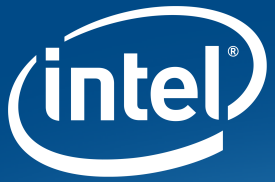

Intel's Journey to Build Quality In:

How QA and Test Automation Drive DevOps

MANISH AGGARWAL

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Agenda

- Introduction
- What we do
- Software delivery challenges
- Where we started
- Solution Discussion: Design principles and best practices
- Where we ended up
- Q&A

About Myself

- Software Engineering Manager at INTEL, Austin, TX
- 19+ years of software design/development experience in Telecom and Networking
- Working at INTEL for 9 years in Data Center Group (DCG)

"I believe that quality products lead to happy customers, and happy customers keep companies in business."

What we do!

- Deliver System on Chip (SoC) to the top tier wireless telecom vendors in the world
- So whenever you use your Smartphone, watch a YouTube Video, or communicate over an LTE network you are probably using some hardware or software that we built!

- Note: Don’t waste time comparing iPhone X and Galaxy 8. Buy both ☺

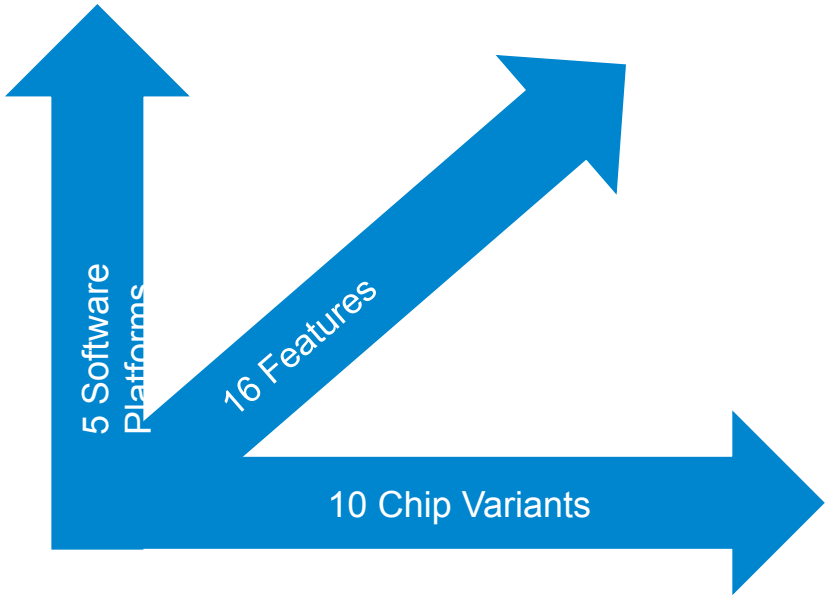
Why is Quality Assurance So Difficult?

QA and Test Automation – why so difficult for DevOps?

- The middle child of your pipeline, gets the least love/visibility
- Last check point in the release cycle. Absorbs delays.
- It is actually hard
- Ever increasing Test matrix
- Embedded device config that cannot be easily updated
- Traditional manual testing is risky :
  - Slow and Error prone
  - Repetitive ; Monotonous
  - Subject to Delays, re-work and unpredictability
  - Test engineers commonly scramble to navigate between the pace of Dev, and the requirements of Ops around environments, compliance, security, and more.

What was our challenge?
20,000+ Test Matrix, and growing!

Business need to verify the Hardware part for a wide range of combinations.



Hundreds of Tests for each Engine

The Test Matrix Grows Exponentially
Why?

- ***Legacy!!*** *Many years of baggage!*
- ***Backward Compatibility:*** *Deliver new features without breaking any old functionality*
- ***New Flavors always keep pouring!*** *It never ends*
- ***Need to decouple dependency between team/flavors:*** *to be able to release independently*
- ***Time to market driven by large OEM/device manufacturers :*** *the customer is asking for a release sooner than planned. Can we do that without de-scoping any features!*
- ***How much testing is enough?***

