

Cloud computing at ABB Robotics

Guest lecture at UiS, Morten Mossige and Lydia Sun

About us

- Dr. Morten Mossige
- Technology Manager Software
- More than 25 years experience in embedded software
- Research interest: automatic testing of embedded systems / testing of robot system



- Dr. Lydia Sun
- R&D Software Developer
- ~~— Less than 25 years~~ 8 months experience in software development
- ~~— Research interest: Breath of the Wild~~



ABB at a glance

ABB is a technology leader in electrification and automation, enabling a more sustainable and resource-efficient future.

The company's solutions connect engineering know-how and software to optimize how things are manufactured, moved, powered and operated. Building on over 140 years of excellence, ABB's more than 105,000 employees are committed to driving innovations that accelerate industrial transformation.

ABB Purpose and customer offering aligned with secular trends

ABB PURPOSE

We enable a more sustainable and resource-efficient future with our technology leadership in electrification and automation.

MEGATRENDS

- ☀️ New energy sources
- ⚡ Higher energy-efficiency
- ▬▬▬ Shrinking labor force
- 💡 Increased electrification

ABB OFFERINGS

SUPPORT CUSTOMERS TO

- Accelerate energy transition
- Optimize, electrify, and decarbonize
- Avoid emissions
- Reduce waste and increase circularity
- Increase productivity
- Increase energy efficiency
- Increase flexibility
- Increase safety and improve working environment
- Reduce downtime

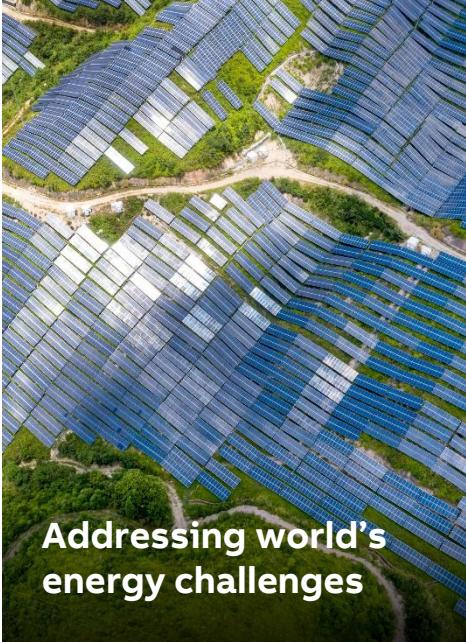




ABB in numbers

Company facts

140+
years history

105,000+

Employee globally

173

Nationalities

\$34 bn

Order intake

\$32 bn

Revenues

16.9%

Operational EBITA
margin

177

Manufacturing
sites globally

\$1.3 bn

R&D investment

26,000+

Number of
patents filed

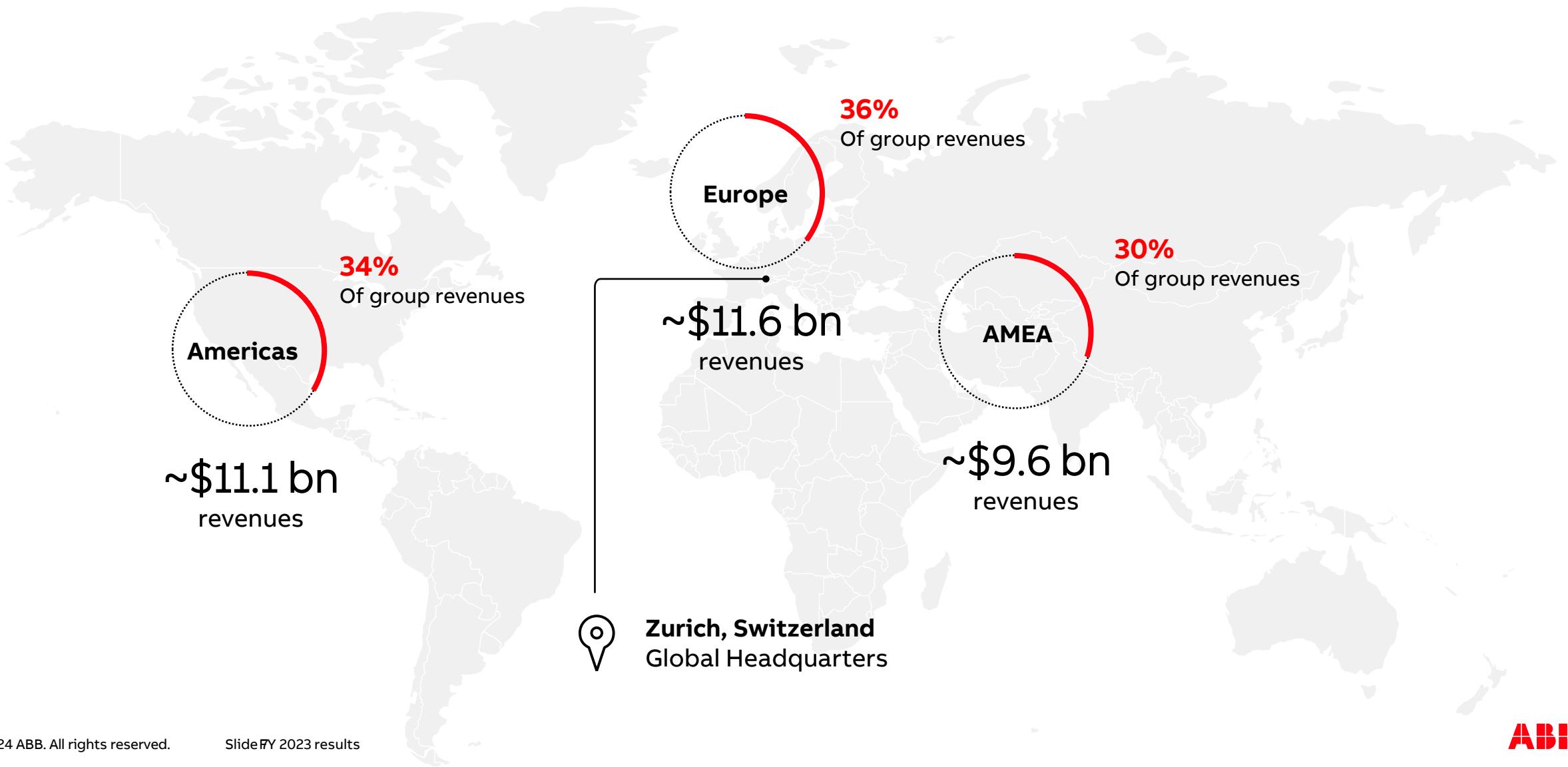
21%

Women in senior
management
positions

76%

Reduction of scope 1
and 2 GHG emissions
since 2019

Well positioned across global markets



Serving customers from a wide range of industries

Deep domain
expertise and a
commitment to
customer value



Aluminum



Automotive



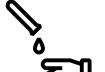
Building and
Infrastructure



Cement



Channel
Partners



Chemical



Data
Centers



Food and
Beverage



Life Sciences



Marine



Metals



Mining



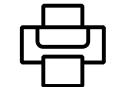
Oil and Gas



Ports



Power
Generation



Printing



Process
Automation



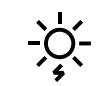
Pulp and
Paper



Railway



Smart Cities



Solar Power



Water



Wind Power

Our Business Areas



Electrification



Motion



Process
Automation



Robotics & Discrete
Automation



Robotics & Discrete Automation Business Area



Revenues \$3.6 bn

Employees ~11 k

Global market position No. 2

Divisions

- Robotics
- Machine Automation

ABB's Robotics & Discrete Automation business area enables companies to become more resilient, flexible and efficient through our value-added solutions in robotics as well as machine and factory automation.

With our integrated automation solutions, our application expertise across a wide scope of industries and our global presence, we deliver tangible customer value.

Our focus on innovation includes extensive work in artificial intelligence, as well as an ecosystem of digital partnerships and the expansion of our production and research capabilities.

ABB in Norway - overview

Key information

- Revenues: 10.6 Billion NOK
- Orders: 13.1 Billion NOK
- No. of employees: 2045
- Lead business: Energy Industries

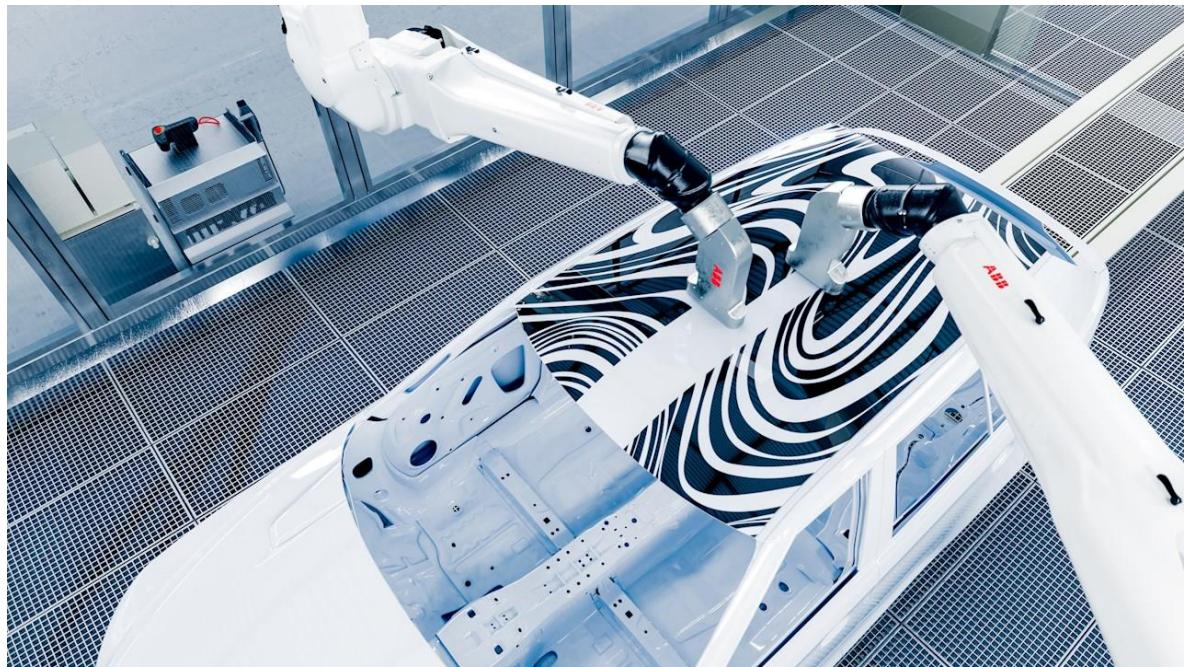
Other Divisions/Business Areas:

- Electrification
- E-mobility
- Marine and Ports
- Motion
- Robotics and Discrete Automation



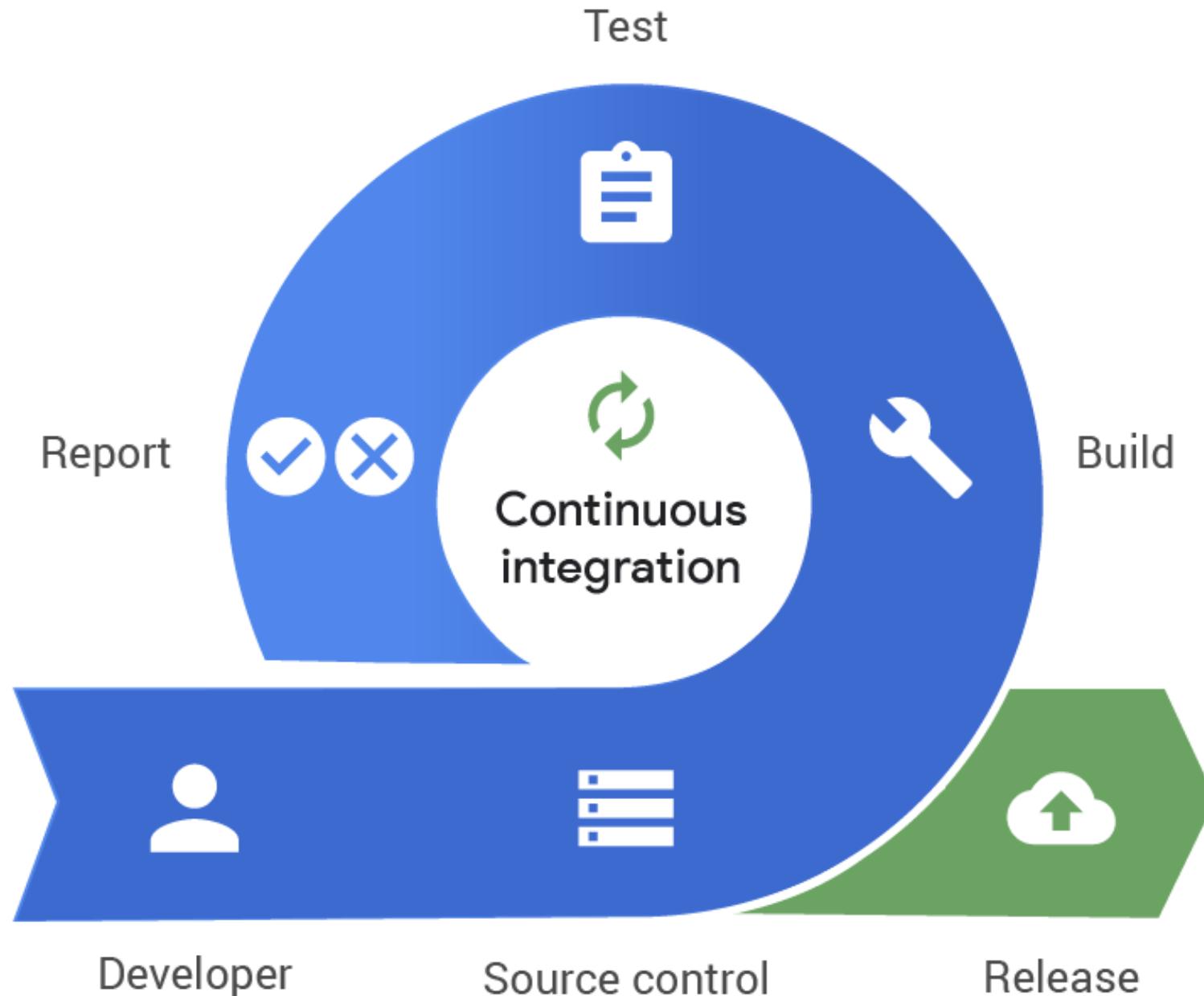
ABB Robotics (and Discrete Automation), Norway

