Model-Based Testing

with Kristian Karl

Who am I?

- Programming software since 1990
- Started with testing 1994
- Started with automation 1994
- Discovered Model-Based Testing 2004
- Open source project GraphWalker 2005
- Test Manager at Spotify 2010

Agenda - topics to cover in unordered fashion

- Why Model-Based Testing?
- When to use it?
- When not to use it?
- What is it good for?

[Very] [and unscientific] brief history of MBT

- **15 May, 1997**

  Software Quality Week Conference in May, 1997
  http://www.geocities.ws/model_based_testing/sqw97.pdf

- **13:52, 30 December 2004**

  First edit in Wikipedia
  https://en.wikipedia.org/wiki/Model-based_testing

- **I met Harry Robinson May 2004**

  http://www.harryrobinson.net/

What is Model-Based Testing?

MBT is an application of ***model-based design*** for designing and optionally also executing artifacts to perform software testing or system testing. Models can be used to represent the ***desired behavior*** of a System Under Test, or to represent testing strategies and a test environment.

https://en.wikipedia.org/wiki/Model-based_testing

What is Model-Based Testing?

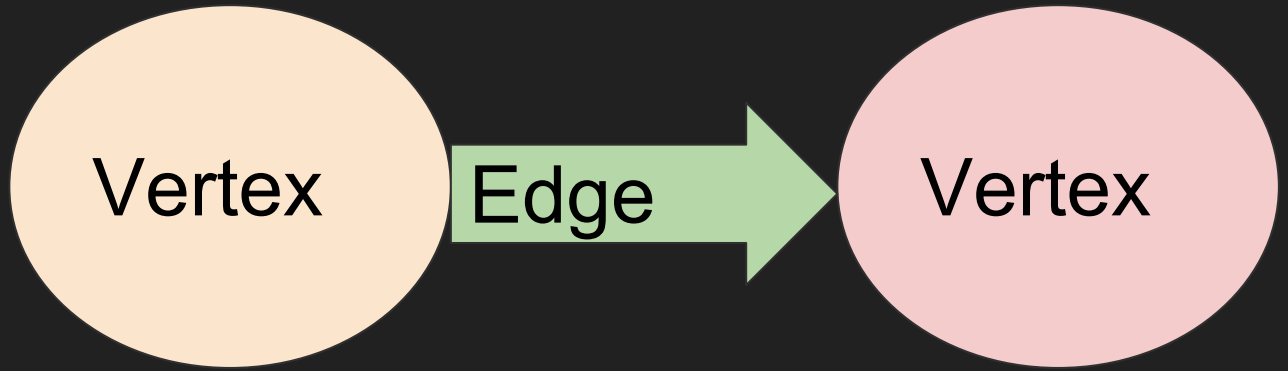
Models can be used to represent the ***[expected] desired behavior*** of a System Under Test [SUT].

A model is much simpler than the SUT.

State models are a set of states and events and the relationship between them.

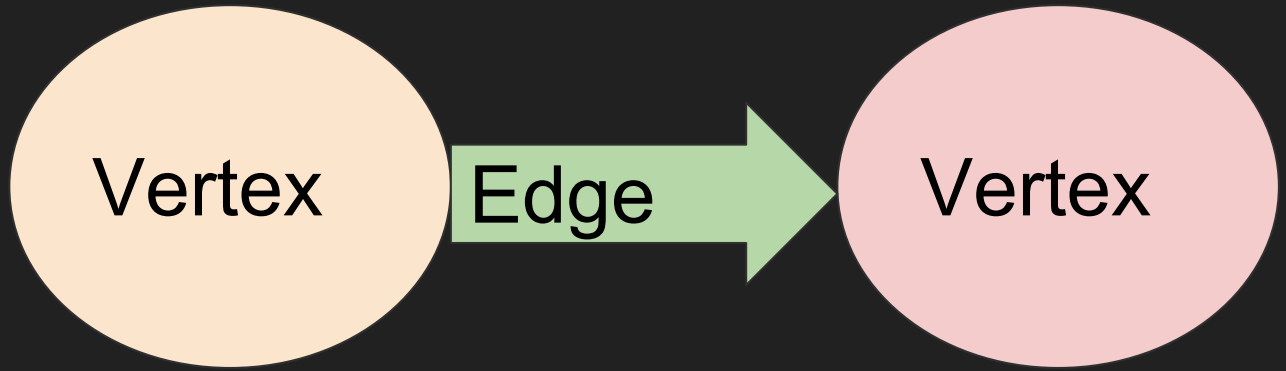
Vertex, node, state

- Represents an expected state that we can verify.
- In the automation code, here is where you'll find the assertions, the oracles, the verification of the state(s).



Edge, transition

- Represents the transition from one state to another state.
- It’s whatever action is needed, to make it to some other state. *It could be selecting some menu choice, clicking a button, or making a REST API call, or even a timeout.*

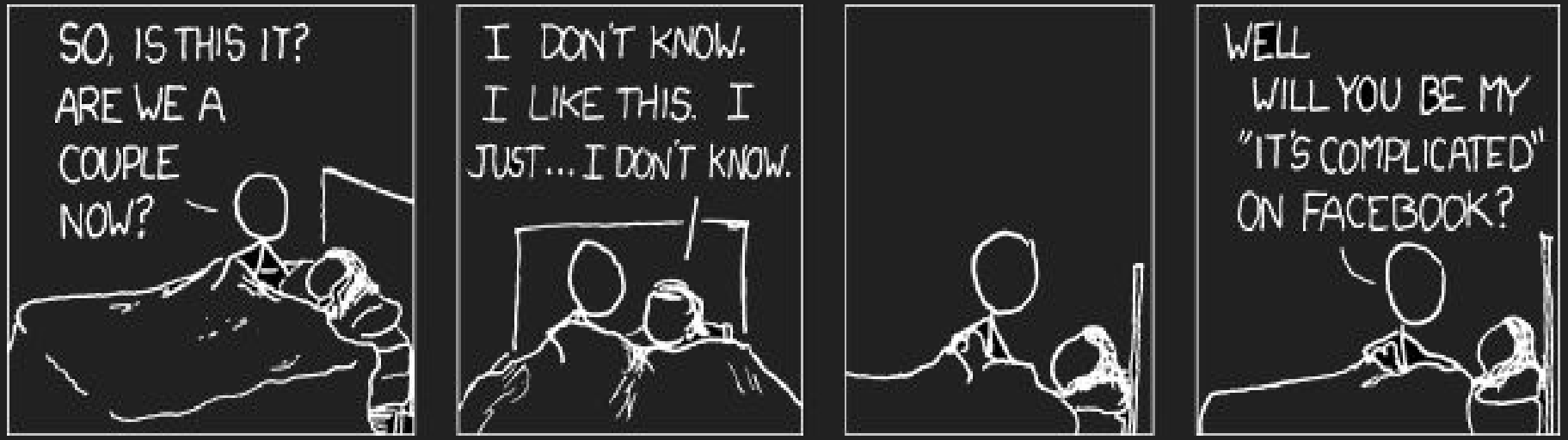


Combined step of an edge and vertex

A pair of an **action**, and a **result** is a combined step

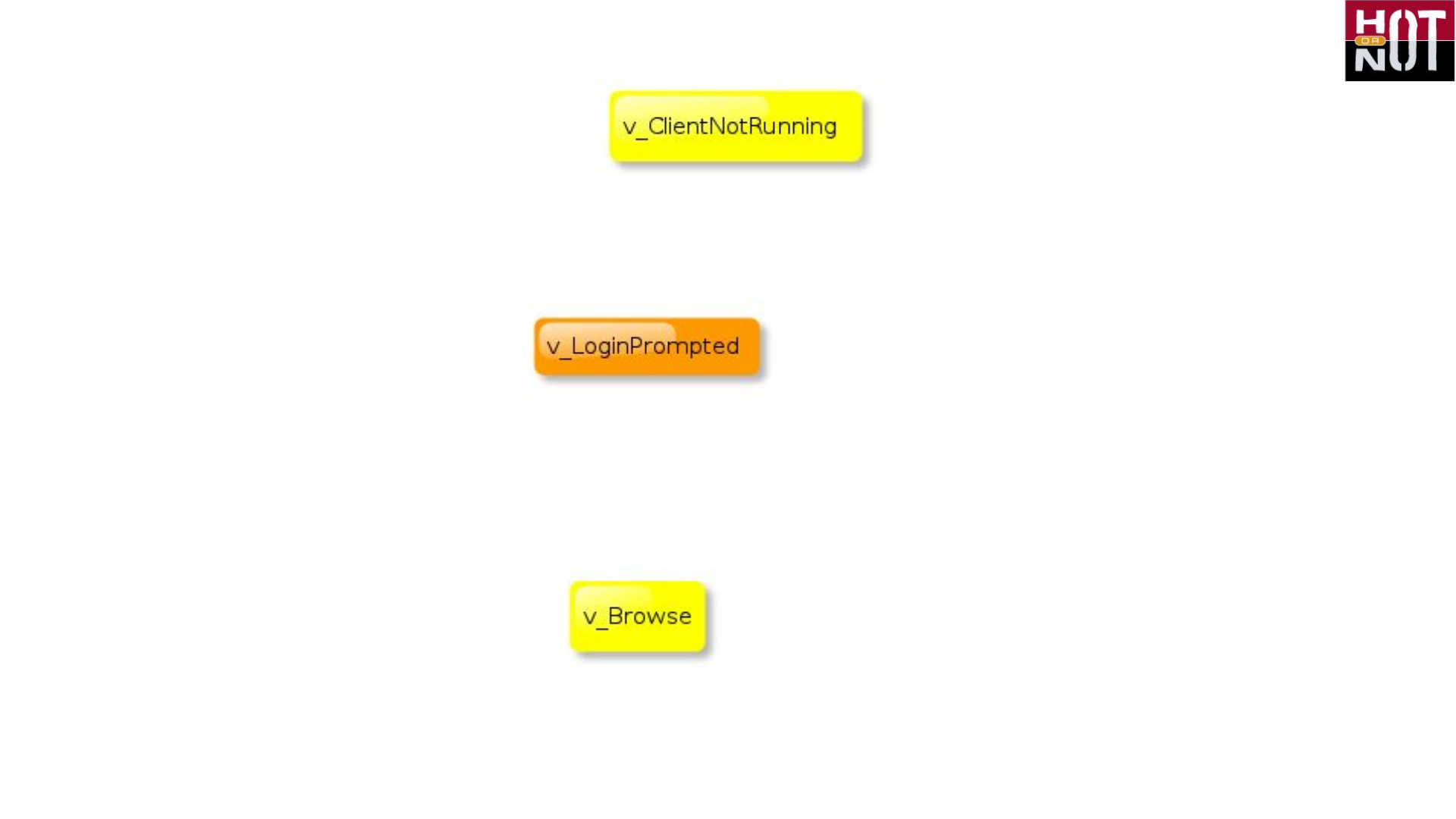
Multiple steps are a path, or a test sequence

