squash the flakes!

Software Architecture Summit 2024

Daniel Hiller

agenda

- about me
- about flakes
- impact of flakes
- flake process
- tools
- the future
- Q&A

about me

- Software Engineer @ Red Hat OpenShift Virtualization team
- KubeVirt CI, automation in general

about flakes

a ***flake?***

...

...

...

about flakes

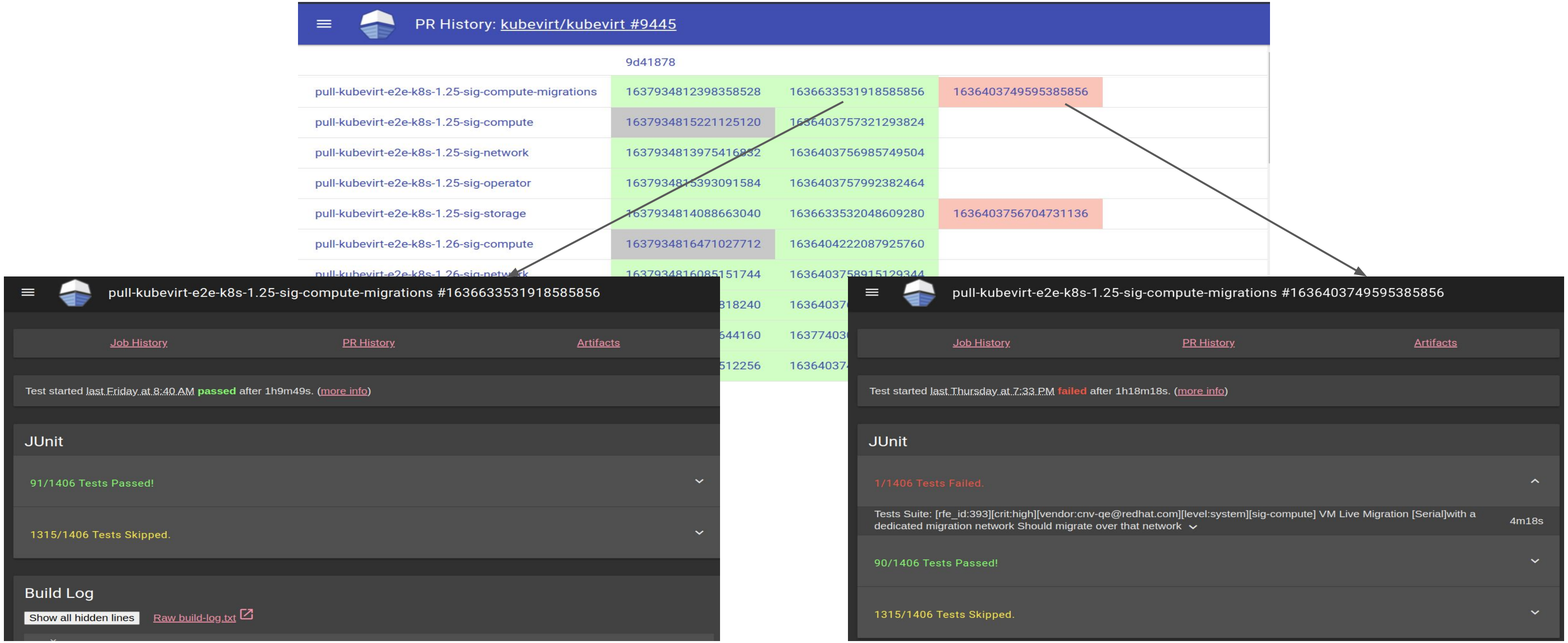
a ***flake***

is a **test** that

without any code change

will either **fail** or **pass** in successive runs

about flakes



PR History: kubevirt/kubevirt #9445

	9d41878		
pull-kubevirt-e2e-k8s-1.25-sig-compute-migrations	1637934812398358528	1636633531918585856	1636403749595385856
pull-kubevirt-e2e-k8s-1.25-sig-compute	1637934815221125120	1636403757321293824	
pull-kubevirt-e2e-k8s-1.25-sig-network	1637934813975416832	1636403756985749504	
pull-kubevirt-e2e-k8s-1.25-sig-operator	1637934815393091584	1636403757992382464	
pull-kubevirt-e2e-k8s-1.25-sig-storage	1637934814088663040	1636633532048609280	1636403756704731136
pull-kubevirt-e2e-k8s-1.26-sig-compute	1637934816471027712	1636404222087925760	
pull-kubevirt-e2e-k8s-1.26-sig-network	1637934816085151744	1636403758915129344	
	818240	163640376	
	644160	16377403	
	512256	16364037	

pull-kubevirt-e2e-k8s-1.25-sig-compute-migrations #1636633531918585856

Test started last Friday at 8:40 AM **passed** after 1h9m49s. (more info)

JUnit

91/1406 Tests Passed!

1315/1406 Tests Skipped.

Build Log

pull-kubevirt-e2e-k8s-1.25-sig-compute-migrations #1636403749595385856

Test started last Thursday at 7:33 PM **failed** after 1h18m18s. (more info)

JUnit

1/1406 Tests Failed.

Tests Suite: [rfe_id:393][crit:high][vendor:cnv-qe@redhat.com][level:system][sig-compute] VM Live Migration [Serial]with a dedicated migration network Should migrate over that network 4m18s

90/1406 Tests Passed!

1315/1406 Tests Skipped.

source: https://prow.ci.kubevirt.io/pr-history/?org=kubevirt&repo=kubevirt&pr=9445

about flakes

is it important?

about flakes

does it occur regularly?

about flakes

how often do you have to deal with it?

about flakes

“... test flakiness was a **frequently encountered problem**, with

- **20%** of respondents claiming to experience it **monthly**,
- **24%** encountering it on a **weekly** basis and
- **15%** dealing with it **daily**”

source: “A survey of flaky tests”

about flakes

“… In terms of severity, of the **91% of developers** who claimed to deal with flaky tests at least a few times a year,

- **56%** described them as a **moderate** problem and
- **23%** thought that they were a **serious** problem. …”

source: “A survey of flaky tests”

about flakes

flakes are caused

either by **production code** (a bug)

or **flaky test code** (also a bug, but handled differently)

impact of flakes

from “A survey of flaky tests”:

- **97%** of flakes were **false alarms***, and
- **more than 50%** of flakes could not be **reproduced** in isolation

conclusion: “ignoring flaky tests is ok”