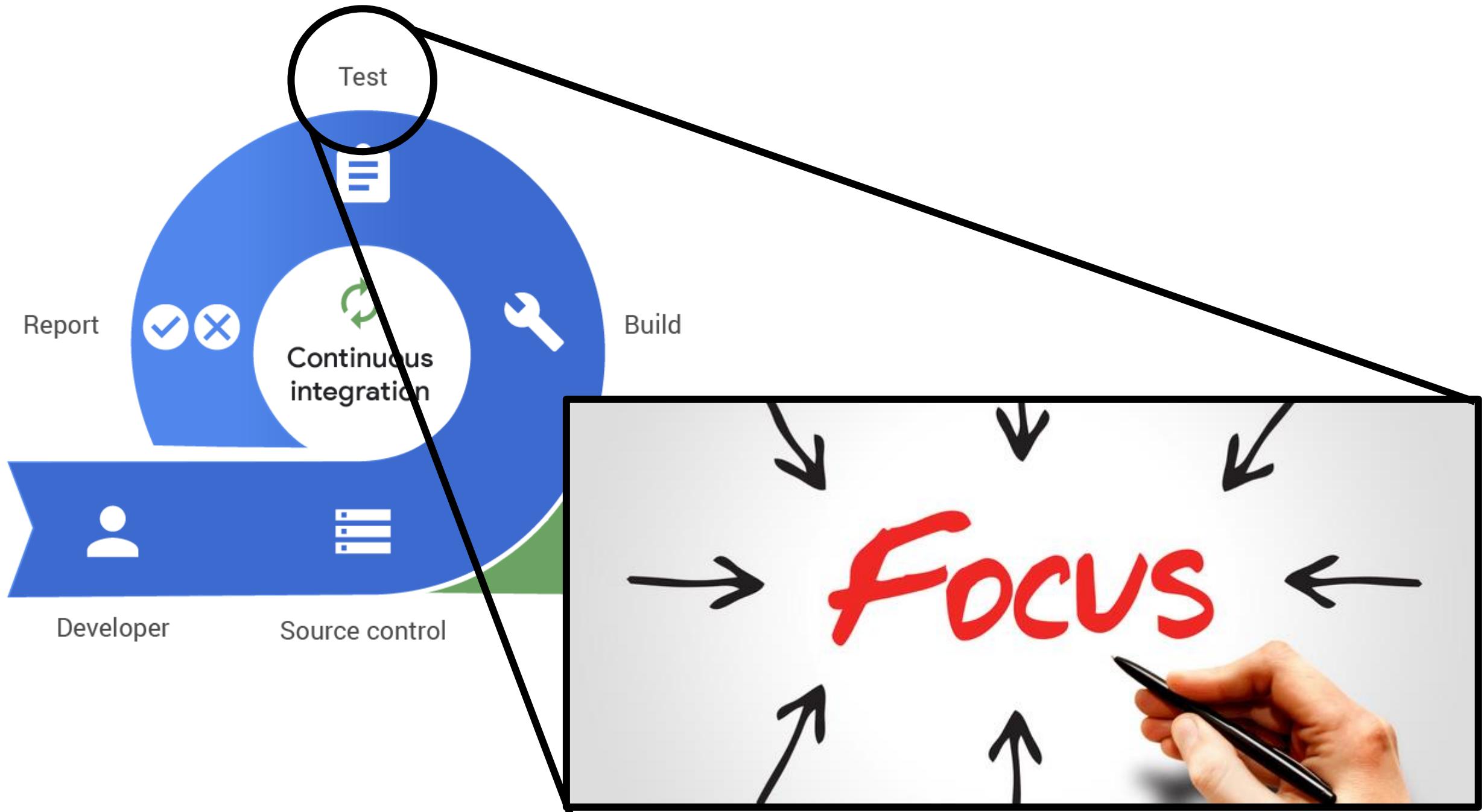
- World-class R&D for paint robots, Bryne
- Competence/development crucial for new ABB products
- World's first paint robot in 1969, sold to Gustavberg i Sweden



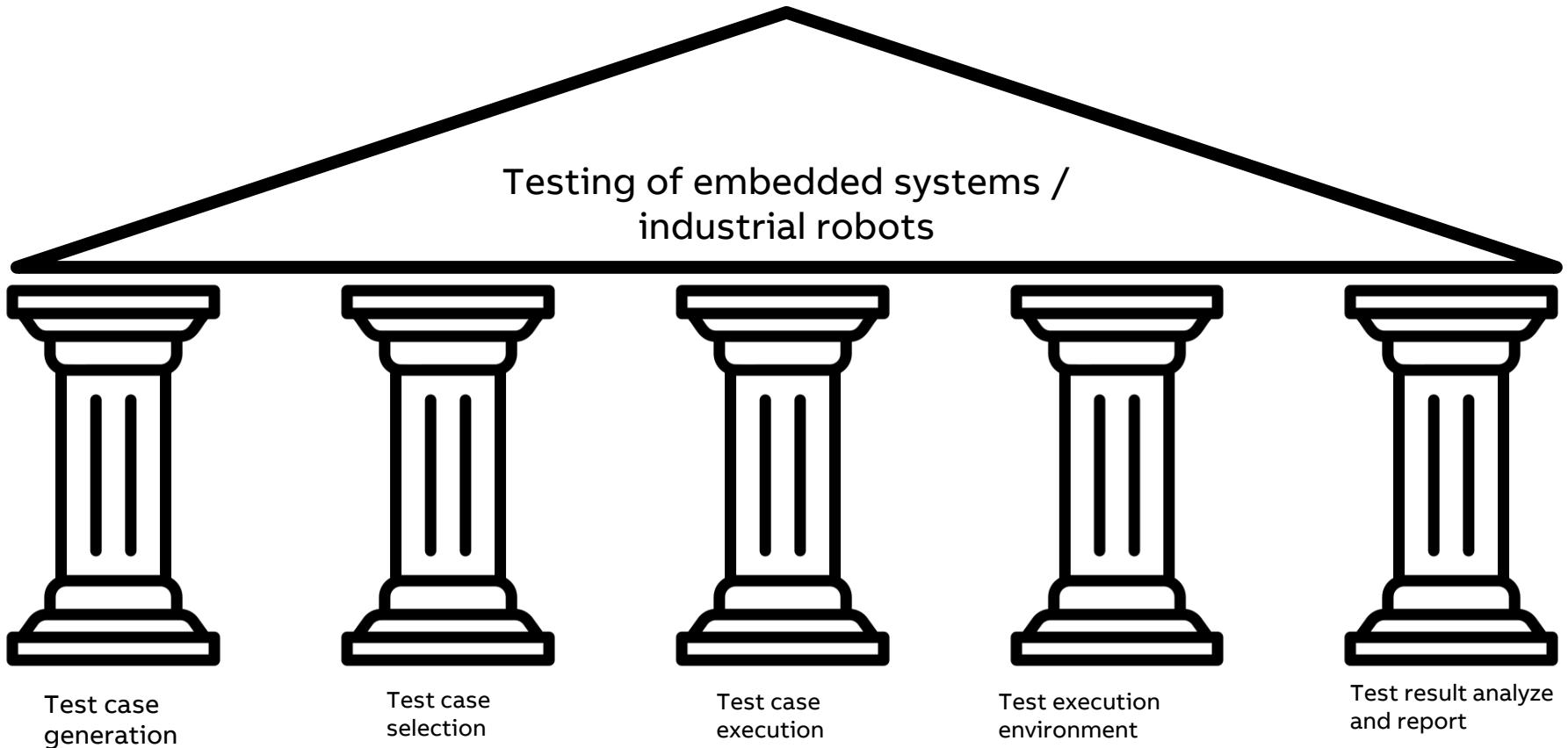
World-class R&D for paint robots

How ABB Robotics use cloud computing related to software development of robotic systems

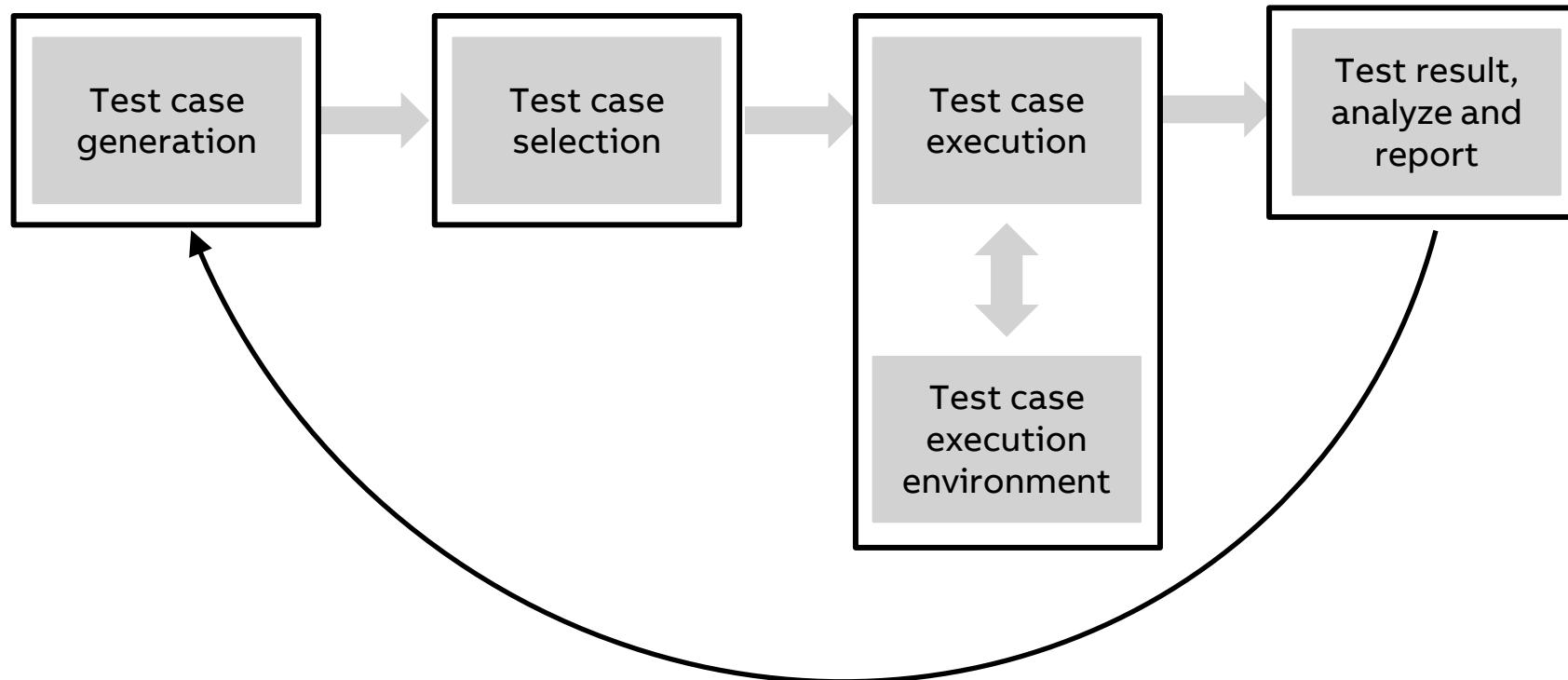




Pillars of testing

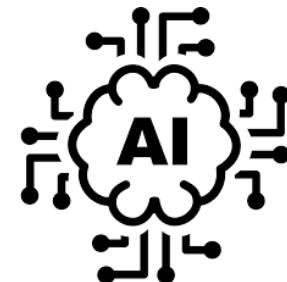
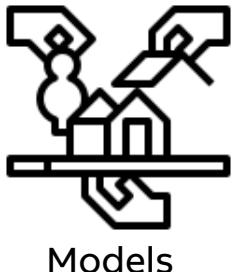


