 million .. 100 million lines of code

c. > 100 million lines of code

Source: Gentner, BMW

Why Multi-Stage-CI ?

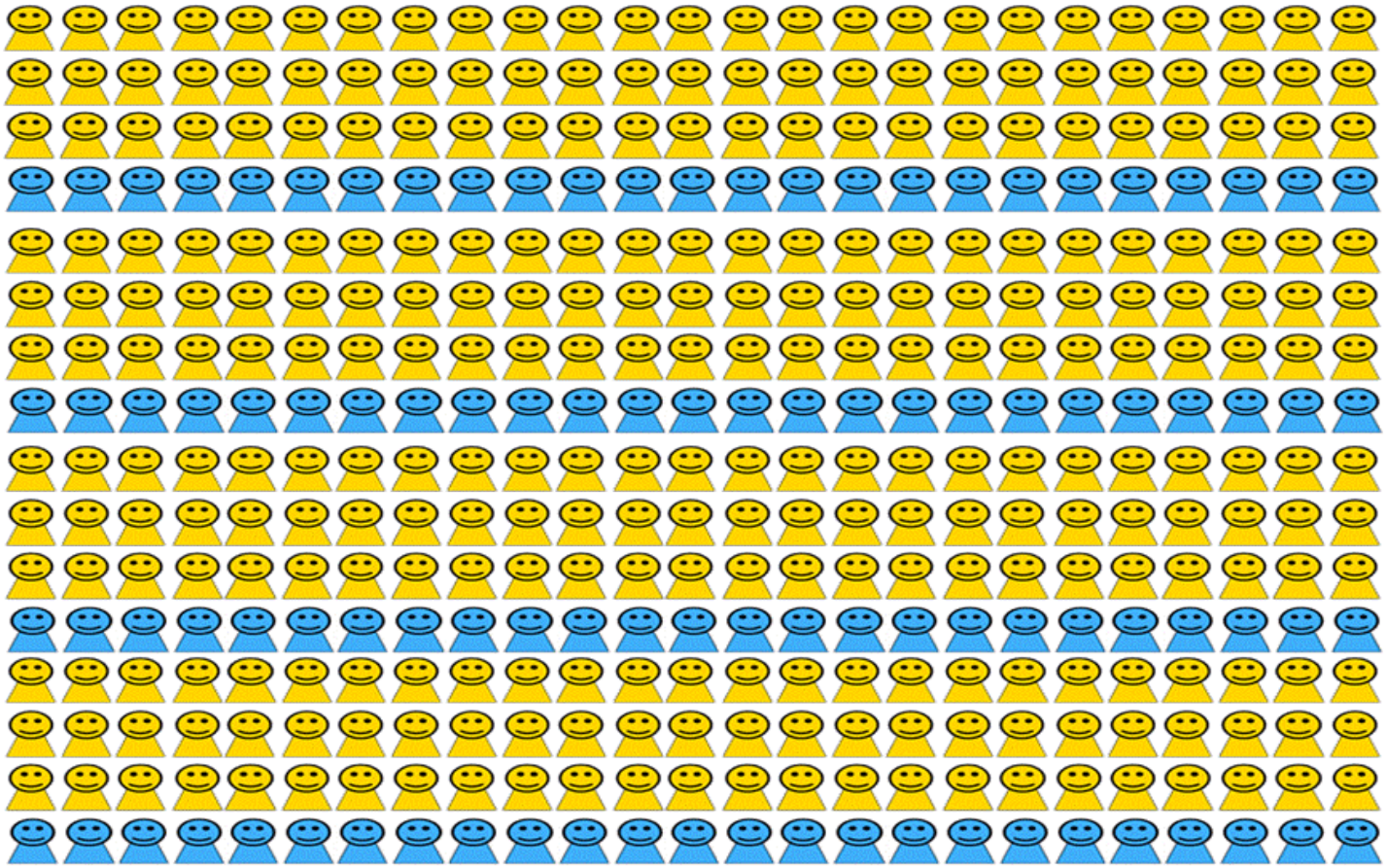
HOW IS THE INTEGRATION CHAIN ORGANIZED ?



Important note:
Picture is just showing an example

WHO DELIVERS WHAT AND HOW FOR YOUR PRODUCT ?

300 SW developers + 100 SW test engineers = 400 people



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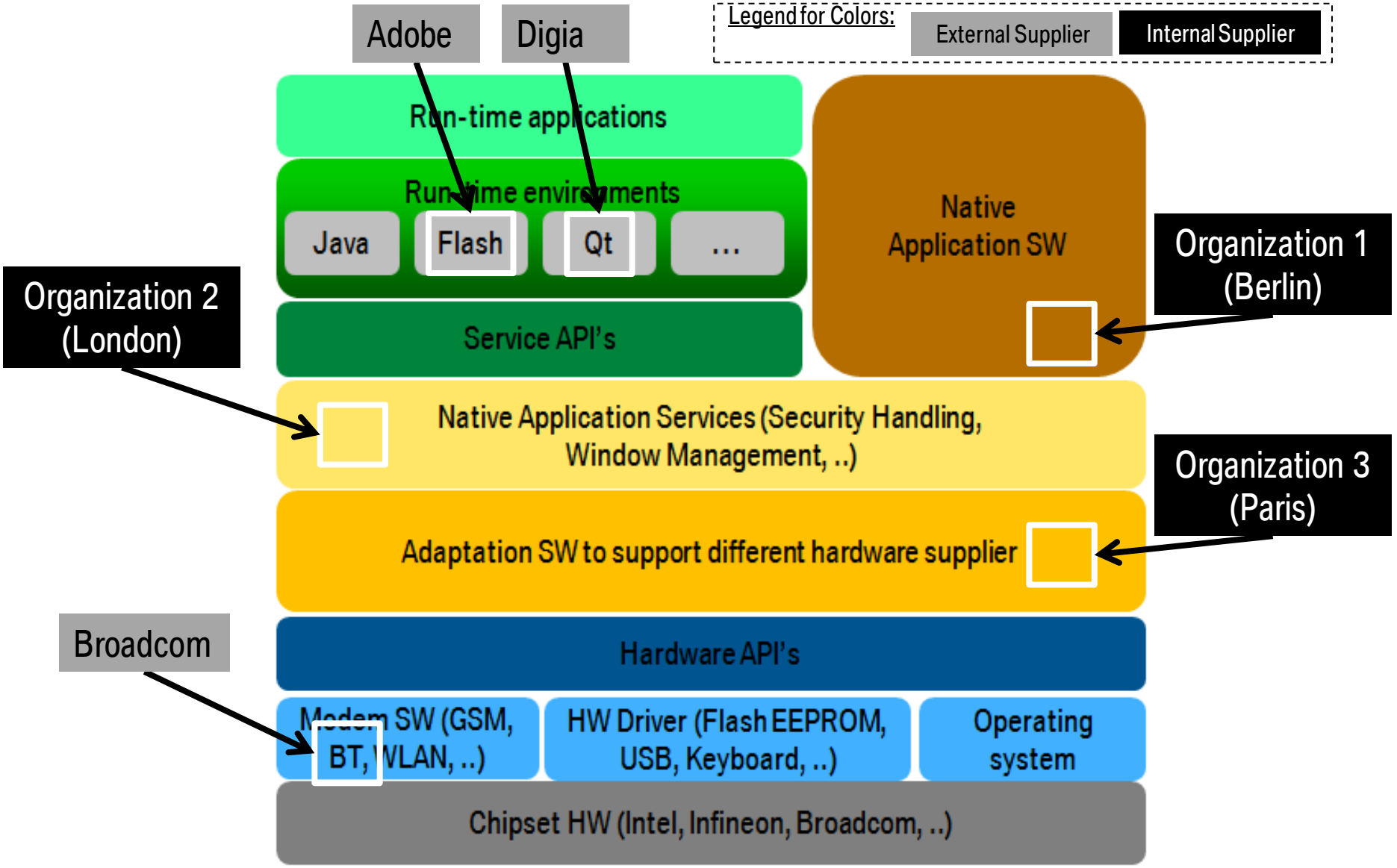

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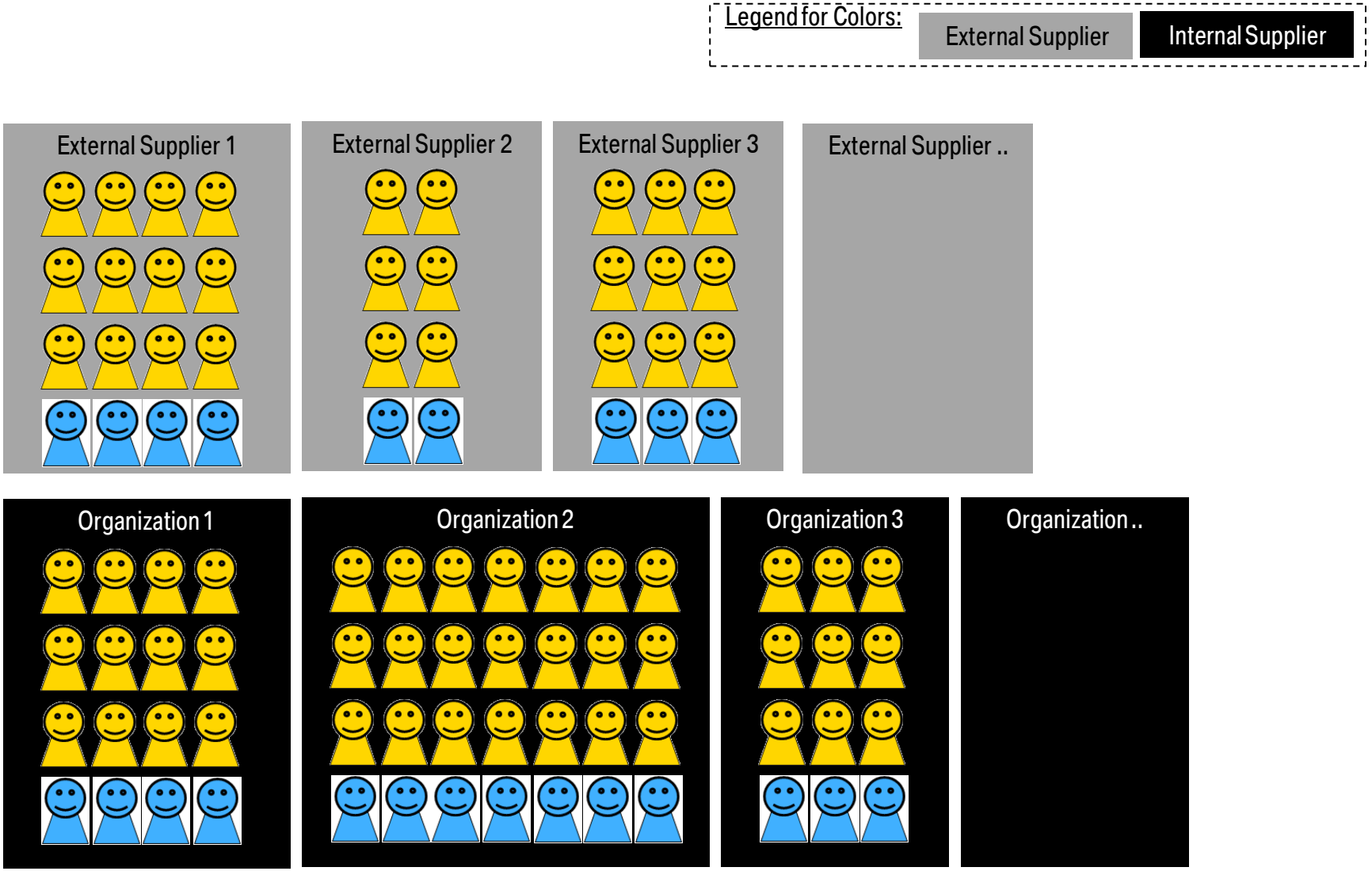
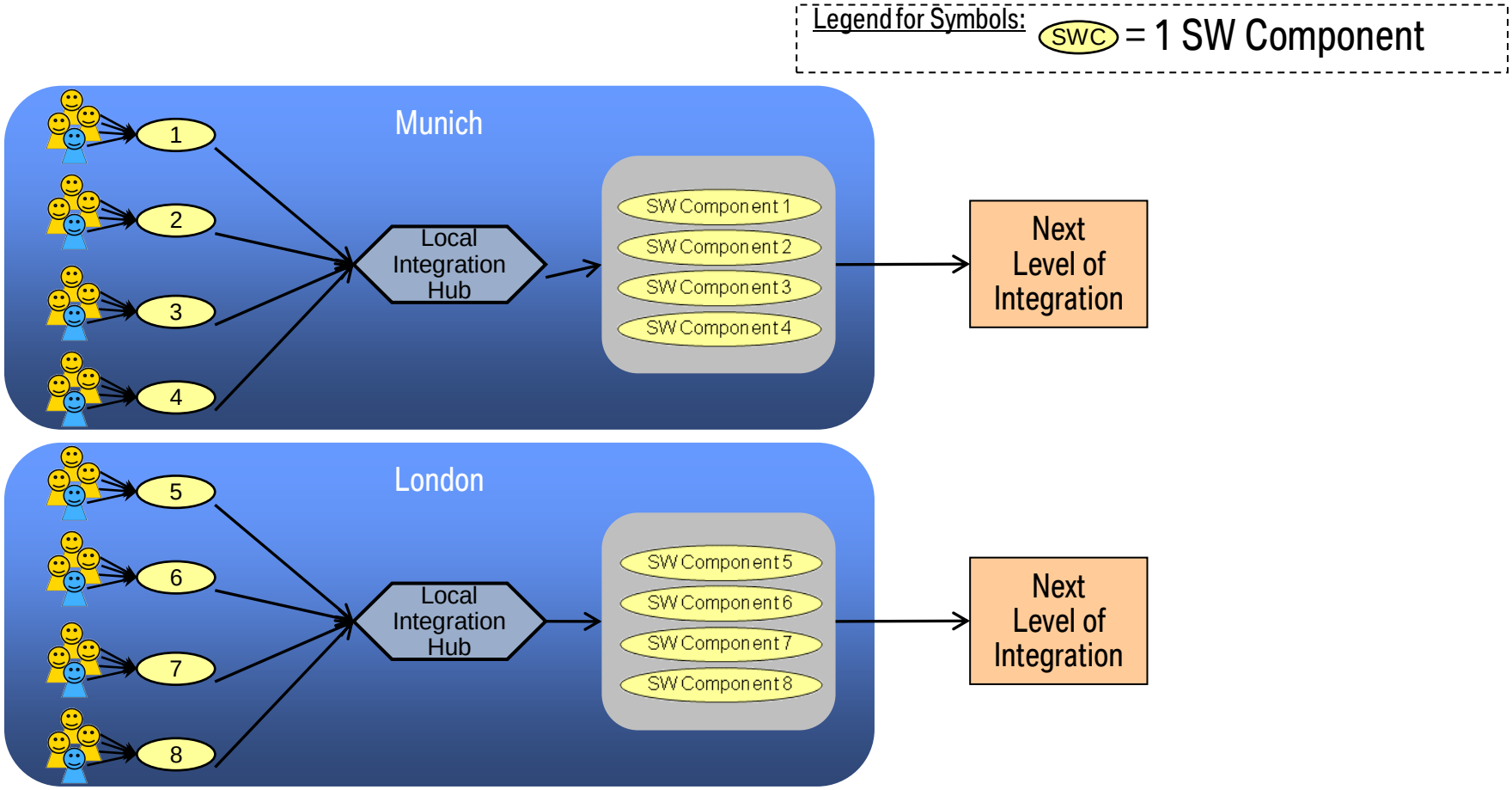
Picture is just showing an example

