

Event-Based Testing

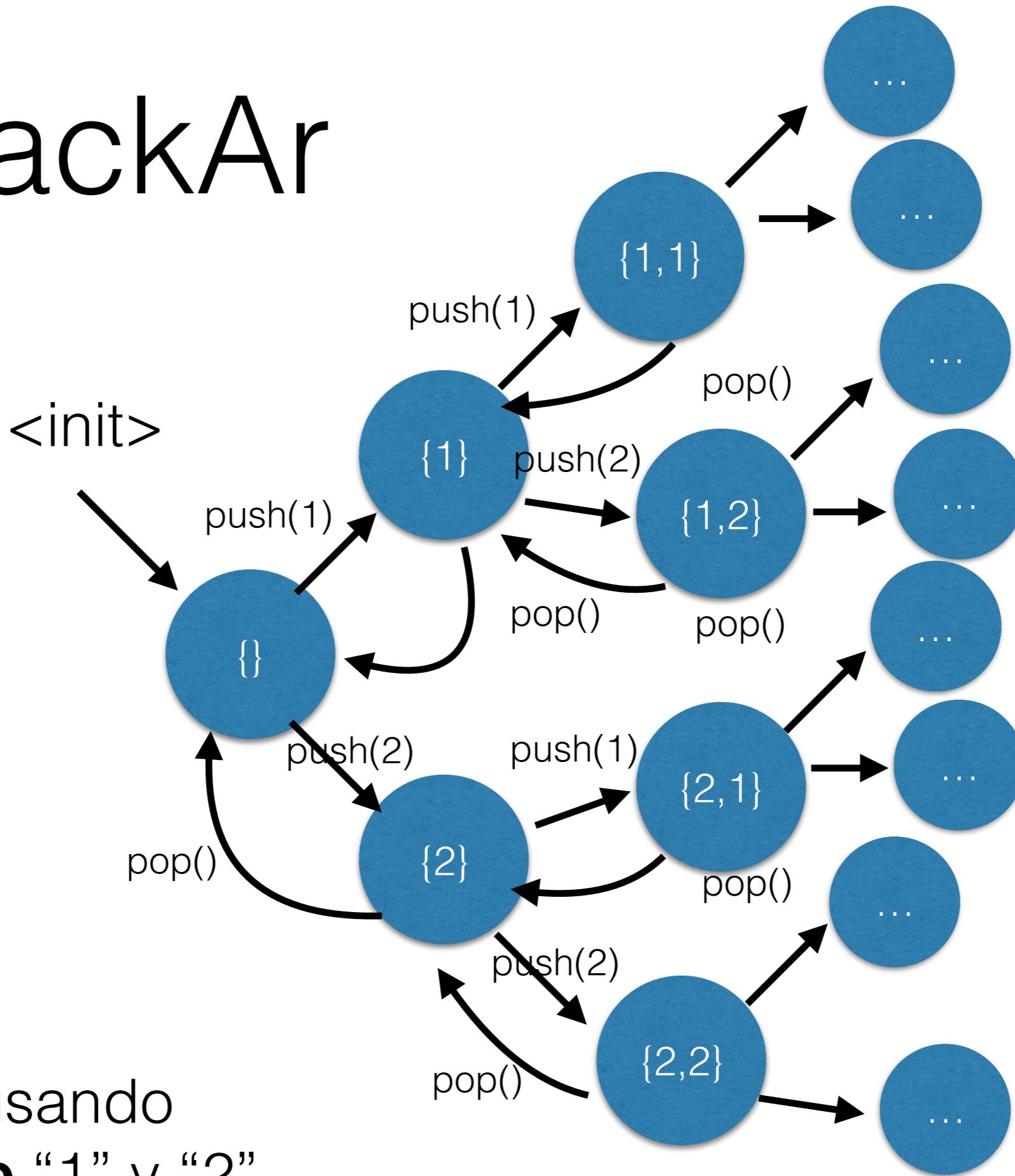
Generación Automática de Casos de Test - 2018

La Clase StackAr

- **Observadores**
 - boolean isFull()
 - boolean isEmpty()
- **Mutadores**
 - StackAr() [10 elementos]
 - void push(Object)
 - Object pop()

¿Qué “estados” posibles tiene una instancia Stack?