*code under test actually is not broken, but it works as expected

impact of flakes

impact of flakes

in CI automated testing **MUST** give a **reliable signal of stability**

any failed test run signals that the product is **unstable**

test runs failed due to flakes do not give this reliable signal

they only waste time

impact of flakes

Flaky tests waste everyone’s time - they cause

- **longer feedback cycles** for developers
- **slowdown of merging** pull requests - “retest trap”
- **reversal of acceleration** effects (i.e. batch testing)

impact of flakes

Flaky tests also **cause trust issues** - they make people

- **lose** trust in automated testing
- **ignore** test results

minimizing the impact

def: **quarantine** [1]

to exclude a flaky test from test runs **as early as possible**, but **only as long as necessary**

[1] Martin Fowler - Eradicating Non-Determinism in Tests

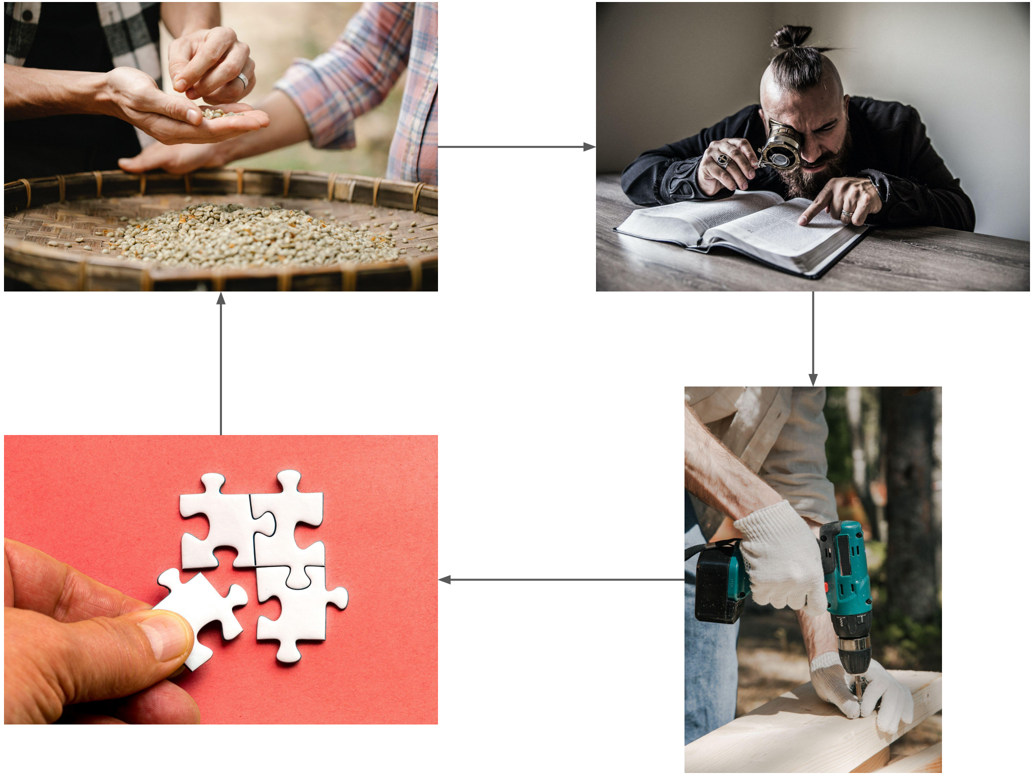
the flake process

regular meeting

- look at flakes
- decide: fix or quarantine?
- hand to dev
- bring back in

emergency quarantine

source: QUARANTINE.md

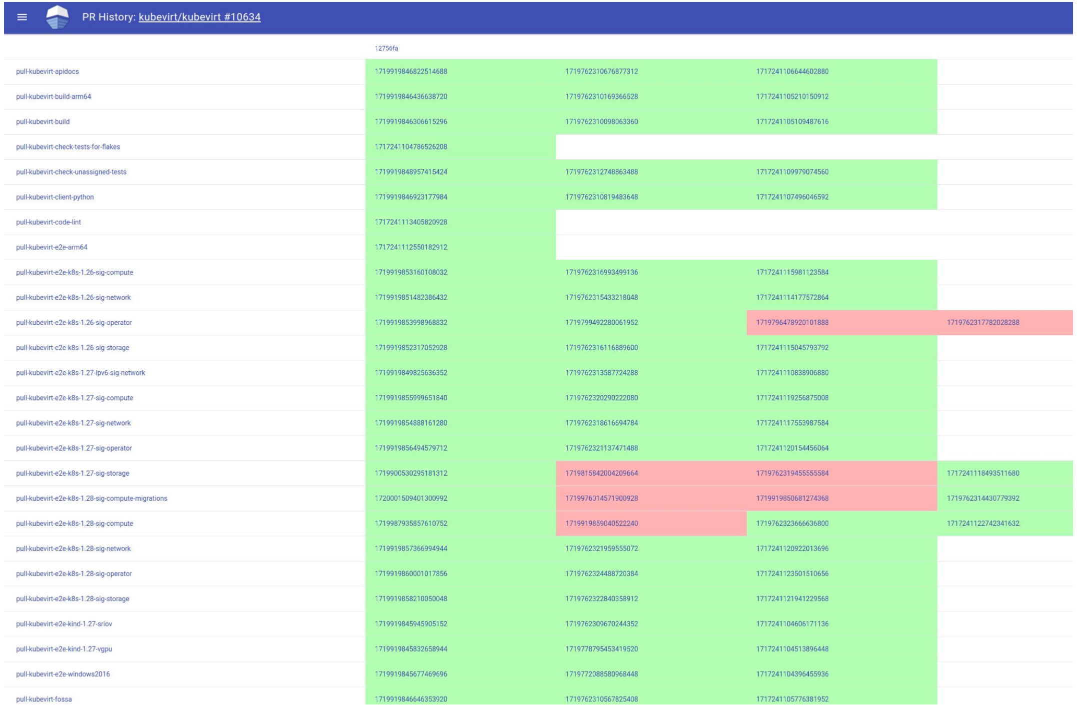


minimizing the impact

how to find flaky tests?

any merged PR had all tests succeeding in the end,

thus any test run with test failures from that PR *might* contain execution of flaky tests