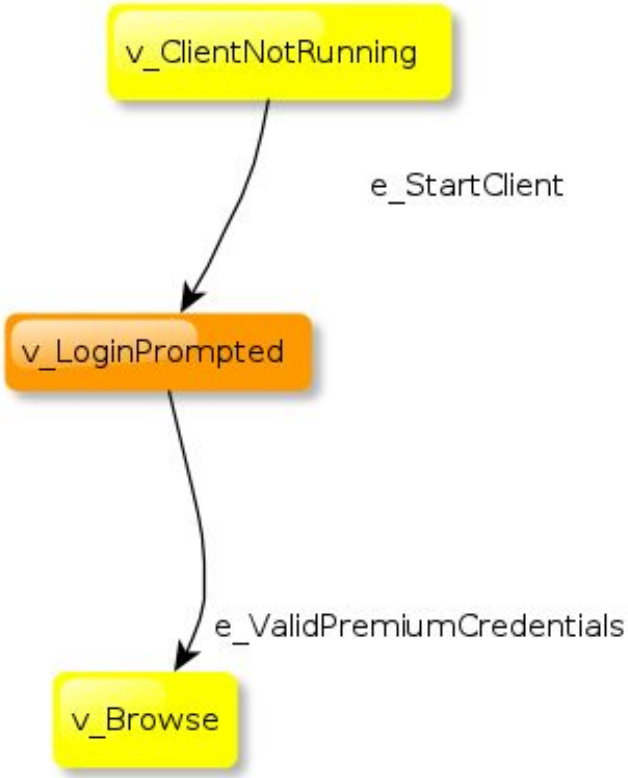
The Relationship Game

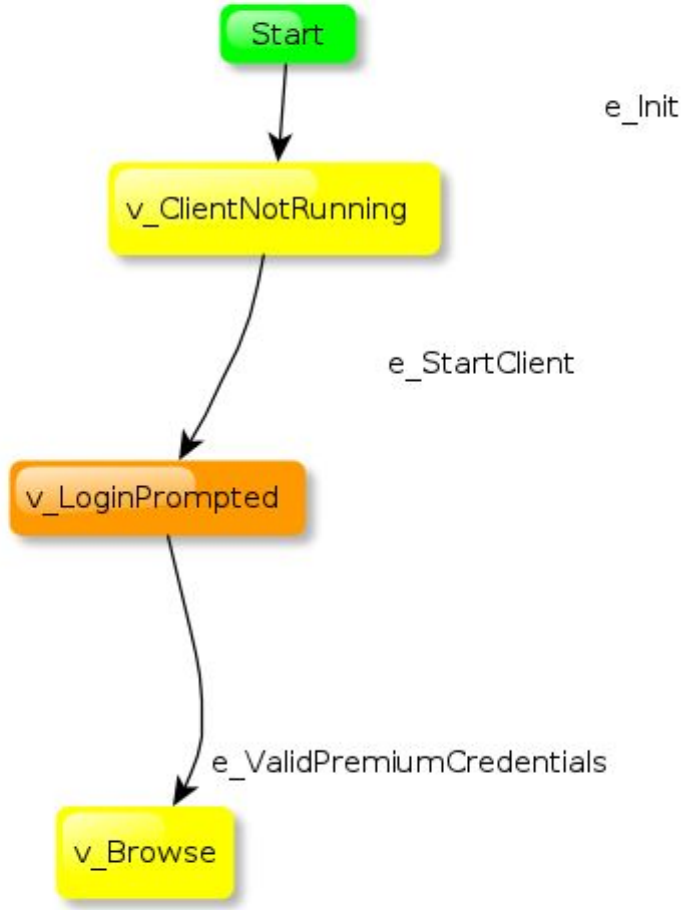


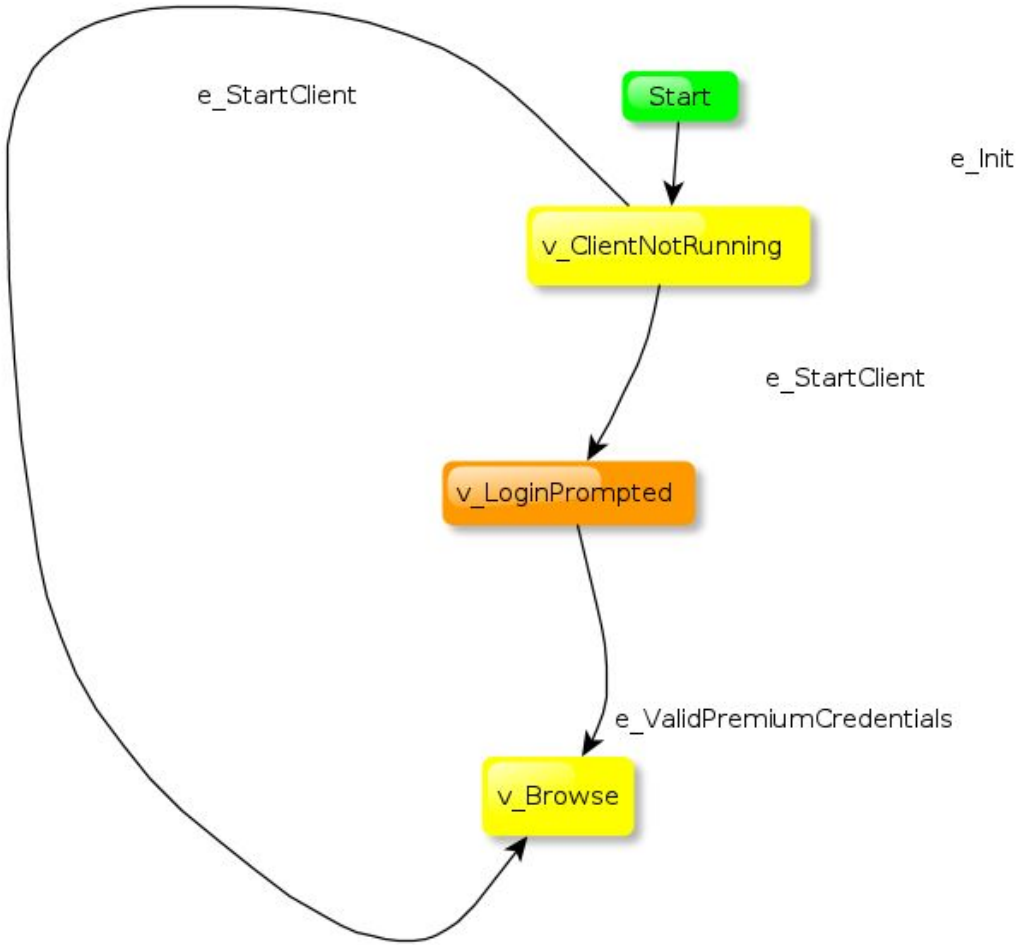
Login feature on Spotify desktop app

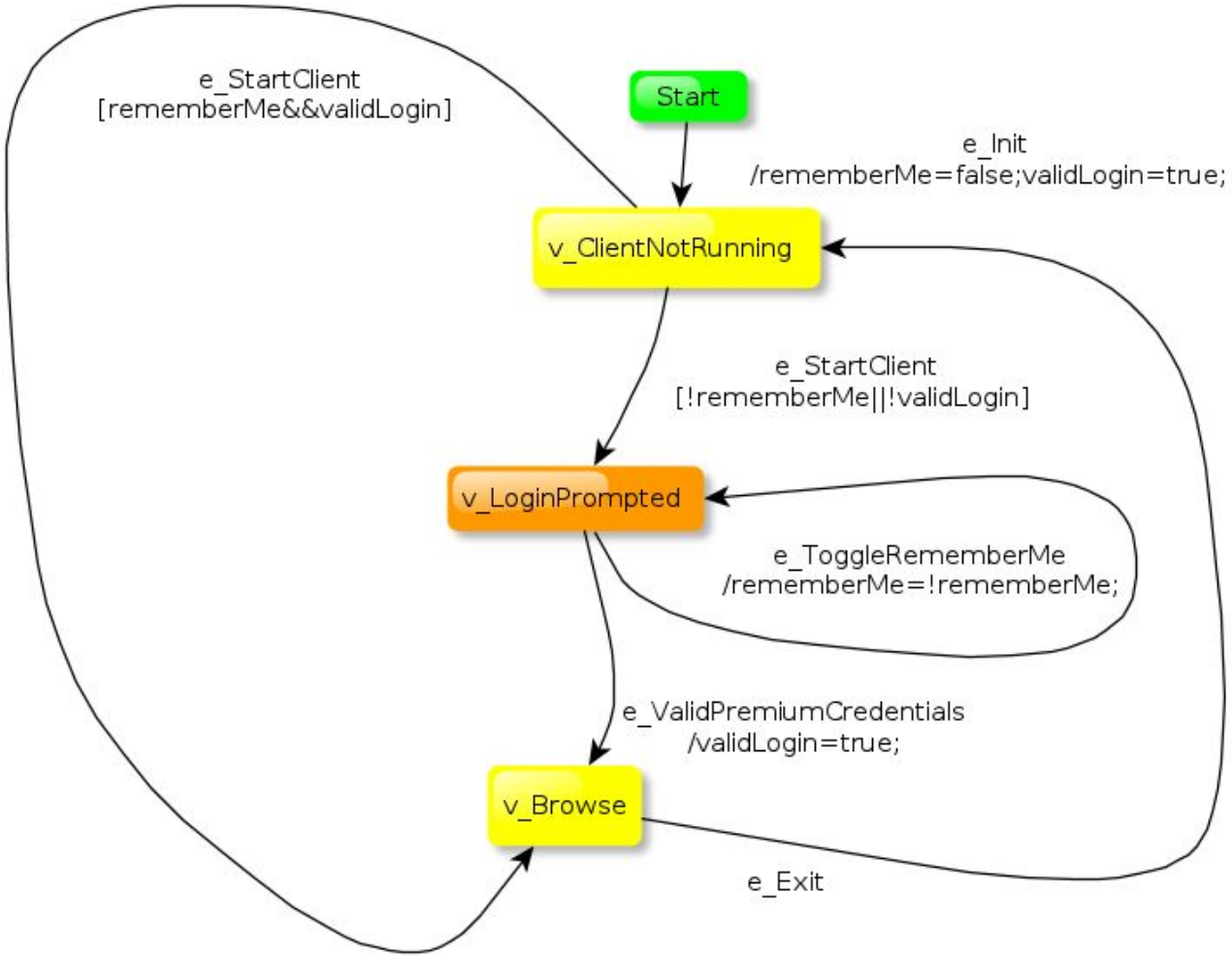
- *As a user, when starting the app and entering correct credentials, I expect the Browse page.*
- *As a user, when using stored credentials, I expect the Browse page displayed, without being asked for credentials.*
- *As a user entering invalid credentials, I expect not to be logged in.*

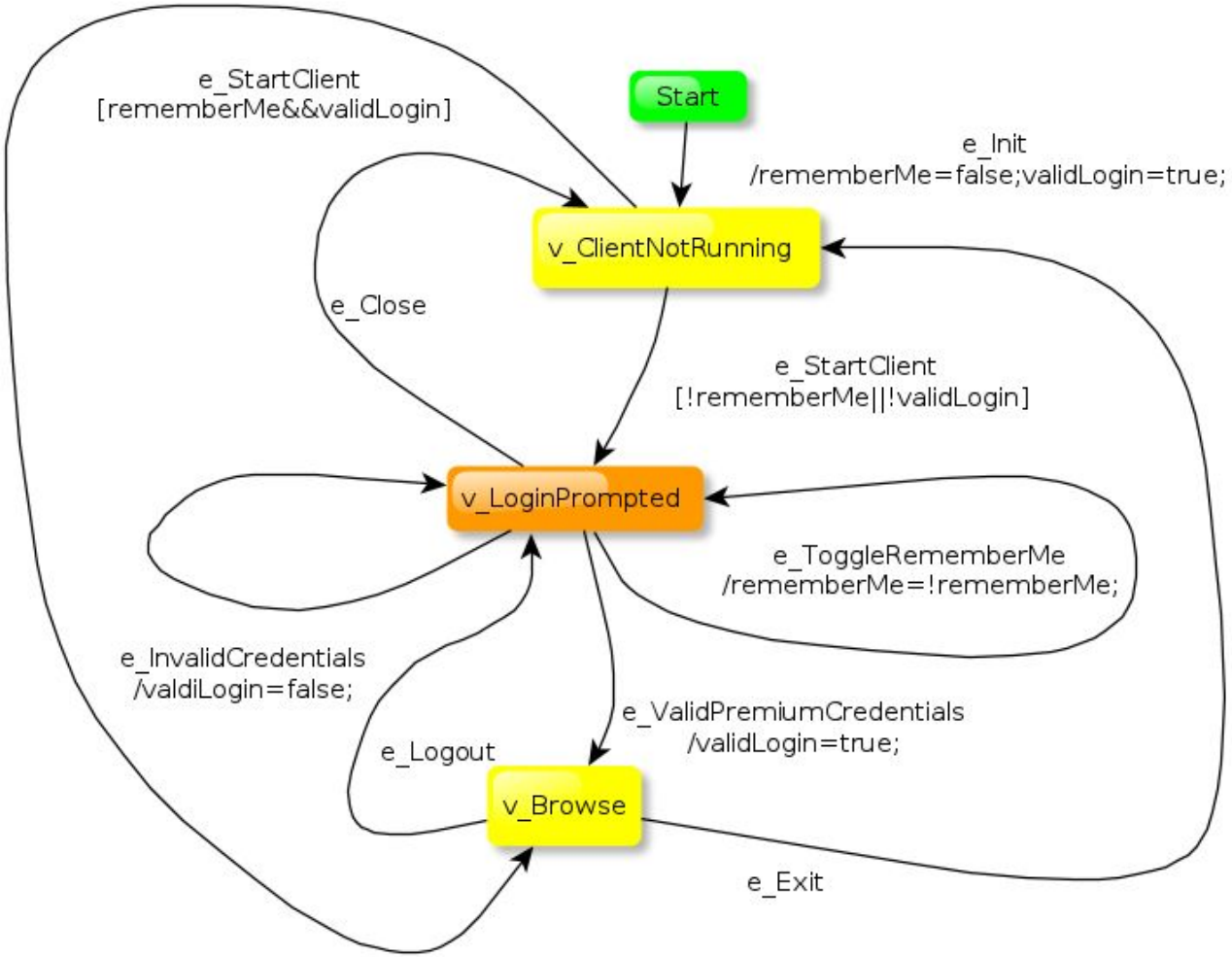

v_ClientNotRunning
v_LoginPrompted
v_Browse


v_ClientNotRunning
e_StartClient
v_LoginPrompted
e_ValidPremiumCredentials
v_Browse