StackAr

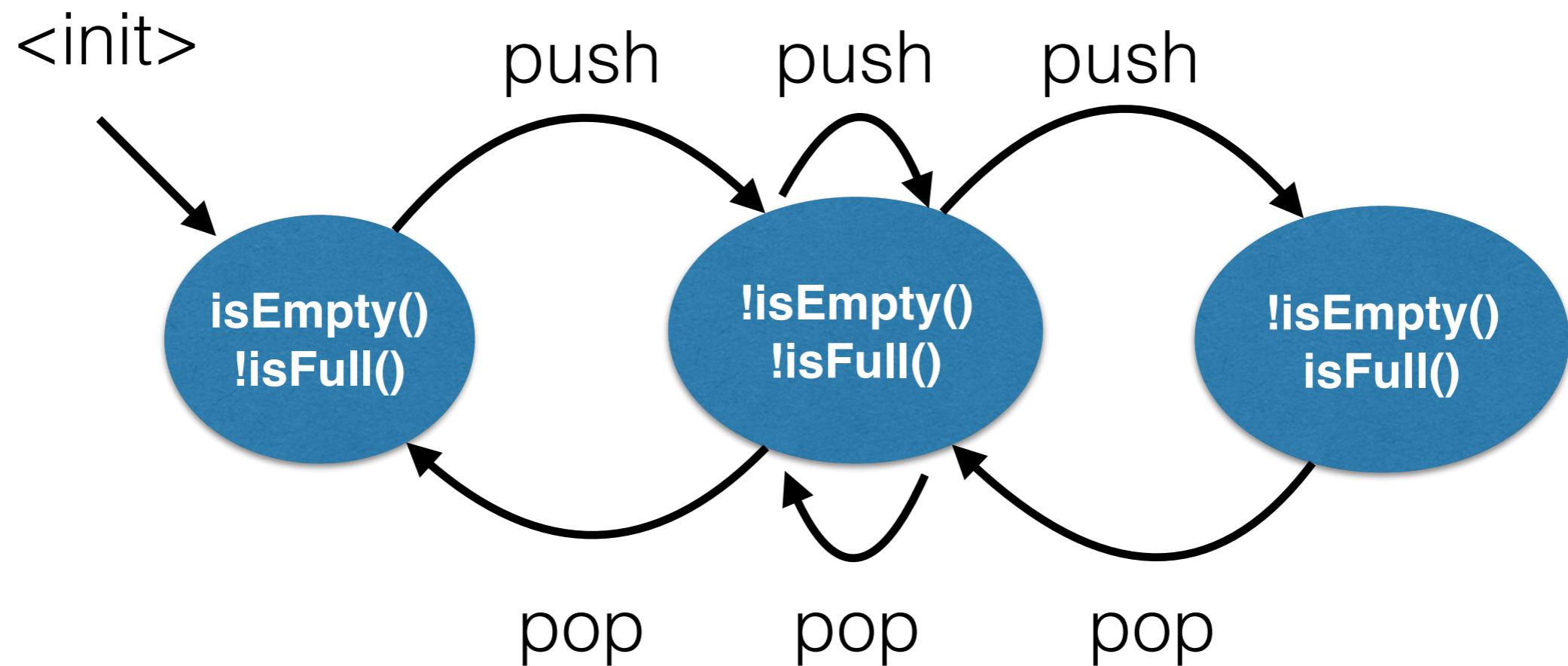


Instancias usando
únicamente “1” y “2”

Model-Based Testing

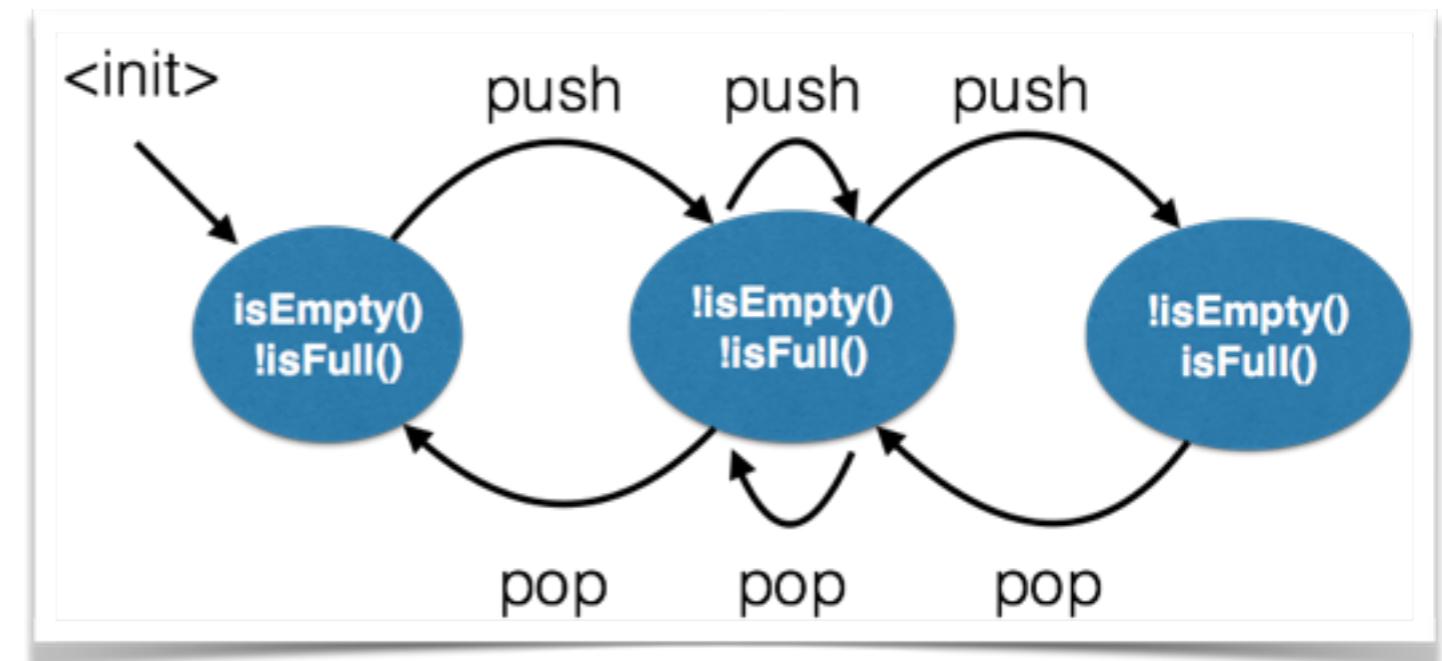
- Creamos un *modelo* (generalmente **finito**) que representa un conjunto (posiblemente **infinito**) de instancias concretas.
- Podemos representar un **Finite State Machine** (FSM) de todas las instancias posibles del StackAr clasificándolas por el valor de sus observadores (isEmpty/isFull)