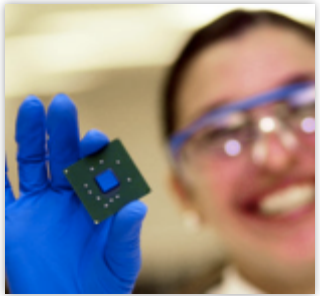
4
Releases/Year

DAYS
QA Lead Time per CI Cycle

85%+
Unknown Code coverage

3M
Lines of Code

100's
cases run/day



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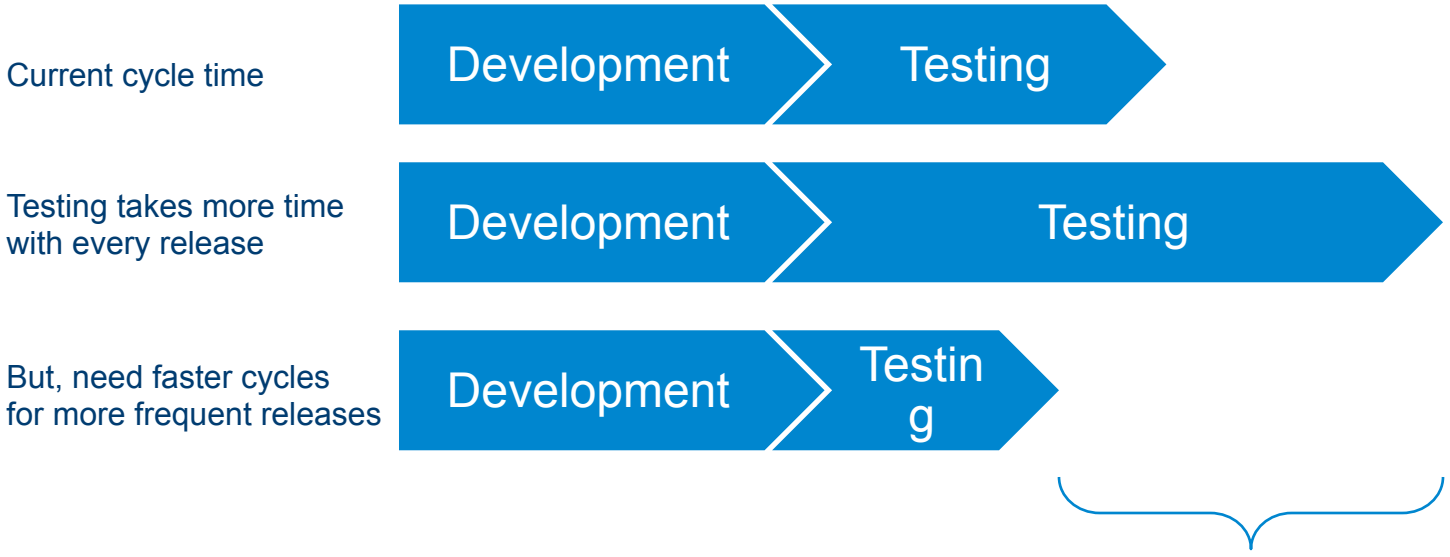
Permutations of S/W and H/W per product

Where we started

How it looks on the ground:

- ***It worked on my machine!***
- **Flaky/inconsistent test:**
  - This test was working till yesterday. Not sure why is this failing now.
  - How to troubleshoot? Can you go back to an older build and check when did this test last work?
- **Show me the numbers! What's our status?**
  - Customer is asking for code coverage numbers and memory leak testing. BTW, did I tell you that due to budget constraints, we have a strict hiring freeze this year.
  - How many tests do we have?
  - How many tests are passing? How soon can we make a release?
- **No additional headcount**

Time to Market (TTM) or Quality?



Options:

- Increase cycles times and delay TTM?
- Shorten cycle times and risk quality?
- **Test smarter and faster with automatio**

What we want to achieve:

1. Testing at scale: growing matrix, limited resources
2. Consistency (repeatability)
3. Visibility
4. Known Quality & status
5. Metrics drive decisions
    - Elevate and share metrics dashboards and our status across the organization
    - Keep everyone in Sync

How do you support 20,000 Test Cases!!

Our Solution: Design Principles

1. **Create test scripts that are re-usable**
   - Parameters to the rescue!
2. **On-demand is key:**
   - Tests are stored in on-demand **self-service repository** for engineers to access
   - On-demand **environment provisioning/ configuration**
3. **Easy Access:**
   - Users **access the repository** the way they prefer: using UI, CLI, Script/API, triggered automatically from a pipeline task, etc.
   - Can choose existing test to re-use or customize
   - Can run set of test cases manually or on a schedule.
4. **Provide shared visibility that's easy to consume:**
   - High level status dashboards
   - Drill down capabilities/alerts

How ElectricFlow from Electric Cloud Helped?

- ElectricFlow forms a single, flexible, scalable platform for us to design around
- All tests automated using ElectricFlow
- Custom UI for accessing tests across the org
- Results automatically emailed to stake holders
- Based on test results the pipeline automatically proceeds: approval gates, change requests, and consequent pipeline stages are triggered.
- Shared reports and dashboards provide visibility

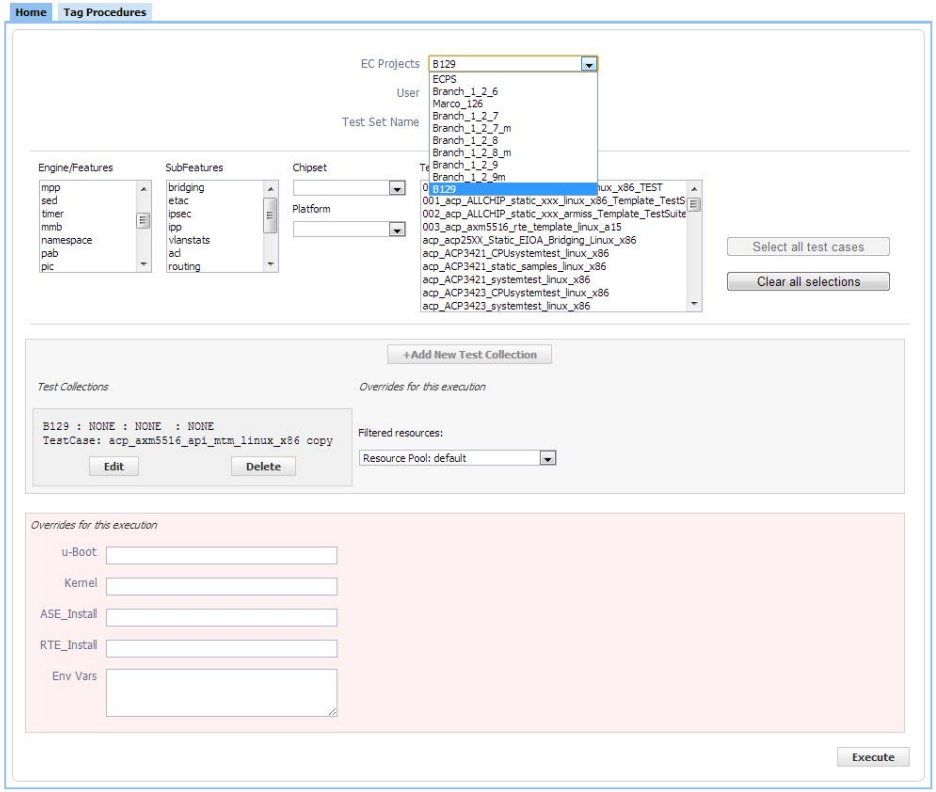
1. Re-usable, Parameterized Test Automation Scripts