Start
e_Init
v_ClientNotRunning
e_StartClient
v_LoginPrompted
e_ValidPremiumCredentials
v_Browse

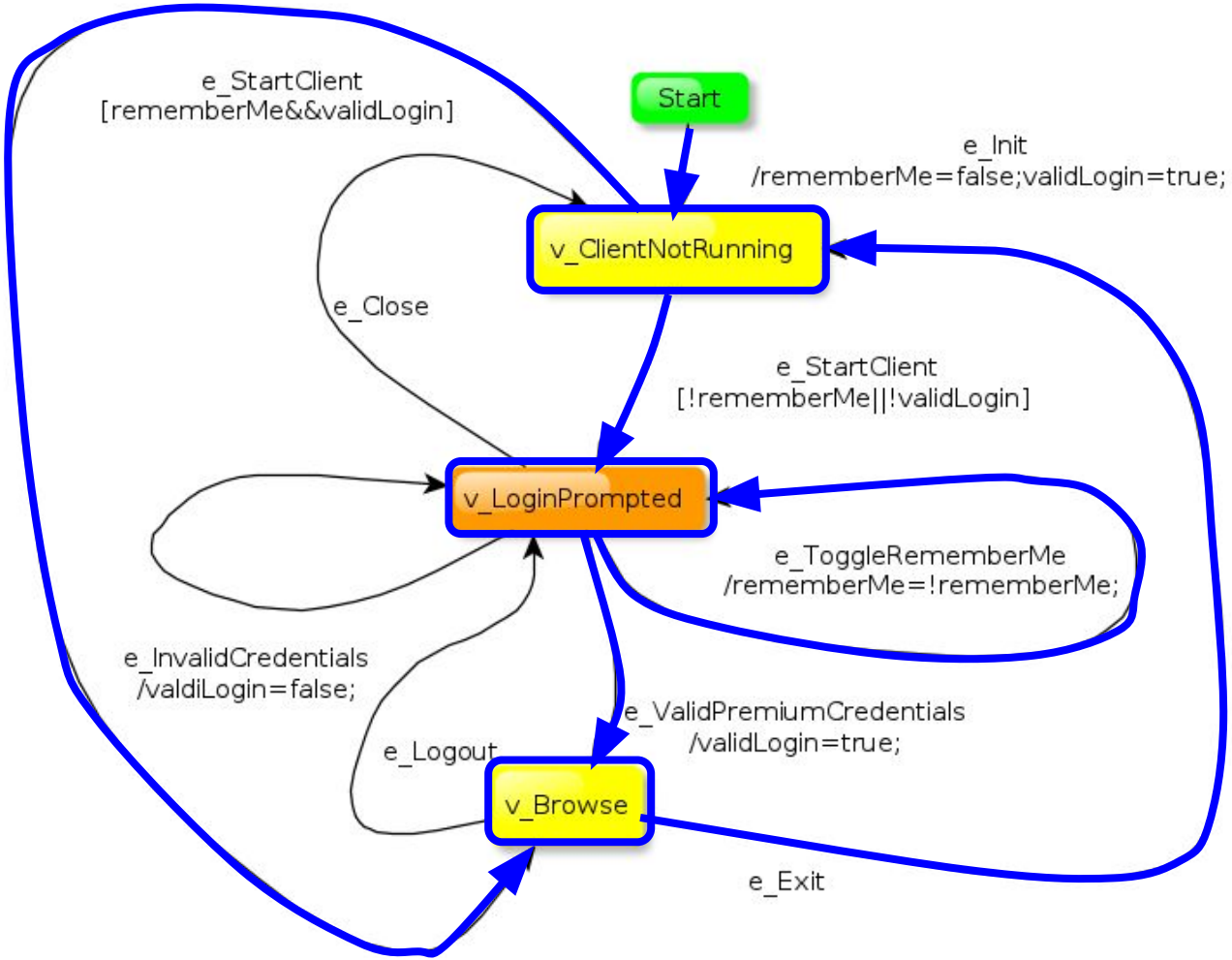

e_StartClient
Start
e_Init
v_ClientNotRunning
e_StartClient
v_LoginPrompted
e_ValidPremiumCredentials
v_Browse


e_StartClient
[rememberMe&&validLogin]
Start
e_Init
/rememberMe=false;validLogin=true;
v_ClientNotRunning
e_StartClient
[!rememberMe||!validLogin]
v_LoginPrompted
e_ToggleRememberMe
/rememberMe=!rememberMe;
e_ValidPremiumCredentials
/validLogin=true;
v_Browse
e_Exit

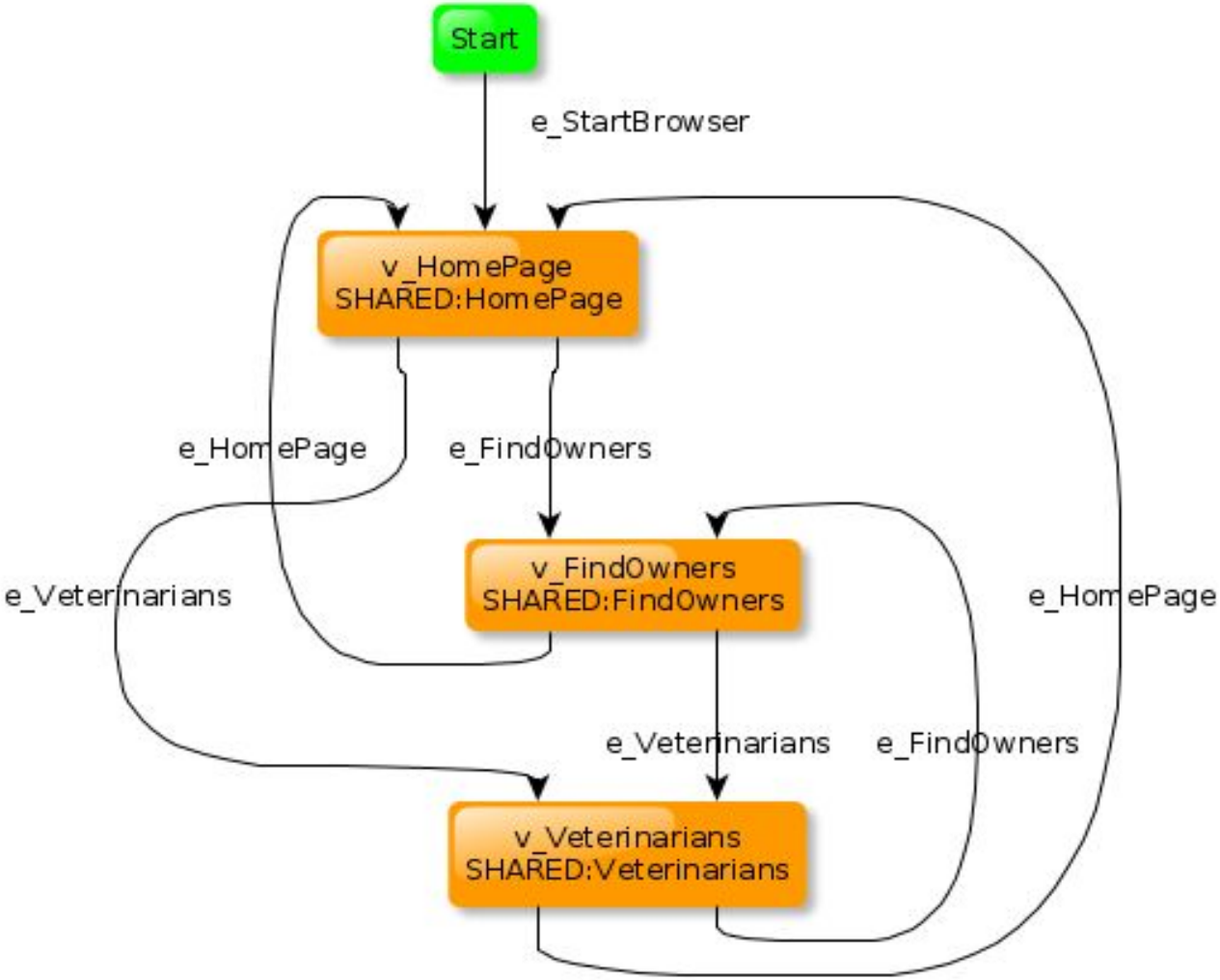

Start
e_Init
/rememberMe=false;validLogin=true;
v_ClientNotRunning
e_StartClient
[rememberMe&&validLogin]
e_Close
e_StartClient
[!rememberMe||!validLogin]
v_LoginPrompted
e_ToggleRememberMe
/rememberMe=!rememberMe;
e_InvalidCredentials
/valdiLogin=false;
e_ValidPremiumCredentials
/validLogin=true;
e_Logout
v_Browse
e_Exit