FSM de StackAr



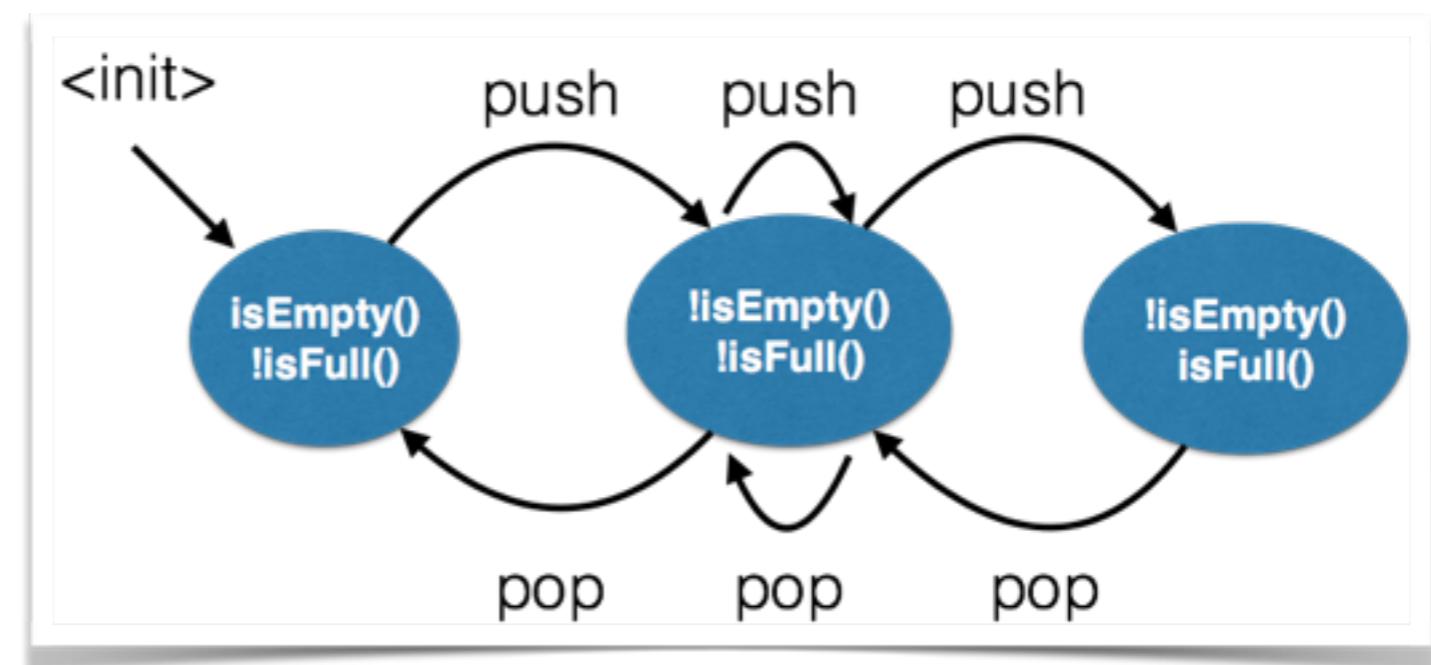
Criterios de Cobertura

- All-states
- All-actions
- All-transitions
- All-loop-free-paths
- All-one-loop-paths
- All-paths



Observadores y Modelos

- El Modelo depende de los observadores y las operaciones
- Si agregamos el observador **top()** o la operación **<init>(int)**, el modelo será distinto



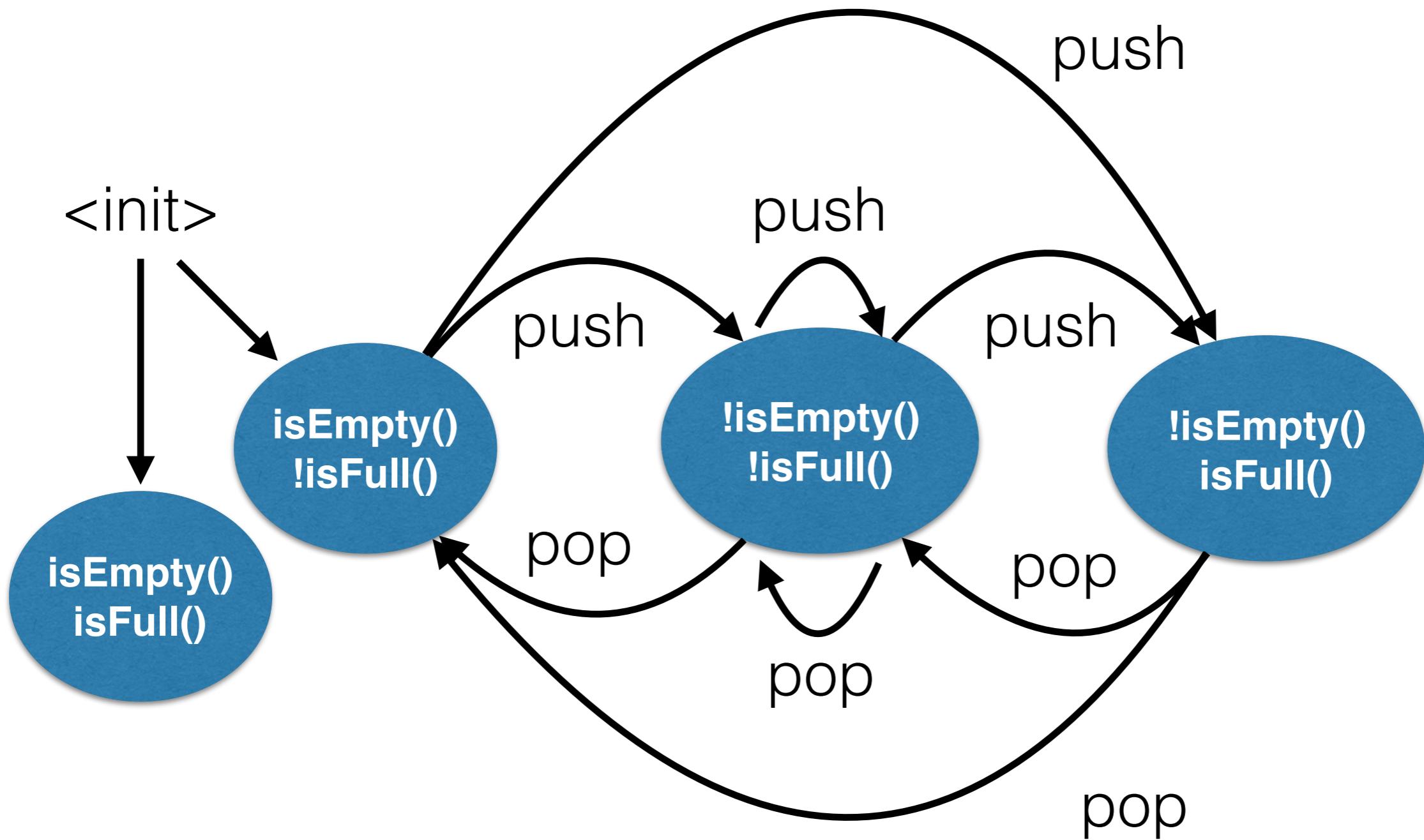
StackAr

- Si consideramos el constructor StackAr(int) y únicamente los valores “1” y “2”(para push y pop)
 - ¿Cuántas estados concretos de StackAr hay?
 - ¿Cuántas estados “abstractos” considerando únicamente isEmpty, isFull?