The testing-loop, part of continuous integration

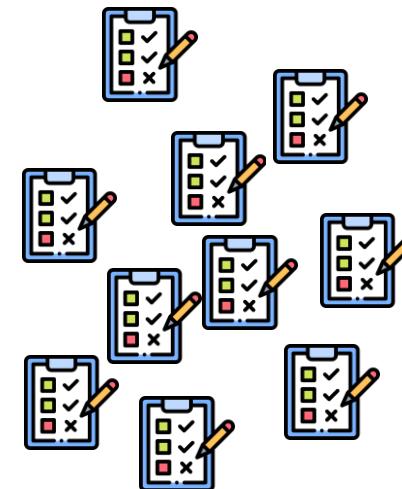


Test case generation – “How to create the test-case”

- Based on a model or some rules, generate the test case in opposite to manually write the test-case
- This can be used on tests intended for manual execution as well as for test-cases intended for automatic execution
- The test-case can be generated just in time when executing the test, or in advance.
- Very good candidate for use of AI

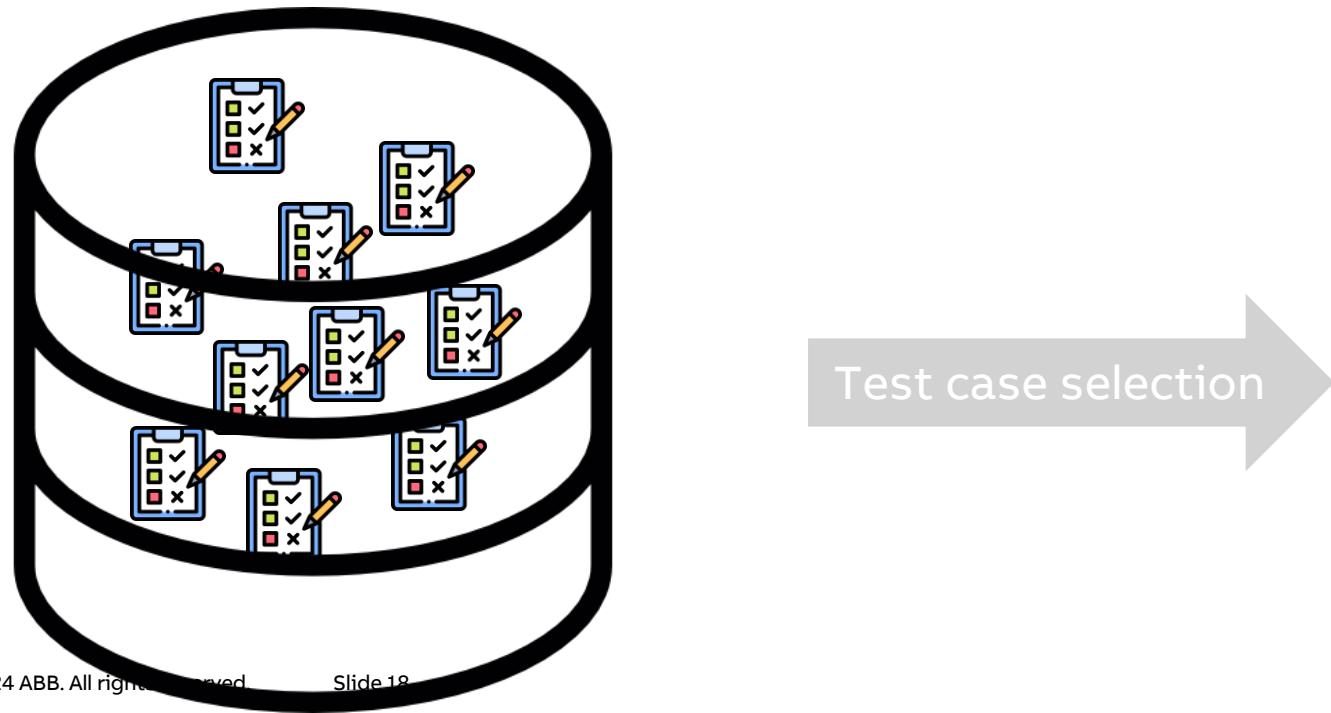


Test case generation



Test case selection – “How to select the best test-case for execution”

- From a large collection of test-cases, select the most promising test-case.
- The selection can be optimized based on one or more objectives:
 - Time since last execution
 - Priority of the test
 - The most likely test-case to find faults
 - Utilization of the test-infrastructure



Test case execution – “How to manage running of the test-case”

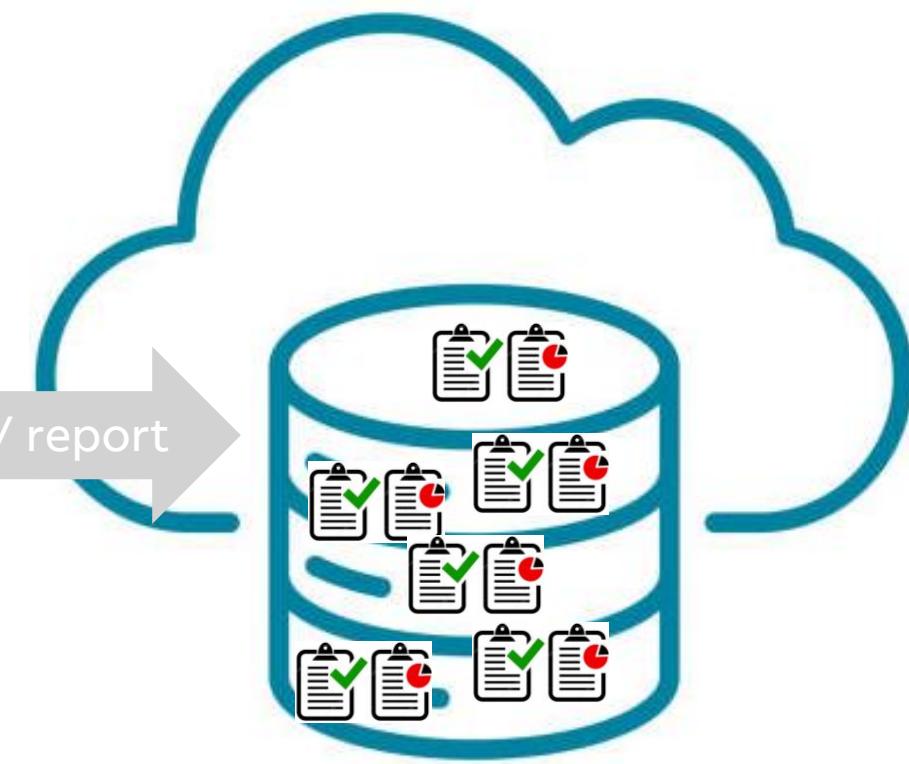
- How to actually run and execute the test case
 - Setting up the physical computer where to run the test-case. Should we run in a simulated cloud environment or on physical hardware?
 - Collection and analyzing test result and log reports from the execution after the test has finished running.



Test case execution

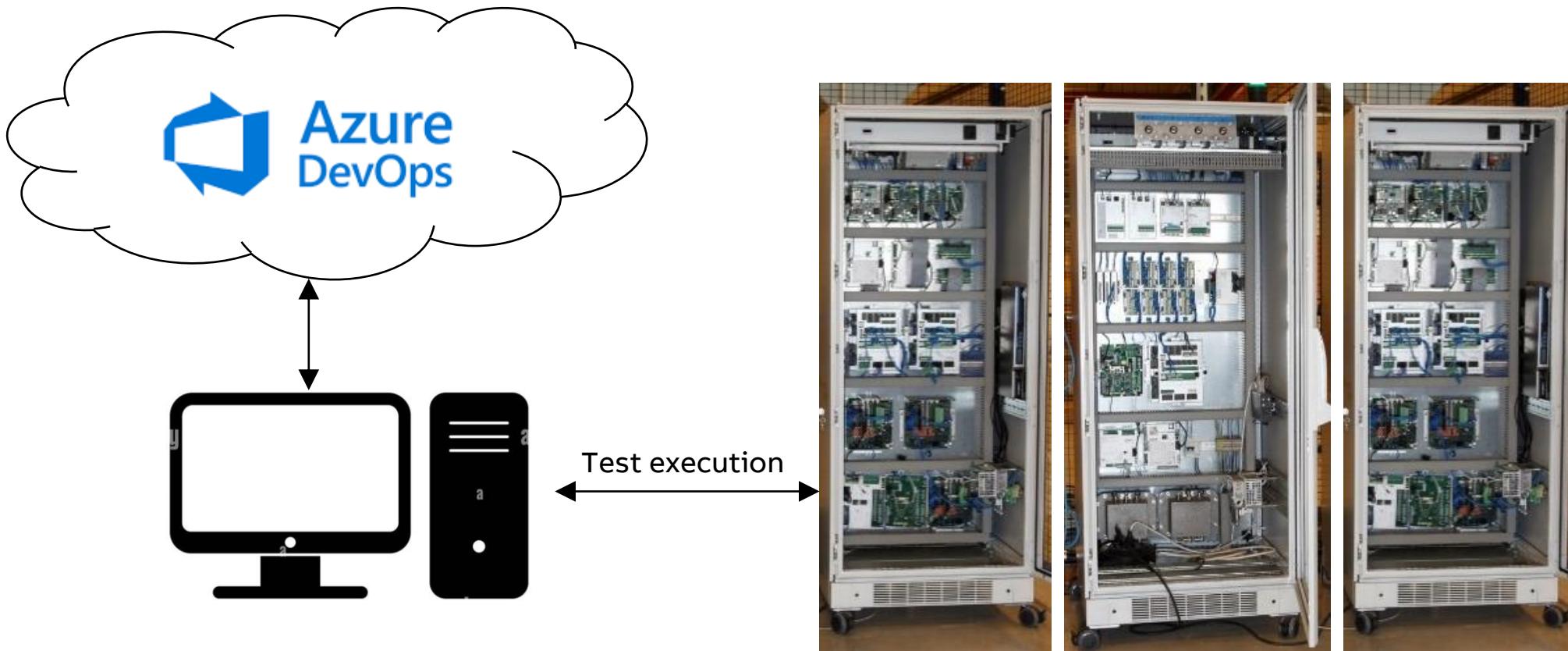


Log / report



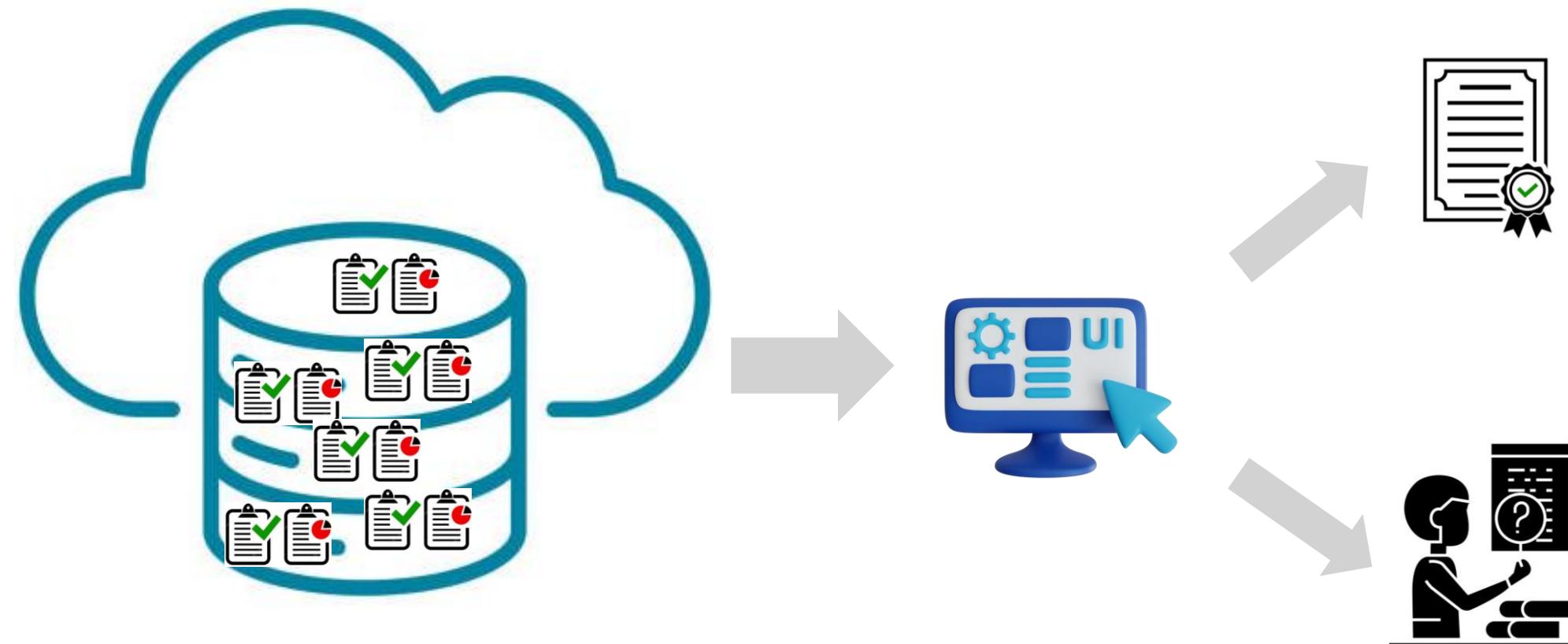
Test case execution environment – “The actual hardware”