- Object-oriented approach:
  - Each tier in the test scripts is **parameterized**: Jobs, Procedures, Releases, Teams etc.
- Each test is categorized/labeled with these parameters, for **easy grouping and sorting**:
  - Release Branch
  - Engine/Feature
  - Sub Feature
  - Chip Type
  - Platform
  - Test Type
- Procedures supply information for data-driven execution
  - Create lists from the data in properties (e.g. Engine, Subfeature, Chipset, Platform)
  - Default operational parameters, overridden during automation
  - This way, we create dynamic and variable-length option lists

2. On-demand Self-service Tests Repository

- This vastly improves the maintainability!
- Users can view all tests and procedures based on search criteria/filters that they care about.
  - The procedures visible are lot more manageable.
  - Users can save their customized test-lists.
  - Users can refer to the test-lists saved by other users.
- Users easily choose test to re-use or modify – using UI, CLI, Script/API, triggered automatically from a pipeline task, etc.
- Users can select tests to run:
  - executed as-is.
  - Modified
  - executed with different builds
  - Executed using different resources
- Everyone share the same tests! Developers can run the QA tests, against their sand-box, even before check-in!!

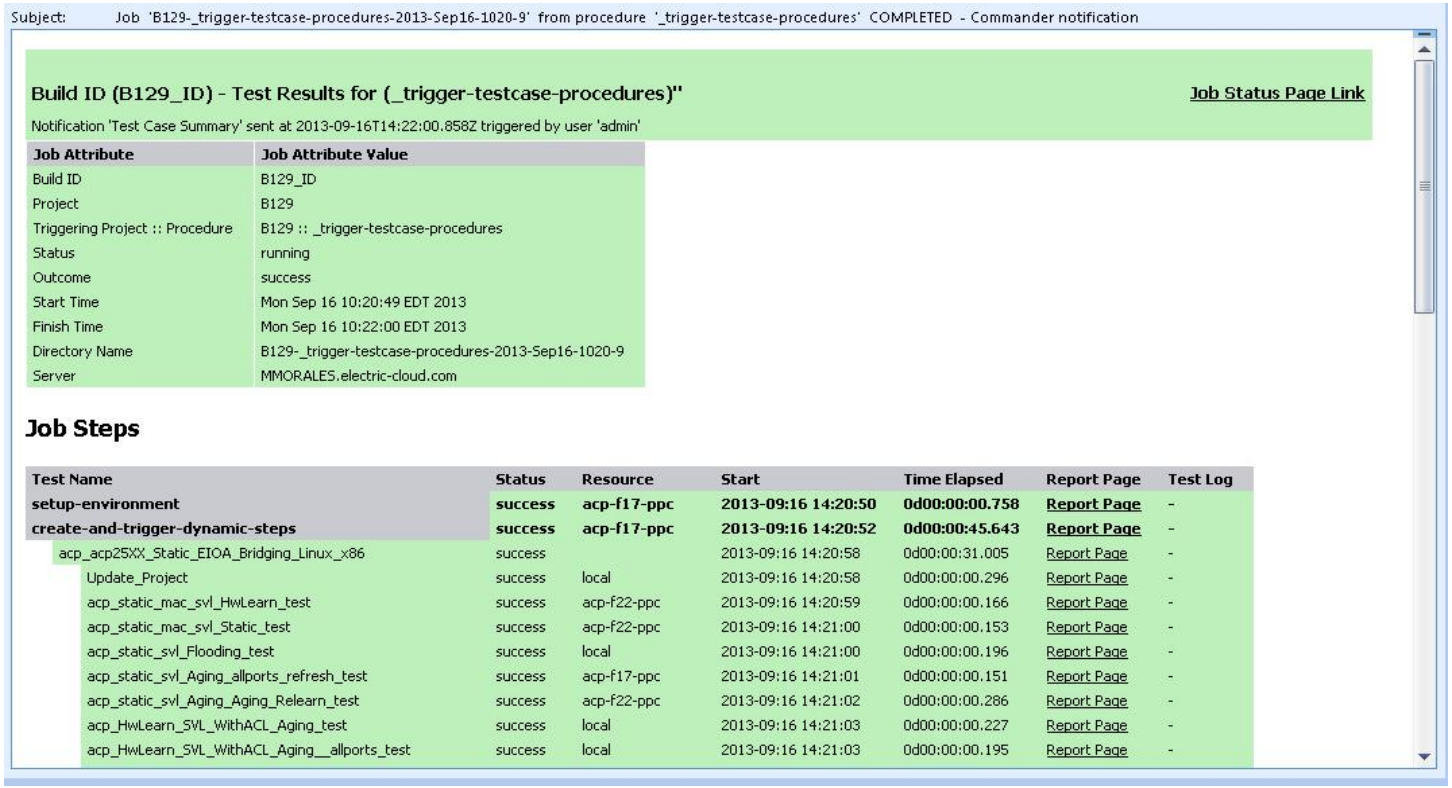
Accessing the catalog:



Accelerated Feedback Loops

- Color-coded email notification sent to tester for reviewing / troubleshooting.
- Notifications for certain critical tests (Regression) are sent to an expanded list of recipients, including Management.
- Notifications have all the information needed for troubleshooting (links to logs, test results, etc.)

Email Notification



Subject: Job 'B129-_trigger-testcase-procedures-2013-Sep16-1020-9' from procedure '_trigger-testcase-procedures' COMPLETED - Commander notification

Build ID (B129_ID) - Test Results for (_trigger-testcase-procedures)" Job Status Page Link

Notification 'Test Case Summary' sent at 2013-09-16T14:22:00.858Z triggered by user 'admin'

Job Attribute	Job Attribute Value
Build ID	B129_ID
Project	B129
Triggering Project :: Procedure	B129 :: _trigger-testcase-procedures
Status	running
Outcome	success
Start Time	Mon Sep 16 10:20:49 EDT 2013
Finish Time	Mon Sep 16 10:22:00 EDT 2013
Directory Name	B129-_trigger-testcase-procedures-2013-Sep16-1020-9
Server	MMORALES.electric-cloud.com

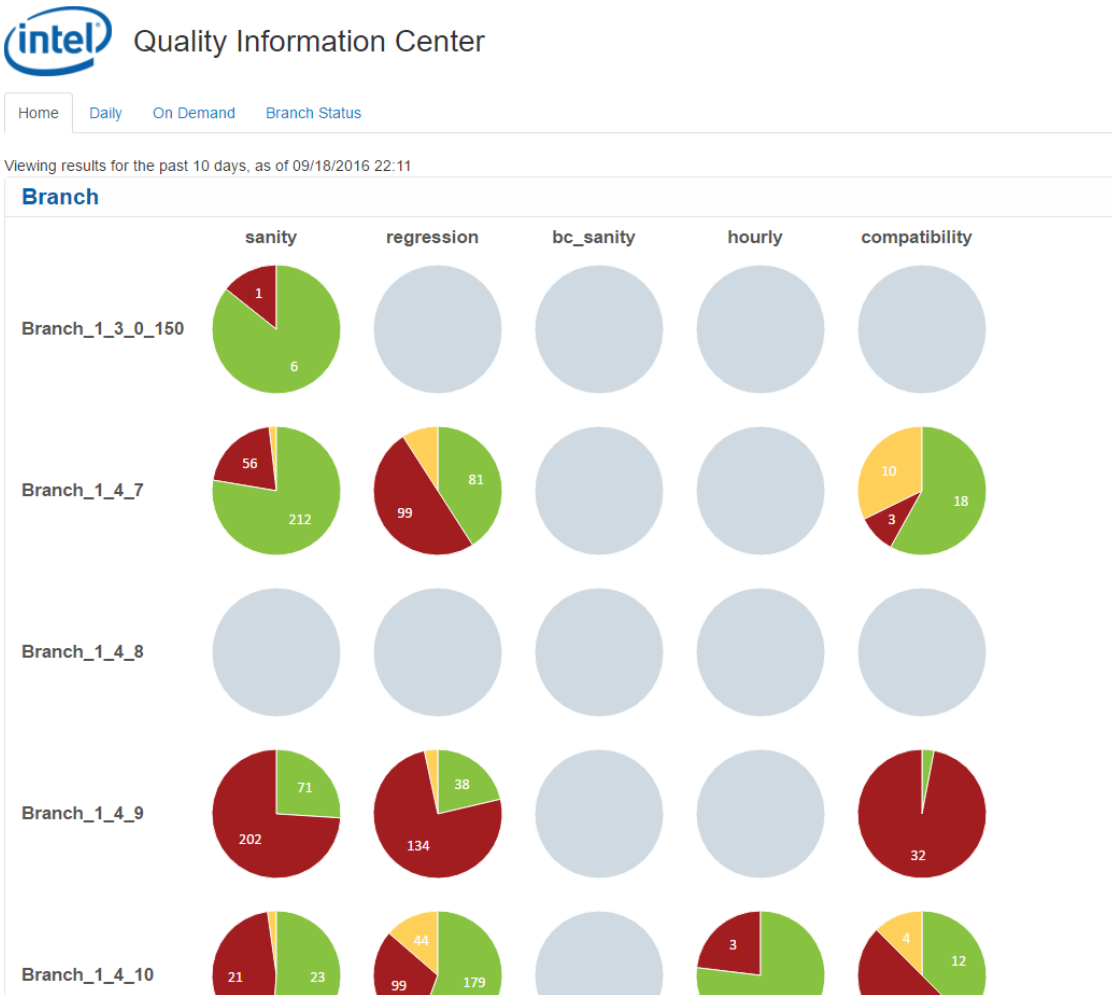
Job Steps

Test Name	Status	Resource	Start	Time Elapsed	Report Page	Test Log
setup-environment	**success**	**acp-f17-ppc**	**2013-09-16 14:20:50**	**0d00:00:00.758**	**Report Page**	-
create-and-trigger-dynamic-steps	**success**	**acp-f17-ppc**	**2013-09-16 14:20:52**	**0d00:00:45.643**	**Report Page**	-
acp_acp25XX_Static_EIOA_Bridging_Linux_x86	success		2013-09-16 14:20:58	0d00:00:31.005	Report Page	-
Update_Project	success	local	2013-09-16 14:20:58	0d00:00:00.296	Report Page	-
acp_static_mac_svl_HwLearn_test	success	acp-f22-ppc	2013-09-16 14:20:59	0d00:00:00.166	Report Page	-
acp_static_mac_svl_Static_test	success	acp-f22-ppc	2013-09-16 14:21:00	0d00:00:00.153	Report Page	-
acp_static_svl_Flooding_test	success	local	2013-09-16 14:21:00	0d00:00:00.196	Report Page	-
acp_static_svl_Aging_allports_refresh_test	success	acp-f17-ppc	2013-09-16 14:21:01	0d00:00:00.151	Report Page	-
acp_static_svl_Aging_Aging_Relearn_test	success	acp-f22-ppc	2013-09-16 14:21:02	0d00:00:00.286	Report Page	-
acp_HwLearn_SVL_WithACL_Aging_test	success	local	2013-09-16 14:21:03	0d00:00:00.227	Report Page	-
acp_HwLearn_SVL_WithACL_Aging__allports_test	success	local	2013-09-16 14:21:03	0d00:00:00.195	Report Page	-