StackAr tiene infinitas estados concretos

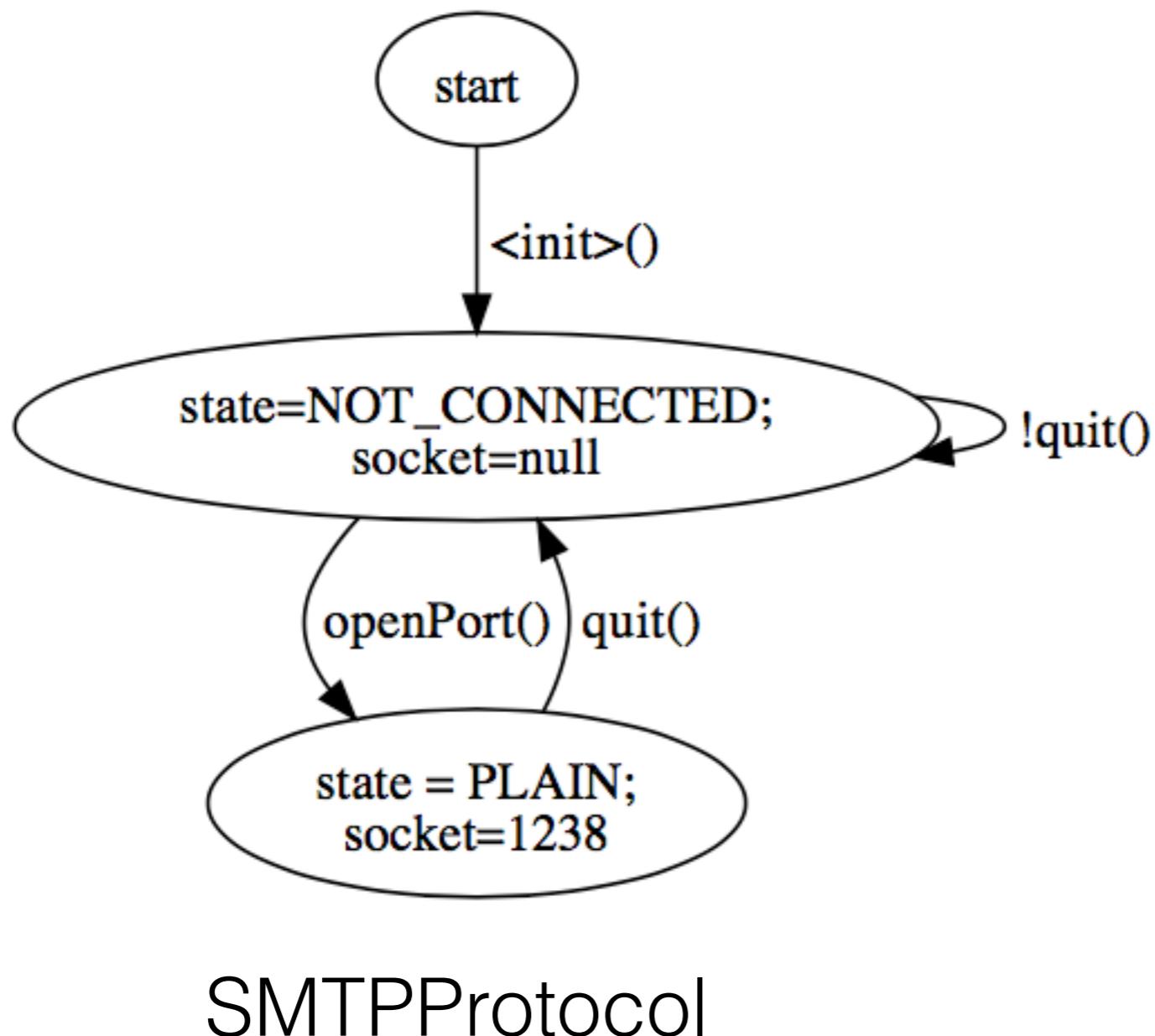
StackAr tiene finitos estados concretos (FSM)