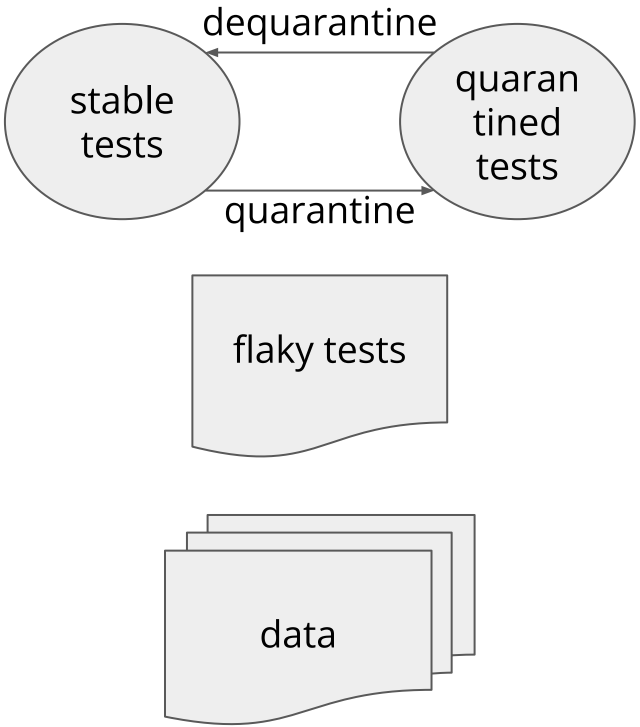
PR History: kubevirt/kubevirt #10634

	12756fa			
pull-kubevirt-apidocs	1719919846822514688	1719762310676877312	1717241106644602880	
pull-kubevirt-build-arm64	1719919846436638720	1719762310169366528	1717241105210150912	
pull-kubevirt-build	1719919846306615296	1719762310098063360	1717241105109487616	
pull-kubevirt-check-tests-for-flakes	1717241104786526208			
pull-kubevirt-check-unassigned-tests	1719919848957415424	1719762312748863488	1717241109979074560	
pull-kubevirt-client-python	1719919846923177984	1719762310819483648	1717241107496046592	
pull-kubevirt-code-lint	1717241113405820928			
pull-kubevirt-e2e-arm64	1717241112550182912			
pull-kubevirt-e2e-k8s-1.26-sig-compute	1719919853160108032	1719762316993499136	1717241115981123584	
pull-kubevirt-e2e-k8s-1.26-sig-network	1719919851482386432	1719762315433218048	1717241114177572864	
pull-kubevirt-e2e-k8s-1.26-sig-operator	1719919853998968832	1719799492280061952	1719796478920101888	1719762317782028288
pull-kubevirt-e2e-k8s-1.26-sig-storage	1719919852317052928	1719762316116889600	1717241115045793792	
pull-kubevirt-e2e-k8s-1.27-ipv6-sig-network	1719919849825636352	1719762313587724288	1717241110838906880	
pull-kubevirt-e2e-k8s-1.27-sig-compute	1719919855999651840	1719762320290222080	1717241119256875008	
pull-kubevirt-e2e-k8s-1.27-sig-network	1719919854888161280	1719762318616694784	1717241117553987584	
pull-kubevirt-e2e-k8s-1.27-sig-operator	1719919856494579712	1719762321137471488	1717241120154456064	
pull-kubevirt-e2e-k8s-1.27-sig-storage	1719900530295181312	1719815842004209664	1719762319455555584	1717241118493511680
pull-kubevirt-e2e-k8s-1.28-sig-compute-migrations	1720001509401300992	1719976014571900928	1719919850681274368	1719762314430779392
pull-kubevirt-e2e-k8s-1.28-sig-compute	1719987935857610752	1719919859040522240	1719762323666636800	1717241122742341632
pull-kubevirt-e2e-k8s-1.28-sig-network	1719919857366994944	1719762321959555072	1717241120922013696	
pull-kubevirt-e2e-k8s-1.28-sig-operator	1719919860001017856	1719762324488720384	1717241123501510656	
pull-kubevirt-e2e-k8s-1.28-sig-storage	1719919858210050048	1719762322840358912	1717241121941229568	
pull-kubevirt-e2e-kind-1.27-sriov	1719919845945905152	1719762309670244352	1717241104606171136	
pull-kubevirt-e2e-kind-1.27-vgpu	1719919845832658944	1719778795453419520	1717241104513896448	
pull-kubevirt-e2e-windows2016	1719919845677469696	1719772088580968448	1717241104396455936	
pull-kubevirt-fossa	1719919846646353920	1719762310567825408	1717241105776381952	

minimizing the impact

what do we need?

- easily move a test between the **set of stable** tests and the **set of quarantined** tests
- a **report** over possible flaky tests
- enough **runtime data** to triage flakes
  - devs decide whether we quarantine right away or they can fix them in time

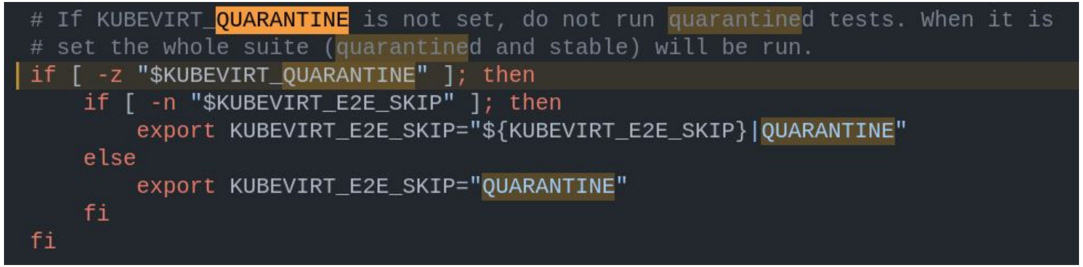


tools - isolation

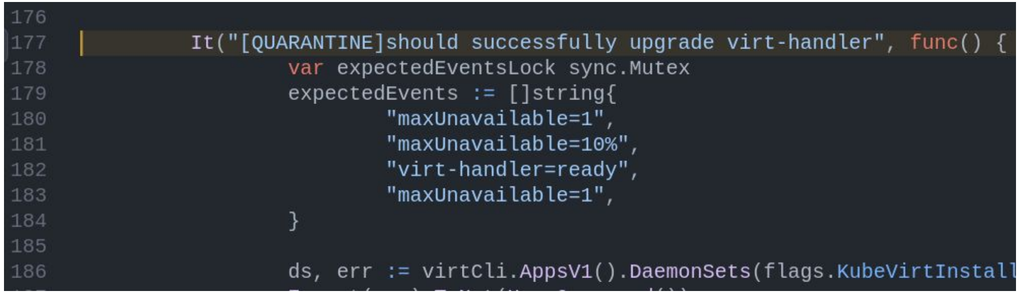
tools

quarantine mechanics:
ci honoring **QUARANTINE label**

- pre-merge tests **skip** quarantined tests
- periodics **execute** quarantined tests to check their stability



```
# If KUBEVIRT_QUARANTINE is not set, do not run quarantined tests. When it is
# set the whole suite (quarantined and stable) will be run.
if [ -z "$KUBEVIRT_QUARANTINE" ]; then
    if [ -n "$KUBEVIRT_E2E_SKIP" ]; then
        export KUBEVIRT_E2E_SKIP="${KUBEVIRT_E2E_SKIP}|QUARANTINE"
    else
        export KUBEVIRT_E2E_SKIP="QUARANTINE"
    fi
fi
```



```
        It("[QUARANTINE]should successfully upgrade virt-handler", func() {
                var expectedEventsLock sync.Mutex
                expectedEvents := []string{
                        "maxUnavailable=1",
                        "maxUnavailable=10%",
                        "virt-handler=ready",
                        "maxUnavailable=1",
                }

                ds, err := virtCli.AppsV1().DaemonSets(flags.KubeVirtInstall
```

sources:

- https://github.com/kubevirt/kubevirt/blob/38c01c34acecfafc89078b1bbaba8d9cf3cf0d4d/automation/test.sh#L452
- https://github.com/kubevirt/kubevirt/blob/38c01c34acecfafc89078b1bbaba8d9cf3cf0d4d/hack/functests.sh#L69
- https://github.com/kubevirt/kubevirt/blob/38c01c34acecfafc89078b1bbaba8d9cf3cf0d4d/tests/canary_upgrade_test.go#L177

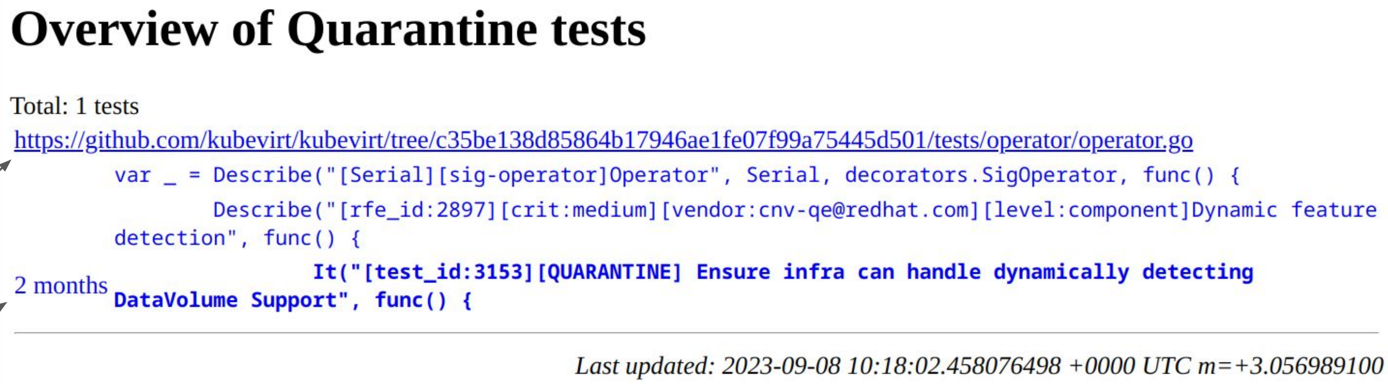
tools

quarantine overview

(source)

where?

since when?



Overview of Quarantine tests

Total: 1 tests

https://github.com/kubevirt/kubevirt/tree/c35be138d85864b17946ae1fe07f99a75445d501/tests/operator/operator.go

2 months

```
var _ = Describe("[Serial][sig-operator]Operator", Serial, decorators.SigOperator, func() {
        Describe("[rfe_id:2897][crit:medium][vendor:cnv-qe@redhat.com][level:component]Dynamic feature detection", func() {
                It("[test_id:3153][QUARANTINE] Ensure infra can handle dynamically detecting DataVolume Support", func() {
```

Last updated: 2023-09-08 10:18:02.458076498 +0000 UTC m=+3.056989100

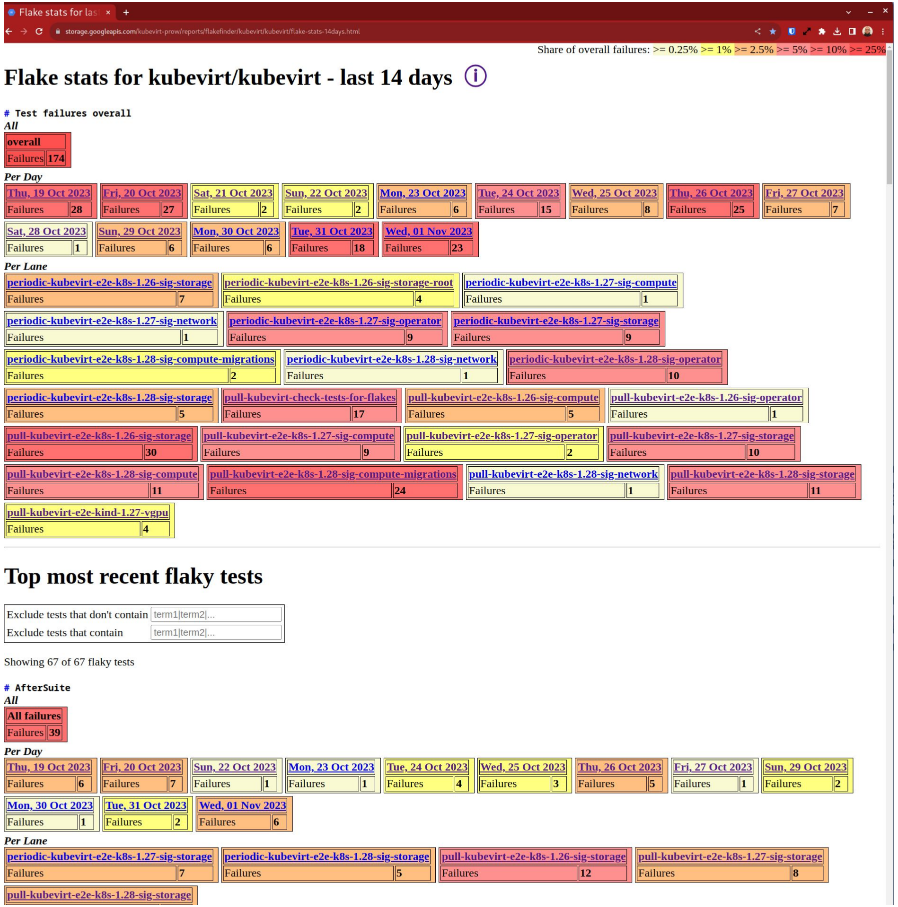
tools - health metrics

tools

flake stats report

the high level overview

(source)



Flake stats for las
storage.googleapis.com/kubevirt-prow/reports/flakefinder/kubevirt/kubevirt/flake-stats-14days.html

Share of overall failures: >= 0.25% >= 1% >= 2.5% >= 5% >= 10% >= 25%

Flake stats for kubevirt/kubevirt - last 14 days ⓘ

```
# Test failures overall
```