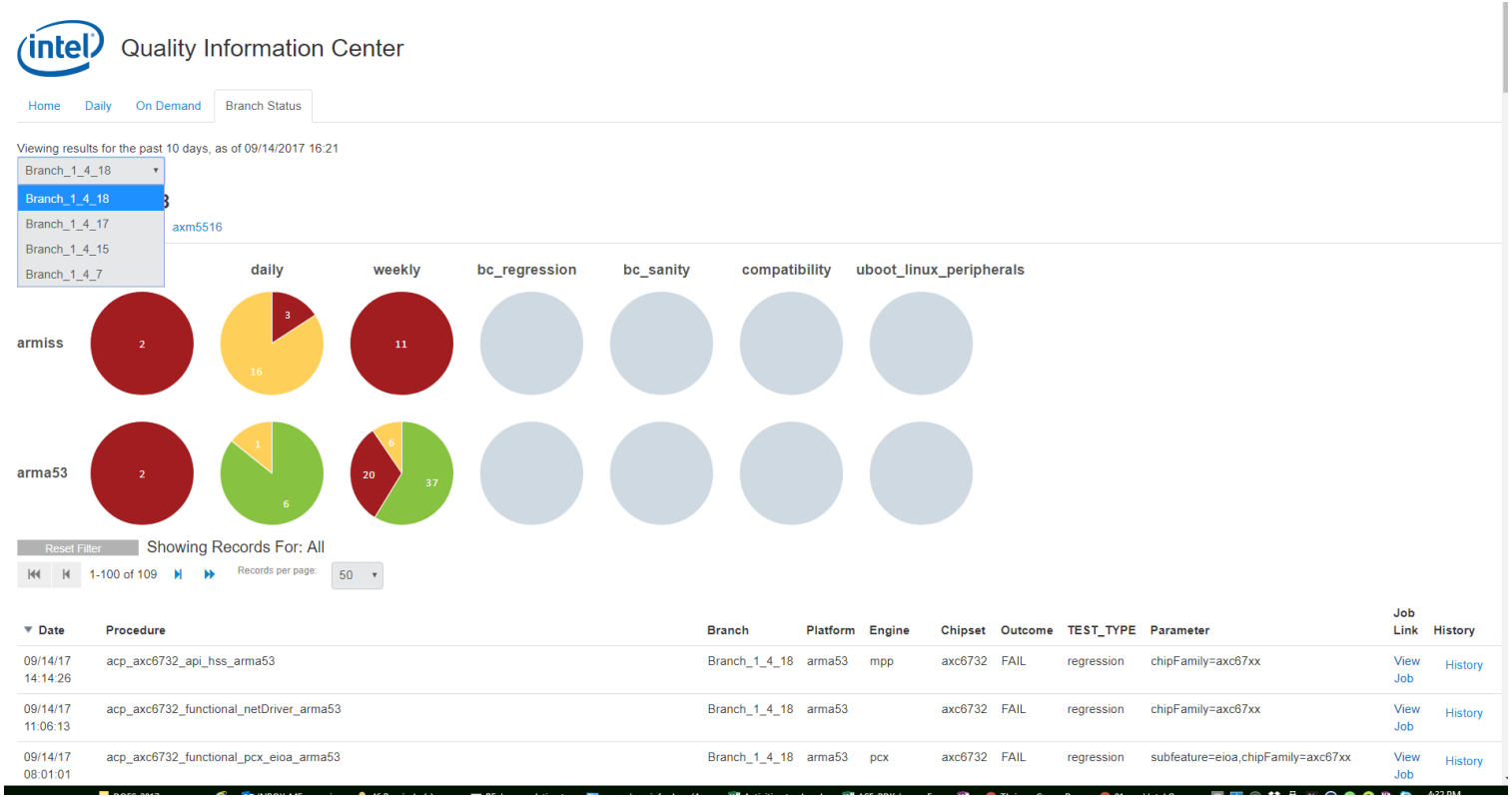
Shared Visibility

- **Bird's eye view is critical + the ability to drill down**
- **Shared language around metrics and status, along with ability to troubleshoot**
- Reports and Dashboards provide at-a-glance visibility to all stake holders re: the health and quality of the release and critical milestones.
- Easy to consume charts for high-level visibility (no need for drill-down data for non-engineers/management)
- Reports are used heavily internally as a gauge for the business, and determine release-readiness
- Data drives the business- we all converge on these metrics