FSM ampliado



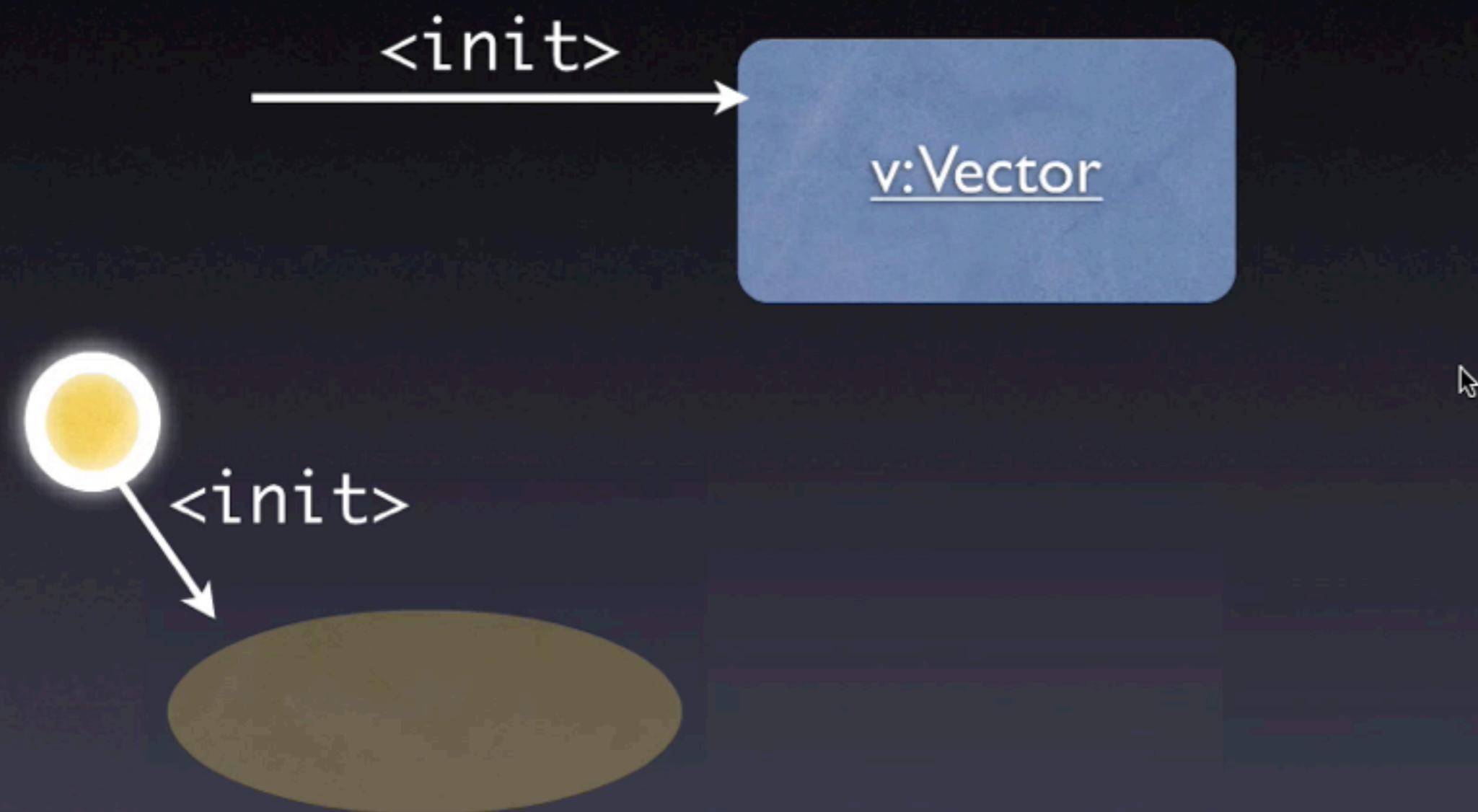
Agregamos el constructor **StackAr(int)** al modelo

Object Behaviour Model



- **Mutators**
(Operaciones)
- **Inspectors**
(Observadores)
- !Mutator = ejecutar esa operación lleva a una **excepción**

Building Models



Enabledness Preservation Abstractions (EPAs)

- Una acción está **habilitada (enabled)** si existe un input tal que la acción es ejecutada y puede terminar normalmente (ie sin que ocurra una excepción)
- Dos instancias de un objeto pertenecen al mismo estado si comparten el mismo conjunto de acciones habilitadas
- Con una cantidad finita de acciones, hay una cantidad finita de estados

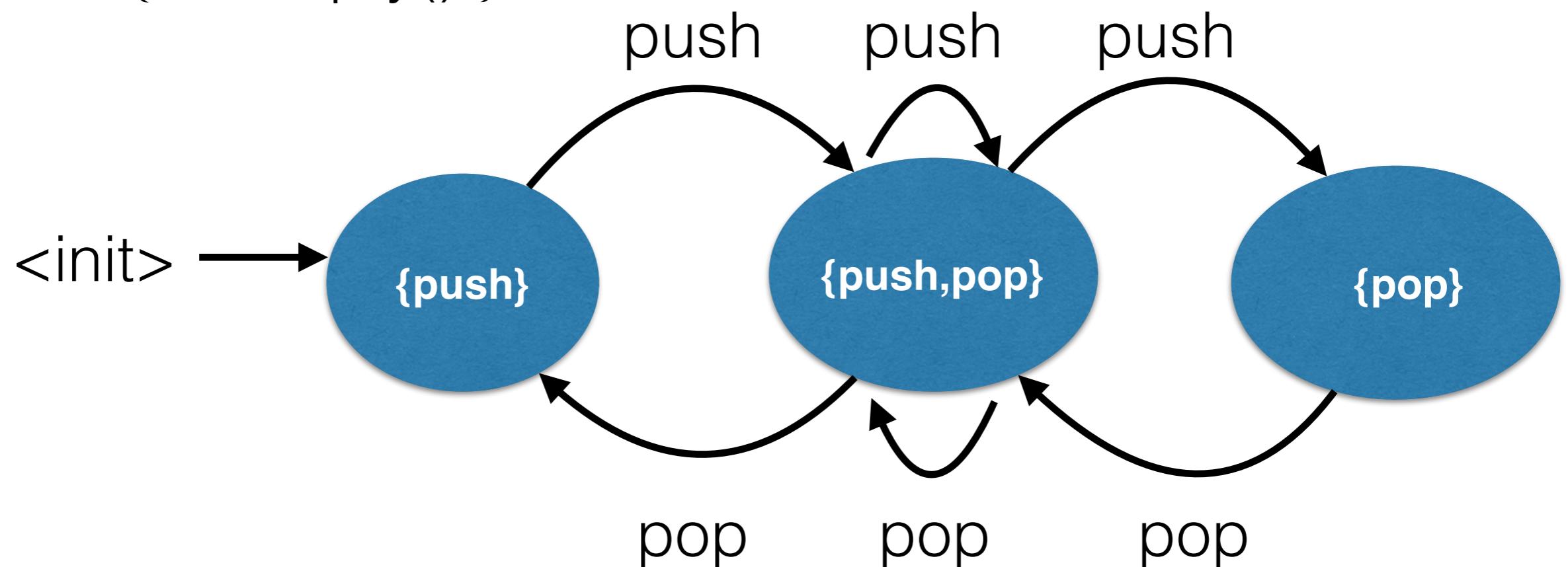
¿Cuál es la EPA de StackAr?

push():