TYPICAL ORGANIZATIONAL STRUCTURE IN COMPANIES



Important note:
Picture is just showing an example

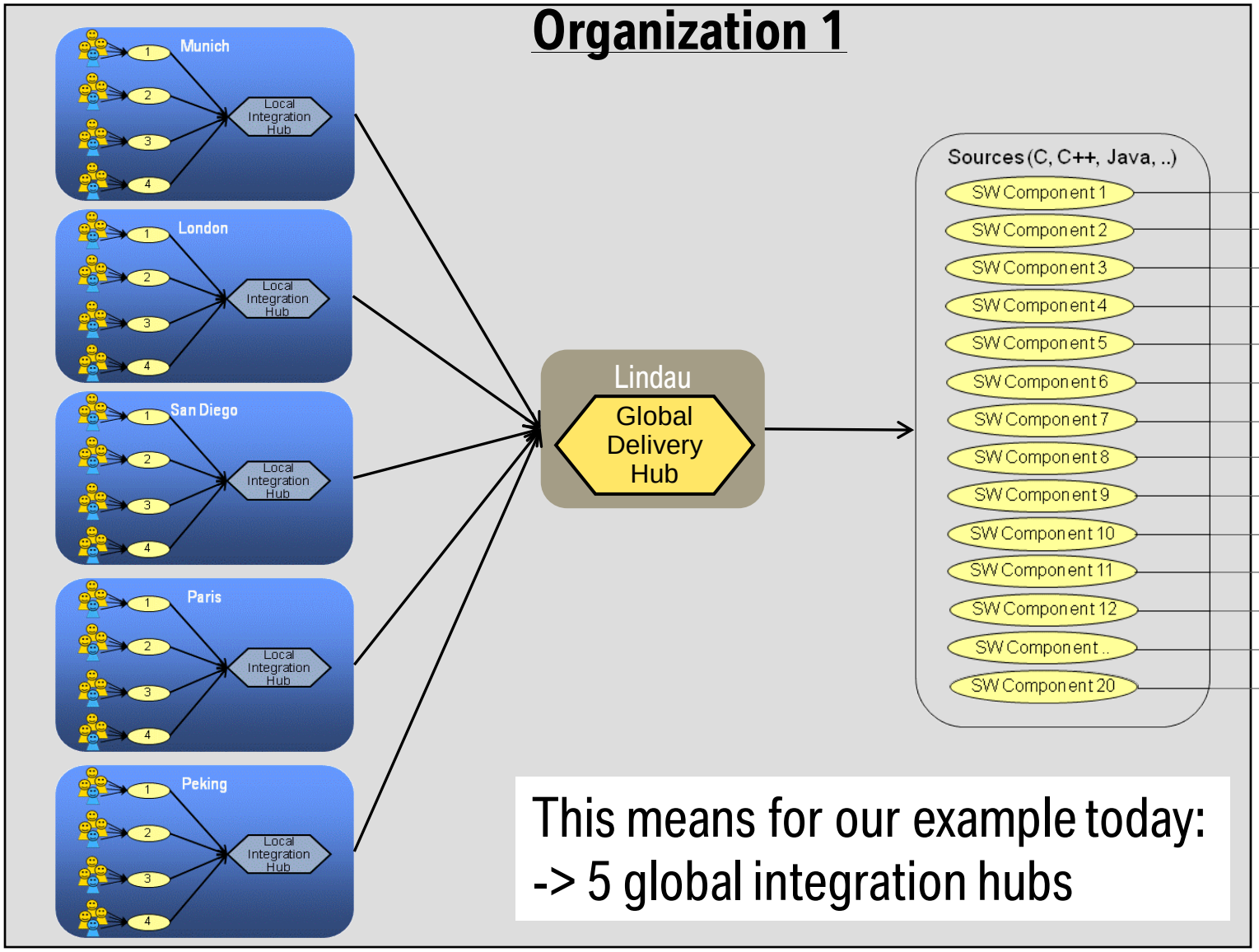
LOCAL INTEGRATION HUBS



This means for our example today:
-> 25 local integration hubs

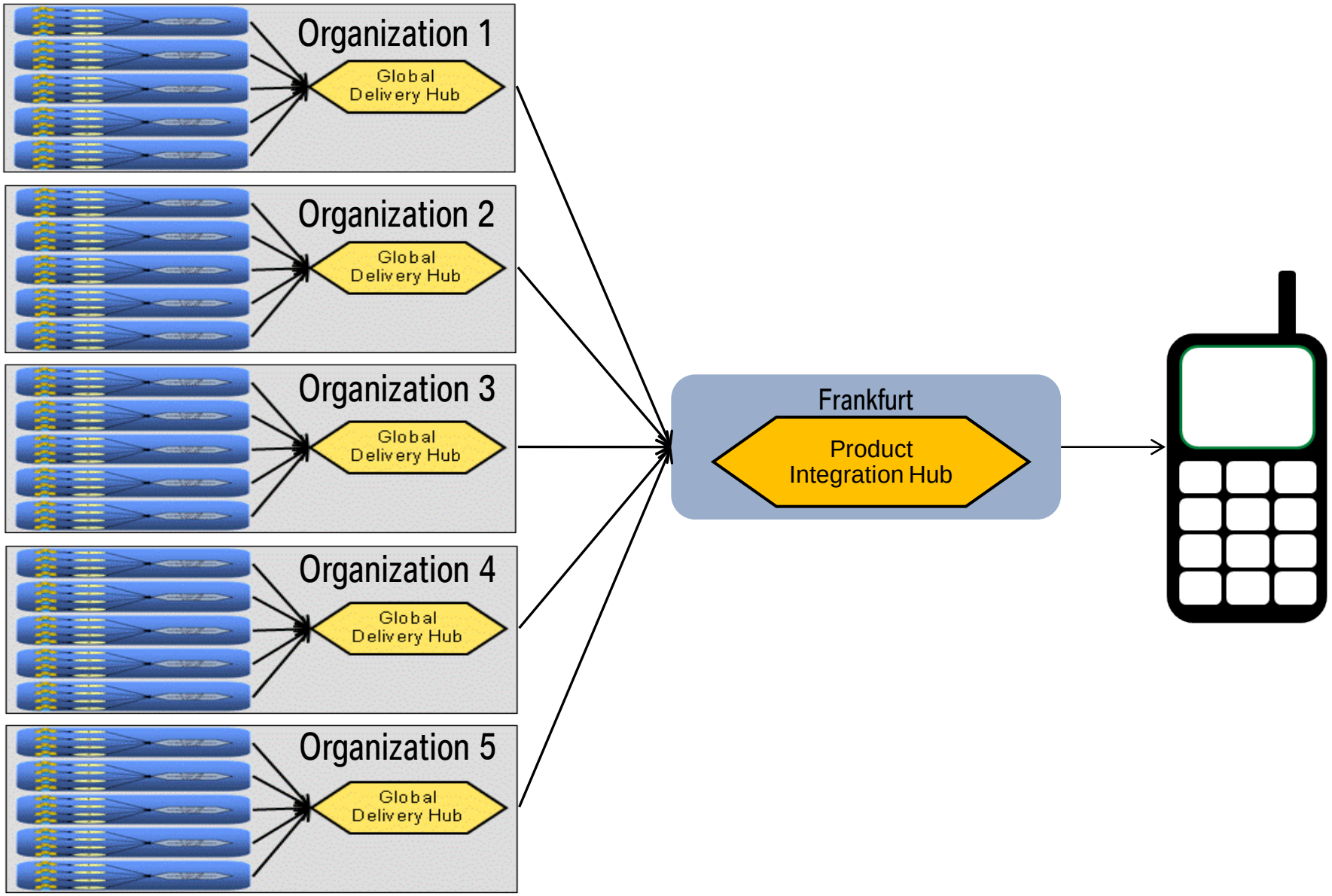
Important note:
Picture is just showing an example

GLOBAL INTEGRATION HUBS FOR ONE ORGANIZATION



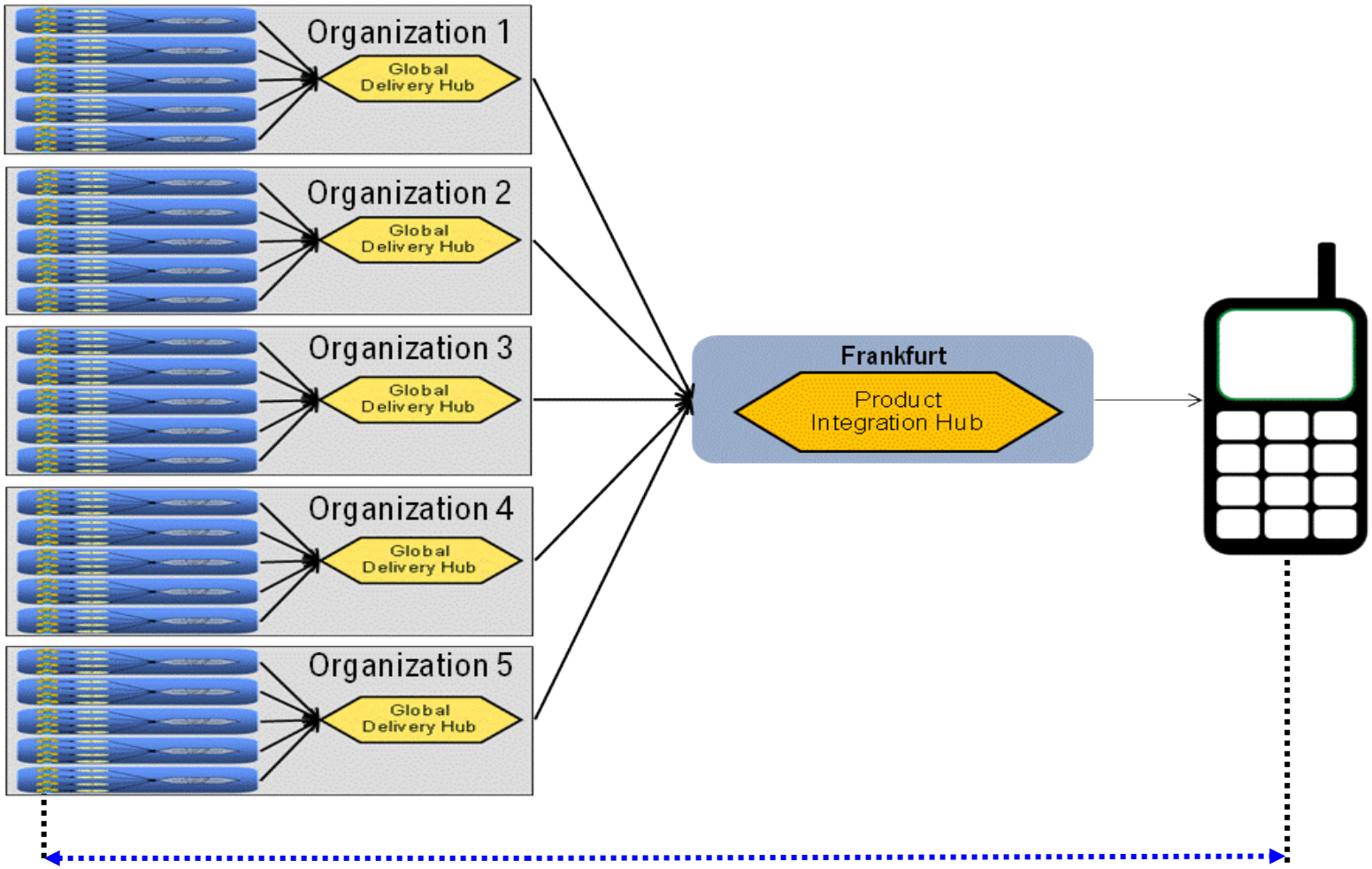
Important note:
Picture is just showing an example