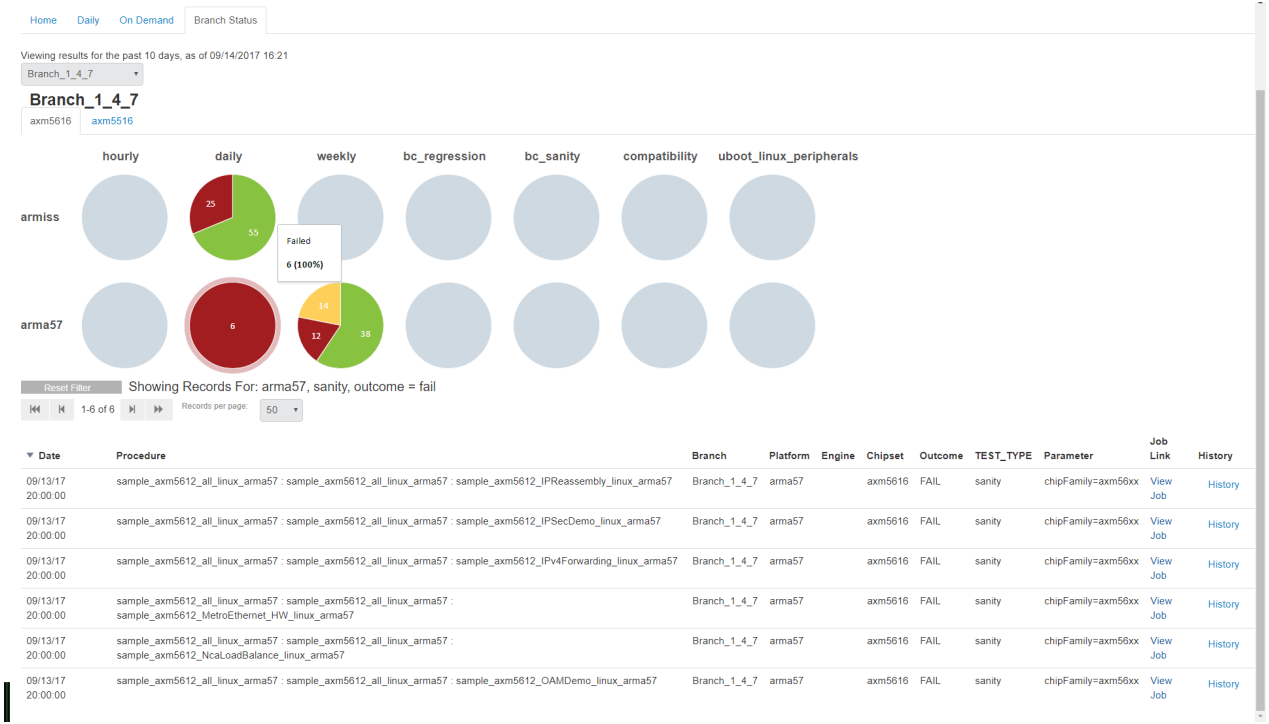
Major Release



Specific release/platform health

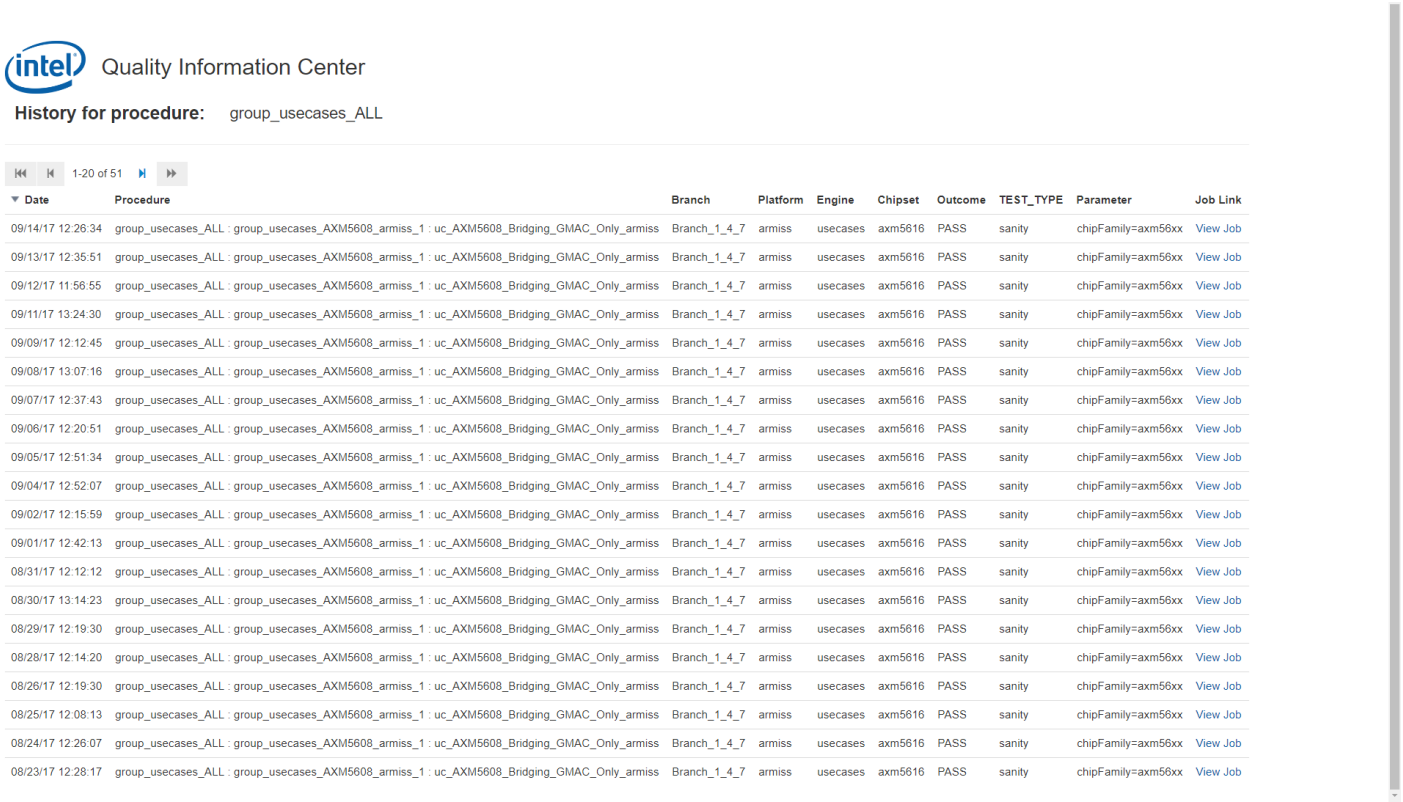


What tests are failing?



Date	Procedure	Branch	Platform	Engine	Chipset	Outcome	TEST_TYPE	Parameter	Job Link	History
09/13/17 20:00:00	sample_axm5612_all_linux_arma57 : sample_axm5612_all_linux_arma57 : sample_axm5612_IPReassembly_linux_arma57	Branch_1_4_7	arma57		axm5616	FAIL	sanity	chipFamily=axm56xx	View Job	History
09/13/17 20:00:00	sample_axm5612_all_linux_arma57 : sample_axm5612_all_linux_arma57 : sample_axm5612_IPSecDemo_linux_arma57	Branch_1_4_7	arma57		axm5616	FAIL	sanity	chipFamily=axm56xx	View Job	History
09/13/17 20:00:00	sample_axm5612_all_linux_arma57 : sample_axm5612_all_linux_arma57 : sample_axm5612_IPv4Forwarding_linux_arma57	Branch_1_4_7	arma57		axm5616	FAIL	sanity	chipFamily=axm56xx	View Job	History
09/13/17 20:00:00	sample_axm5612_all_linux_arma57 : sample_axm5612_all_linux_arma57 : sample_axm5612_MetroEthernet_HW_linux_arma57	Branch_1_4_7	arma57		axm5616	FAIL	sanity	chipFamily=axm56xx	View Job	History
09/13/17 20:00:00	sample_axm5612_all_linux_arma57 : sample_axm5612_all_linux_arma57 : sample_axm5612_NcaLoadBalance_linux_arma57	Branch_1_4_7	arma57		axm5616	FAIL	sanity	chipFamily=axm56xx	View Job	History
09/13/17 20:00:00	sample_axm5612_all_linux_arma57 : sample_axm5612_all_linux_arma57 : sample_axm5612_OAMDemo_linux_arma57	Branch_1_4_7	arma57		axm5616	FAIL	sanity	chipFamily=axm56xx	View Job	History

When did this last pass?