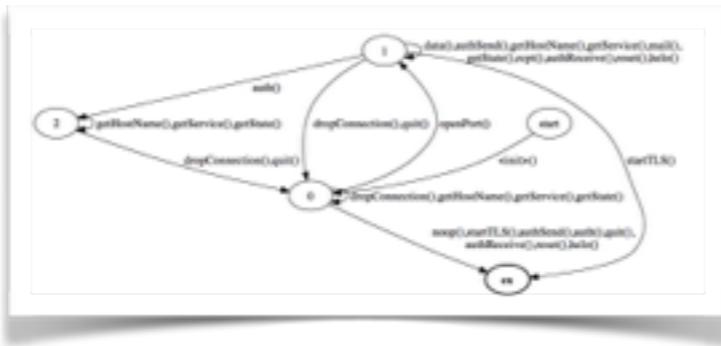
requires { !isFull() }

pop():

requires { !isEmpty() }



A partir de las ejecuciones extraigo un modelo



A partir del modelo
mido la cobertura
y/o exploro nuevas
instancias

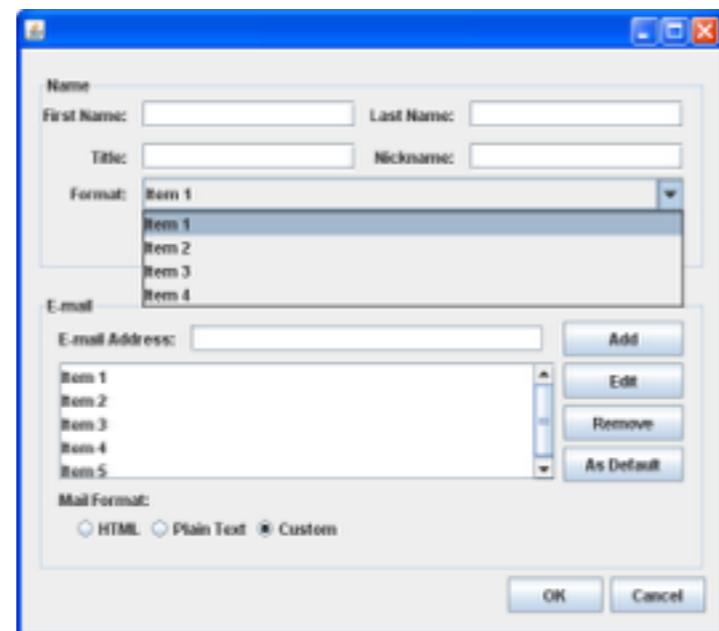
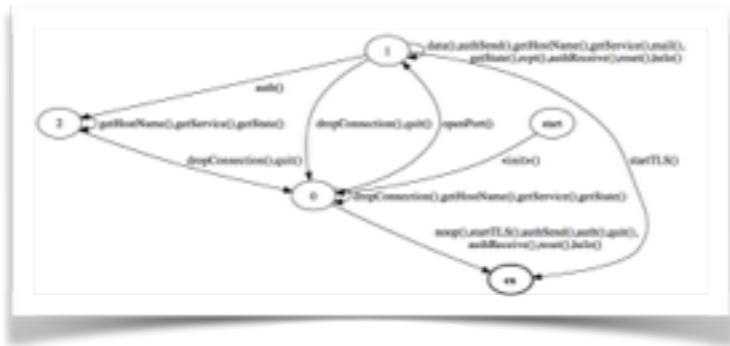
Una Clase

```
    (id)(id)
    {
        return [id] in dictionary
    }

    (id)(id)dictionary "Value"
    {
        idVal = [parse id]
        if (idVal in idD) {
            if (dictionary == null) {
                _idDictionary = idD
            }
            else {
                _idDictionary = dictionary
            }
            _idDictionary[idVal] = value
        }
        else {
            _idDictionary[idVal] = dictionary
        }
        return idVal
    }

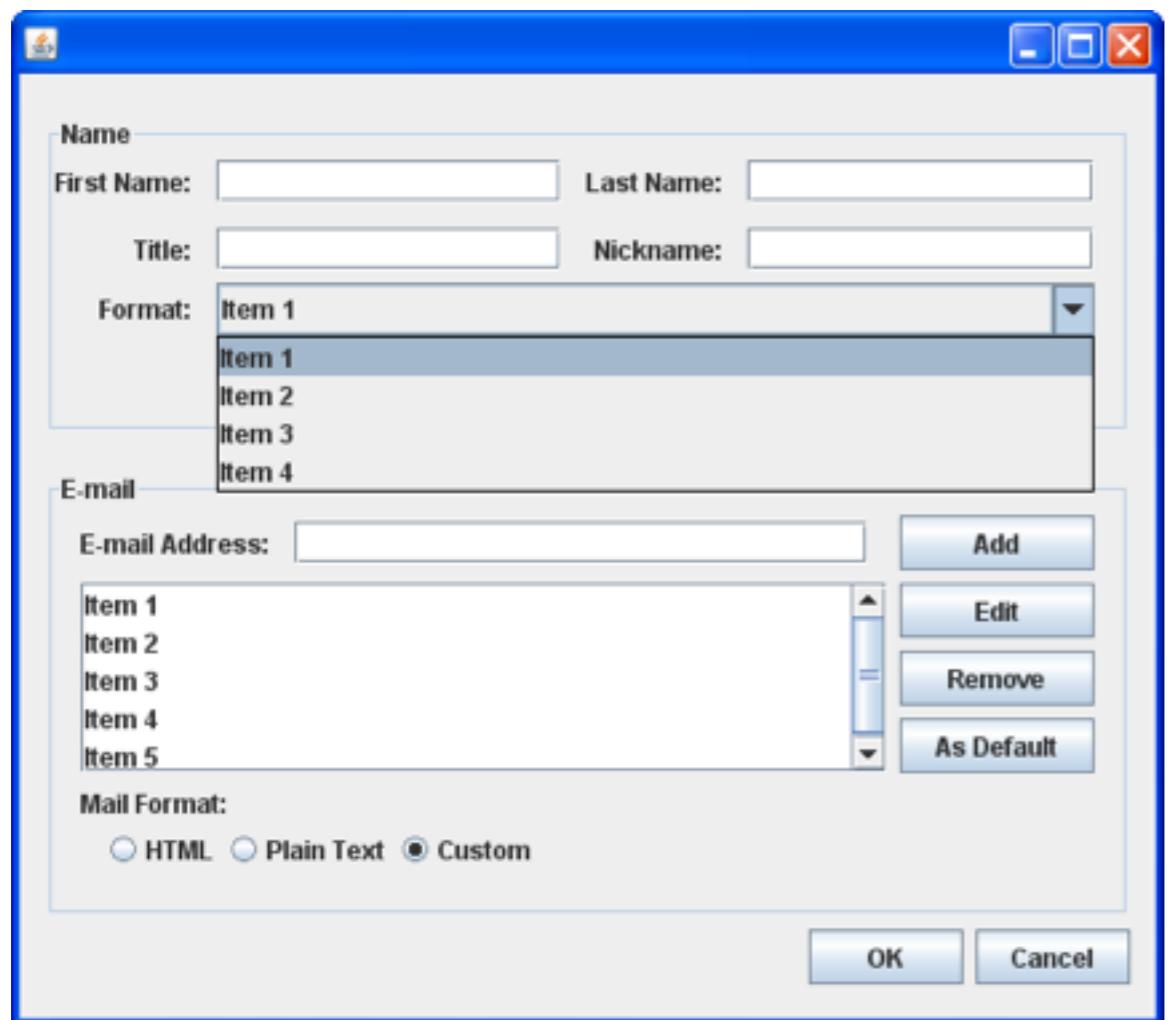
    (value)(value)
    {
        [id] = [parse id]
        _value = value
        if (id == null) {
            id = 0 + 1
        }
    }
```