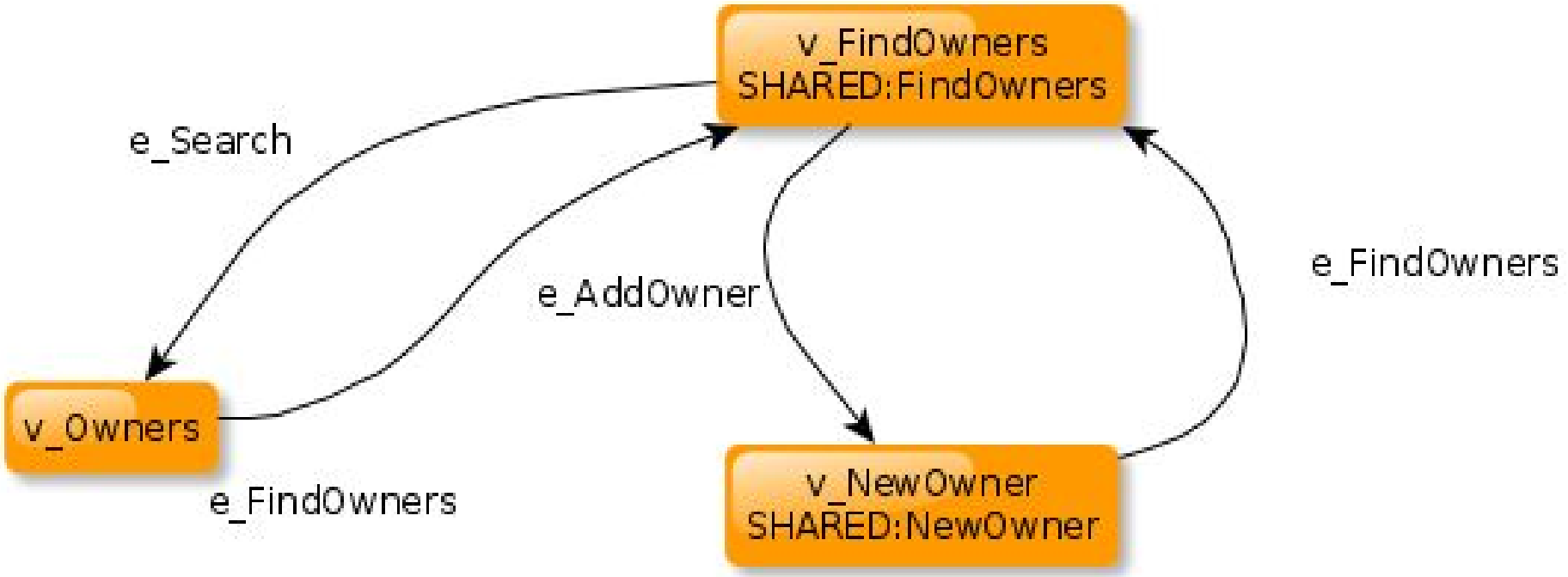
Test path generation

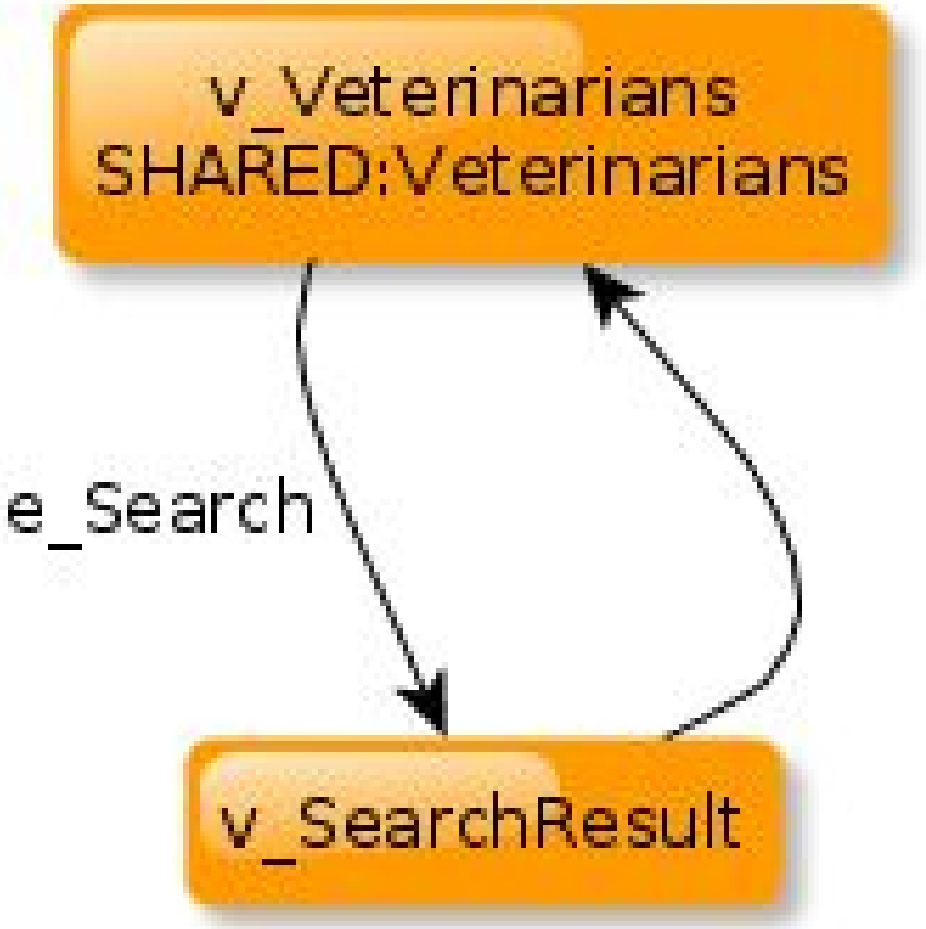
```
e_Init → v_ClientNotRunning → e_StartClient →
v_LoginPrompted → e_ValidPremiumCredentials →
v_Browse → e_Logout → v_LoginPrompted →
e_ToggleRememberMe → v_LoginPrompted →
e_Close → v_ClientNotRunning → e_StartClient
→ v_Browse → e_Logout → v_LoginPrompted → ...
```

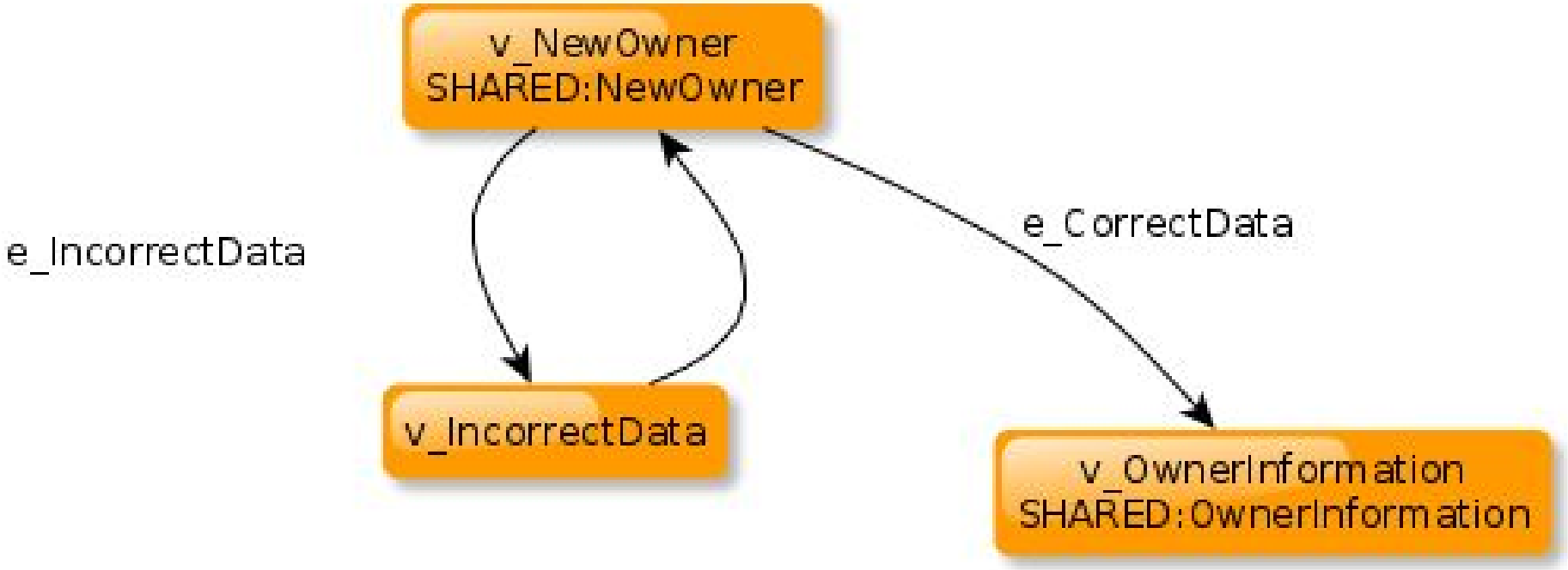

e_StartClient
[rememberMe&&validLogin]
Start
e_Init
/rememberMe=false;validLogin=true;
v_ClientNotRunning
e_Close
e_StartClient
[!rememberMe||!validLogin]
v_LoginPrompted
e_ToggleRememberMe
/rememberMe=!rememberMe;
e_InvalidCredentials
/valdiLogin=false;
e_ValidPremiumCredentials
/validLogin=true;
e_Logout
v_Browse
e_Exit