- The physical racks typically located in the lab at ABB
- Also called BVT-rack in short (BVT = Build Verification Test)
- Contains physical boards and a lot of extra equipment for generating test-stimuli and ways to read back status from the system



Test result analyze and report – “How to analyze the test-result”

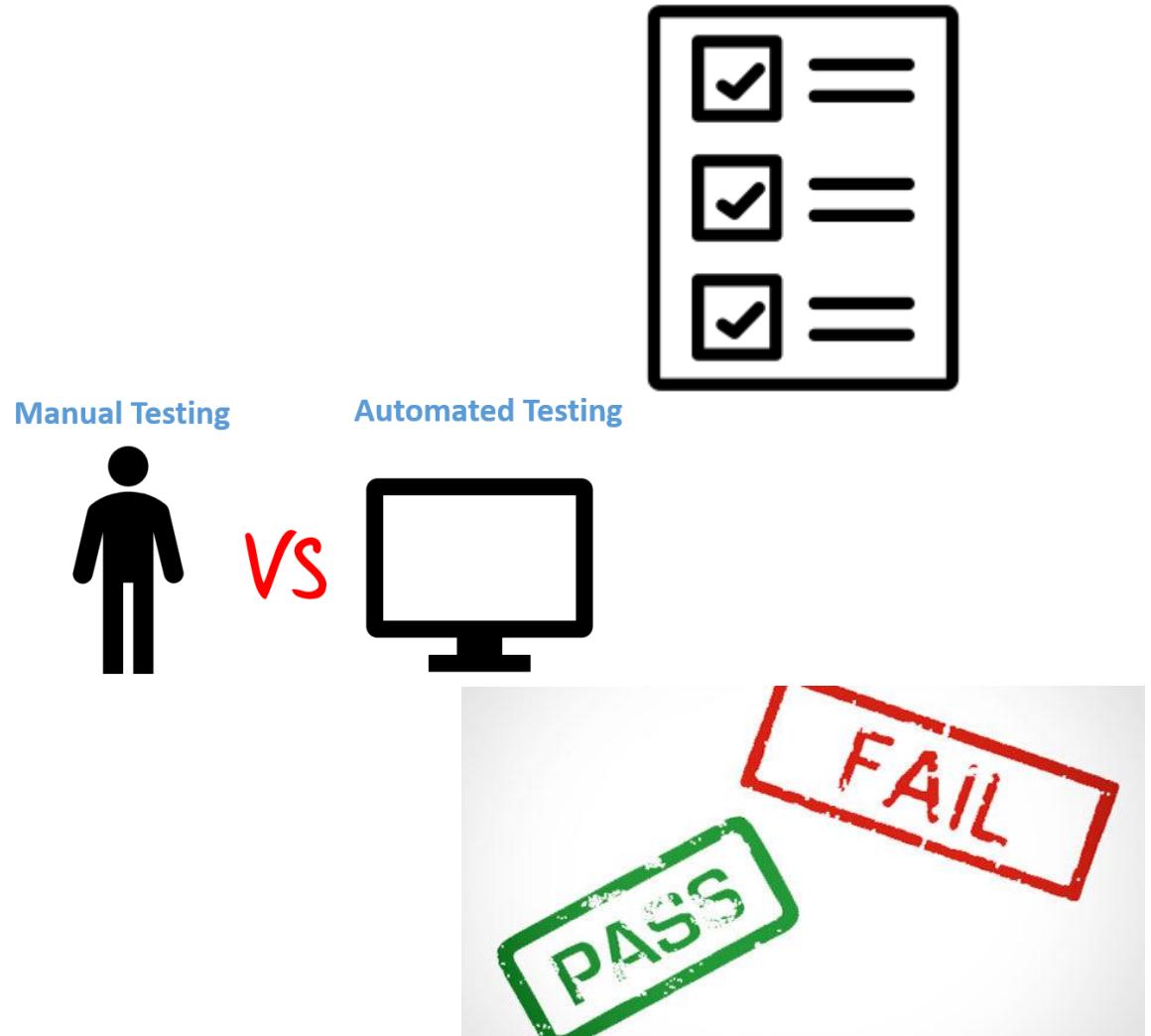
- The front-end / tool for accessing test-result
- Generate reports for use in certification of ex and safety
- Front-end for test-engineers and developers for viewing test-results and reports



Some general introduction to testing

What is a test-case?

- A test case is a description of how to test a specific function or part of a software. It describes what to test, what input to use, and what the expected result is.
- Can be manual or automatic
- The output of a test-case is preferably 'passed'/'error'
- **(Passed, Warning, Error or Aborted.)**



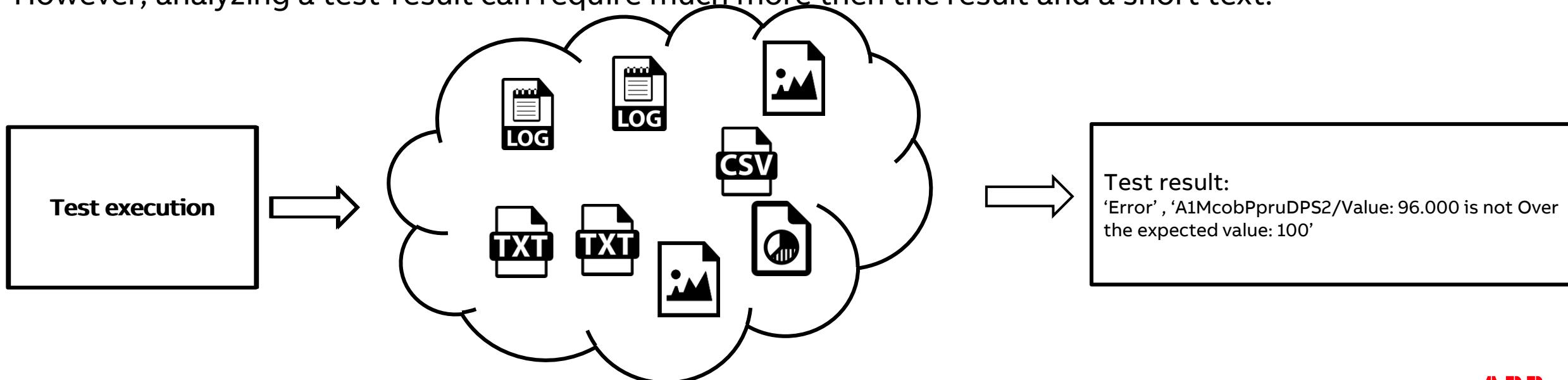
What is the result of a test-case?

In most cases the result will be **Passed**, **Warning**, **Error** or **Aborted**.

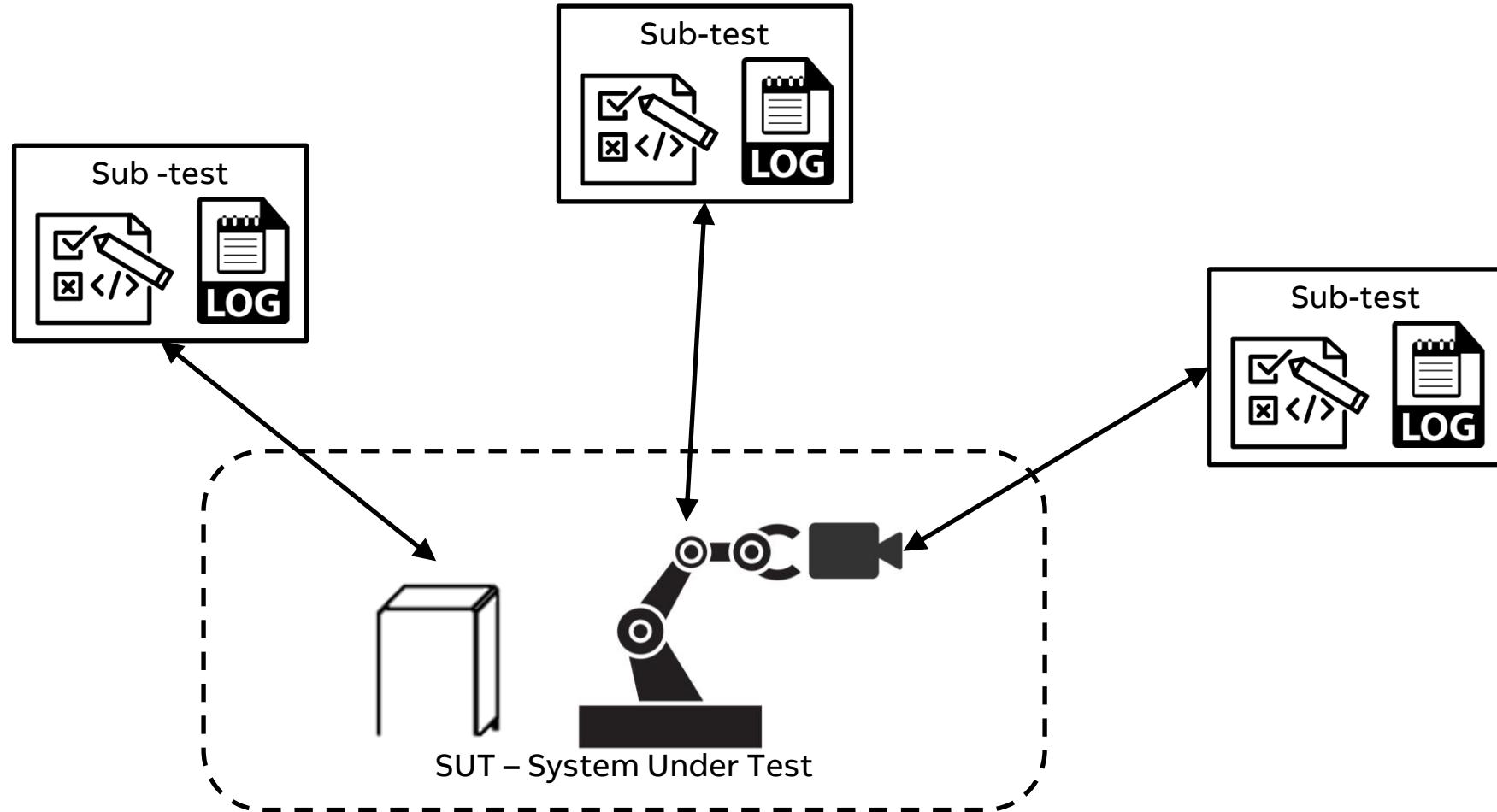
It is also very common to associate the test-result with a short text:

“A1McobPpruDPS2/Value: 96.000 is not Over the expected value: 100”

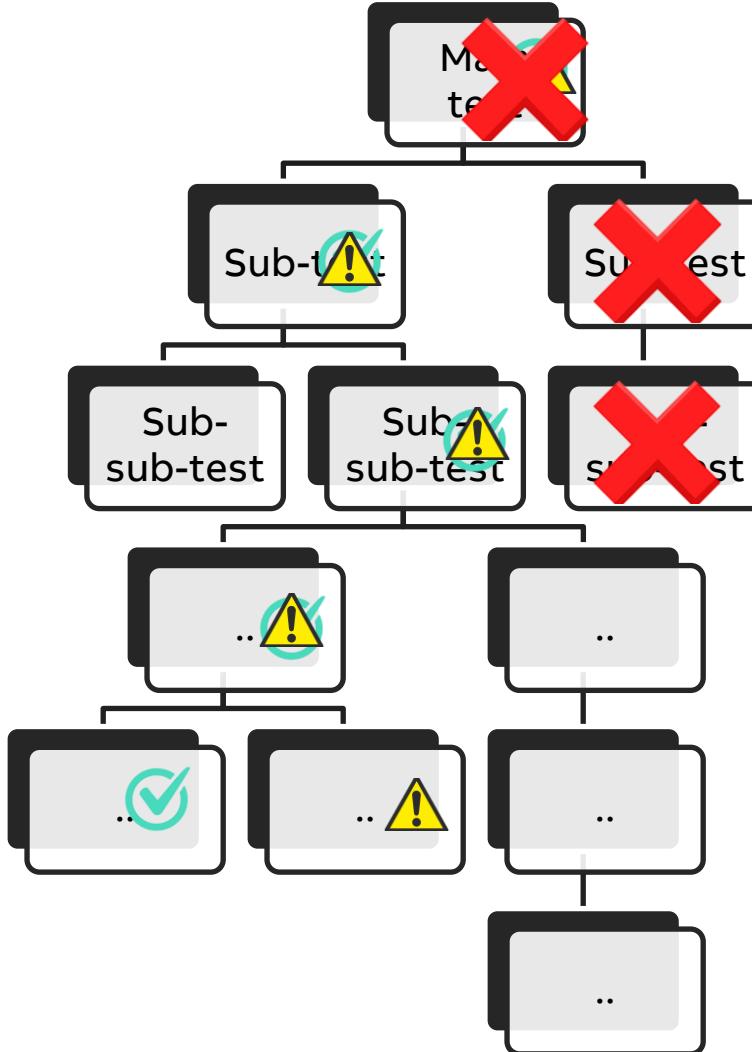
However, analyzing a test-result can require much more than the result and a short text.