All

overall		
Failures	**174**	

Per Day

Thu, 19 Oct 2023	Failures	**28**
Fri, 20 Oct 2023	Failures	**27**
Sat, 21 Oct 2023	Failures	**2**
Sun, 22 Oct 2023	Failures	**2**
Mon, 23 Oct 2023	Failures	**6**
Tue, 24 Oct 2023	Failures	**15**
Wed, 25 Oct 2023	Failures	**8**
Thu, 26 Oct 2023	Failures	**25**
Fri, 27 Oct 2023	Failures	**7**
Sat, 28 Oct 2023	Failures	**1**
Sun, 29 Oct 2023	Failures	**6**
Mon, 30 Oct 2023	Failures	**6**
Tue, 31 Oct 2023	Failures	**18**
Wed, 01 Nov 2023	Failures	**23**

Per Lane

periodic-kubevirt-e2e-k8s-1.26-sig-storage	Failures	**7**
periodic-kubevirt-e2e-k8s-1.26-sig-storage-root	Failures	**4**
periodic-kubevirt-e2e-k8s-1.27-sig-compute	Failures	**1**
periodic-kubevirt-e2e-k8s-1.27-sig-network	Failures	**1**
periodic-kubevirt-e2e-k8s-1.27-sig-operator	Failures	**9**
periodic-kubevirt-e2e-k8s-1.27-sig-storage	Failures	**9**
periodic-kubevirt-e2e-k8s-1.28-sig-compute-migrations	Failures	**2**
periodic-kubevirt-e2e-k8s-1.28-sig-network	Failures	**1**
periodic-kubevirt-e2e-k8s-1.28-sig-operator	Failures	**10**
periodic-kubevirt-e2e-k8s-1.28-sig-storage	Failures	**5**
pull-kubevirt-check-tests-for-flakes	Failures	**17**
pull-kubevirt-e2e-k8s-1.26-sig-compute	Failures	**5**
pull-kubevirt-e2e-k8s-1.26-sig-operator	Failures	**1**
pull-kubevirt-e2e-k8s-1.26-sig-storage	Failures	**30**
pull-kubevirt-e2e-k8s-1.27-sig-compute	Failures	**9**
pull-kubevirt-e2e-k8s-1.27-sig-operator	Failures	**2**
pull-kubevirt-e2e-k8s-1.27-sig-storage	Failures	**10**
pull-kubevirt-e2e-k8s-1.28-sig-compute	Failures	**11**
pull-kubevirt-e2e-k8s-1.28-sig-compute-migrations	Failures	**24**
pull-kubevirt-e2e-k8s-1.28-sig-network	Failures	**1**
pull-kubevirt-e2e-k8s-1.28-sig-storage	Failures	**11**
pull-kubevirt-e2e-kind-1.27-vgpu	Failures	**4**

Top most recent flaky tests

Exclude tests that don't contain term1|term2|...
Exclude tests that contain term1|term2|...

Showing 67 of 67 flaky tests

```
# AfterSuite
```

All

All failures		
Failures	**39**	

Per Day

Thu, 19 Oct 2023	Failures	**6**
Fri, 20 Oct 2023	Failures	**7**
Sun, 22 Oct 2023	Failures	**1**
Mon, 23 Oct 2023	Failures	**1**
Tue, 24 Oct 2023	Failures	**4**
Wed, 25 Oct 2023	Failures	**3**
Thu, 26 Oct 2023	Failures	**5**
Fri, 27 Oct 2023	Failures	**1**
Sun, 29 Oct 2023	Failures	**2**
Mon, 30 Oct 2023	Failures	**1**
Tue, 31 Oct 2023	Failures	**2**
Wed, 01 Nov 2023	Failures	**6**

Per Lane

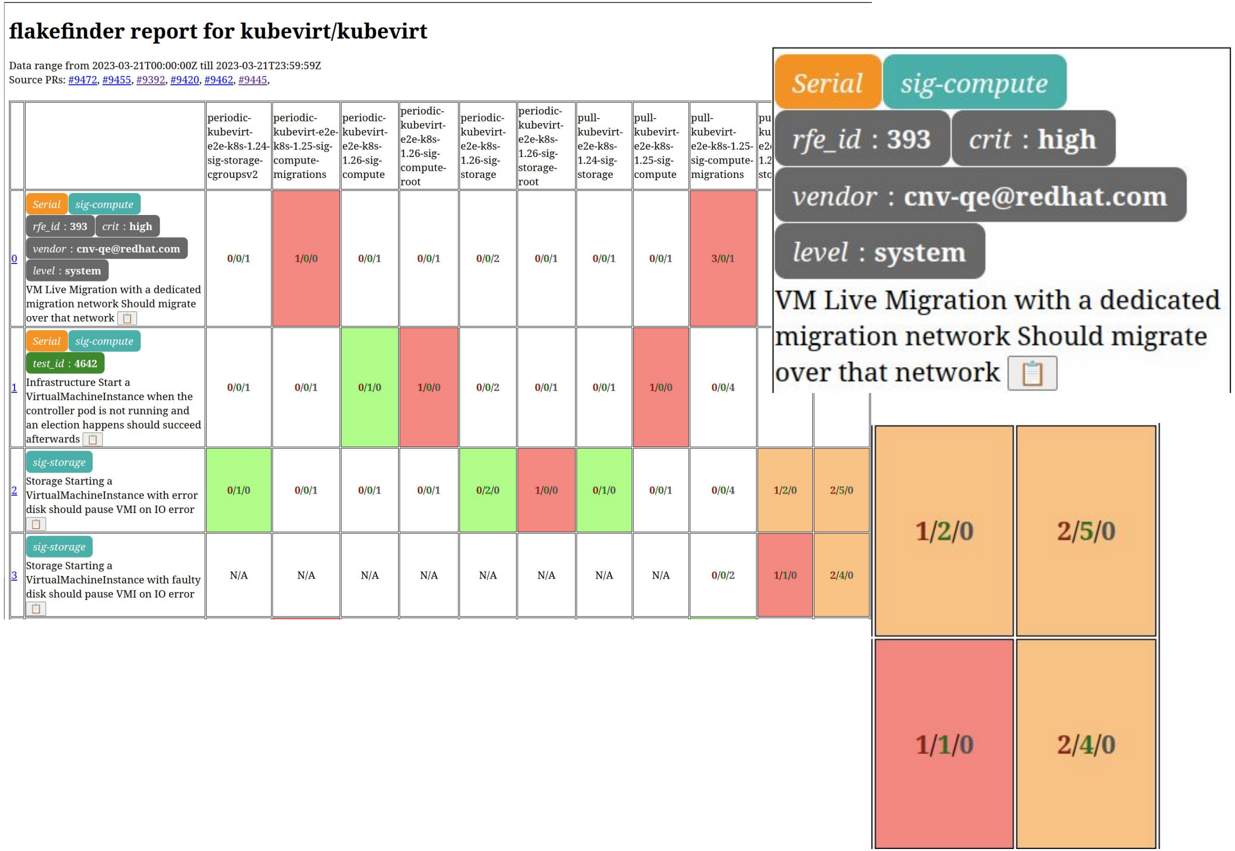
periodic-kubevirt-e2e-k8s-1.27-sig-storage	Failures	**7**
periodic-kubevirt-e2e-k8s-1.28-sig-storage	Failures	**5**
pull-kubevirt-e2e-k8s-1.26-sig-storage	Failures	**12**
pull-kubevirt-e2e-k8s-1.27-sig-storage	Failures	**8**
pull-kubevirt-e2e-k8s-1.28-sig-storage		