- **Acciones:** Métodos de la clase
 - **Estados:** Observadores o Acciones Habilitadas



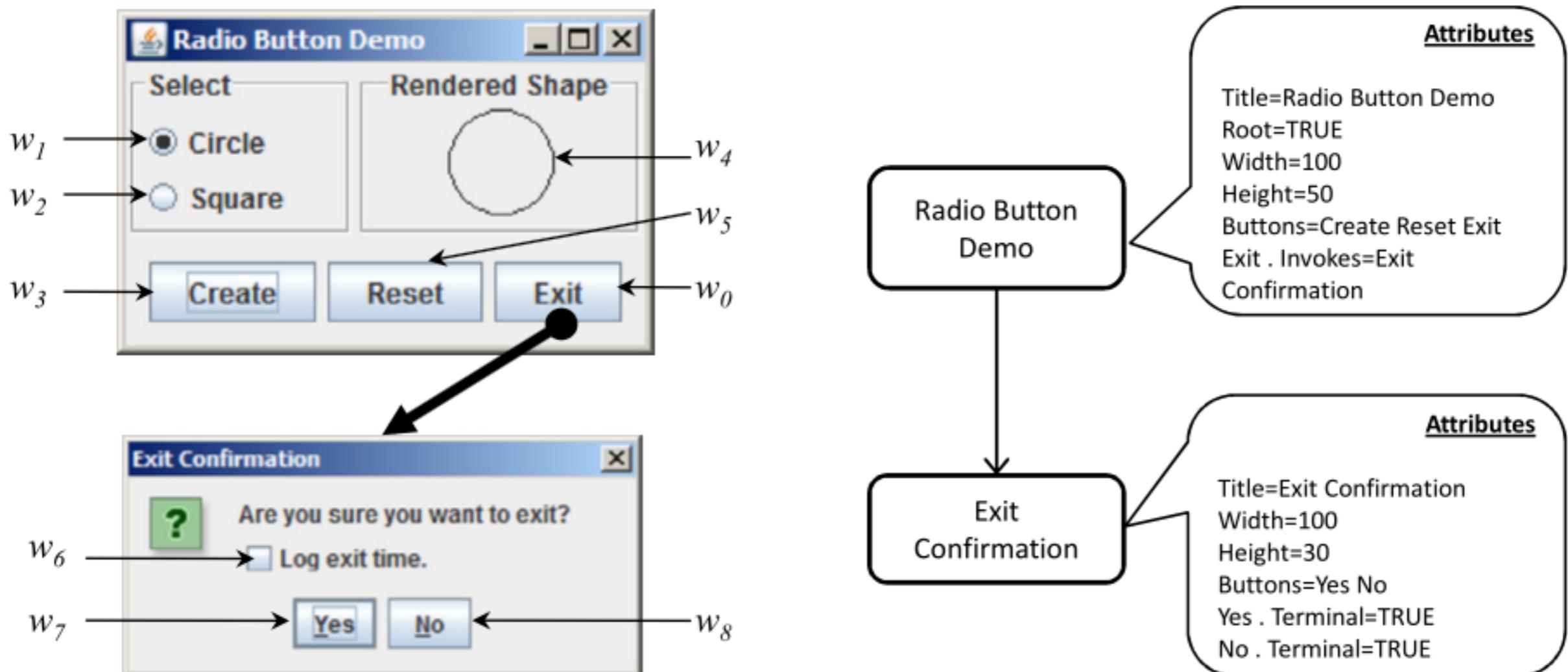
Una Aplicación con
una GUI

GUI Applications



- **Acciones:** eventos sobre widgets (click, double-click, drag&drop, enter text, enter number, etc)
- **Estados:**
 - Widgets habilitados
 - Valores de Atributos