1 GLOBAL PRODUCT INTEGRATION HUB



Important note:
Picture is just showing an example

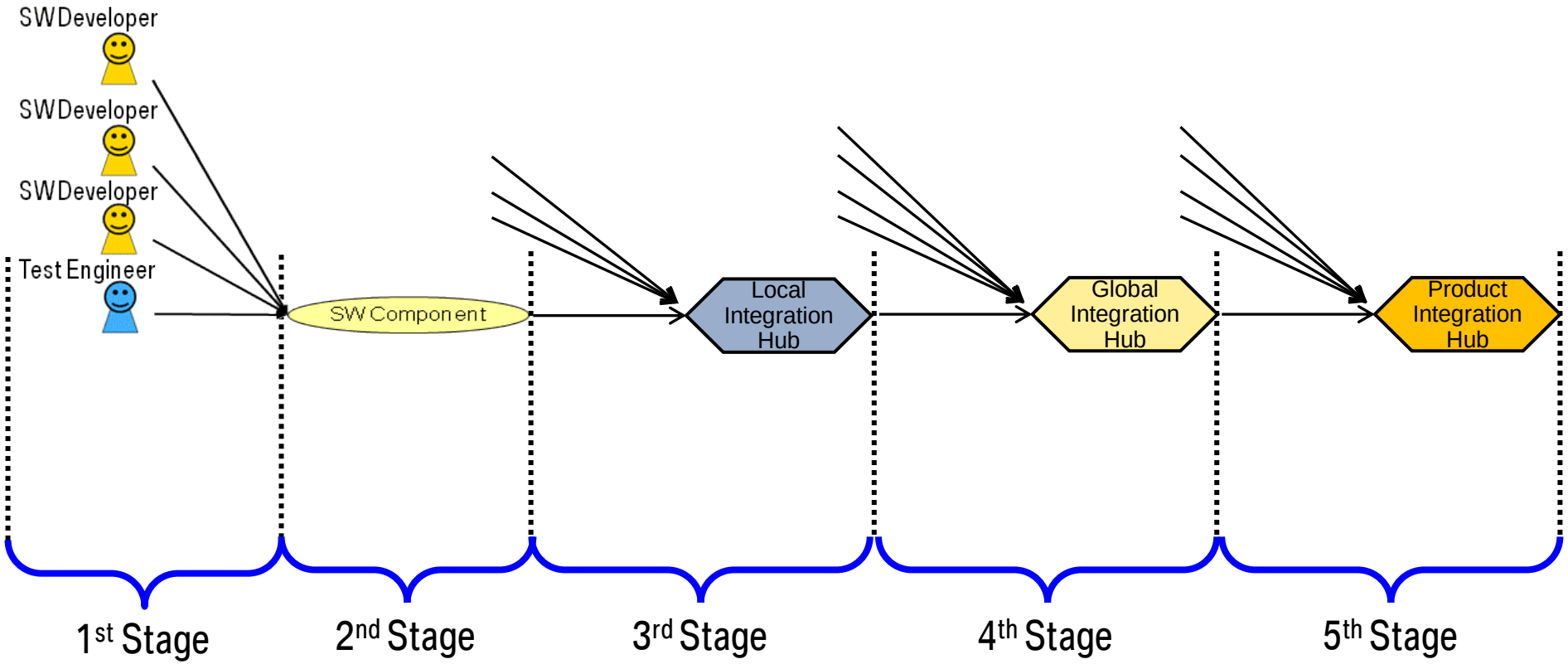
HOW MANY STAGES IN THE INTEGRATION CHAIN ?



How many Stages in Integration Chain ?

Important note:
Picture is just showing an example

HOW MANY STAGES IN THE INTEGRATION CHAIN ?



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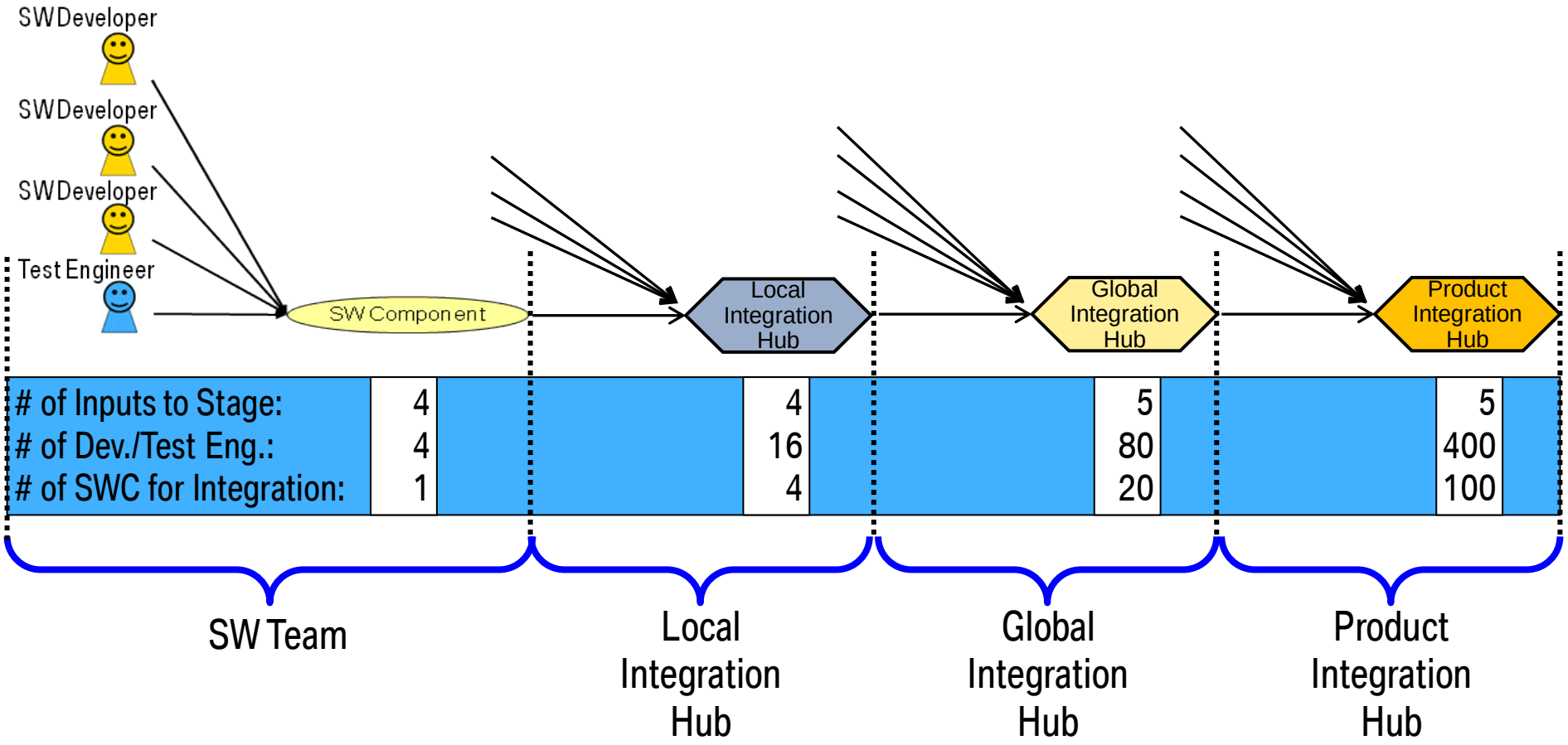
COMPLEXITY OF THE R&D INTEGRATION CHAIN



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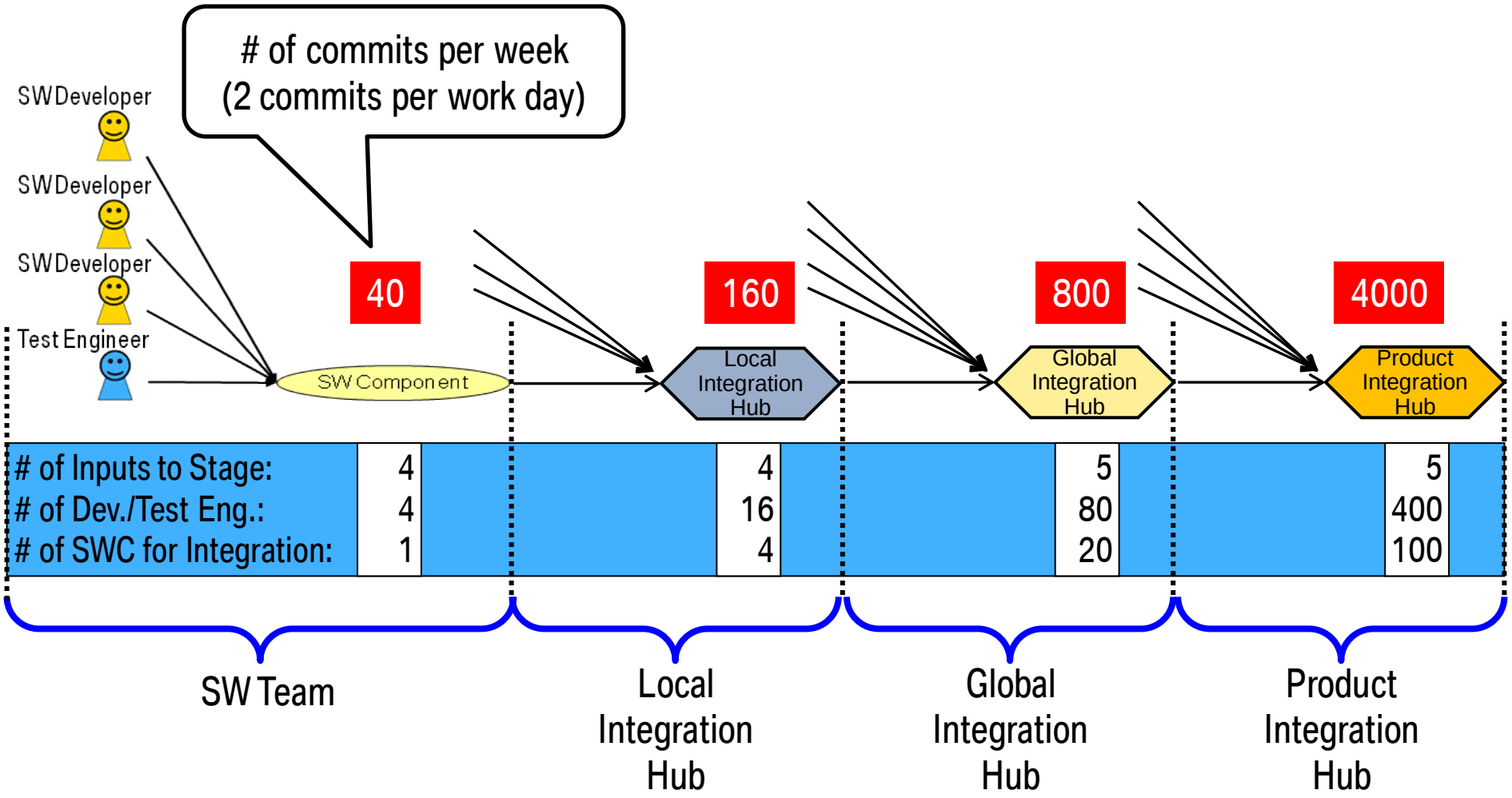
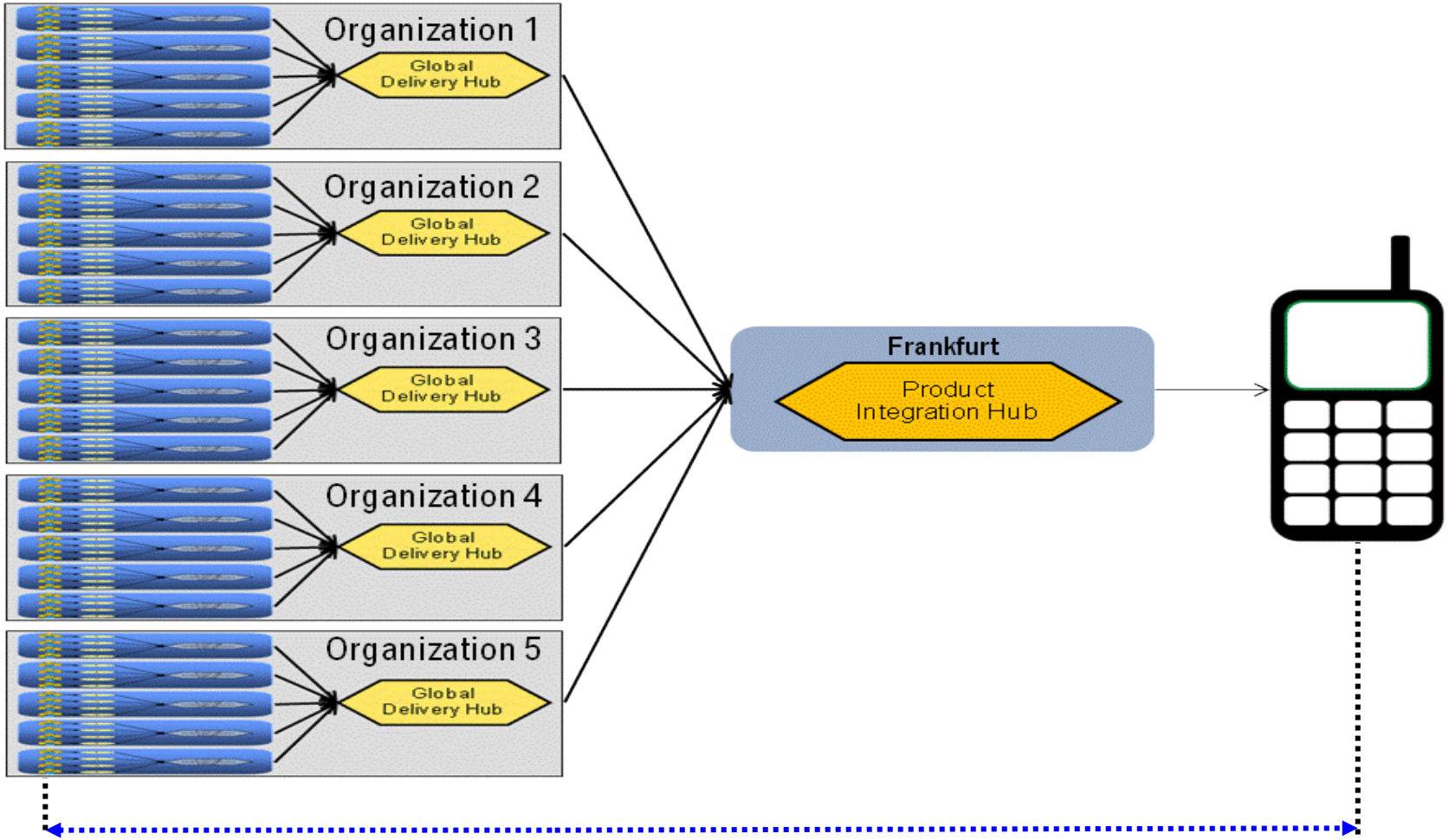
COMPLEXITY OF THE R&D INTEGRATION CHAIN