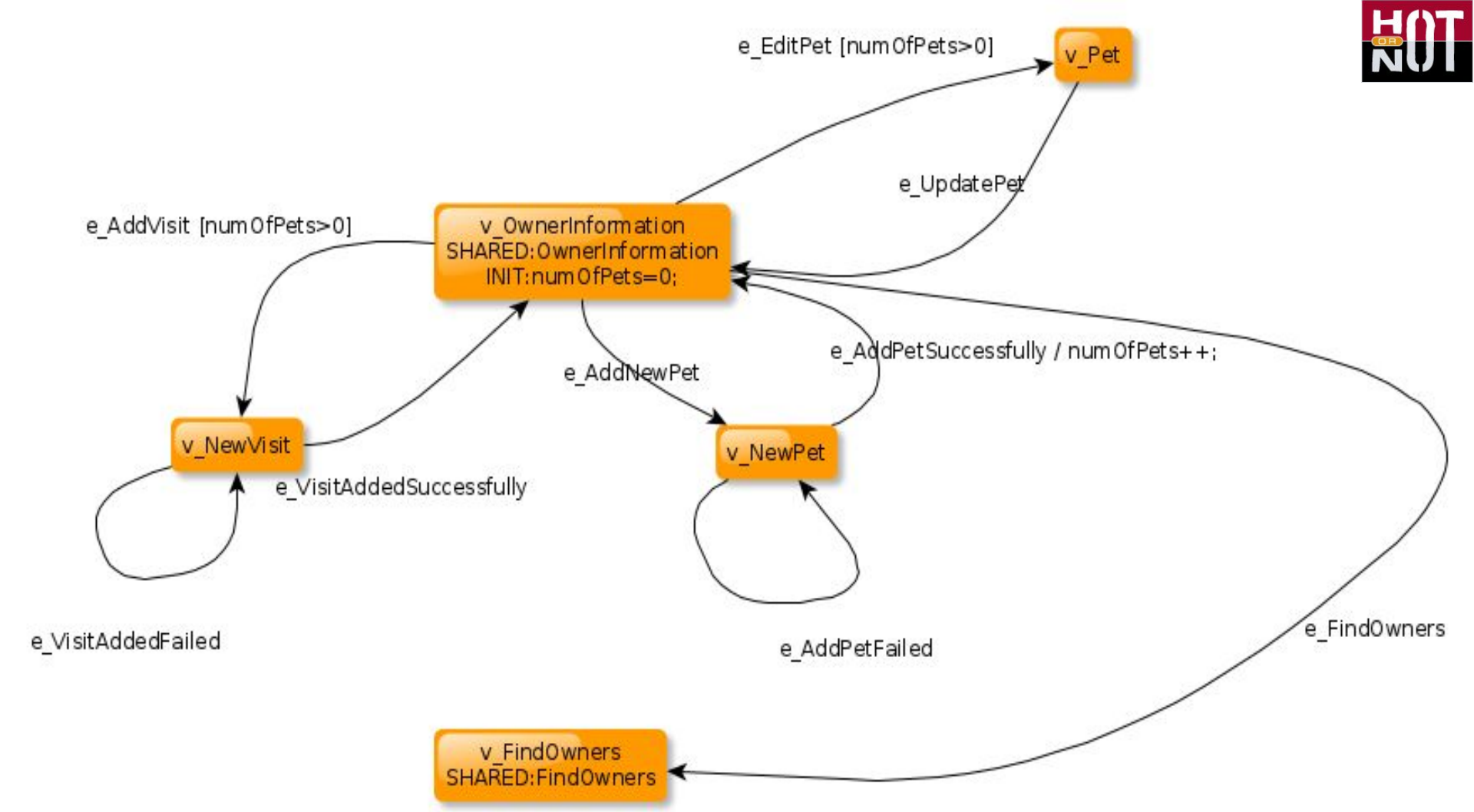
The Petclinic

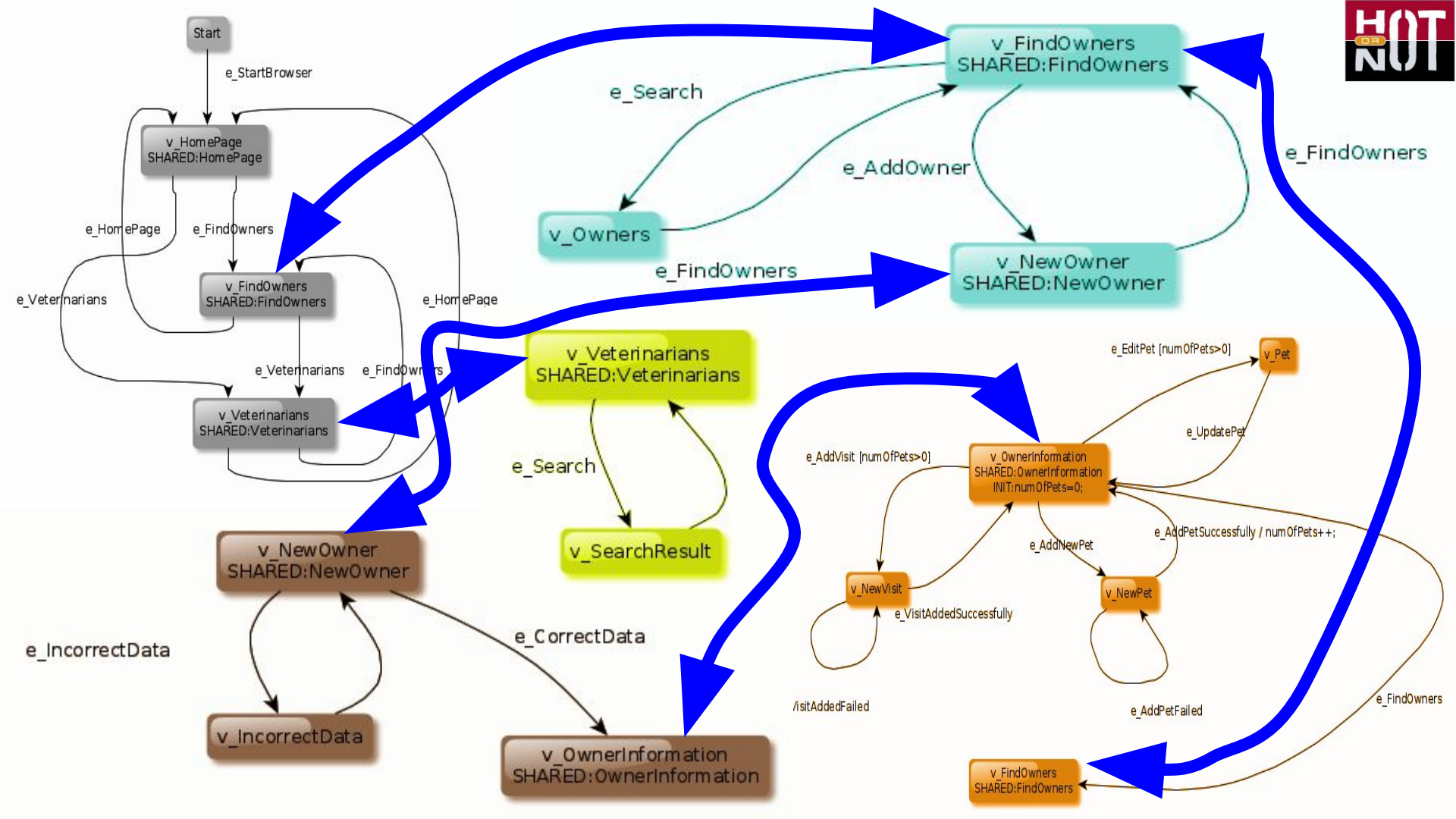

Start
e_StartBrowser
v_HomePage
SHARED:HomePage
e_HomePage
e_FindOwners
e_Veterinarians
v_FindOwners
SHARED:FindOwners
e_HomePage
e_Veterinarians
e_FindOwners
v_Veterinarians
SHARED:Veterinarians


v_FindOwners
SHARED:FindOwners
e_Search
e_AddOwner
e_FindOwners
v_Owners
e_FindOwners
v_NewOwner
SHARED:NewOwner


v_Veterinarians
SHARED:Veterinarians
e_Search
v_SearchResult


v_NewOwner
SHARED:NewOwner
e_IncorrectData
e_CorrectData
v_IncorrectData
v_OwnerInformation
SHARED:OwnerInformation


e_EditPet [numOfPets>0]
v_Pet
e_UpdatePet
e_AddVisit [numOfPets>0]
v_OwnerInformation
SHARED:OwnerInformation
INIT:numOfPets=0;
e_AddPetSuccessfully / numOfPets++;
e_AddNewPet
v_NewVisit
v_NewPet
e_VisitAddedSuccessfully
e_VisitAddedFailed
e_AddPetFailed
e_FindOwners
v_FindOwners
SHARED:FindOwners


Start
e_StartBrowser
v_HomePage
SHARED:HomePage
e_HomePage
e_FindOwners
v_FindOwners
SHARED:FindOwners
e_Veterinarians
e_HomePage
e_Veterinarians
e_FindOwners
v_Veterinarians
SHARED:Veterinarians
v_FindOwners
SHARED:FindOwners
e_Search
e_AddOwner
v_Owners
e_FindOwners
v_NewOwner
SHARED:NewOwner
e_FindOwners
v_Veterinarians
SHARED:Veterinarians
e_Search
v_SearchResult
v_NewOwner
SHARED:NewOwner
e_IncorrectData
e_CorrectData
v_IncorrectData
v_OwnerInformation
SHARED:OwnerInformation
e_EditPet [numOfPets>0]
v_Pet
e_UpdatePet
e_AddVisit [numOfPets>0]
v_OwnerInformation
SHARED:OwnerInformation
INIT:numOfPets=0;
e_AddPetSuccessfully / numOfPets++;
e_AddNewPet
v_NewVisit
v_NewPet
e_VisitAddedSuccessfully
/isitAddedFailed
e_AddPetFailed
e_FindOwners
v_FindOwners
SHARED:FindOwners

Demo of running the Petclinic GraphWalker MBT Test

It’s all about da code

- Create a boiler plate project

```
mvn archetype:generate -B -
DarchetypeGroupId=org.graphwalker -
DarchetypeArtifactId=graphwalker-maven-
archetype -DgroupId=com.company -
DartifactId=myProject
```

- Compile and run it

```
mvn graphwalker:test
```

It’s all about da code

- GraphWalker Maven plugin

  `graphwalker:generate-sources`

  `graphwalker:generate-test-sources`

- Models in:

  `src/main/resources/<package>`

  `src/test/resources/<package>`

- Generated Interfaces in:

  `target/generated-sources/grahwalker<package>`

  `target/generated-test-sources/grahwalker<package>`

What is, and what does graphwalker do?

- MIT licensed, open source project since 2005
- Made by testers
- Reads graphml, json and simple dot files
- Generates path sequences, either offline or online
- Concept of stop conditions
- Multi model support

...and what does it not do?

- It does not interact with the system under test.
- It has no graph editor. *Yet...*
- It has no working shortest all paths generator.
- It has no native support for anything besides of java. *(But there is Python implementation)*
- It has no elaborate reporting of results - it’s up to the developer to implement that.

offline

- Generate a path once, use many times
- Covers the same path every execution
- Predictable runtimes
- Needs an adapter to run the path

online

- Generates path at runtime
- Random permutations created each time
- Unpredictable runtimes
- No need for an adapter to run the path