tools

flakefinder report

the detail overview

gives an overview of the current flaky tests



flakefinder report for kubevirt/kubevirt

Data range from 2023-03-21T00:00:00Z till 2023-03-21T23:59:59Z
Source PRs: #9472, #9455, #9392, #9420, #9462, #9445,

		periodic-kubevirt-e2e-k8s-1.24-sig-storage-cgroupsv2	periodic-kubevirt-e2e-k8s-1.25-sig-compute-migrations	periodic-kubevirt-e2e-k8s-1.26-sig-compute	periodic-kubevirt-e2e-k8s-1.26-sig-compute-root	periodic-kubevirt-e2e-k8s-1.26-sig-storage	periodic-kubevirt-e2e-k8s-1.26-sig-storage-root	pull-kubevirt-e2e-k8s-1.24-sig-storage	pull-kubevirt-e2e-k8s-1.25-sig-compute	pull-kubevirt-e2e-k8s-1.25-sig-compute-migrations	pu ku e2 1.2 sto	
0	*Serial* *sig-compute* *rfe_id* : **393** *crit* : **high** *vendor* : **cnv-qe@redhat.com** *level* : **system** VM Live Migration with a dedicated migration network Should migrate over that network 📋	0/0/1	1/0/0	0/0/1	0/0/1	0/0/2	0/0/1	0/0/1	0/0/1	3/0/1		
1	*Serial* *sig-compute* *test_id* : **4642** Infrastructure Start a VirtualMachineInstance when the controller pod is not running and an election happens should succeed afterwards 📋	0/0/1	0/0/1	0/1/0	1/0/0	0/0/2	0/0/1	0/0/1	1/0/0	0/0/4		
2	*sig-storage* Storage Starting a VirtualMachineInstance with error disk should pause VMI on IO error 📋	0/1/0	0/0/1	0/0/1	0/0/1	0/2/0	1/0/0	0/1/0	0/0/1	0/0/4	1/2/0	2/5/0
3	*sig-storage* Storage Starting a VirtualMachineInstance with faulty disk should pause VMI on IO error 📋	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0/0/2	1/1/0	2/4/0

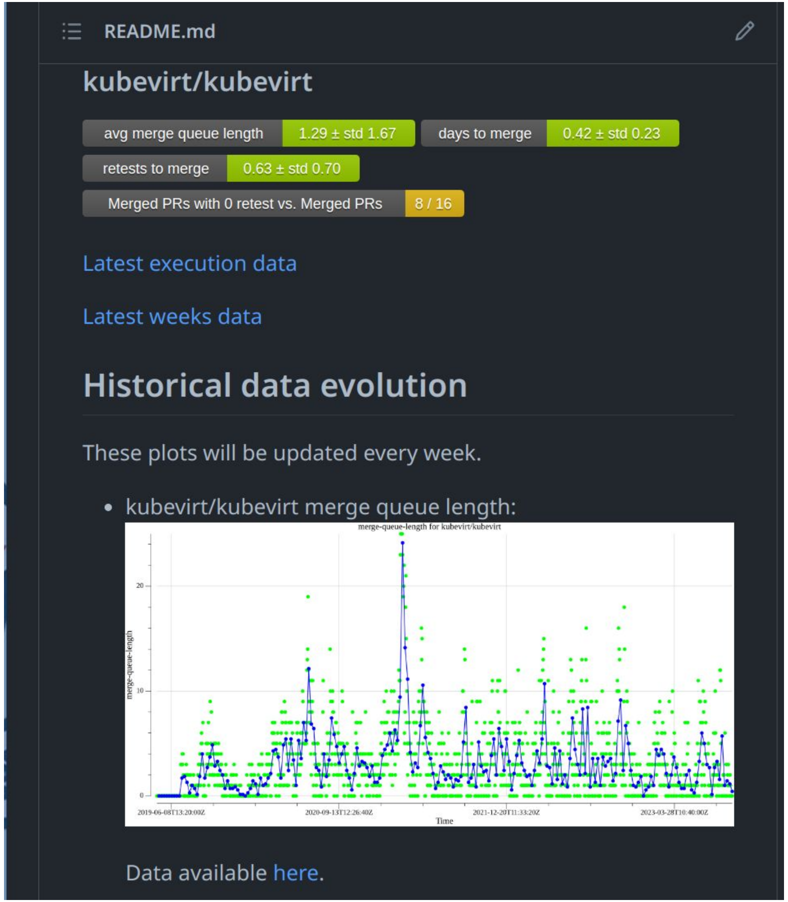
Serial *sig-compute*
rfe_id : **393** *crit* : **high**
vendor : **cnv-qe@redhat.com**
level : **system**
VM Live Migration with a dedicated migration network Should migrate over that network 📋

1/2/0	2/5/0
1/1/0	2/4/0

tools

ci-health

metrics
merge-queue-length,
time-to-merge,
retests-to-merge and
merges-per-day



README.md

kubevirt/kubevirt

avg merge queue length 1.29 ± std 1.67 | days to merge 0.42 ± std 0.23

retests to merge 0.63 ± std 0.70

Merged PRs with 0 retest vs. Merged PRs 8 / 16

Latest execution data

Latest weeks data

Historical data evolution

These plots will be updated every week.

- kubevirt/kubevirt merge queue length:

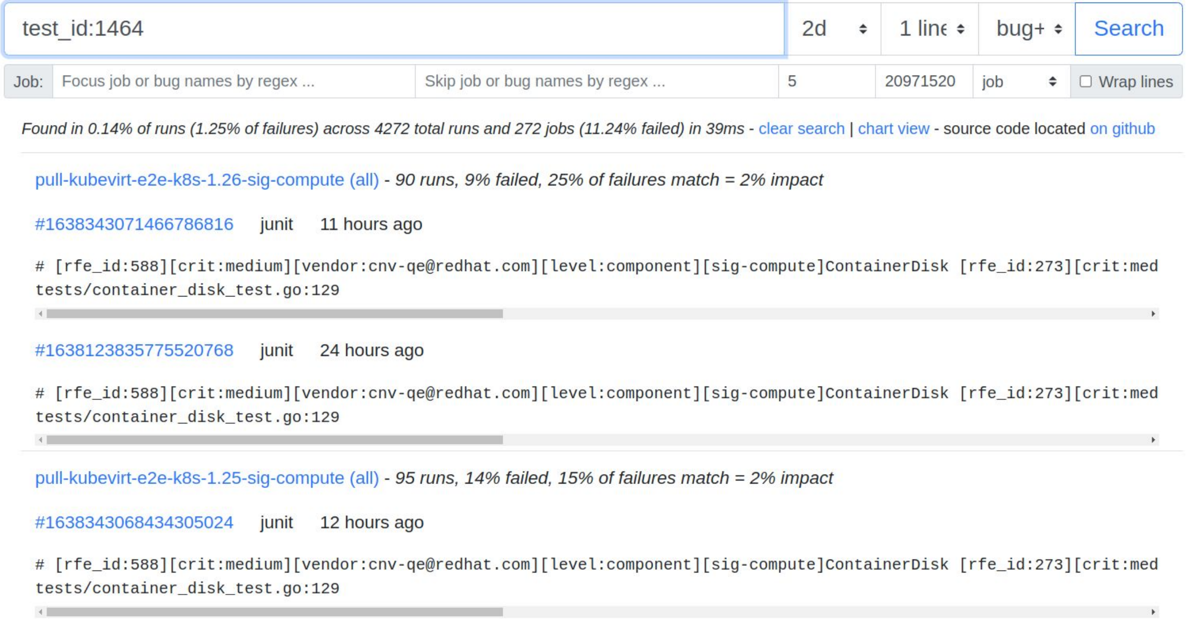
Data available here.

tools - analysis

tools

ci-search

search for terms in prow job logs (see openshift ci-search)



test_id:1464 | 2d | 1 line | bug+ | Search

Job: Focus job or bug names by regex ... | Skip job or bug names by regex ... | 5 | 20971520 | job | □ Wrap lines

Found in 0.14% of runs (1.25% of failures) across 4272 total runs and 272 jobs (11.24% failed) in 39ms - clear search | chart view - source code located on github

pull-kubevirt-e2e-k8s-1.26-sig-compute (all) - *90 runs, 9% failed, 25% of failures match = 2% impact*

#1638343071466786816 junit 11 hours ago

```
# [rfe_id:588][crit:medium][vendor:cnv-qe@redhat.com][level:component][sig-compute]ContainerDisk [rfe_id:273][crit:med
tests/container_disk_test.go:129
```

#1638123835775520768 junit 24 hours ago

```
# [rfe_id:588][crit:medium][vendor:cnv-qe@redhat.com][level:component][sig-compute]ContainerDisk [rfe_id:273][crit:med
tests/container_disk_test.go:129
```

pull-kubevirt-e2e-k8s-1.25-sig-compute (all) - *95 runs, 14% failed, 15% of failures match = 2% impact*

#1638343068434305024 junit 12 hours ago

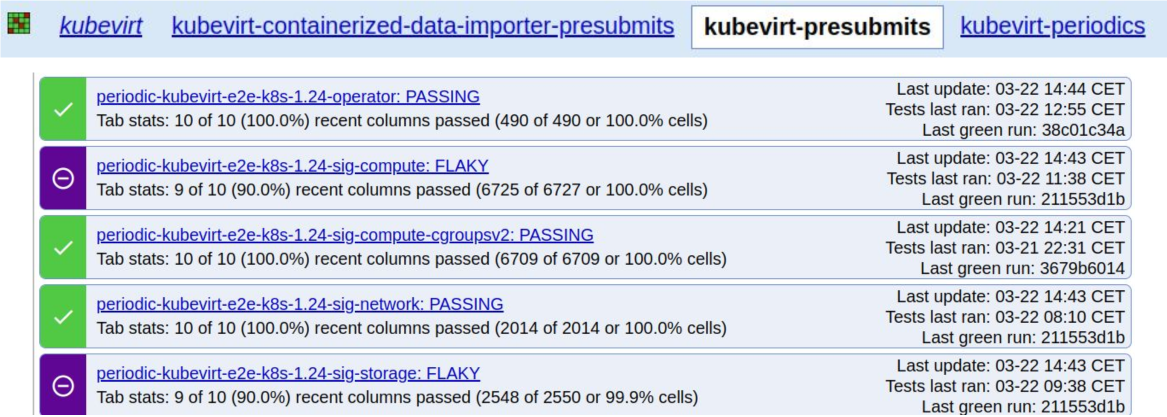
```
# [rfe_id:588][crit:medium][vendor:cnv-qe@redhat.com][level:component][sig-compute]ContainerDisk [rfe_id:273][crit:med
tests/container_disk_test.go:129
```

BUCHAREST TECH WEEK

tools

testgrid

drill down on all jobs for kubevirt/kubevirt that are running inside KubeVirt Prow



kubevirt | kubevirt-containerized-data-importer-presubmits | **kubevirt-presubmits** | kubevirt-periodics

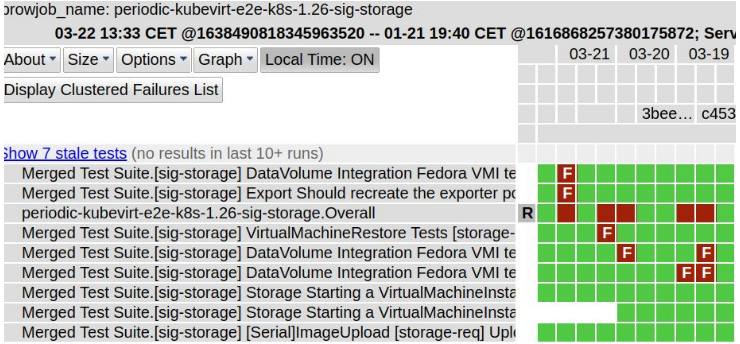
✓ periodic-kubevirt-e2e-k8s-1.24-operator: PASSING
Tab stats: 10 of 10 (100.0%) recent columns passed (490 of 490 or 100.0% cells)
Last update: 03-22 14:44 CET
Tests last ran: 03-22 12:55 CET
Last green run: 38c01c34a

⊖ periodic-kubevirt-e2e-k8s-1.24-sig-compute: FLAKY
Tab stats: 9 of 10 (90.0%) recent columns passed (6725 of 6727 or 100.0% cells)
Last update: 03-22 14:43 CET
Tests last ran: 03-22 11:38 CET
Last green run: 211553d1b

✓ periodic-kubevirt-e2e-k8s-1.24-sig-compute-cgroupsv2: PASSING
Tab stats: 10 of 10 (100.0%) recent columns passed (6709 of 6709 or 100.0% cells)
Last update: 03-22 14:21 CET
Tests last ran: 03-21 22:31 CET
Last green run: 3679b6014

✓ periodic-kubevirt-e2e-k8s-1.24-sig-network: PASSING
Tab stats: 10 of 10 (100.0%) recent columns passed (2014 of 2014 or 100.0% cells)
Last update: 03-22 14:43 CET
Tests last ran: 03-22 08:10 CET
Last green run: 211553d1b