Example of test execution at ABB



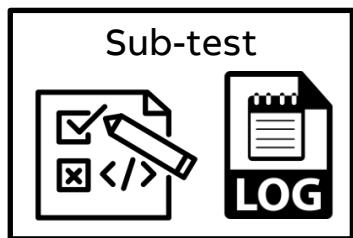
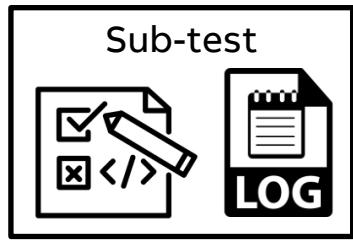
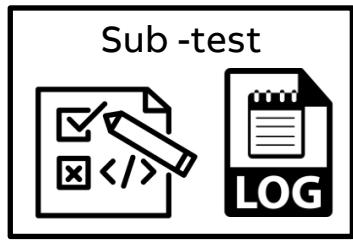
Propagation of test-result



How testing is related to cloud computing at ABB?

NAST

Test execution



Permanent storage



NASTWeb

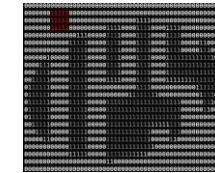
View and analyze results

NASTWeb



NAST

- NAST is a testing framework written and developed at ABB
- Main target is testing of ABBs paint control system (IPS), but can also be used for testing other stuff
- Written in Python
- After a test is finished, the end-result is uploaded into Azure



NASTWeb

- NASTWeb is a web-site for presenting test-results stored in Azure
- NASTWeb is written in a combination of Java-script and Python
- Hosted in Azure (Azure static web app)
- Code located in and Azure DevOps with CI/CD pipeline with automatic deployment to Azure



General overview of Nast / NastWeb

Azure Cosmos DB

- Globally Distributed Database Service: Low latency and high availability worldwide.
- Multi-Model Support: Document, key-value, graph, and column-family models.
- Fully Managed: No infrastructure management needed.

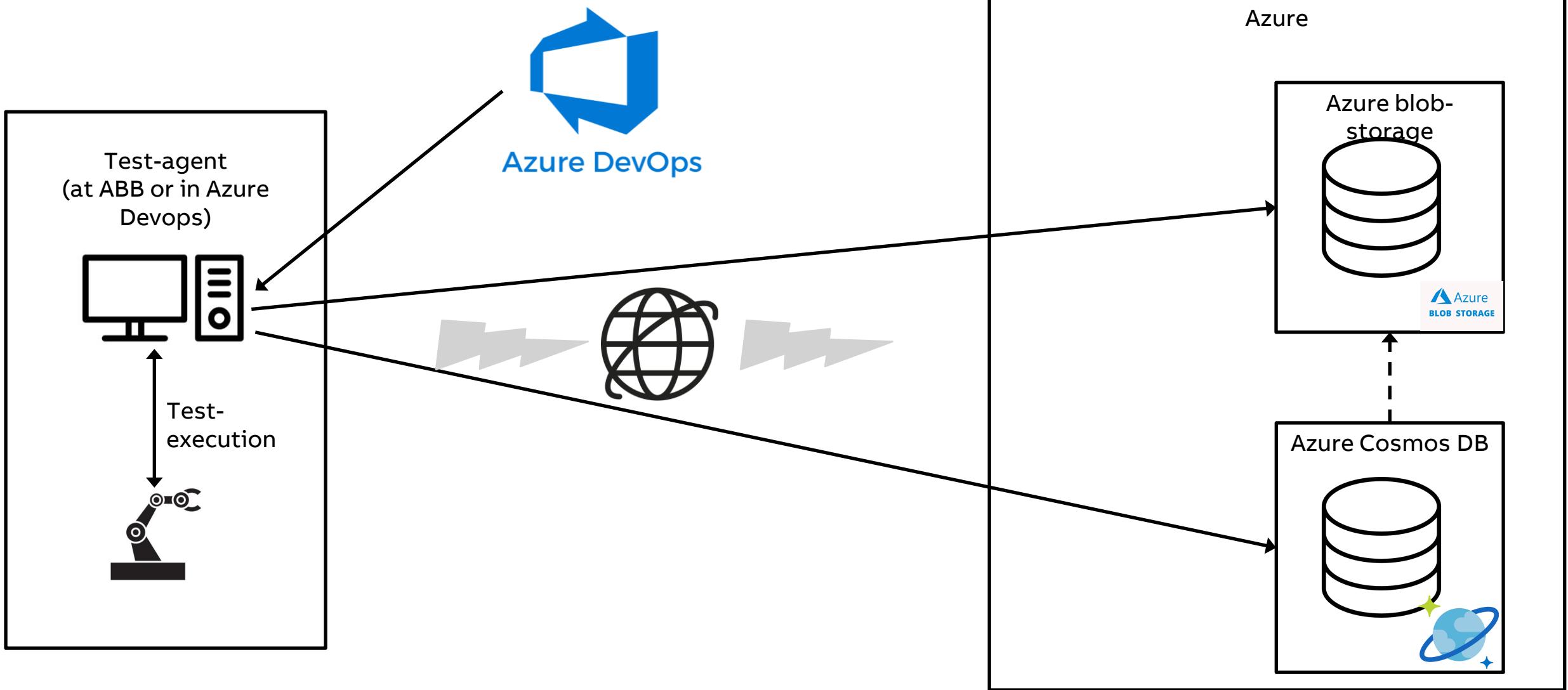


Azure Blob storage

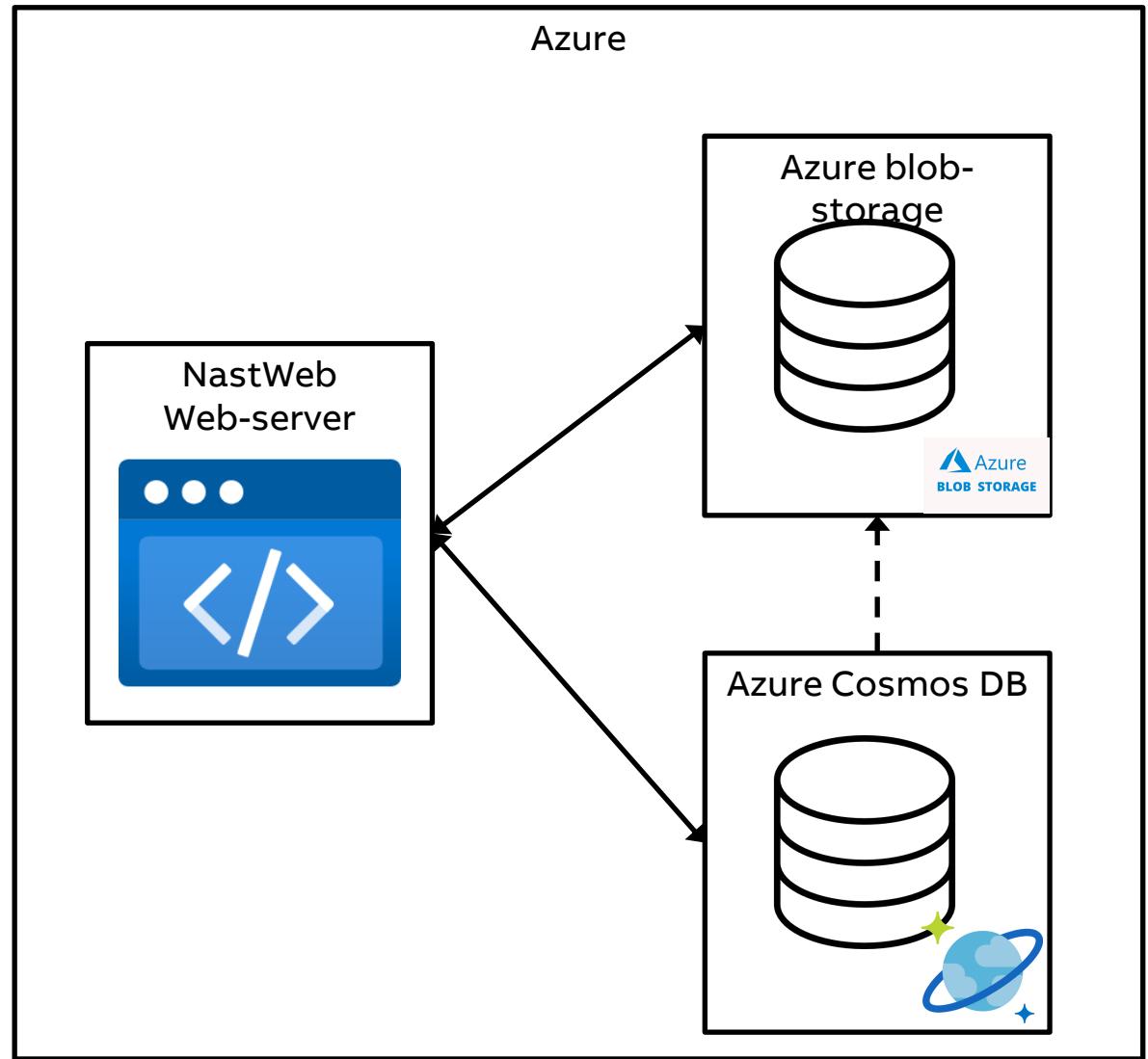
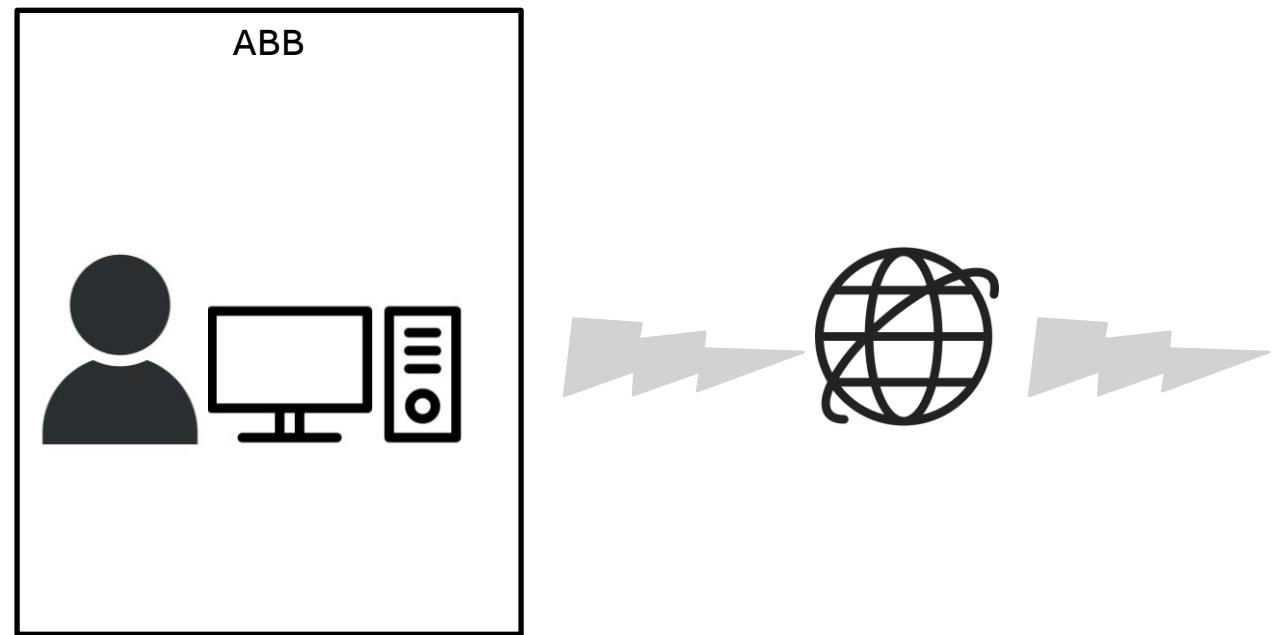
- Object Storage Solution: Designed for storing large amounts of unstructured data, such as text or binary data.
- Scalable and Secure: Easily scales to meet your data storage needs while ensuring data security.