Important note:
Picture is just showing an example

HOW LONG DOES IT TAKE TO DEPLOY ONE SINGLE LINE OF CODE FROM ONE SW DEVELOPER TO THE PRODUCT ?



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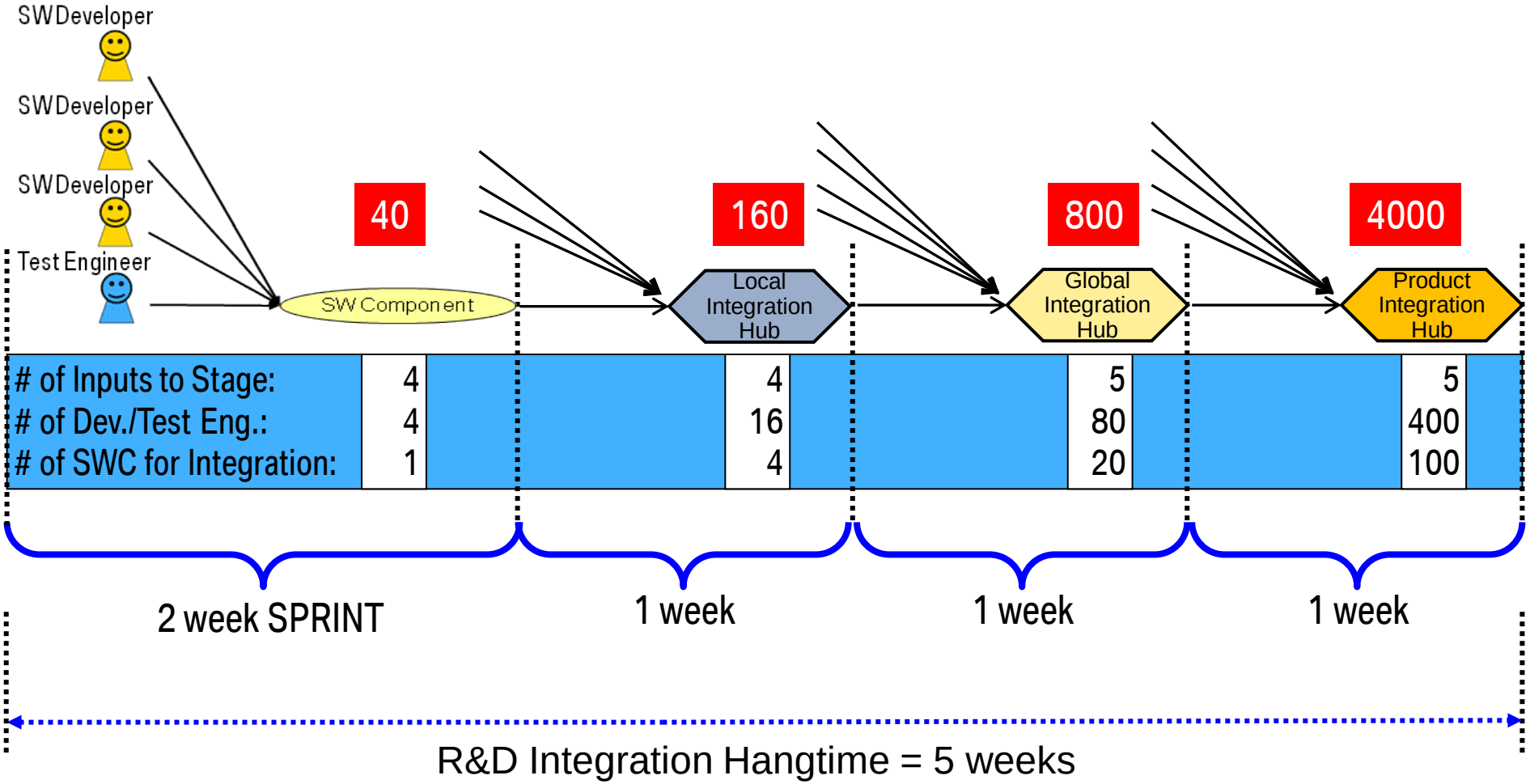

Important note:
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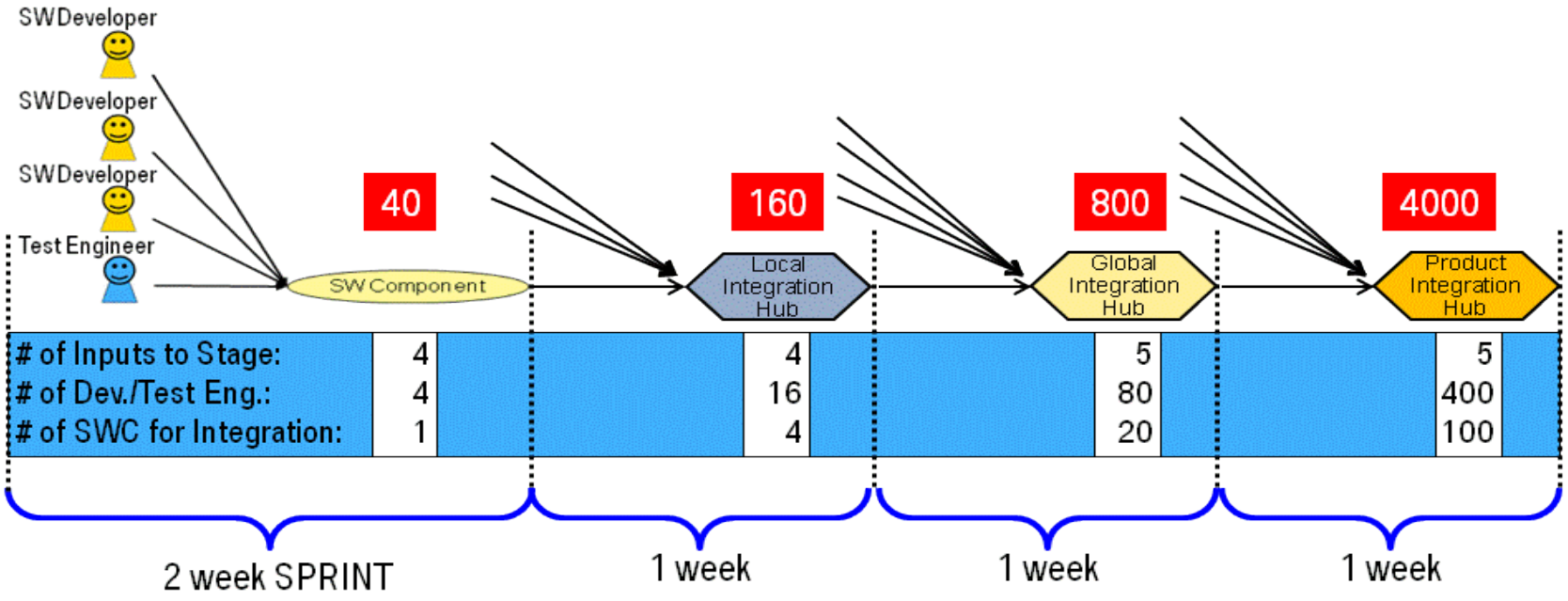
SLOW FEEDBACK & INTERRUPTS BY DELIVERY HUBS



Maximum feedback time from Product Delivery Hub > 4 weeks

Feedback to SW Developer

Commit by SW Developer

Minimum feedback time from Product Delivery Hub > 2 weeks

Commit by SW Developer

Important note:
Picture is just showing an example

PROBLEM STATEMENTS, CHALLENGES, ..

Hundreds of people need to work in the same way

Big integration hangtime

External suppliers

Organizational borders

Late interrupts to developers

Company borders

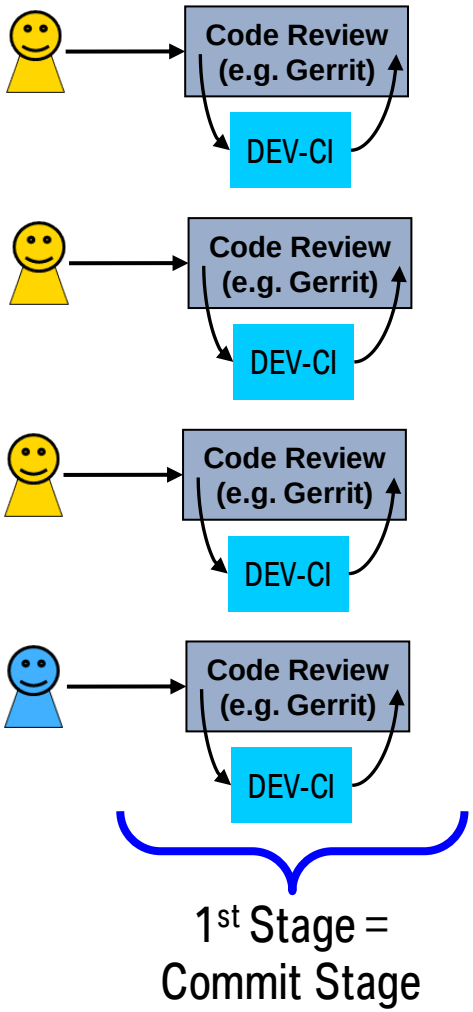
Big band integration in each Delivery Hub

...