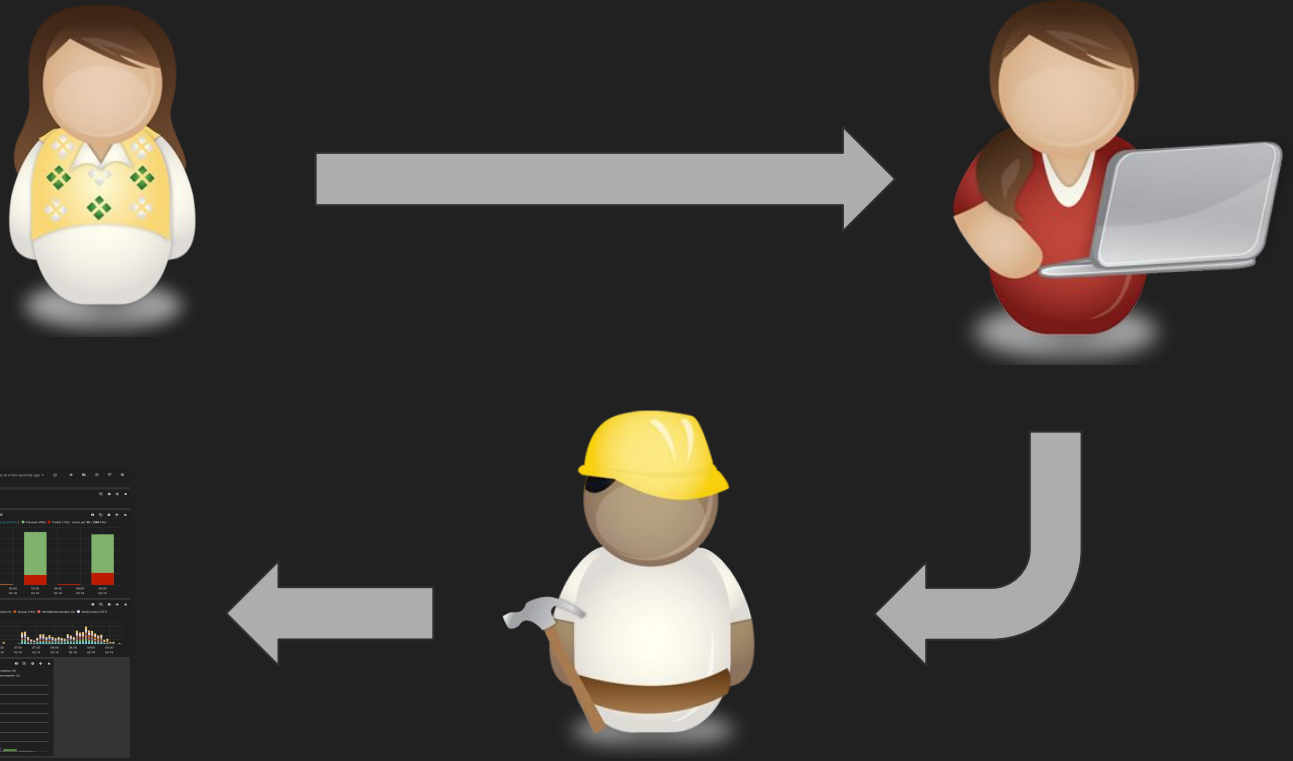
generator

- A Star
- Random
- Quick Random
- Weighted Random
- Combined

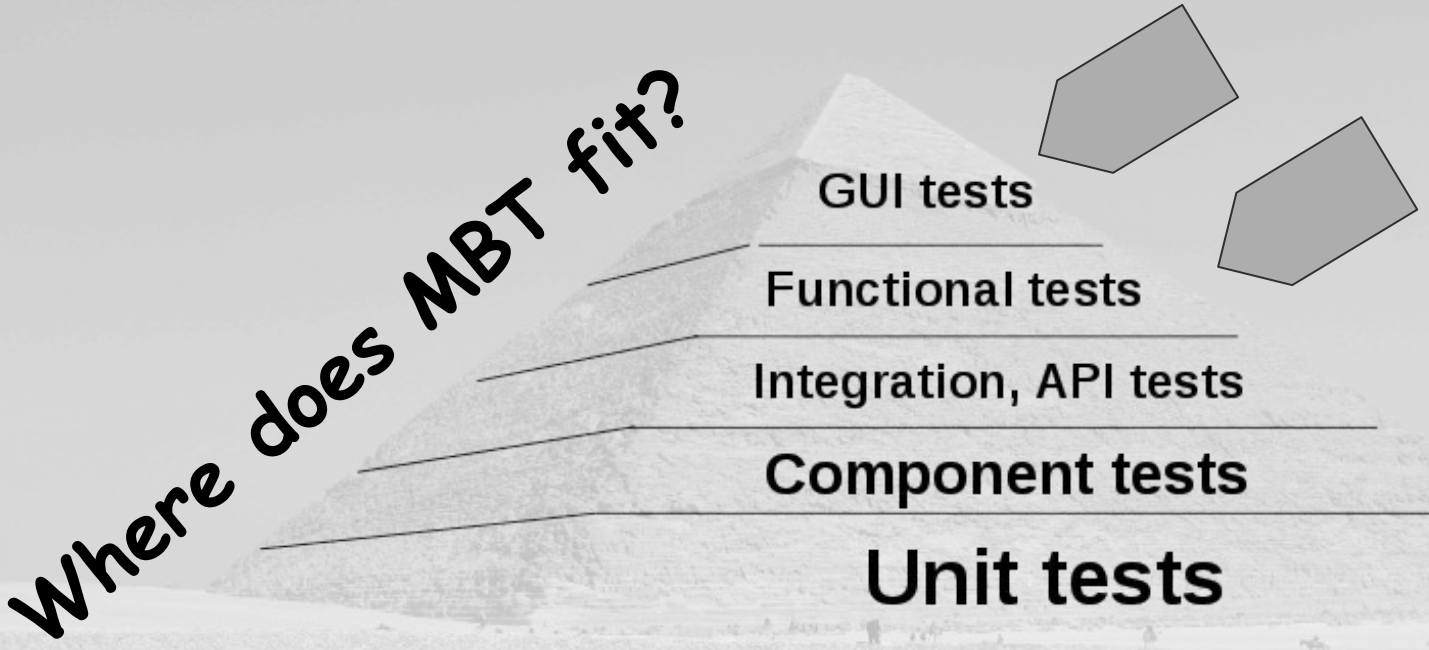
stop condition

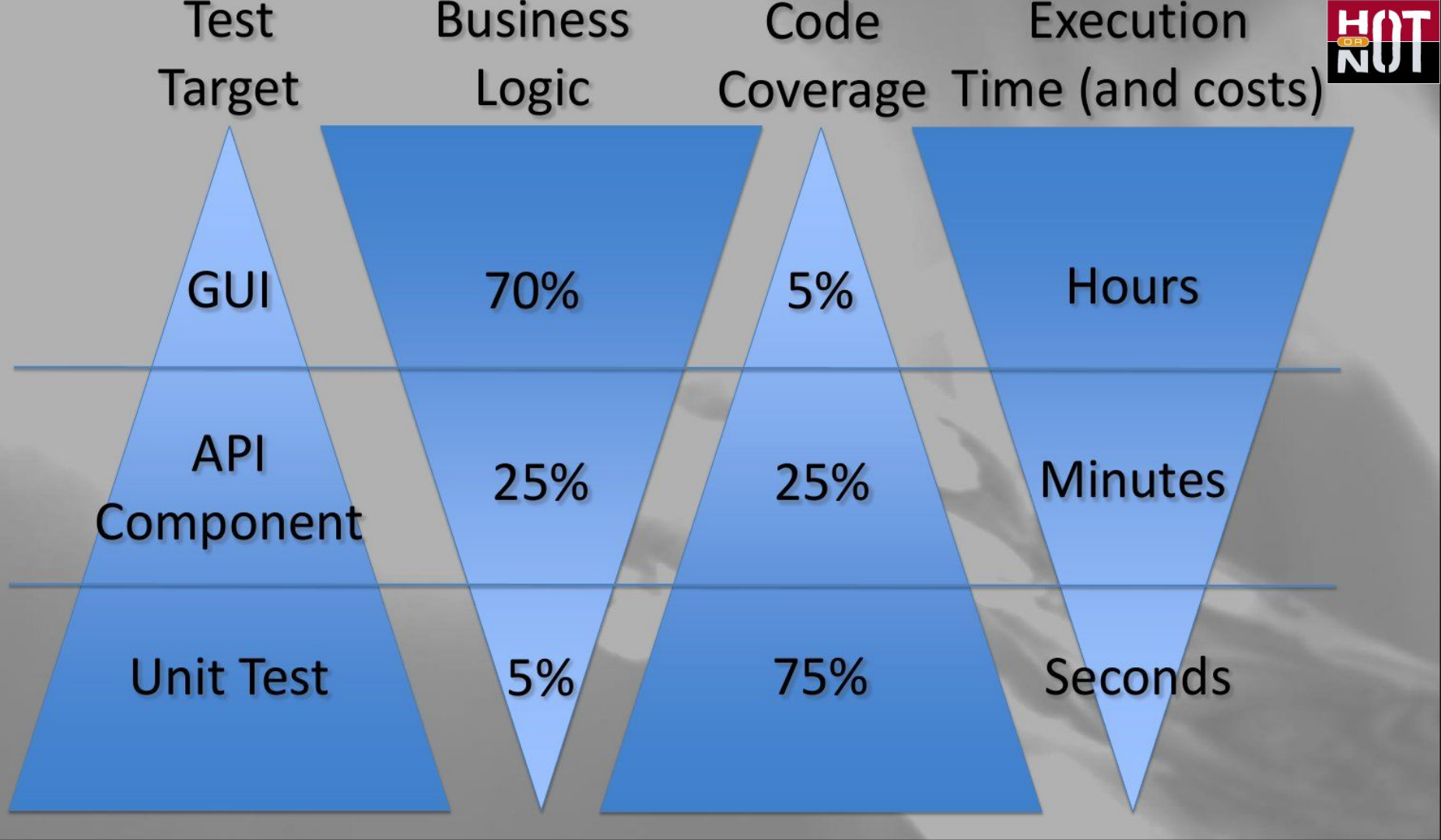
- Edge Coverage
- Vertex Coverage
- Requirement Coverage
- Reached Edge
- Reached Vertex
- Time
- Length

Some words about the workflow



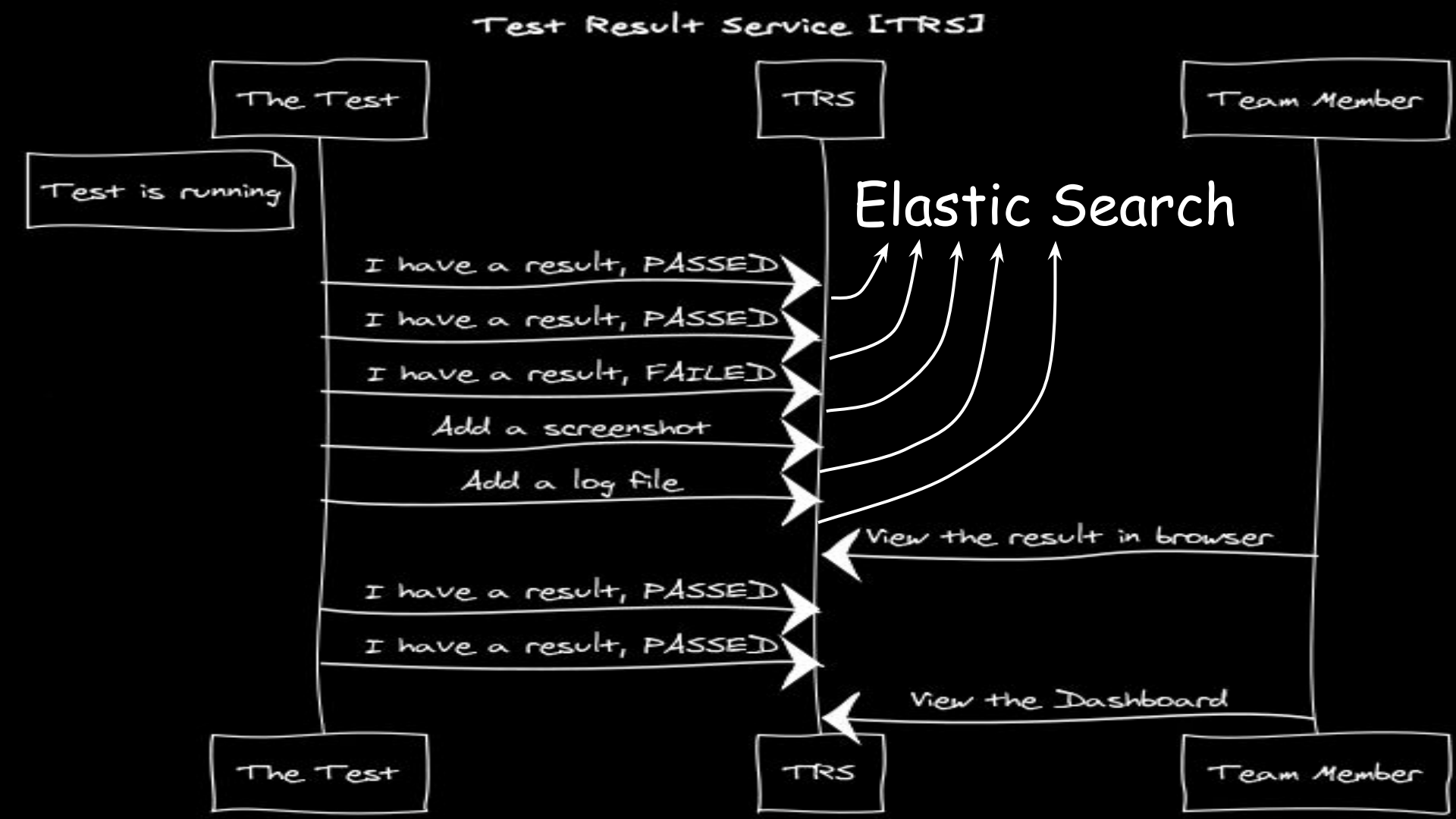
Automation

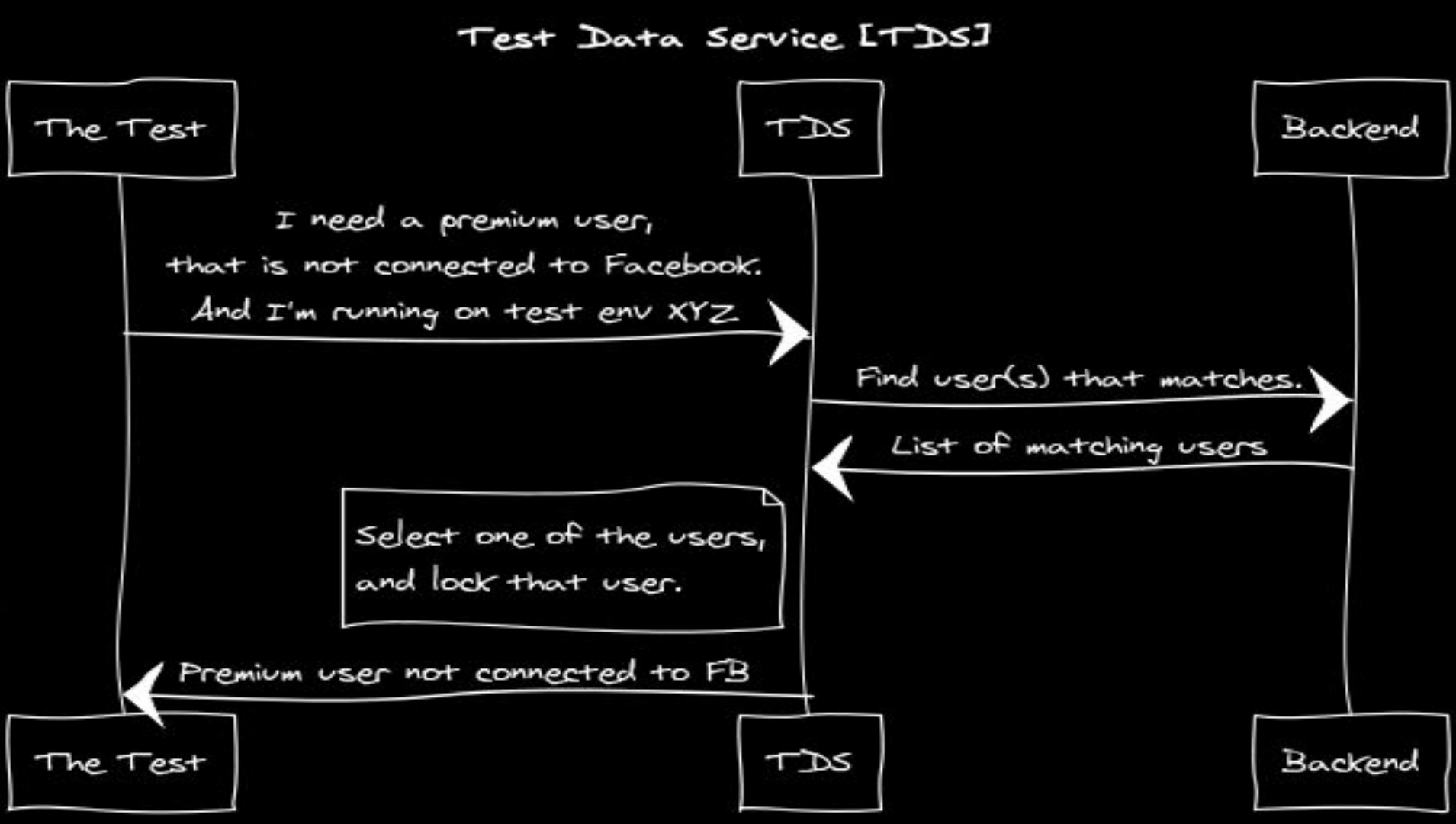

Where does MBT fit?
GUI tests
Functional tests
Integration, API tests
Component tests
Unit tests