⊖ periodic-kubevirt-e2e-k8s-1.24-sig-storage: FLAKY
Tab stats: 9 of 10 (90.0%) recent columns passed (2548 of 2550 or 99.9% cells)
Last update: 03-22 14:43 CET
Tests last ran: 03-22 09:38 CET
Last green run: 211553d1b



prowjob_name: periodic-kubevirt-e2e-k8s-1.26-sig-storage

03-22 13:33 CET @1638490818345963520 -- 01-21 19:40 CET @1616868257380175872; Serv

Show 7 stale tests (no results in last 10+ runs)

				03-21		03-20			03-19		
							3bee…			c453	
Merged Test Suite.[sig-storage] DataVolume Integration Fedora VMI te		🟩	F	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Merged Test Suite.[sig-storage] Export Should recreate the exporter pc		🟩	F	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
periodic-kubevirt-e2e-k8s-1.26-sig-storage.Overall	R	🟩	🟥	🟩	🟥	🟥	🟩	🟩	🟥	🟥	🟩
Merged Test Suite.[sig-storage] VirtualMachineRestore Tests [storage-		🟩	🟩	🟩	F	🟩	🟩	🟩	🟩	🟩	🟩
Merged Test Suite.[sig-storage] DataVolume Integration Fedora VMI te		🟩	🟩	🟩	🟩	F	🟩	🟩	🟩	F	🟩
Merged Test Suite.[sig-storage] DataVolume Integration Fedora VMI te		🟩	🟩	🟩	🟩	🟩	🟩	🟩	F	F	🟩
Merged Test Suite.[sig-storage] Storage Starting a VirtualMachineInsta		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Merged Test Suite.[sig-storage] Storage Starting a VirtualMachineInsta						🟩	🟩	🟩	🟩	🟩	🟩
Merged Test Suite.[sig-storage] [Serial]ImageUpload [storage-req] Upl		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

tools - detection before merge

tools

check-tests-for-flakes test lane

goal: catch flakes before entering main

(source)

a test lane that

- selects the changed e2e test files from the commit set
- runs changed e2e tests five times
- runs in random execution order to catch order-dependent test

tools

referee bot

goal: avoid excessive number of retests due to instabilities

(source)

- prow external plugin
- holds[1] PRs that have 5+ retests without any code change

reasoning: if a pull request is getting retested without any changes this points to an instability or flakiness that needs attention

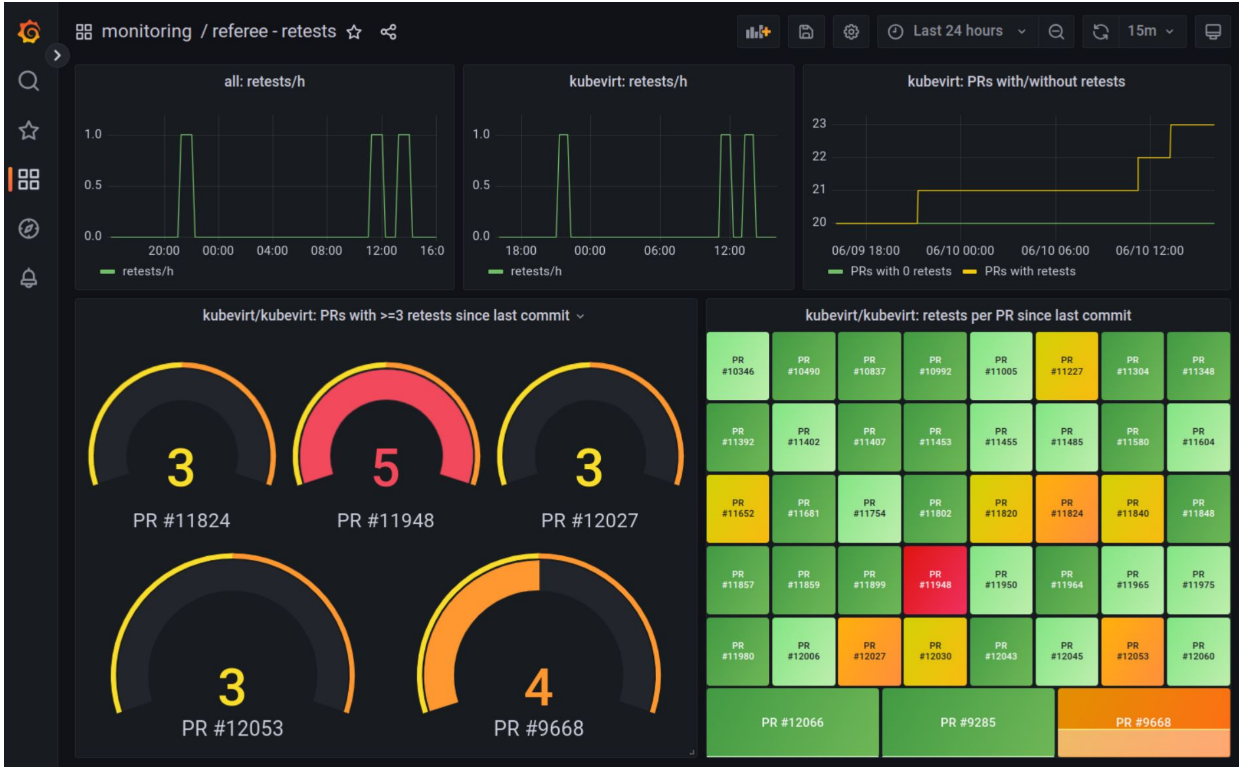
[1]: “holding” here means avoiding automated retesting

tools

retest metrics dashboard

motivation:

- show overall CI health via number of retests on PRs
- show PRs exceeding retest count where authors might need support



in a nutshell

In regular intervals:

- follow up on previous action items
- look at data and derive action items
- hand action items over to dev teams
- revisit and dequarantine quarantined tests

the future - more data, more tooling

gaps we want to close:

- collect more data - run the majority of tests frequently
- steadily improve in detecting new flakes
- long term - automatic quarantine PRs when new flakes have entered the codebase

Q&A

Any questions?

Any suggestions for improvement?

Who else is trying to tackle this problem?

What have you done to solve this?

Thank you for attending!

Further questions?

Feel free to send questions and comments to:

mailto:	dhiller@redhat.com
k8s slack:	kubernetes.slack.com/ @dhiller
mastodon:	@dhiller@fosstodon.org
web:	www.dhiller.de

kubevirt.io

KubeVirt welcomes all kinds of contributions!

- **Weekly community meeting every Wed 3PM CET**
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  - KubeVirt Contribution Guide
  - GitHub
  - Kubernetes Slack channels
    - #virtualization
    - #kubevirt-dev