Important note:
Picture is just showing an example

Multi-Stage-CI Overview

STAGE 1 - FOR SINGLE SW DEVELOPER

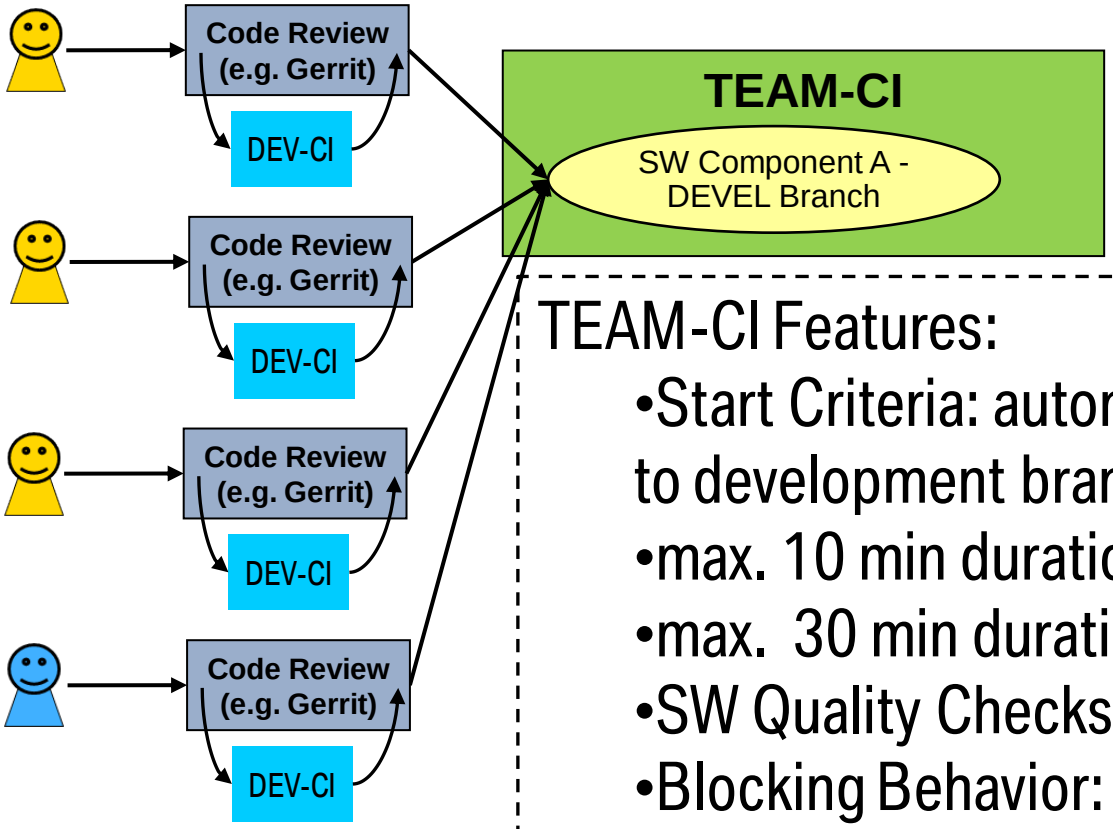


DEV-CI Features:

- Start Criteria: automatically after commit to private branch in Gerrit
- max. 5 min duration
- SW Quality Checks: SW compiling + Unit Tests
- Blocking Behavior: Active for Code Review and all SW Quality Checks running in DEV-CI

Important note:
Picture is just showing an example

STAGE 2 - FOR SINGLE SW COMPONENT



TEAM-CI Features:

- Start Criteria: automatically after submit in Gerrit to development branch of SW component
- max. 10 min duration without HW Tests
- max. 30 min duration with HW Tests
- SW Quality Checks: Everything what is possible
- Blocking Behavior: Active for all SW Quality Checks running in TEAM-CI

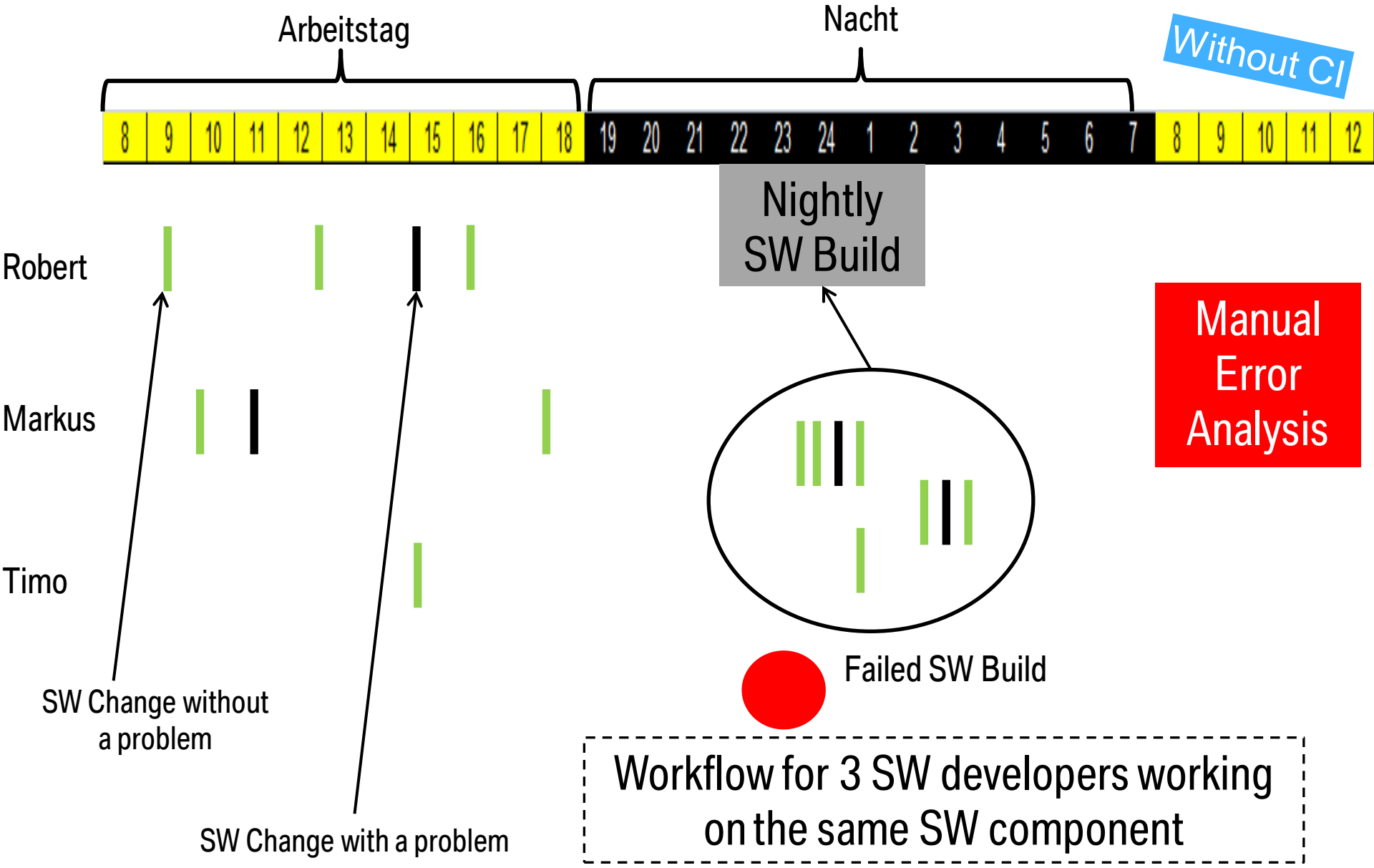
1st Stage = Commit Stage

2nd Stage = Single SW Component

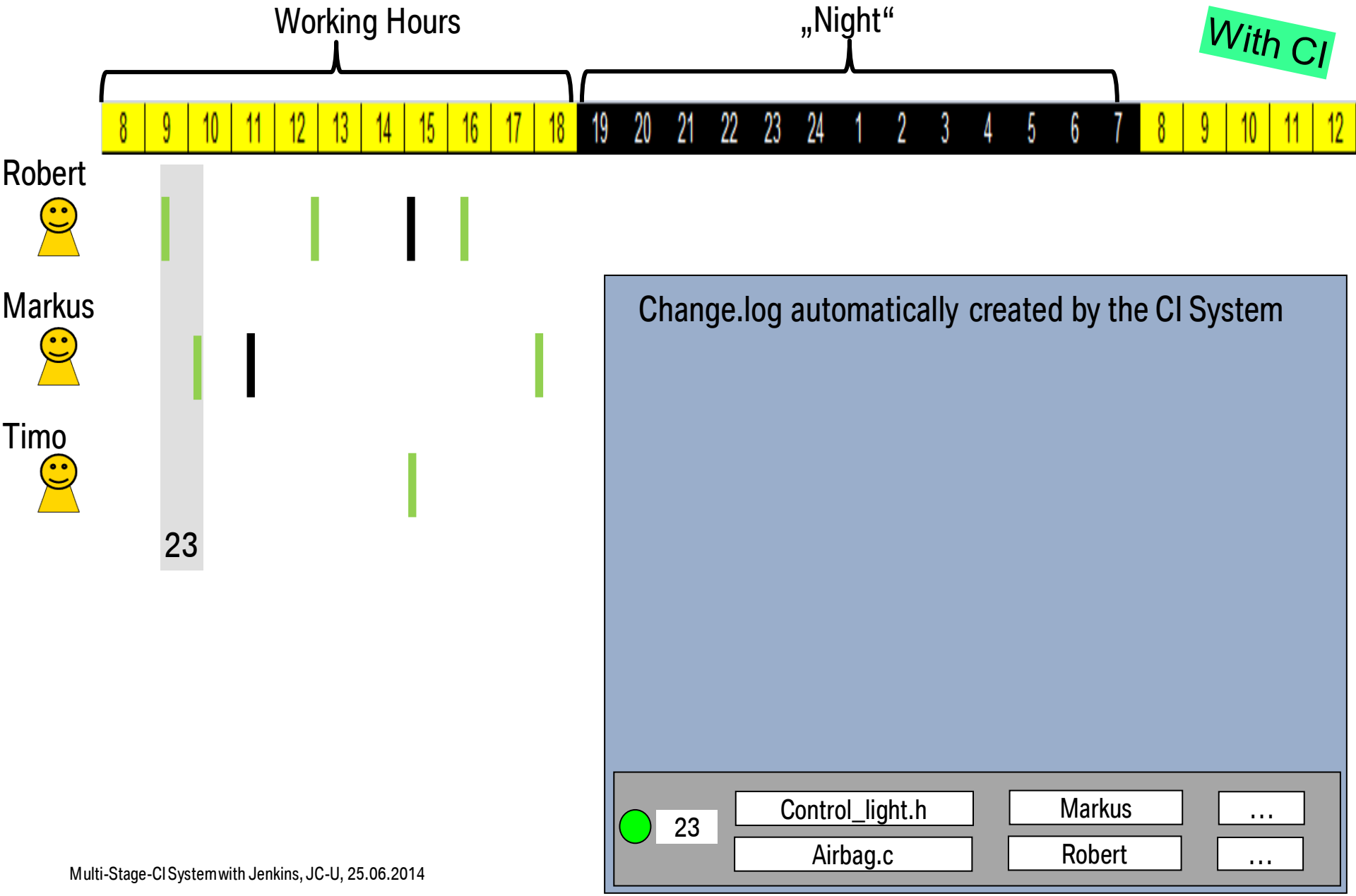
Important note:
Picture is just showing an example