Quality Information Center

History for procedure: group_usecases_ALL

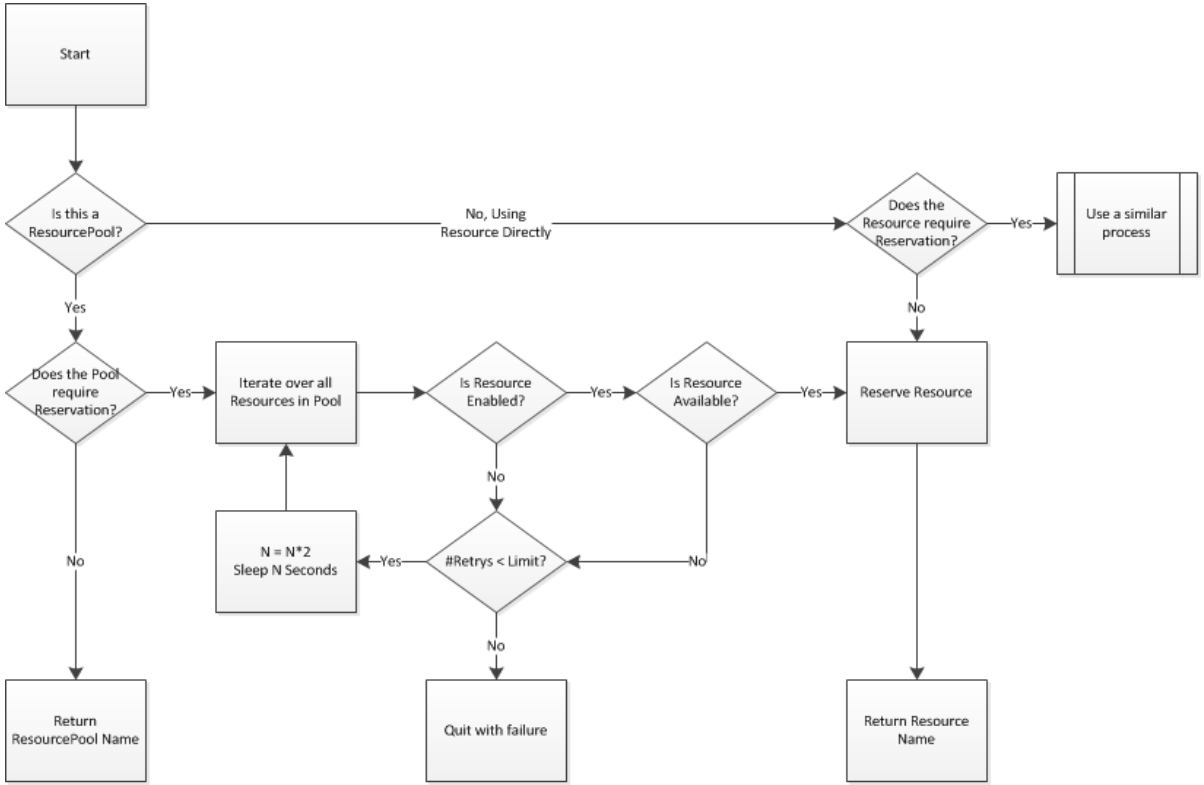
1-20 of 51

Date	Procedure	Branch	Platform	Engine	Chipset	Outcome	TEST_TYPE	Parameter	Job Link
09/14/17 12:26:34	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/13/17 12:35:51	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/12/17 11:56:55	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/11/17 13:24:30	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/09/17 12:12:45	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/08/17 13:07:16	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/07/17 12:37:43	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/06/17 12:20:51	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/05/17 12:51:34	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/04/17 12:52:07	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/02/17 12:15:59	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
09/01/17 12:42:13	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/31/17 12:12:12	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/30/17 13:14:23	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/29/17 12:19:30	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/28/17 12:14:20	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/26/17 12:19:30	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/25/17 12:08:13	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/24/17 12:26:07	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job
08/23/17 12:28:17	group_usecases_ALL : group_usecases_AXM5608_armiss_1 : uc_AXM5608_Bridging_GMAC_Only_armiss	Branch_1_4_7	armiss	usecases	axm5616	PASS	sanity	chipFamily=axm56xx	View Job

On-demand is key

- For both executing test
- And provisioning infrastructure for tests to run!!
- Fully automated spin up/down – no more waiting for IT to provision
- No more drift configuration- consistent throughout all environments
- Shared resources improve utilization

Hardware Reservation Process



Bonus: More tests, better quality, less work!

- The framework was easily extended (thanks to parameters) to allows re-use of the same tests for:
  - Code coverage
  - Memory Leak
  - Binary Compatibility Verification

Keep in mind:

- Divide and conquer
- Continuous improvement – can’t boil the ocean, iterative process of optimization
- Keep focus on the end goal – don’t let the intermediate setbacks de-motivate the team.
- Every code can have bugs. Yes, even automation!

Where we ended up:

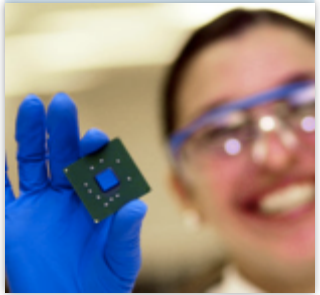
100
Releases/Year

10 min
QA Lead Time per CI Cycle

87%+
Known Code coverage

4M
Lines of Code

15K
Test cases run/day



96
Permutations of S/W and H/W per product

Before … After

Benefits

- Helped manage the enormous amount of work, without increasing head-count.
- Allowing frequent SW deliveries to our customers,
- Continuous monitoring of the health of the product
- More time at hand for test development
- Clear handle on the Quality of the SW that is being shipped out of the doors
- Shared language and metrics: Quality is everyone's responsibility- and now we all know where we stand!

THANK YOU

Q&A