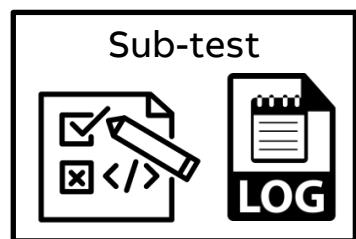
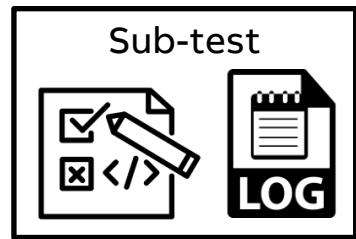
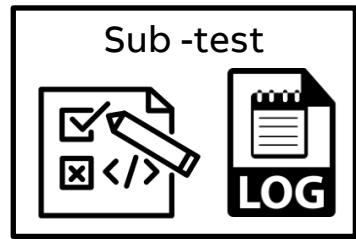
Flow of a test-case execution



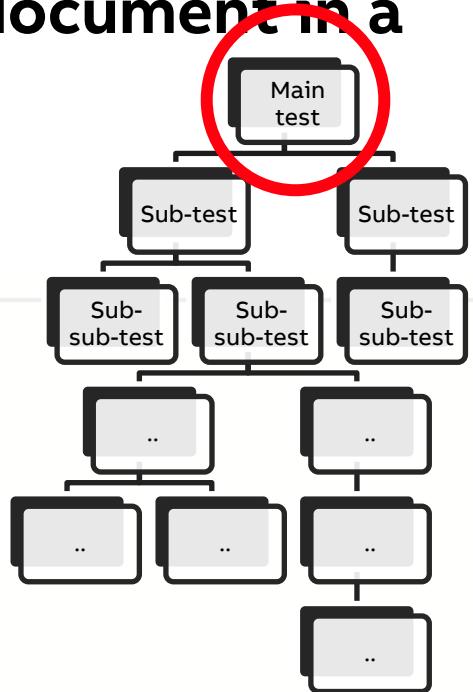
NastWeb



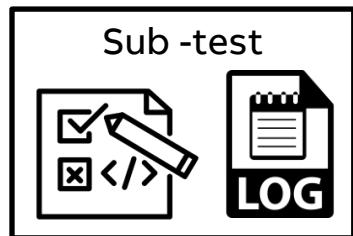
Test results is converted and stored in a structured json-document in a Cosmos DB located in Azure



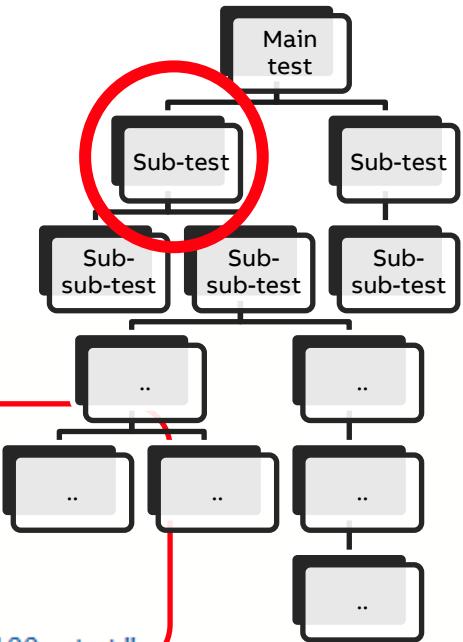
```
"agent_name": "Hosted Agent",
"build_id": "ips5.merge.230913.2",
"duration": 16.785304,
"id": "15fc1f60-49bf-4b73-8c7c-613233b3f63c",
"numberOfAbort": 0,
"numberOfErrors": 0,
"numberOfPassed": 4,
"numberOfWarning": 1,
"run_id": "2047301",
"start_of_test": "2023 09 17 02:06:57.5881",
"testExecutedBy": "VsAdministrator",
"testMsg": "Calling disconnect on robIci caused a caboom: [WinError 64] The specified network name is no longer available",
"testName": "SYSTEMSENSOR",
"testOutcomeString": "Warning",
"testCase_id": "546662",
"testCase_name": "IPSS SENSOR systemtest",
"z_subResults": [
```



Structured storing of sub-test



```
"test case name": "IPSS SENSOR systemtest",
"z_subResults": [
    {
        "consoleendline": 34,
        "consolestartline": 3,
        "duration": 16.785304,
        "log_file_ref": {
            "local_name": "ipssystemtest.txt",
            "remote_name": "ipssystemtest_4097d7da-72c4-4ef0-a5e0-876c7e5d6100_.txt"
        },
        "measurements": {
            "autograph": {},
            "customgraph": {}
        },
        "name": "ipssystemtest",
        "other files refs": [],
        "start of test": "2023-09-17 02:06:57.5881",
        "test_result": "Warning",
        "test_result_int": 1,
        "test_result_message": "Calling disconnect on robIci caused a caboom: [WinError 64] The specified n",
        "tested_system": "IpsSystemTest",
        "z_subResults": [
            ...
        ]
    }
]
```



Using NastWeb

Main screen of NASTWeb

NASTWeb MORTEN.MOSSIGE@NO.ABB.COM Logout

IPS4 IPS5

Queries

- Last 24 hours
- Local tests
- All tests
- Use your own query

Plots

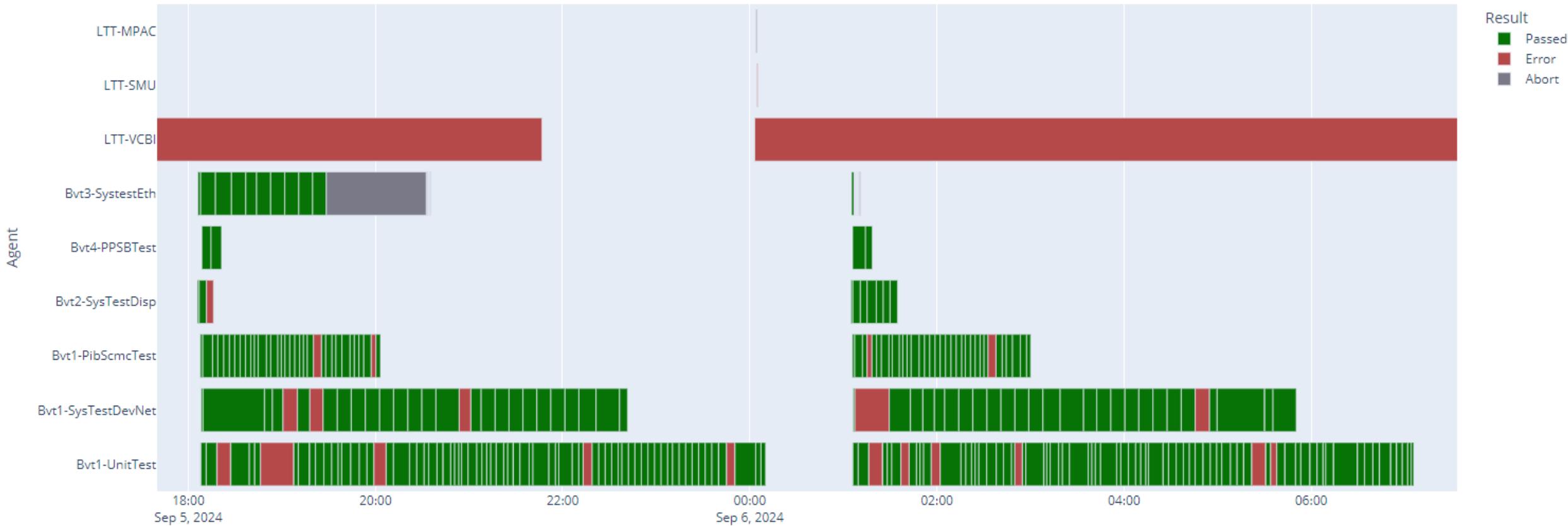
- Plot based on runs
- Plot based on tests results.

Analysis

- Frequently Failing Top 10 Test Cases

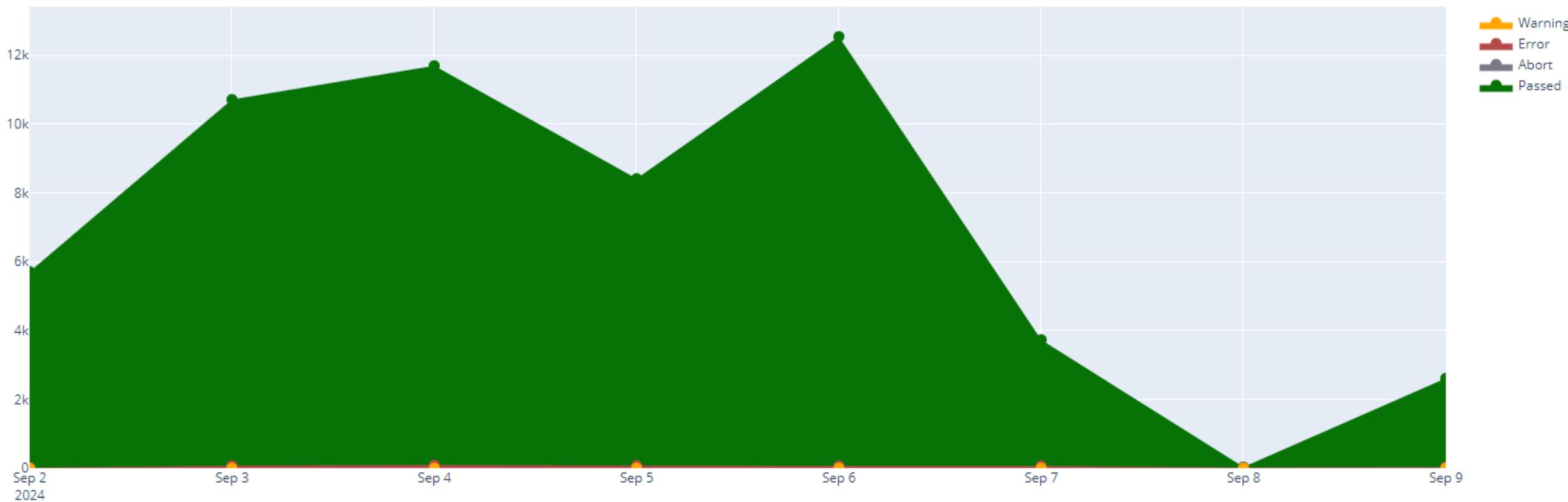
Plot generated based on runs

Condition: Last 7 days (Number of results: 1784)



Plot generated based on results

Condition: Last 7 days (Number of results: 1784)



Test cases from last 24 hours

300 / 339 test cases

Workitem Test Case	Test Script	Build ID	Run ID	Date	Duration	Test Result	Message
		All			All		
ACU with IMS test - 179409	AcuIMS	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:55:49.563	306.926	Passed	None
Model based trig test, no error, Plain - 198674	TrigTest	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:52:21.101	201.467	Passed	None
Test of FILTERDEVICE functions - 113352	IpsTestFiltDev	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:48:45.265	209.623	Passed	None
ACU possible configs test - 112284	PossibleConfigs	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:46:33.417	128.221	Passed	None
ACU intdigin test - 112180	IntDigin	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:43:32.092	178.266	Error	interrupt count expected 1 got 0
ACU digio test - 112289	DigIO	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:41:19.958	128.611	Error	idi1/value: 1 is not Equal to the exp
Default signals tests for different IPS devices - 112461	IpsTestDefault	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:37:45.544	208.029	Passed	None
Test of Brush device functions - 112464	IpsTestBrush	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:31:02.940	389.064	Passed	None
Model based trig test, trigg error on channel 1 - 198675	TrigTest	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:27:57.829	178.707	Passed	None
PPRU default parameters test - 114982	DefaultValues	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:25:48.214	125.813	Passed	None
PPRU digio test - 115004	DigIO	Paint.Main.EmbSw20230916.1	2047230	2023-09-17 05:23:39.550	125.713	Error	idi1/value: 1 is not Equal to the exp