NIGHTLY SW BUILD
VERSUS
CHANGE TRIGGERED CONTINUOUS INTEGRATION

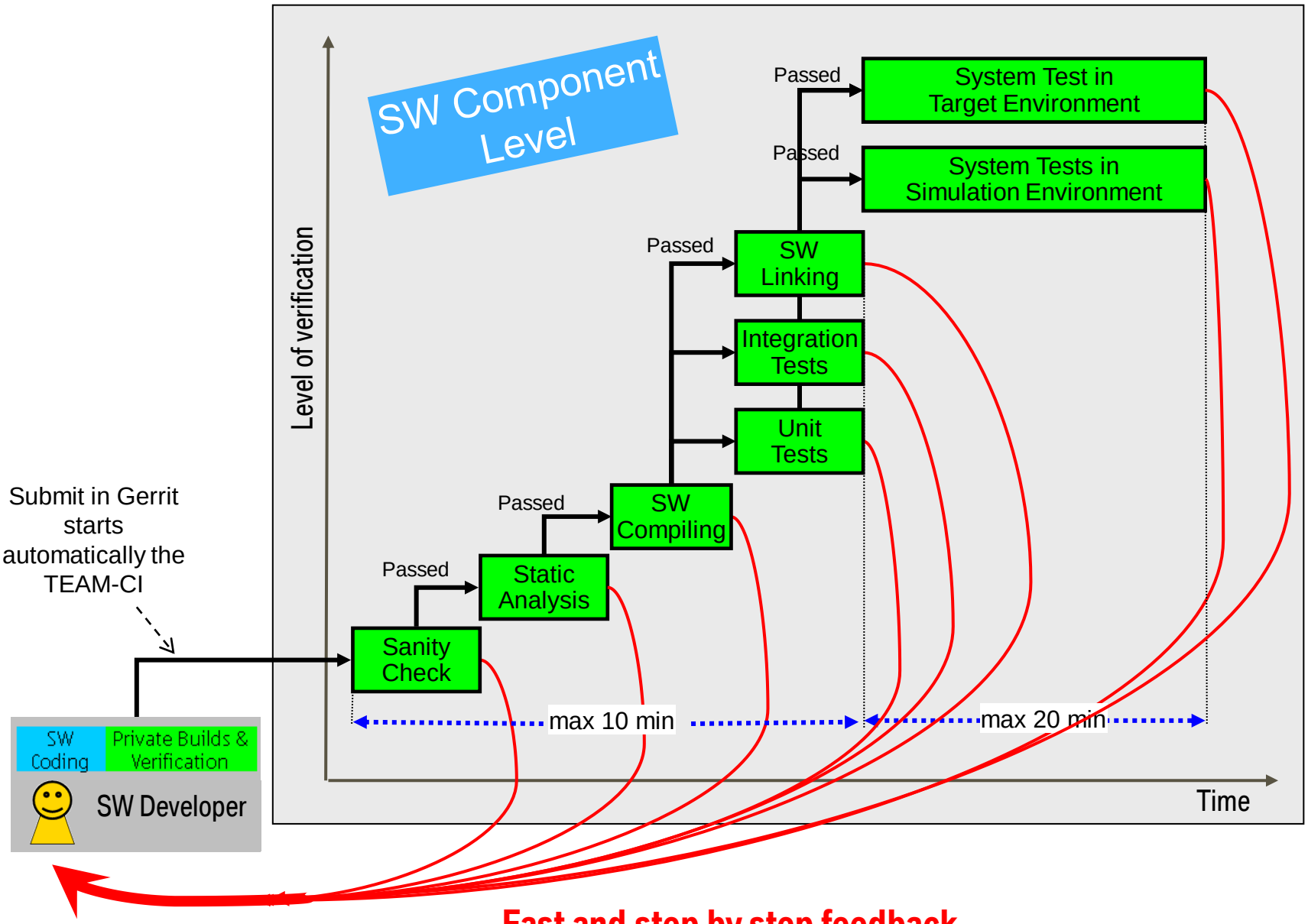
NIGHTLY SW BUILDS WITH MANUAL ERROR ANALYSIS



CHANGE TRIGGERED CI WITHOUT ERROR ANALYSIS

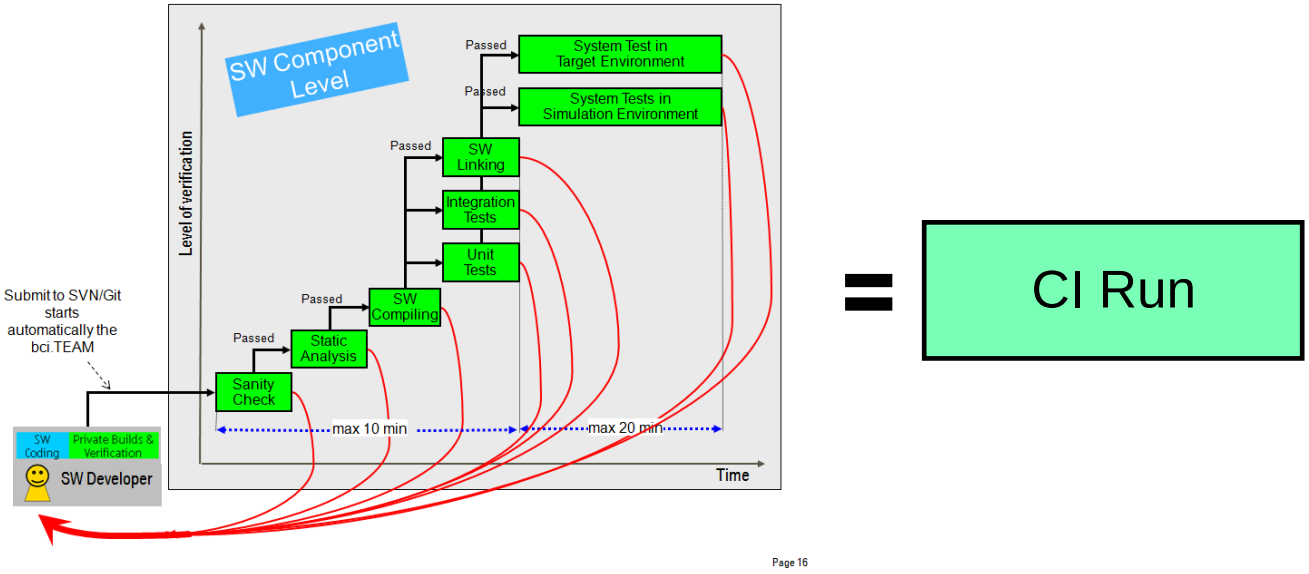


SW QUALITY CHECKS INSIDE TEAM-CI



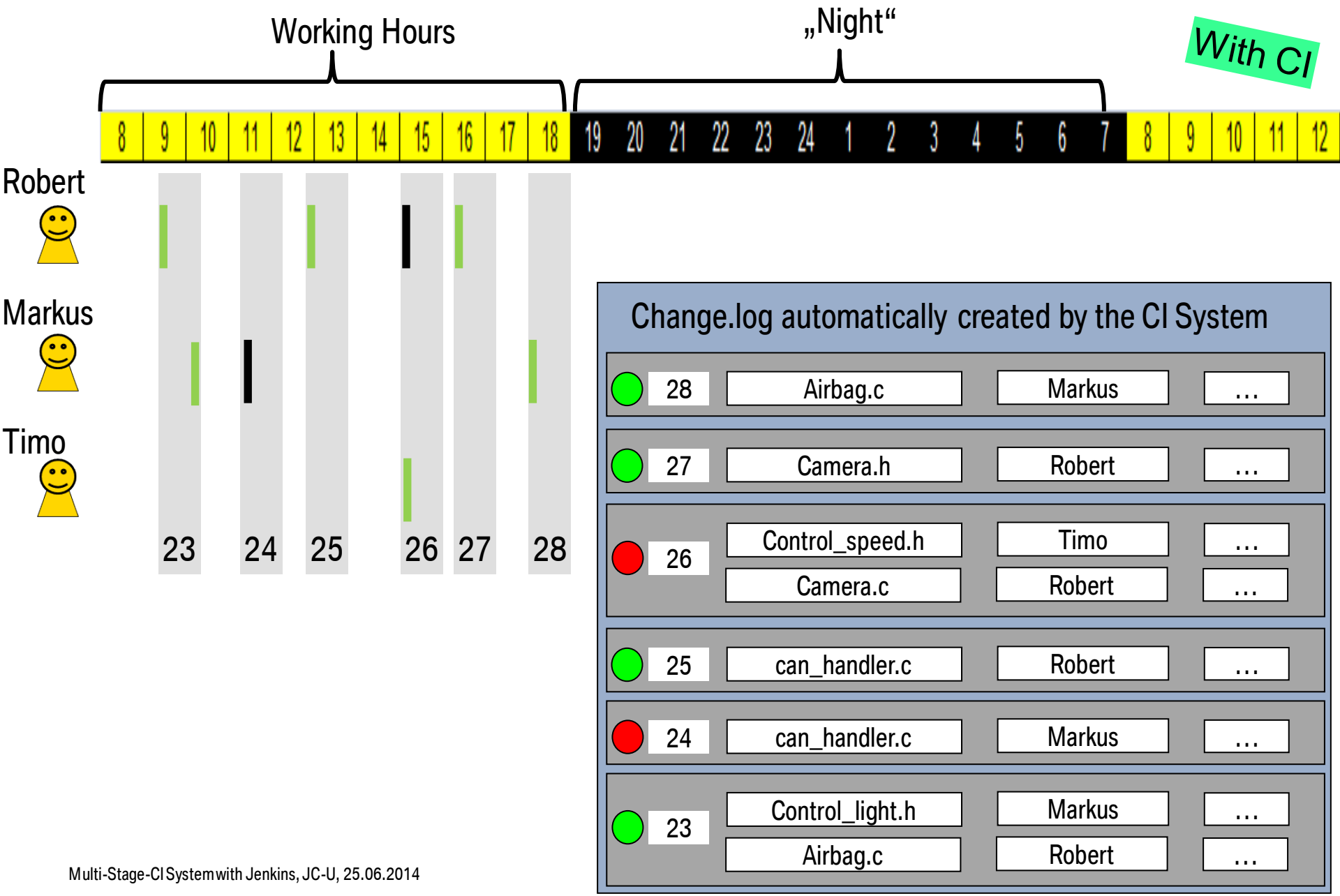
TERMINOLOGY

SW Compiling + SW Linking = SW Build

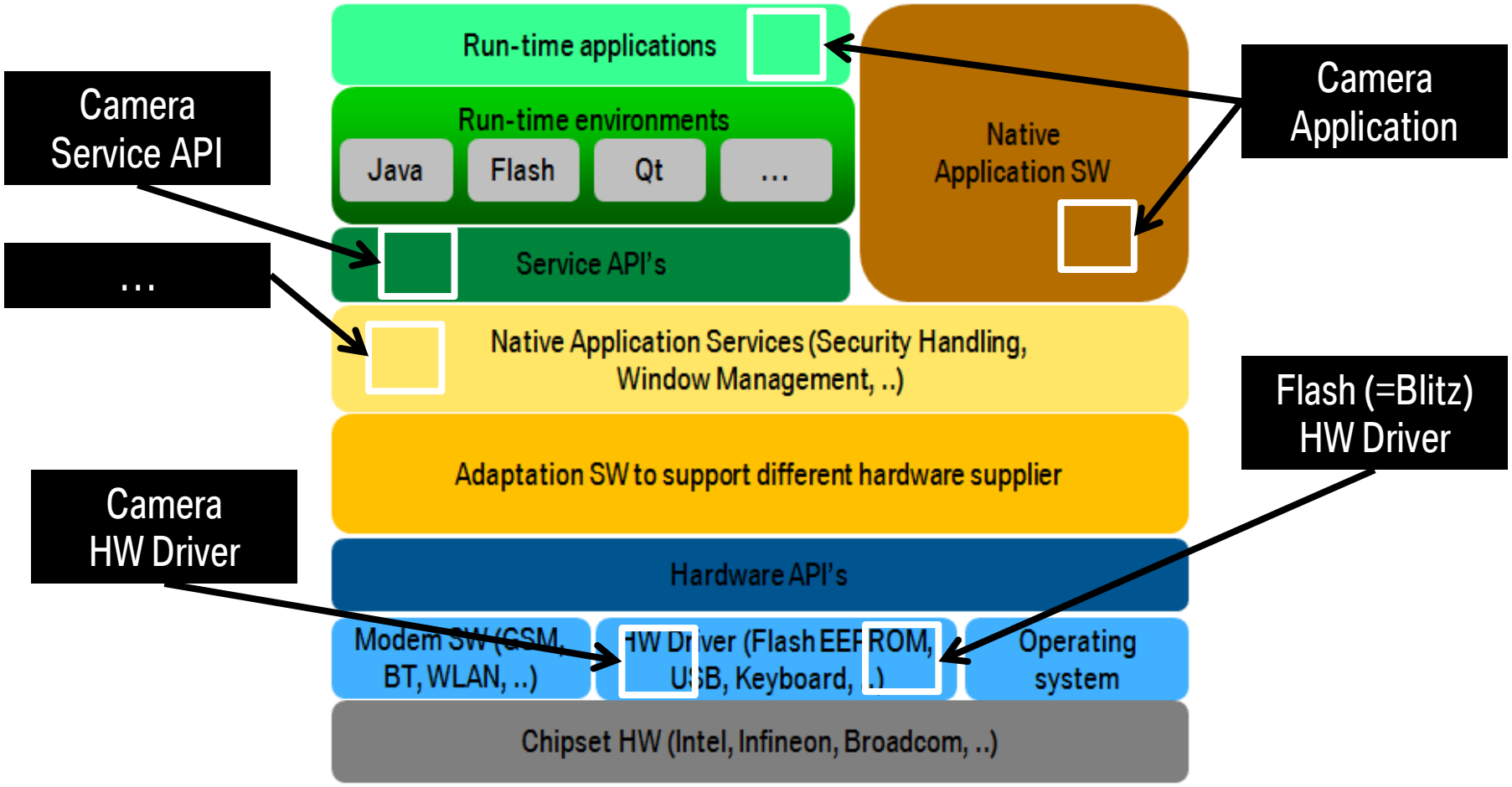


= CI Run

CHANGE TRIGGERED CI WITHOUT ERROR ANALYSIS



STAGE 3 - FOR MULTIPLE SW COMPONENTS



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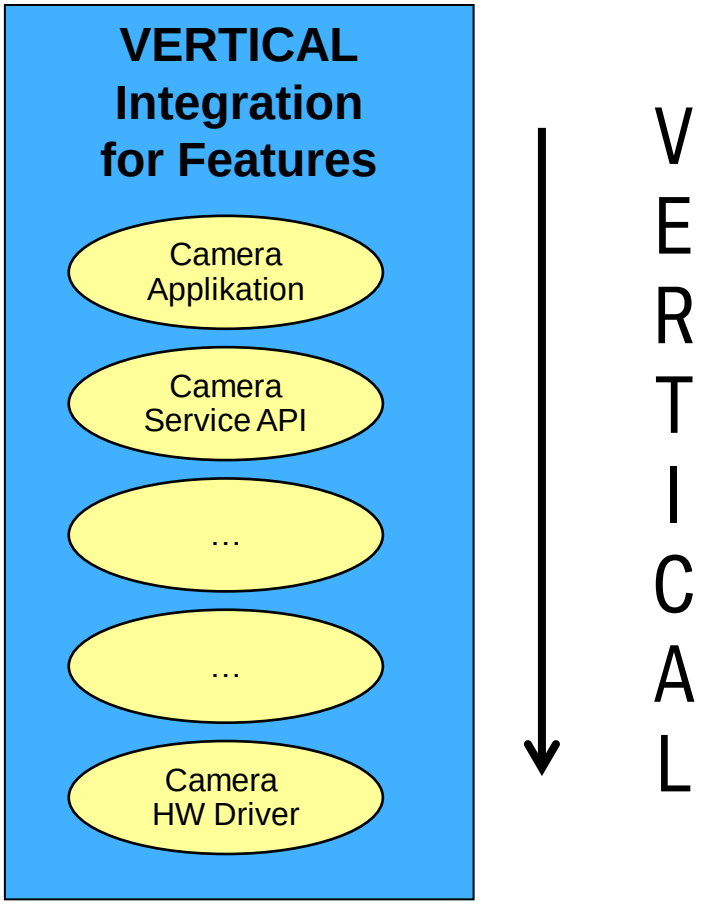
STAGE 3 - FOR MULTIPLE SW COMPONENTS