Test Target
Business Logic
Code Coverage
Execution Time (and costs)
GUI
70%
5%
Hours
API Component
25%
25%
Minutes
Unit Test
5%
75%
Seconds

A little bit about automation @Spotify

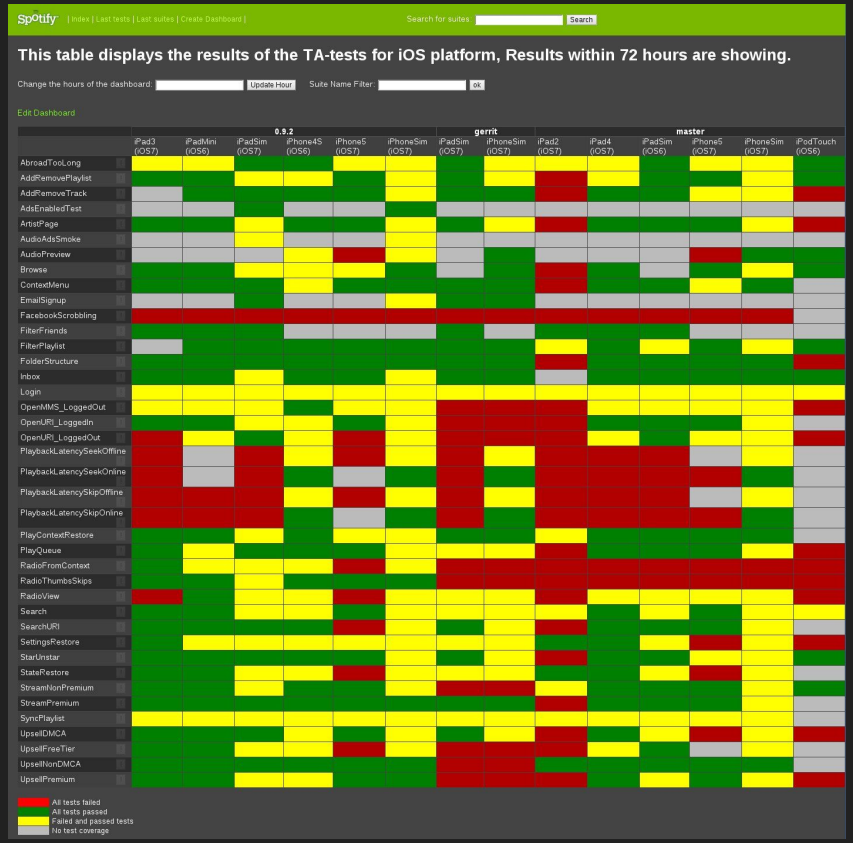
- Unit tests of course
- iOS, Android, Desktop and WEB
- For mobile and desktop, we write our own test drivers
- Build Verification Tests
  Runs in build pipe lines
- Optional pipe line tests - On Demand
  Triggered by keyword in commit
- Outside of pipe line tests - Triggered på time, runs 24/7

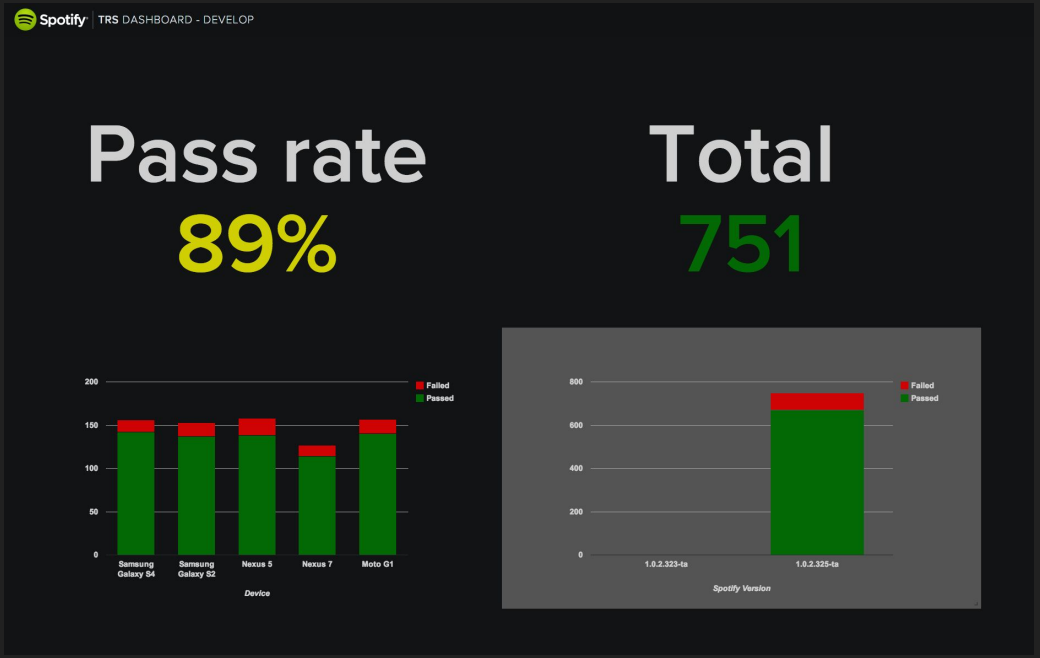

Test Result Service [TRS]
The Test
TRS
Team Member
Test is running
Elastic Search
I have a result, PASSED
I have a result, PASSED
I have a result, FAILED
Add a screenshot
Add a log file
View the result in browser
I have a result, PASSED
I have a result, PASSED
View the Dashboard
The Test
TRS
Team Member


Test Data Service [TDS]
The Test
TDS
Backend
I need a premium user,
that is not connected to Facebook.
And I'm running on test env XYZ
Find user(s) that matches.
List of matching users
Select one of the users,
and lock that user.
Premium user not connected to FB
The Test
TDS
Backend

▶ Vicar In A Tutu - 2011 Re...
https://link.spotify.com/album/5Y0p2XCgRRIjna91aQE8q7
Spotify
Search
Browse
Radio
Your Music
Follow
creamaut...
Vicar In A Tutu - 2011 R
9 There Is A Light That N
10 Some Girls Are Bigger
© 1986 Warner Music UK Ltd
℗ 2011 Rhino UK, a division of Warner
MORE BY THE SMITHS
THE SMITHS "RANK"
Rank
1988
1987
Simple graphml viewer
localhost:9191
+
-
visitedPaths: 0
visitedNoShuffleRepeat: false
noOfTracks: 10
visitedOnlyShuffle: false
visitedShuffleRepeat: false
tracksPlayed: 1
visitedOnlyRepeat: false
playingTrack: 3
lastPlayableTrack: 5
playing: true
PlayerShuffleRepeat
v_InitView
e_OpenAlbumView
v_AlbumView
e_PlayAlbum
v_PlayingAlbum
e_SetShuffleRepeat
v_ShuffleRepeatUpdated

Results, results and more results...





Android MBT

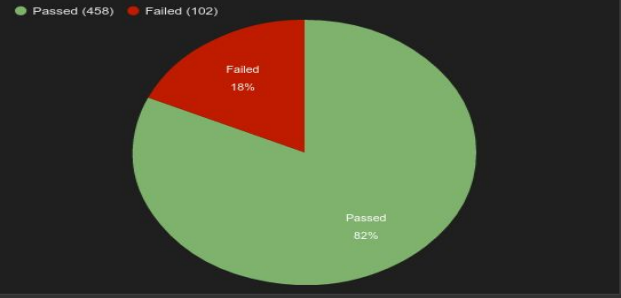
12 hours ago to a few seconds ago

QUERY | FILTERING

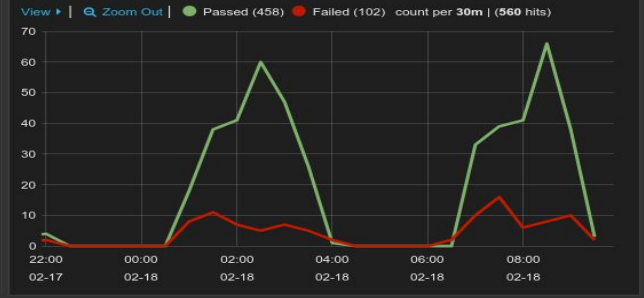
ANDROID KIBANA DASHBOARDS

Build health overview | Build failures overview | Android MBT | Android Perf | Codebase health overview

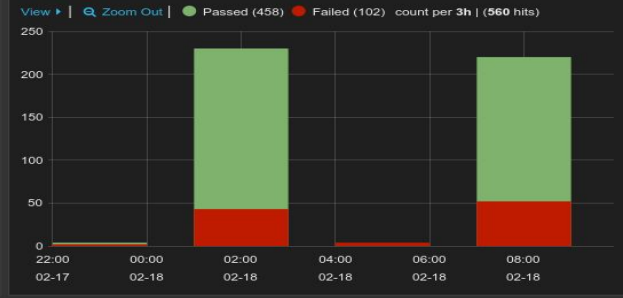
PASS RATE



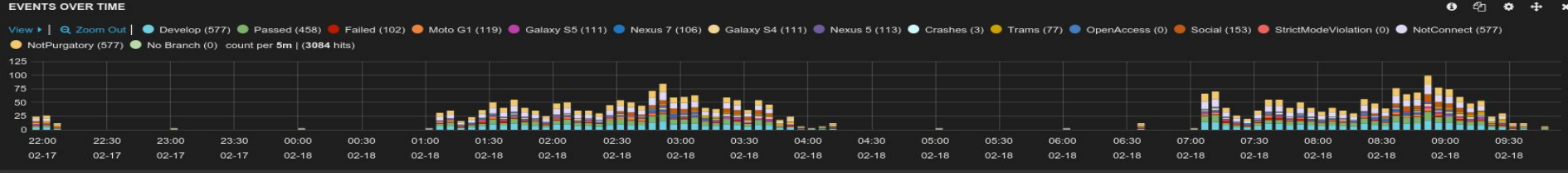
TIMELINE



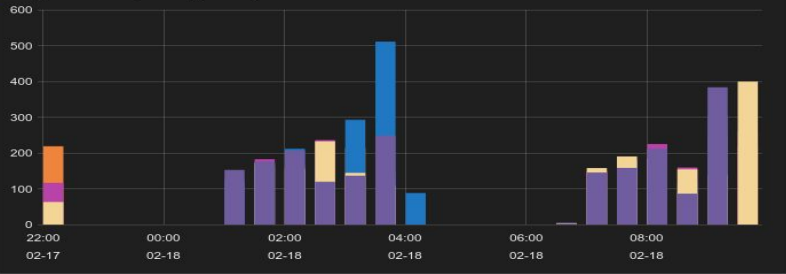
PASS RATE



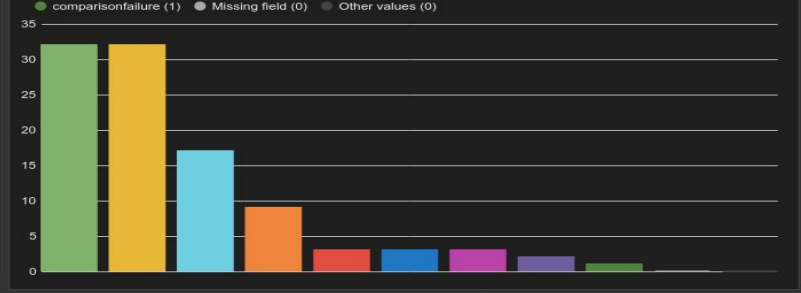
EVENTS OVER TIME



PER DEVICE



EXCEPTIONS



iOS MBT

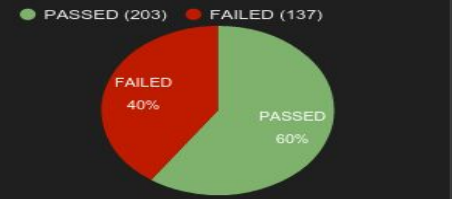
12 hours ago to a minute ago refreshed every 5m