IpsTestTrigLatency: Test of Trig latency(304919)		Passed: 45 Warning: 0 Error: 0 Abort: 0		
User	Run ID	Build ID	Start Time	Duration
no-z8-buildsystem	2047230	Paint.Main.EmbSw20230916.1	2023-09-17 04:27:43.809	732.299s
<ul style="list-style-type: none"><input checked="" type="checkbox"/> ProcessIoCcpu<input checked="" type="checkbox"/> AcuCCPU<input checked="" type="checkbox"/> HVC02CCPU<input checked="" type="checkbox"/> HVC02ACCPU<input checked="" type="checkbox"/> PpriCCPU<input checked="" type="checkbox"/> MC0B01CCPU<input checked="" type="checkbox"/> MC0B-03 CCPU<input checked="" type="checkbox"/> PIBECPU<input checked="" type="checkbox"/> MCB03CCPU<input checked="" type="checkbox"/> ipsunitest<input checked="" type="checkbox"/> testrunner				

Propagation of test-result

! IpsTestTrigLatency: Test of Trig latency(304919)

Passed: 44 Warning: 0 Error: 2 Abort: 0

User	Run ID	Build ID	Start Time
no-z8-buildsystem	2040454	Paint.Dev.EmbSw.CI20230906.4	2023-09-06 22:54:20.129

Error 2/4

ProcessloCcpu

AcuCCPU

TEST AcuCCPU Init Test

TEST AcuCCPU Apply Global Parameters

TEST AcuCCPU Run Iteration 1

TEST AcuCCPU Analysing trig-log

- Verify that best trig is in the range [-0.1, 0.1]ms
- Verify that worst trig is less than 0.5ms
- Verify that mean trigtime is in the range [-0.03, 0.03]
- Verify that variance is in the range [0.0, 0.002]

TEST AcuCCPU Dumping trig-log

TEST AcuCCPU Clean Up Test

HVC02CCPU

HVC02ACCPU

Verify that variance is in the range [0.0, 0.002]

ERROR

Adjust font size

2023-09-06 23:06:09,150 AcuCCPU IpsTestTrigLatency INFO Mean trig: 0.000s

2023-09-06 23:06:09,150 AcuCCPU IpsTestTrigLatency INFO Try to add new op

2023-09-06 23:06:09,150 AcuCCPU IpsTestTrigLatency INFO Mean: 0.000s

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Added New operation

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Variance: 0.000s

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Try to add new op

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Variance: 0.000s

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Added New sub op

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Added New op

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Trig log

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Trig 0 errors

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Trig 1 errors

2023-09-06 23:06:09,151 AcuCCPU IpsTestTrigLatency INFO Trig 2 errors

2023-09-06 23:06:09,152 AcuCCPU IpsTestTrigLatency INFO Trig 3 errors

✓ IpsTestTrigLatency: Test of Trig latency(304919)

Passed: 45 Warning: 0 Error: 0 Abort: 0

User	Run ID	Build ID	Start Time	Duration
no-z8-buildsystem	2047230	Paint.Main.EmbSw20230916.1	2023-09-17 04:27:43.809	732.299s

- ProcessIoCcpu
- AcuCCPU
- HVC02CCPU
- HVC02ACCPU
- PpriCCPU
- MCOB01CCPU
- MCOB-03 CCPU
- PIBECPU
- MCB03CCPU
- ipsunittest
- testrunner

Get trig-queue from t1

PASSED

2023-09-17 04:29:24.195

29.938s

Adjust font size for log: + -

```
2023-09-17 04:29:32,009 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 1 TrigTime: 10. Setting 1 at 13803224 and 0 at 13803229
2023-09-17 04:29:32,092 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 2 TrigTime: 20. Setting 1 at 13803234 and 0 at 13803239
2023-09-17 04:29:32,184 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 3 TrigTime: 30. Setting 1 at 13803244 and 0 at 13803249
2023-09-17 04:29:32,265 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 4 TrigTime: 40. Setting 1 at 13803254 and 0 at 13803259
2023-09-17 04:29:32,356 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 5 TrigTime: 50. Setting 1 at 13803264 and 0 at 13803269
2023-09-17 04:29:32,437 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 6 TrigTime: 60. Setting 1 at 13803274 and 0 at 13803279
2023-09-17 04:29:32,528 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 7 TrigTime: 70. Setting 1 at 13803284 and 0 at 13803289
2023-09-17 04:29:32,609 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 8 TrigTime: 80. Setting 1 at 13803294 and 0 at 13803299
2023-09-17 04:29:32,699 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 9 TrigTime: 90. Setting 1 at 13803304 and 0 at 13803309
2023-09-17 04:29:32,780 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 10 TrigTime: 100. Setting 1 at 13803314 and 0 at 13803319
2023-09-17 04:29:32,863 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 11 TrigTime: 110. Setting 1 at 13803324 and 0 at 13803329
2023-09-17 04:29:32,955 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 12 TrigTime: 120. Setting 1 at 13803334 and 0 at 13803339
2023-09-17 04:29:33,036 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 13 TrigTime: 130. Setting 1 at 13803344 and 0 at 13803349
2023-09-17 04:29:33,128 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 14 TrigTime: 140. Setting 1 at 13803354 and 0 at 13803359
2023-09-17 04:29:33,208 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 15 TrigTime: 150. Setting 1 at 13803364 and 0 at 13803369
2023-09-17 04:29:33,298 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 16 TrigTime: 160. Setting 1 at 13803374 and 0 at 13803379
2023-09-17 04:29:33,381 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 17 TrigTime: 170. Setting 1 at 13803384 and 0 at 13803389
2023-09-17 04:29:33,461 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 18 TrigTime: 180. Setting 1 at 13803394 and 0 at 13803399
2023-09-17 04:29:33,552 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 19 TrigTime: 190. Setting 1 at 13803404 and 0 at 13803409
2023-09-17 04:29:33,643 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 20 TrigTime: 200. Setting 1 at 13803414 and 0 at 13803419
2023-09-17 04:29:33,733 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 21 TrigTime: 210. Setting 1 at 13803424 and 0 at 13803429
2023-09-17 04:29:33,822 ProcessIoCcpu IpsTestTrigLatency INFO TrigNo: 22 TrigTime: 220. Setting 1 at 13803434 and 0 at 13803439
```

Check Historical Data

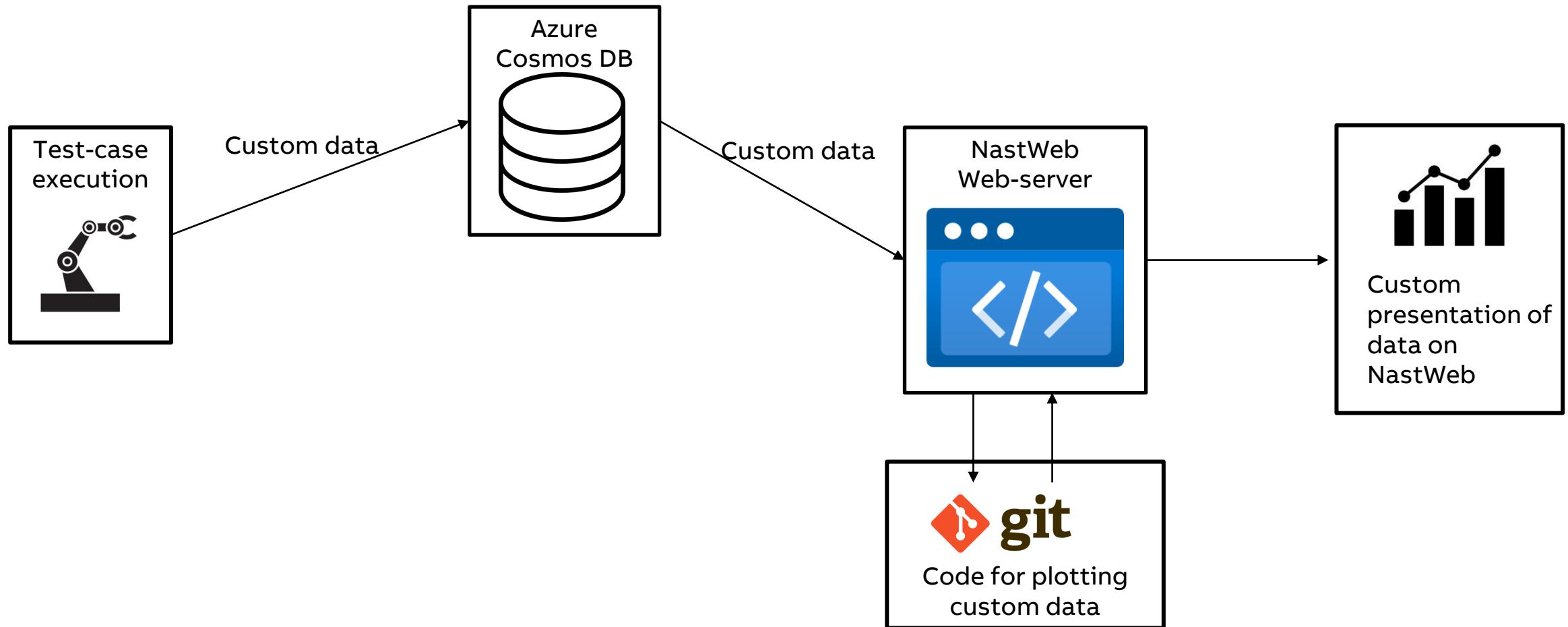
Run measurements

Using ‘autograph’ to monitor trends over time

- Any value (int or float) can be added to a test-result
- One value for each run
- Stored in DB on a key/value scheme.
- NASTWeb will automatically collect and graph all ‘autograph’ values

```
        ],
      "measurements": {
        "autograph": {
          "softwareupgradetime": 0.4194242000000017,
          "loadconfigtime": 35.7057803,
          "inittesttime": 0.0004017000000118287,
          "applyglobalparameterstime": 0.0017452999999960639,
          "applyitterationparameter1time": 0.001695599999990804,
          "best_trig": -0.07860999926924706,
          "worst_trig": 0.20863099955022335,
          "mean_trig": -0.00581544810924679,
          "variance_trig": 0.00047620802234341086,
          "runiteration1time": 637.5434563,
          "testexecetime": 653.9819408999999,
          "cleanuptesttime": 0.001160200000072109
        },
      }
    }
```

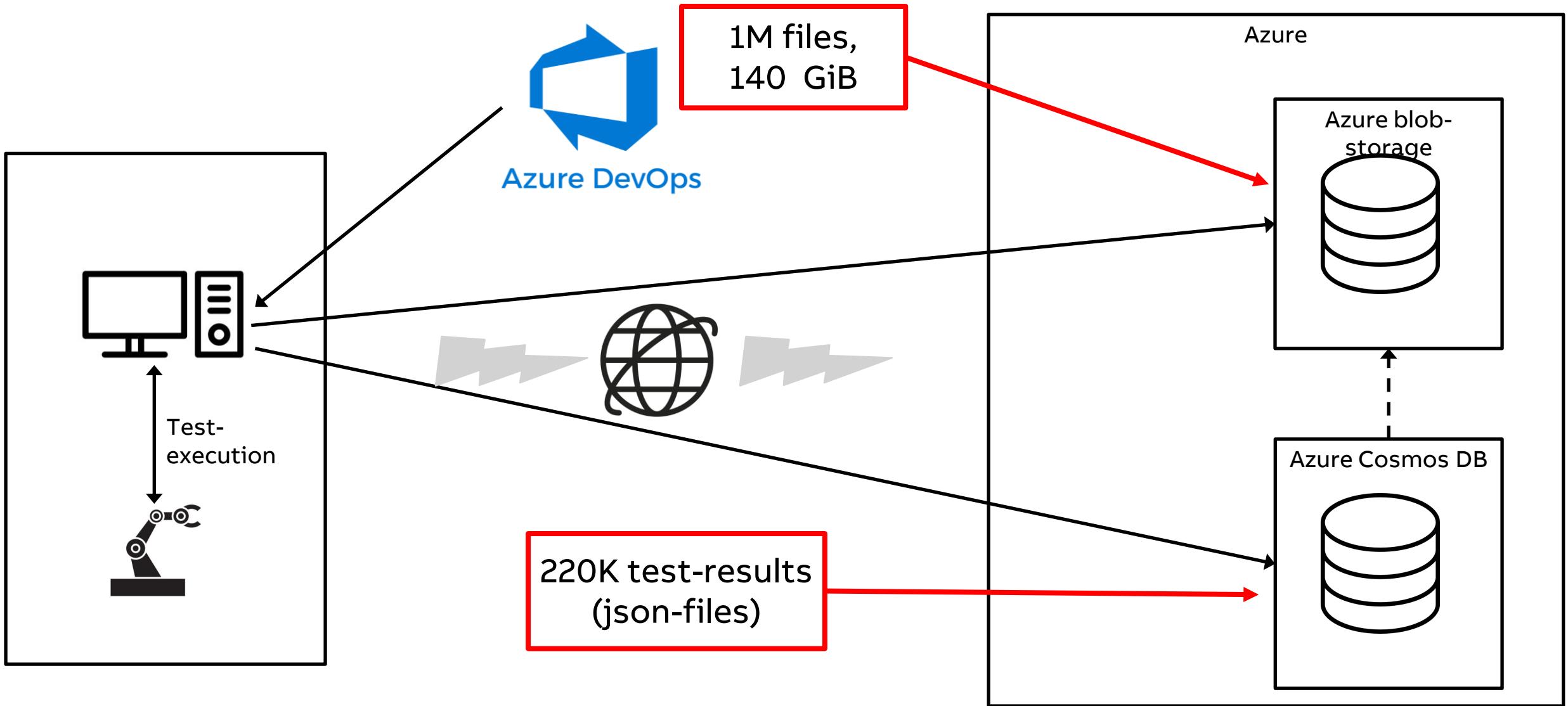
Custom graph



```
],
  "measurements": {
    "autograph": {
      "softwareupgradetime": 0.4043695999999999,
      "loadconfigtime": 35.9819916,
      "inittesttime": 0.6062455,
      "applyglobalparameterstime": 0.0021009000000020706,
      "applyiterationparameter1time": 0.0009964999999994006,
      "min_latencies": 18,
      "max_latencies": 168,
      "avg_latencies": 50,
      "runiteration1time": 602.2813934999999,
      "testexecetime": 605.8132488,
      "cleanuptesttime": 0.569710099999952
    },
    "customgraph": {
      "runningbuild": "Paint.Dev.EmbSw.CI20230917.1",
      "cyclictesthistogram": [
        [
          0,
          1,
          2,
          3,
          4,
          5,
          6,
          7,
          8,
          9,
          10,
          11,
          12
        ]
      ]
    }
  }
}
```