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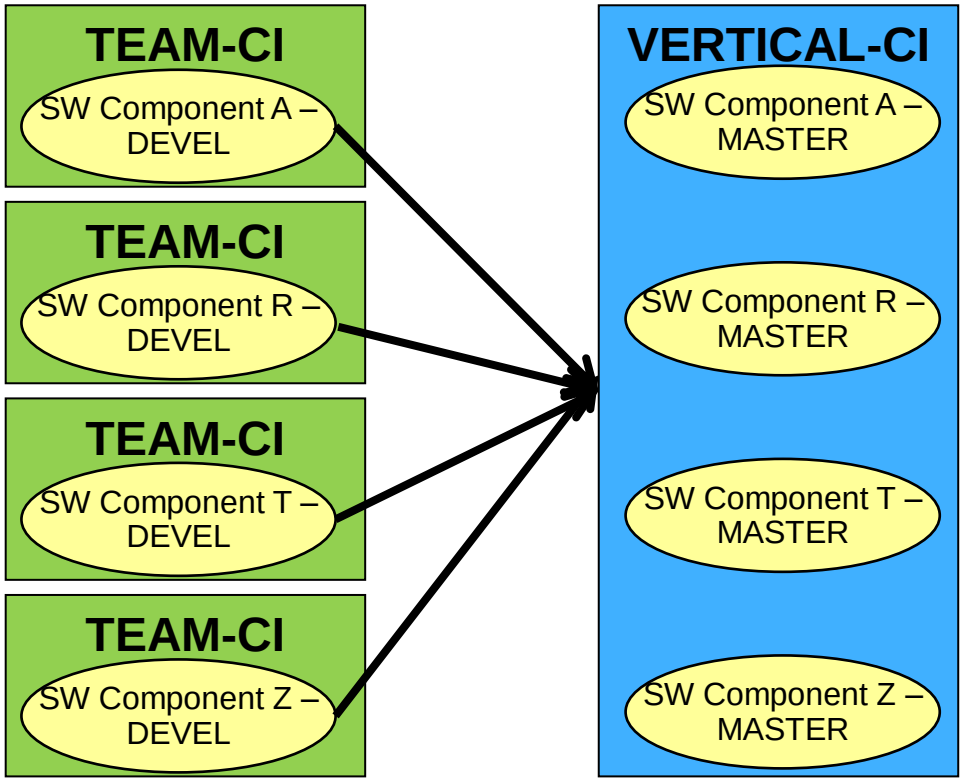
STAGE 3 - FOR MULTIPLE SW COMPONENTS



VERTICAL-CI Features:

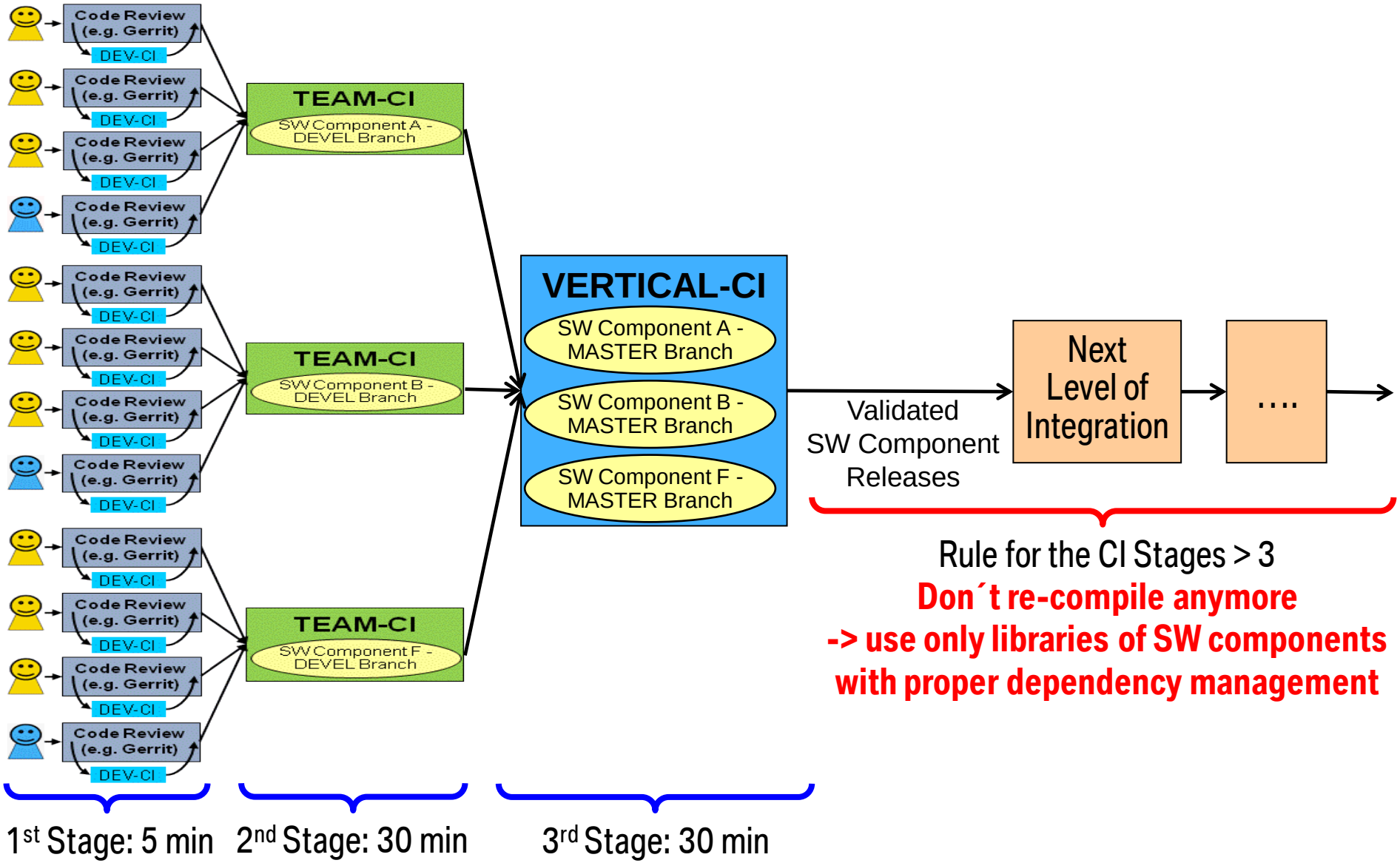
- Same as TEAM-CI but it starts automatically after the "Automatic Merge from DEVEL to MASTER" made by TEAM-CI after all MANDATORY SW Quality Checks are green

2nd Stage = Single SW Component

3rd Stage = Multiple SW Components

Important note:
Picture is just showing an example

FIRST 3 STAGES WITH SOURCES IN SCM (GIT, SVN, ..)



Important note:
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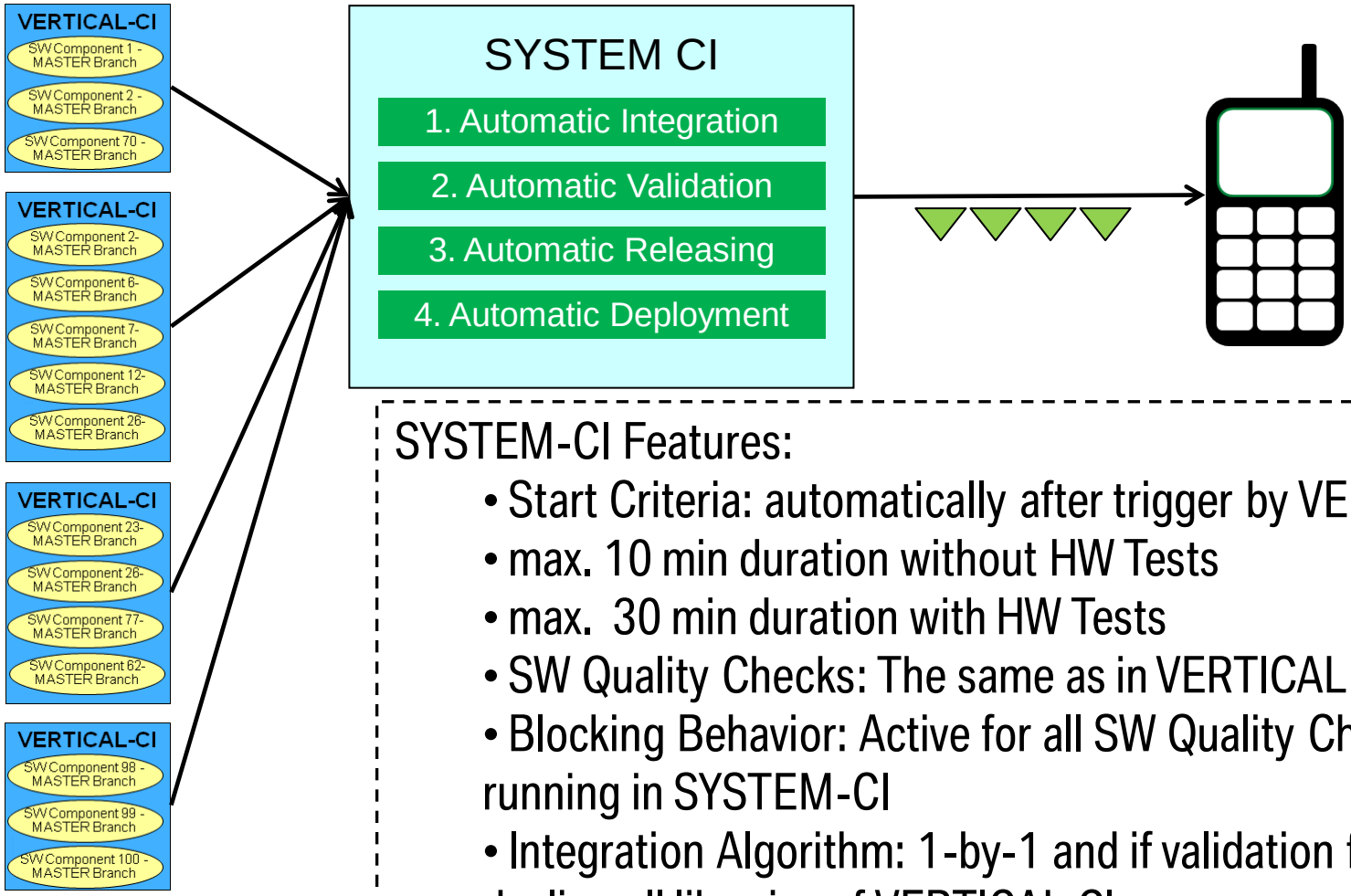
STAGE 4 – SYSTEM INTEGRATION

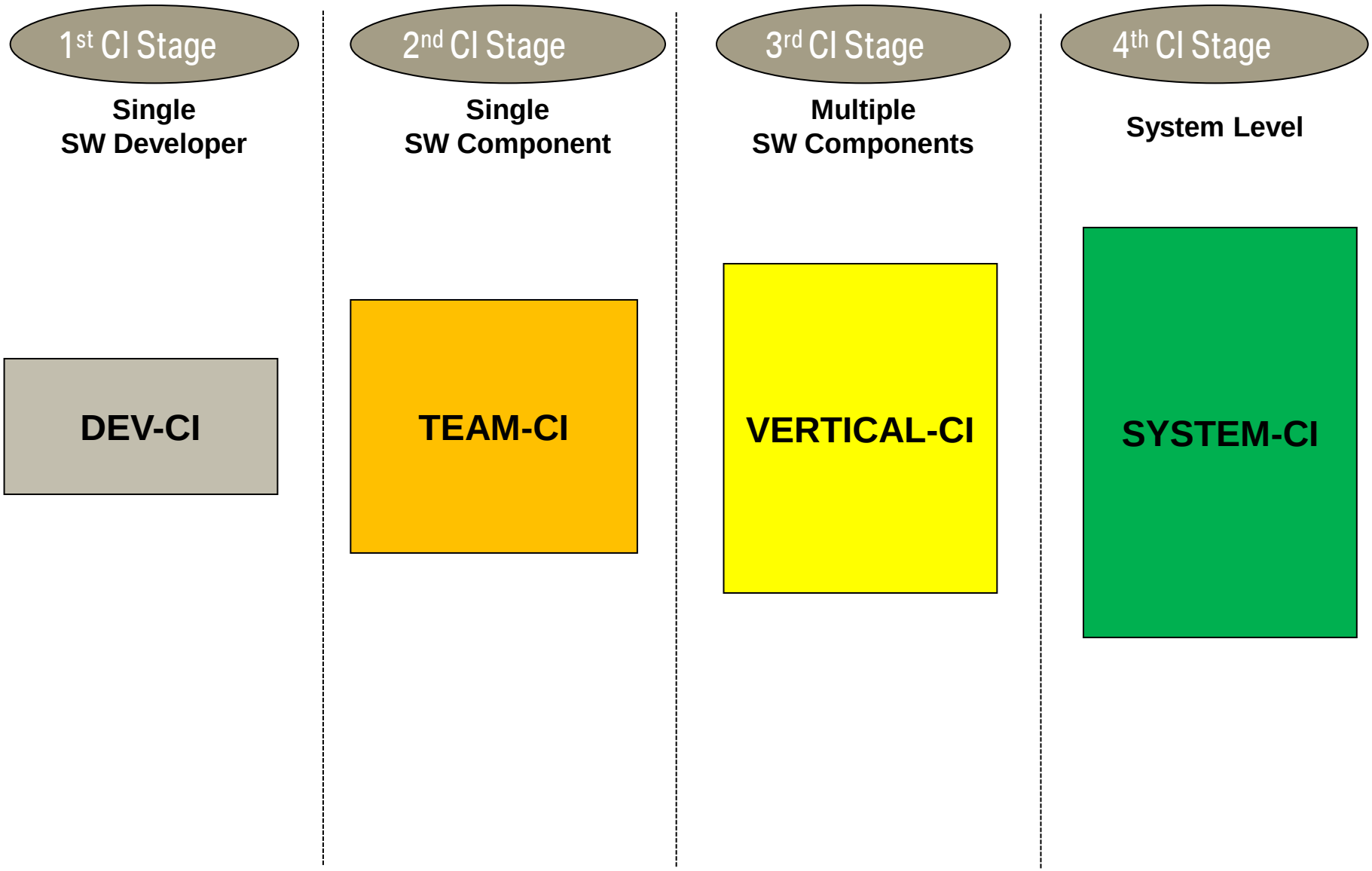


SYSTEM-CI Features:

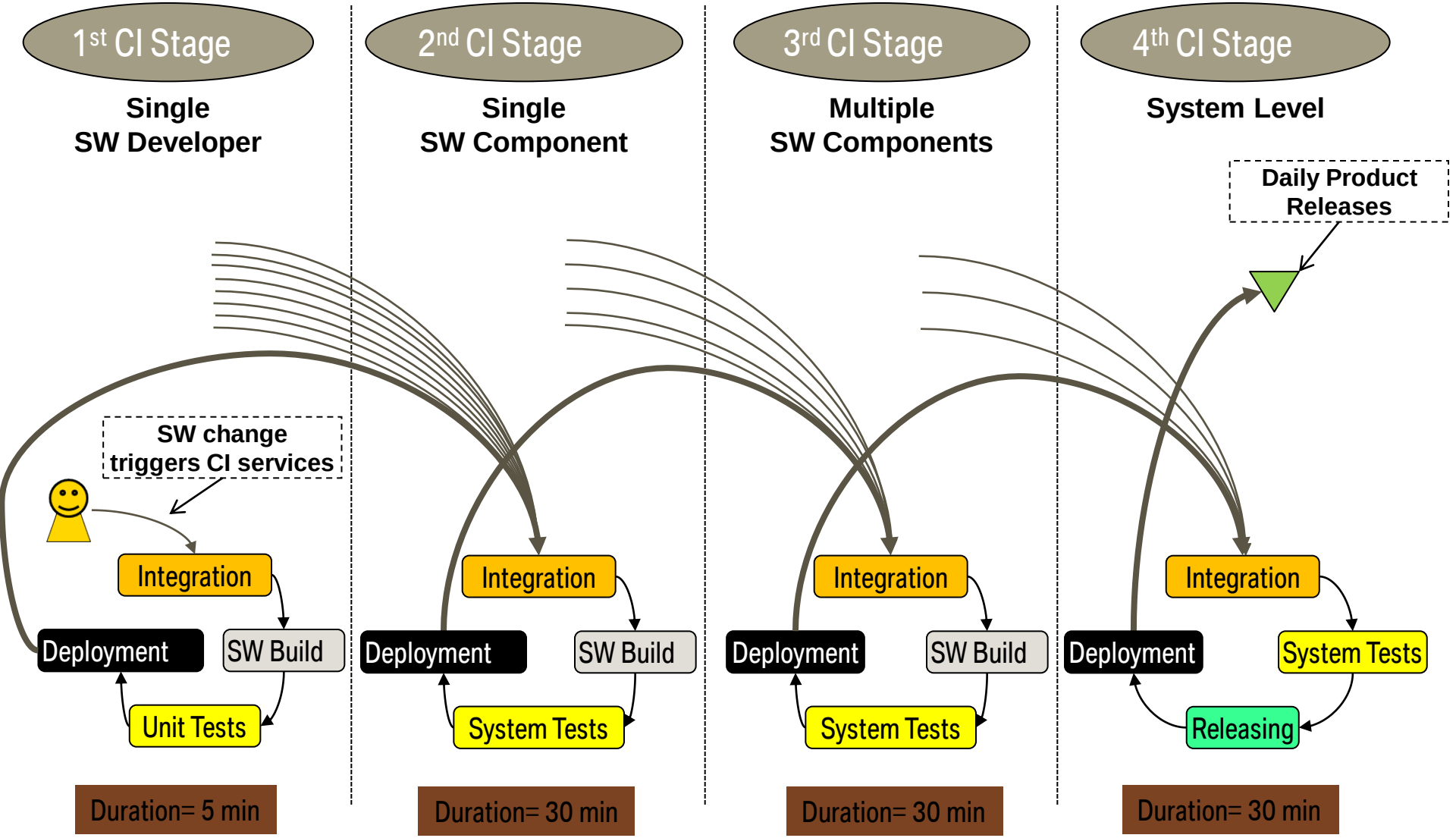
- Start Criteria: automatically after trigger by VERTICAL CI
- max. 10 min duration without HW Tests
- max. 30 min duration with HW Tests
- SW Quality Checks: The same as in VERTICAL CI
- Blocking Behavior: Active for all SW Quality Checks running in SYSTEM-CI
- Integration Algorithm: 1-by-1 and if validation fails than decline all libraries of VERTICAL CI

Important note:
Picture is just showing an example

MULTI-STAGE-CI SYSTEM – CI TYPES



MULTI-STAGE-CI SYSTEM – AUTOMATIC WORKFLOW

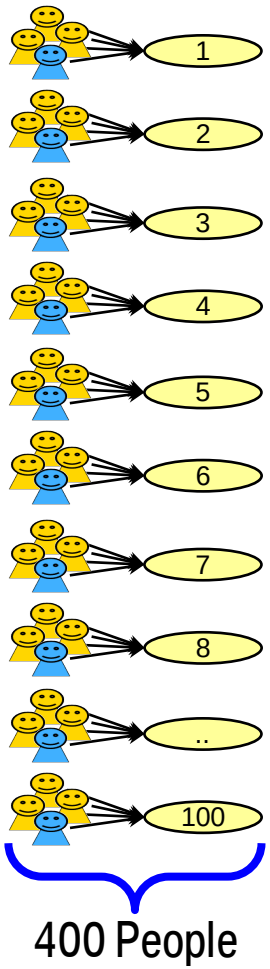


Legend for Symbol:

= SW Developer

Automatic Integration, Flashing and Testing to HW inside the CI System

WHY NO HW TESTS IN DEV-CI ?

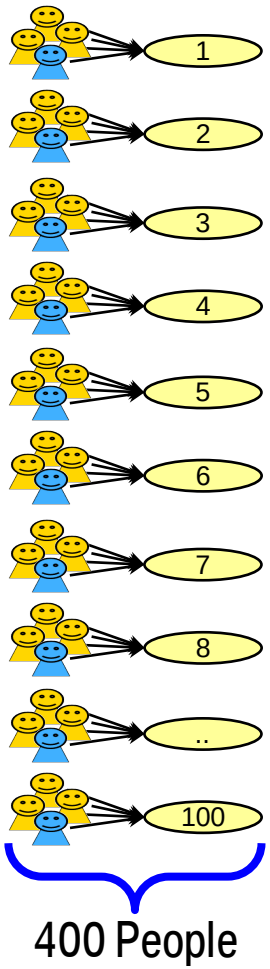


- Input data:
  - DEV-CI starts automatically after commit
  - HW Tests takes 20 min incl. Flashing
- Assumption
  - 1 developer/test engineer creates in average 2 commits per day -> 400 people create 800 commits per day
  - Each prototype can only be flashed 10 000 times
  - Duration of HW tests incl. Flashing takes 20 min
- How many prototypes do we need for the CI System ?
  - Number of tests with one prototype per day: 72
  - Additional 12 prototypes are needed for 1st Stage
  - After ~ 4 months all 12 prototypes need to be exchanged

-> 36 prototypes needed per year for DEV-CI

Important note:
Picture is just showing an example

WHY NO HW TESTS IN DEV-CI ?

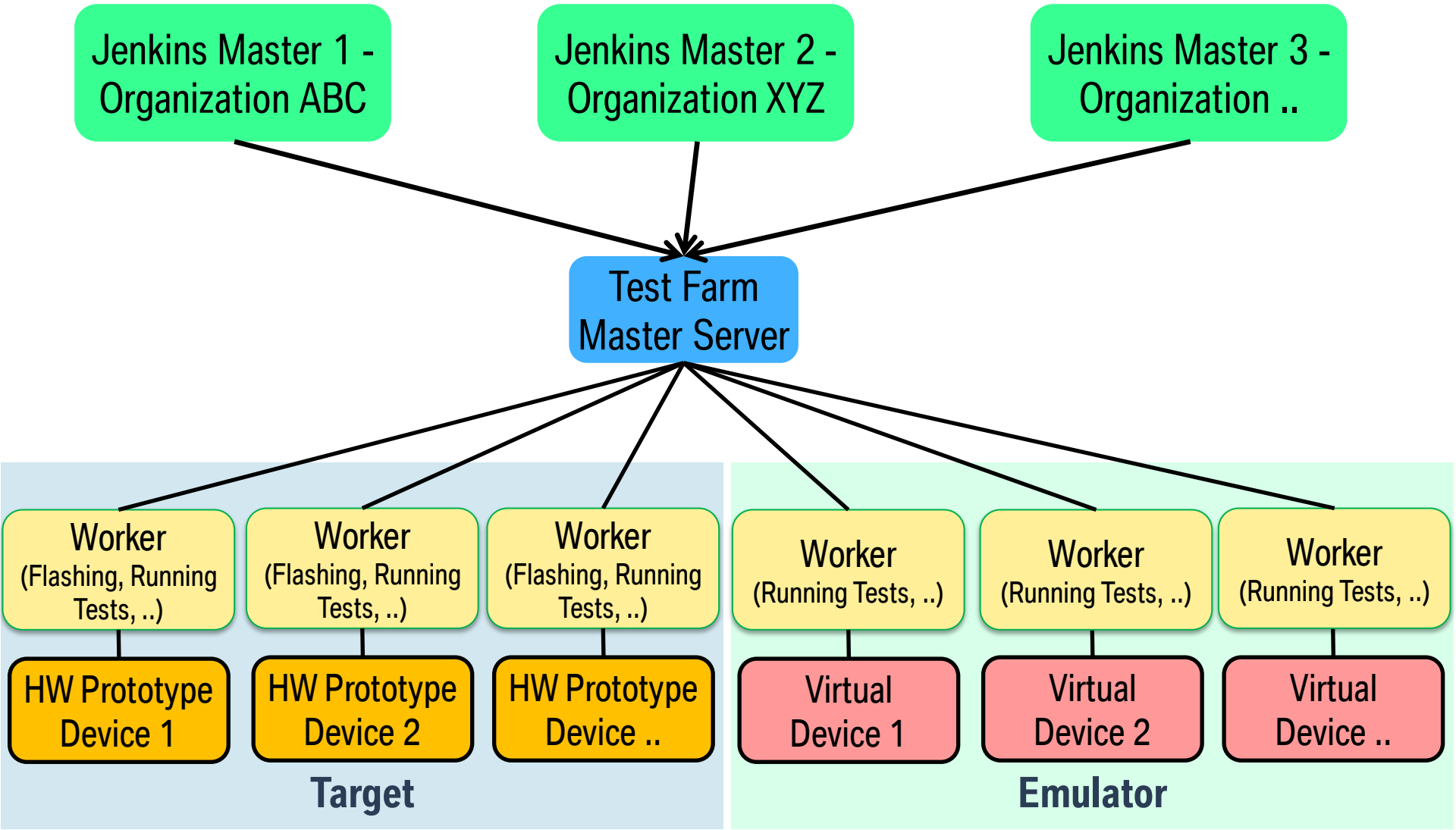


-> 36 additional HW prototypes are needed for DEV-CI

Product	Consumer End Price in EURO	HW Costs for Prototype during development	Additional costs for HW Tests in DEV-CI per year in EURO
Digital Camera	250	800	28 800
Landline phone	120	350	12 600
Mobile Phone – Entry Market	55 .. 85	550	19 800
Mobile Phone – High End	500 .. 800	1500	54 000
BMW X5	> 45 000	> ???	> 1 620 000

Important note:
Picture is just showing an example to underline the challenge of HW costs

HOW TO ORGANIZE HW TEST FARM ?



Important note:
Picture is just showing an example

Challenges and recommendations

RECOMMENDATIONS

- Integration Chain
  - Don't organize your integration chain according to the organizational structure of your company
  - Measure the E2E hangtime automatically and speed-up continuously
  - Block not working SW changes before the Product SW Release.
    - The key is
      Block the problem at the source and not at the destination

RECOMMENDATIONS

- 100% Automation
  - After the commit done by the SW developer everything else in the chain need to be automated incl. SW Release Notes, Test Reports, Management Reports, Management metrics, ..

RECOMMENDATIONS

- HW Prototypes
  - Request enough HW Prototypes dedicated for the CI system before the Product Program is approved by management

RECOMMENDATIONS

- External suppliers
  - Treat external suppliers like internal suppliers

RECOMMENDATIONS

- CI Principles
  - Follow the 10 CI principles made by Martin Fowler

1. Maintain a Single Source Repository.
2. Automate the Build
3. Make Your Build Self-Testing
4. Everyone Commits To the Mainline Every Day
5. Every Commit Should Build the Mainline on an Integration Machine
6. Keep the Build Fast
7. Test in a Clone of the Production Environment
8. Make it Easy for Anyone to Get the Latest Executable
9. Everyone can see what's happening
10. Automate Deployment

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