QUERY | FILTERING

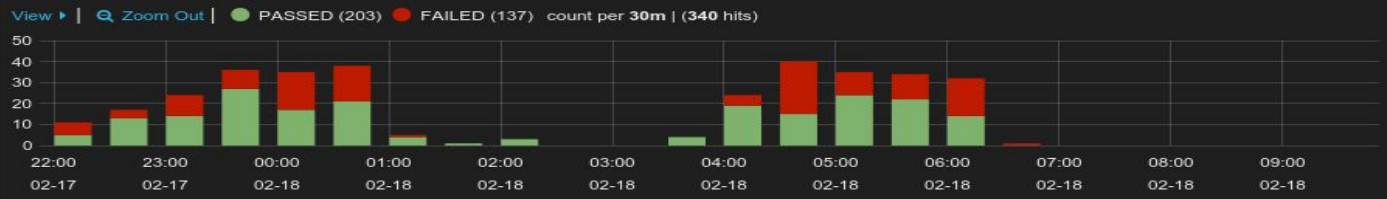
IOS DASHBOARDS OVERVIEW

iOS Release | iOS builds | iOS Spkvonc | iOS Cartel | iOS Cream | iOS Social | iOS Startpage

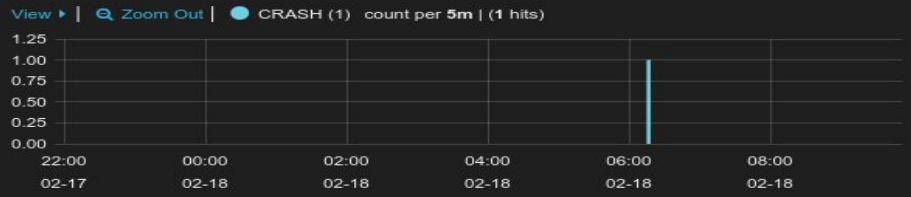
PASS RATE



TEST TIMELINE



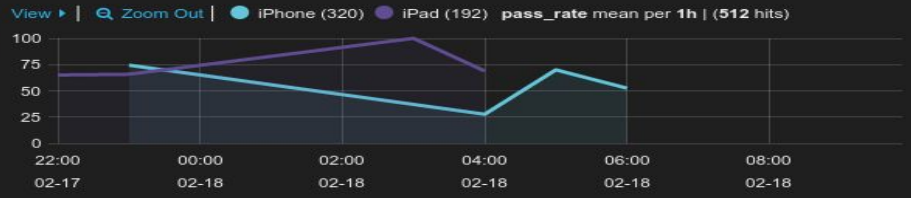
CRASHES



CRASHING TESTS

Term	Count	Action
com.spotify.ta.systemtest.views.platformtest.standardupsellmft	1	
Other values	0	

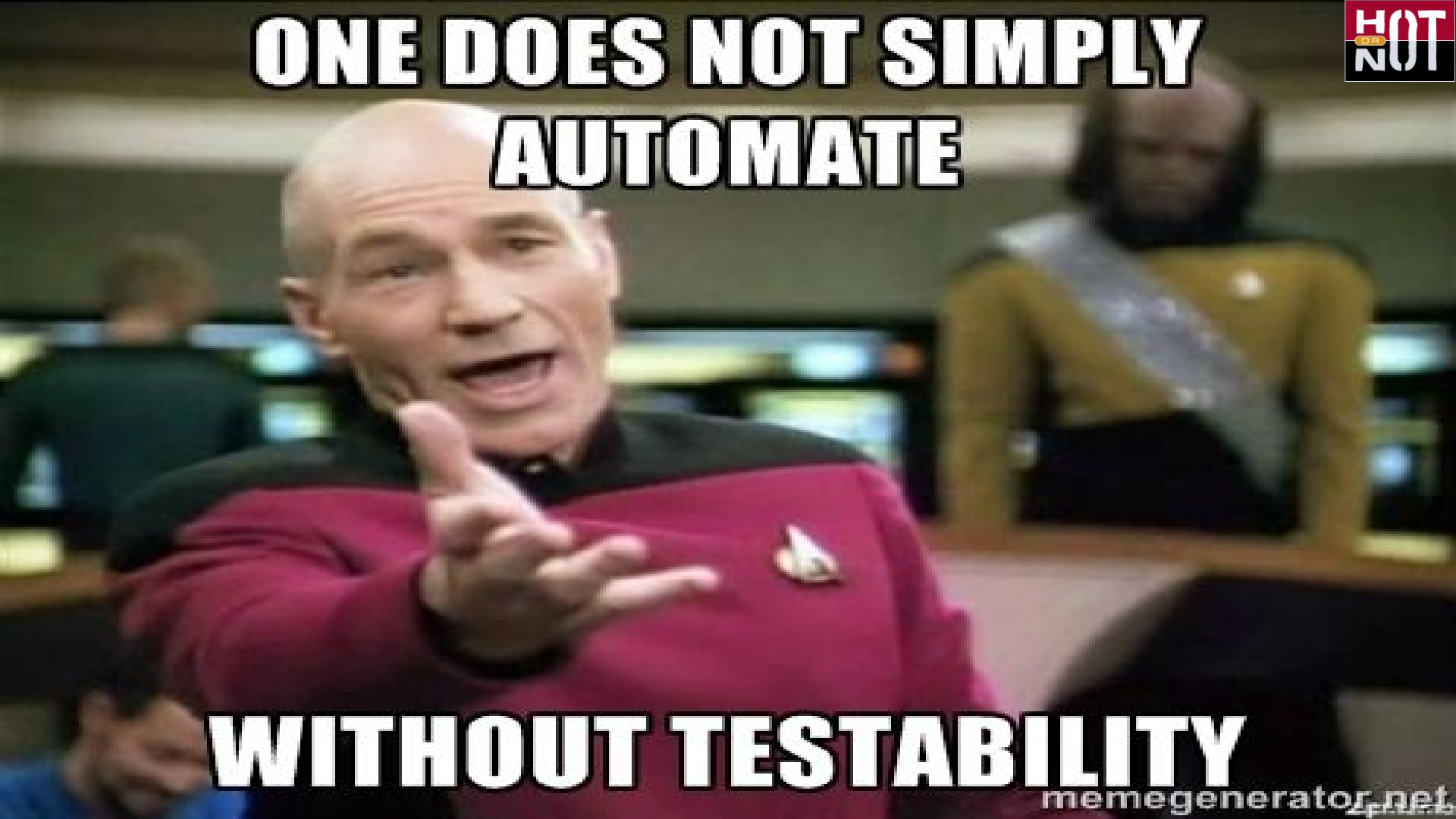
PASS RATE OVER TIME

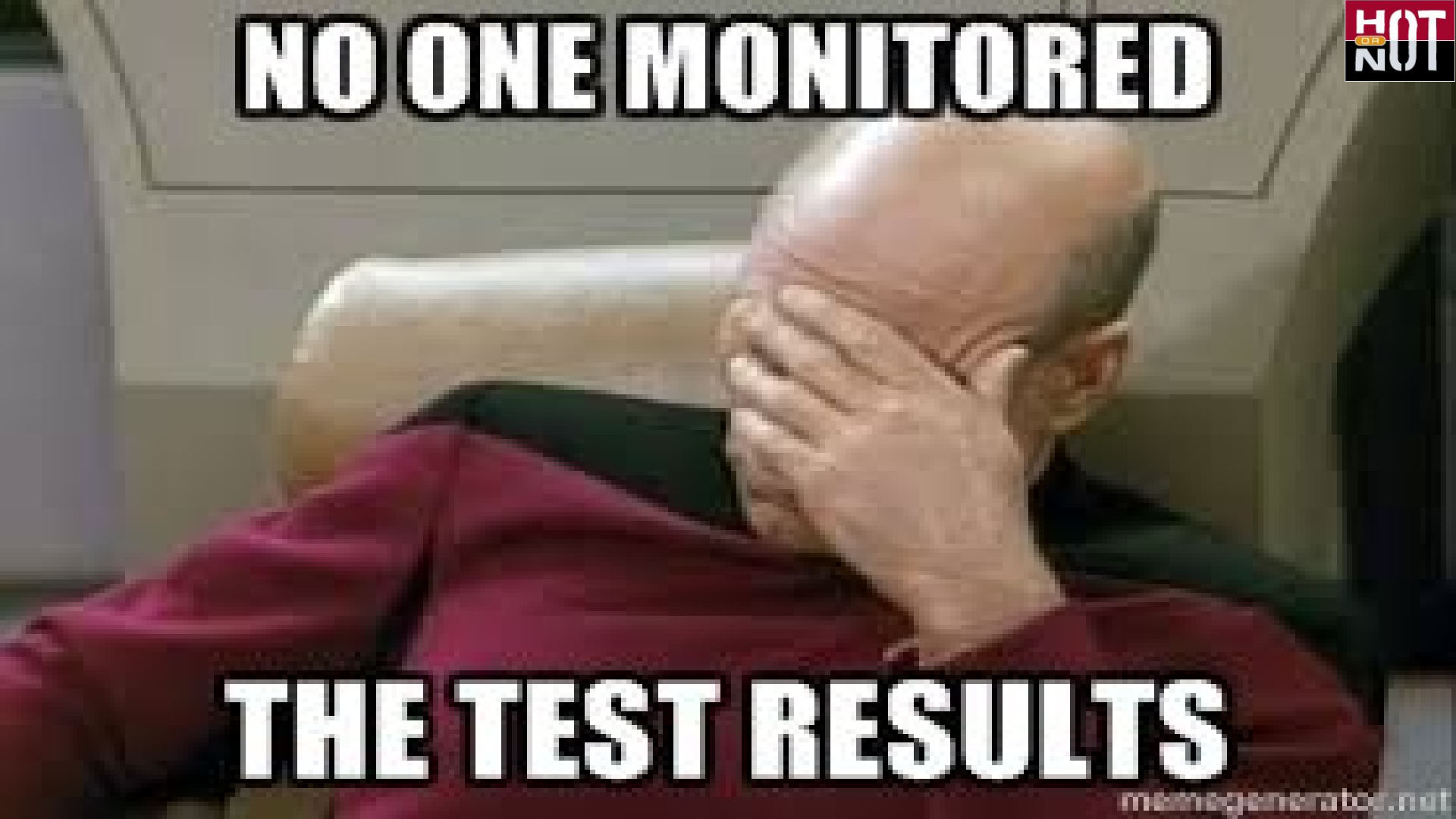


FAILING TESTS

Term	Count	Action
com.spotify.ta.test.testsuiteradio.startradiofromyourmusic	4	
com.spotify.ta.test.testsuiteradio.startradiofromcontext	4	
com.spotify.ta.test.testsuiteradio.radiothumbsskips	4	
com.spotify.ta.test.testsuitecontainer.upsellplayunavailablepremium	4	
com.spotify.ta.test.testsuiteconnect.connectplaybackcontrols	4	
Other values	117	

HOT
OR
NOT


ONE DOES NOT SIMPLY
AUTOMATE
WITHOUT TESTABILITY
memegenerator.net


NO ONE MONITORED
THE TEST RESULTS
memegenerator.net

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Where automation fails...

```
GET /goform/spotifyConnect?action=getInfo HTTP/1.1
Host: [redacted]:9100
User-Agent: Spotify-Unknown/0.71/2027819640
Keep-Alive: 300
Connection: keep-alive
Accept-Encoding: gzip
Content-Type: application/x-www-form-urlencoded
```

https://community.spotify.com/t5/Help-Desktop-Linux-Windows-Web/Spotify-Printing/td-p/1065478

```
GET /goform/spotifyConnect?action=getInfo HTTP/1.1
Host: 172.16.xxx.xx:xxxx
User-Agent: Spotify-Unknown/0.71/2005447208
Keep-Alive: 300
Connection: keep-alive
Accept-Encoding: gzip
Content-Type: application/x-www-form-urlencoded
```

What is it good for? - Burning equipment!

References

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