Live demo

Some numbers



Advanced analytics

- Usage:
 - Compare test run performance -> decide the priority of debugging.
- Approaches
 - Ranking test case by performance.
 - Identify the frequently failing test case.
 - Clustering test case by error messages.
 - Group the test cases that have same problem.
- Host on Azure API function
 - Same with the backend for NASTWeb.

Ranking : AHP-WSM Model

- AHP (Analytic Hierarchy Process)
 - o Decide the weight of each factor
 - o Build a pair-wise comparison matrix -> relative importance
- WSM (Weighted Sum Model)
 - o Calculate the score of each test case based on the result from AHP.

Example:

- Date
- PctPassed
- PctFailed
- Counts

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Counts	4.7%	4	0.9%	0.9%
2	Date	12.9%	3	1.6%	1.6%
3	PctPassed	28.3%	2	3.2%	3.2%
4	PctFailed	54.0%	1	9.0%	9.0%

ID	Counts	Date	PctFailed	PctPassed
tc_1	300	-1	40 %	60 %
tc_2	500	-7	10 %	90 %
tc_3	150	-2	20 %	80 %
tc_4	800	0	60 %	40 %
tc_5	300	-1	50 %	50 %

ref: [AHP Priority C](#)

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3	4
1	1	0.33	0.14	0.11
2	3.00	1	0.50	0.20
3	7.00	2.00	1	0.50
4	9.00	5.00	2.00	1

score
57.591
74.027
55.652
76.18
22.121

Custom time

From 2024-08-01 to 2024-08-07	Last week	Last month	Last 3 months	Overall
-------------------------------	-----------	------------	---------------	---------

Run at: 2024-09-06 05:28:10

Runs every monday.

The used results in this table are from last week. (From 2024-09-02 to 2024-09-08)

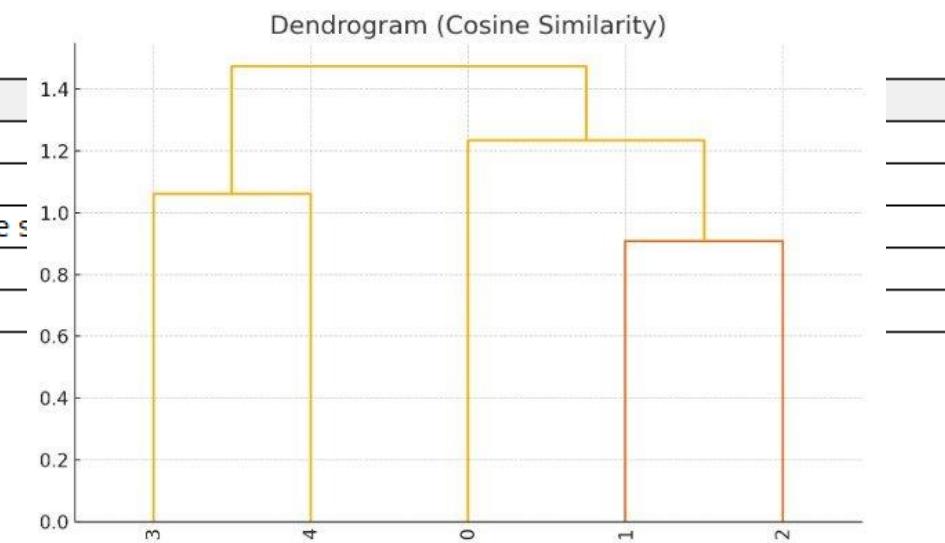
Test Case (Latest result)	Score	Total Failure%	Recent Failure%	(Abort%)	Error%	Warning%)	Latest Fail	Message from the Latest
Test of IPS trig performance-216584 Abort	69.02	100.00% (13/13)	100.00% (13/13)	7.69% (1)	92.31% (12)	0% (0)	Abort 2024-09-01 18:16:14.989	RunIteration error: invalid li
ACU with FCPU Air test-527847 Error	68.72	100.00% (5/5)	100.00% (5/5)	0% (0)	100.00% (5)	0% (0)	Error 2024-09-01 22:56:34.079	AcuFS1/Value: 344.688 is no
ACU with CCPU Air test-526033 Error	55.88	80.00% (4/5)	80.00% (4/5)	0% (0)	100.00% (4)	0% (0)	Error 2024-08-31 21:39:02.788	AcuPS2/Value: -0.072 is not
Test of LCM functions-198620 Abort	39.23	71.43% (5/7)	42.86% (3/7)	33.33% (1)	66.67% (2)	0% (0)	Abort 2024-09-01 05:51:34.969	RunIteration error: list inde
Test of Deviation Alarm functions-112478 Error	38.73	71.43% (5/7)	42.86% (3/7)	0% (0)	100.00% (3)	0% (0)	Error 2024-09-01 18:50:09.289	A1ShapeDev/Active: 1 is no
PIB-Scmc Test Mode Stop-203857 Error	23.88	57.14% (8/14)	14.29% (2/14)	0% (0)	100.00% (2)	0% (0)	Error 2024-09-01 19:58:13.480	IpsCheckElog. Expected elo
PIB TwoPhase test-560278 Error	23.72	57.14% (4/7)	14.29% (1/7)	0% (0)	100.00% (1)	0% (0)	Error 2024-09-01 21:27:09.372	TwoPhEnc2/Value: 40023.09
PIO OnePhase test-559237 Abort	21.89	42.86% (3/7)	14.29% (1/7)	100.00% (1)	0% (0)	0% (0)	Abort 2024-09-01 06:24:26.477	RunIteration error: list inde
PIO TwoPhase test-559240 Abort	21.89	42.86% (3/7)	14.29% (1/7)	100.00% (1)	0% (0)	0% (0)	Abort 2024-09-01 06:30:05.896	RunIteration error: list inde
Test of LOGICDEVICE function-112483 Error	20.39	42.86% (3/7)	14.29% (1/7)	0% (0)	100.00% (1)	0% (0)	Error 2024-09-01 19:24:04.418	\$0 was not received when i

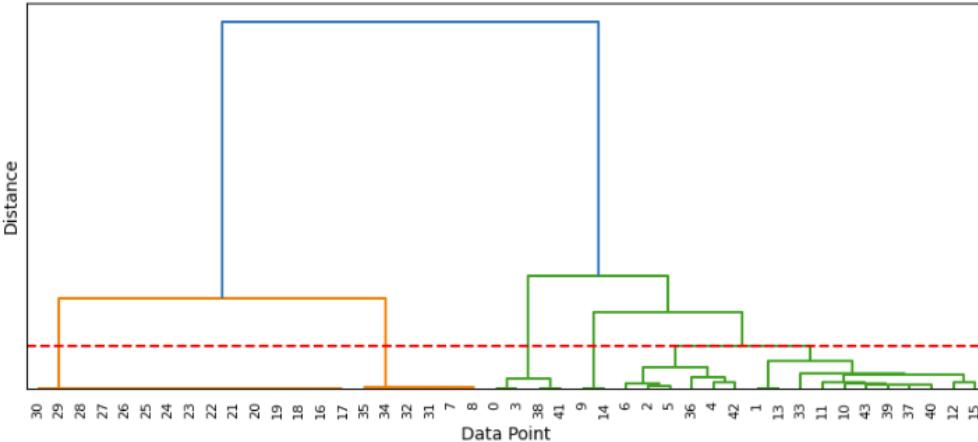
Clustering: Cosine Similarity with Agglomerative Clustering

- Cosine Similarity
 - o Compare two sentence each time, build a similarity matrix.
- Agglomerative Clustering
 - o Based on the similarity matrix, build a tree-like structure: dendrogram. group from bottom to top.
- Example:

ID	Error message
0	1 configfiles failed to load
1	Unable to write signal; ICI Error: Failed to write signal number '3' on: b'V1
2	EasyICl: Unable to query signals on device: Board under client: b'\x01\x04'; Error: Failed to retrieve s
3	Actual elog sequence is not as expected
4	interrupt count expected 1 got 0

$$\begin{bmatrix} 1.0 & 0.15 & 0.13 & 0.0 & 0.0 \\ 0.15 & 1.0 & 0.36 & 0.0 & 0.0 \\ 0.13 & 0.36 & 1.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 & 0.25 \\ 0.0 & 0.0 & 0.0 & 0.25 & 1.0 \end{bmatrix}$$





Cluster #1

RM: Error running InitTest() for test script
 SysTestsTrig error: 403 Access not allowed by your Company policy

Cluster #2

RM: Error running InitTest() for test script
 EthTestSimpleIPS error: 403 Access not allowed by your Company policy

Cluster #3

RM: A1SensorDev/Active: 0 is not Equal to the expected value: 1

Cluster #4

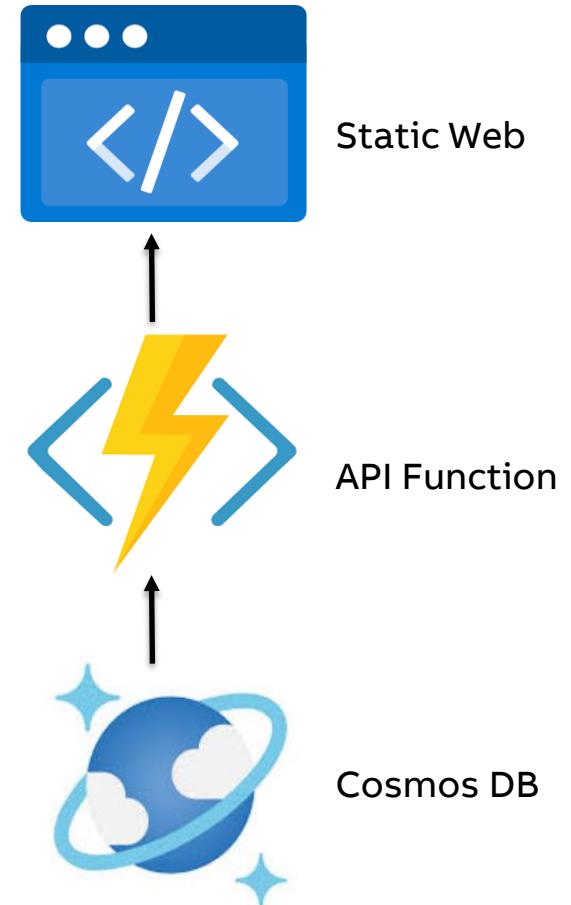
RM: Error running InitTest() for test script
 PerformanceTest_Time error: Not able to connect to ICI-client after waiting 30s!!

Cluster #5

RM: A1McobPpruPS1/Value: 2.514 is not Between 2 and 2.5

Azure API Function

1. Cosmos DB
 - Integrated with Azure functions, easier to pull data
2. Scalability
 - Dynamically allocate the resource.
3. Serverless
 - Focus on algorithm, instead of maintain the server.
 - Keep access to log stream, environment variables, authentication (with Azure AD).
 - Performance overview: failed requests, response time.
4. API management
 - Secure, version-controlled.



Ideas for master thesis at ABB

- AI based scheduling of test-cases based on test-result DB
- AI based analytics of test-result
- AI based compare of test-results

ABB