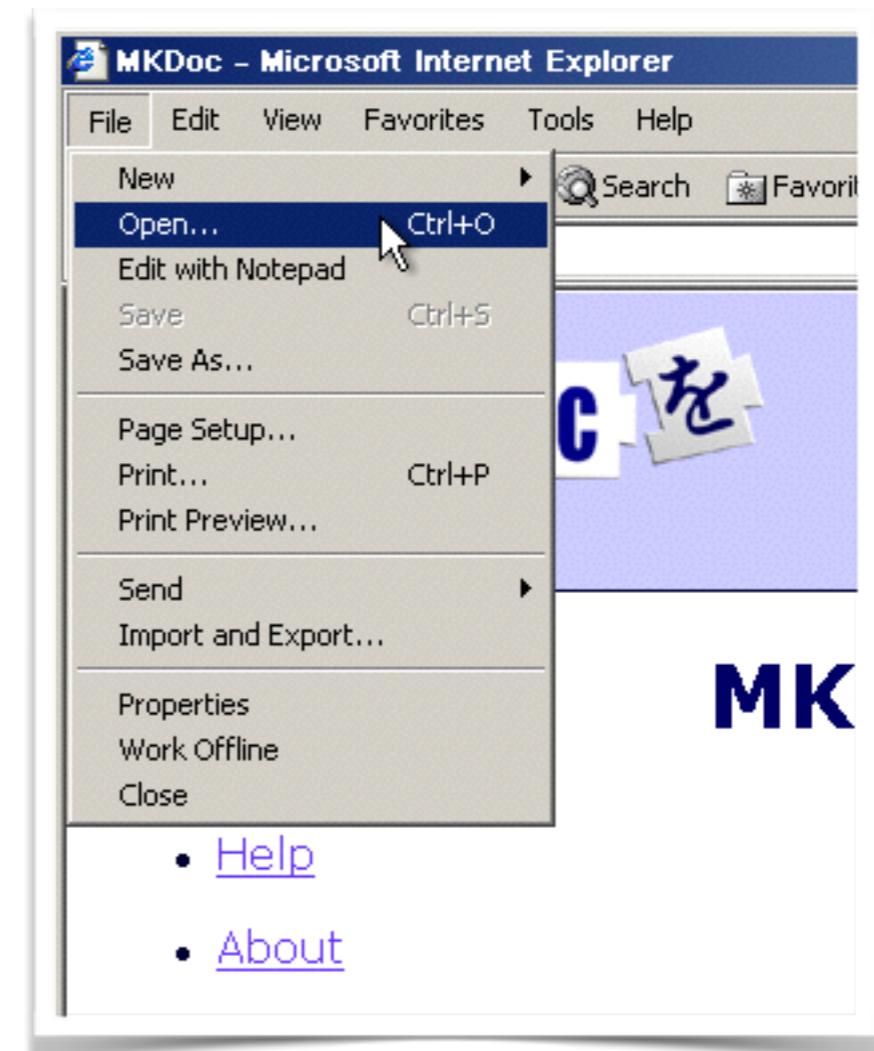
Widgets / Atributos



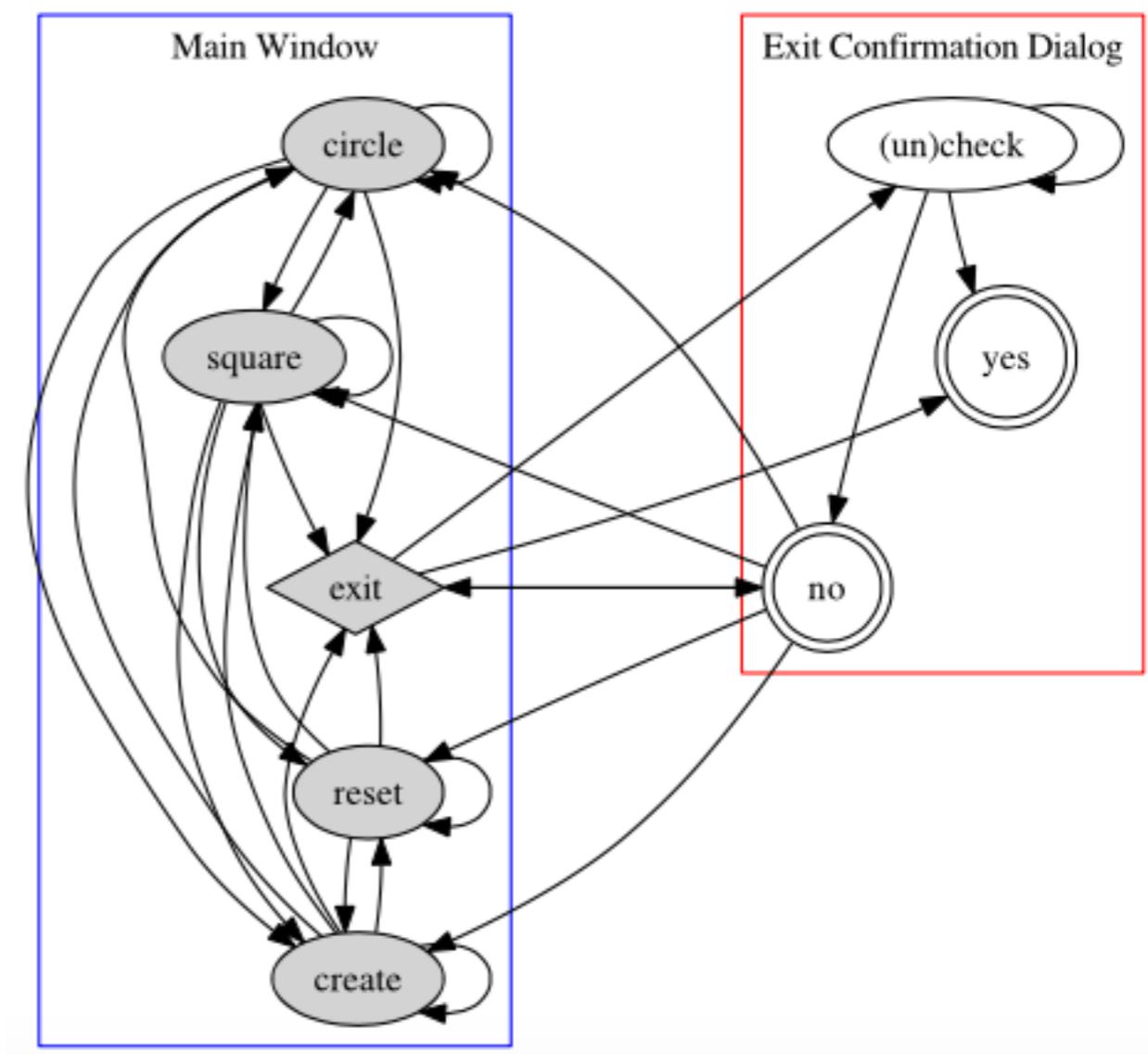
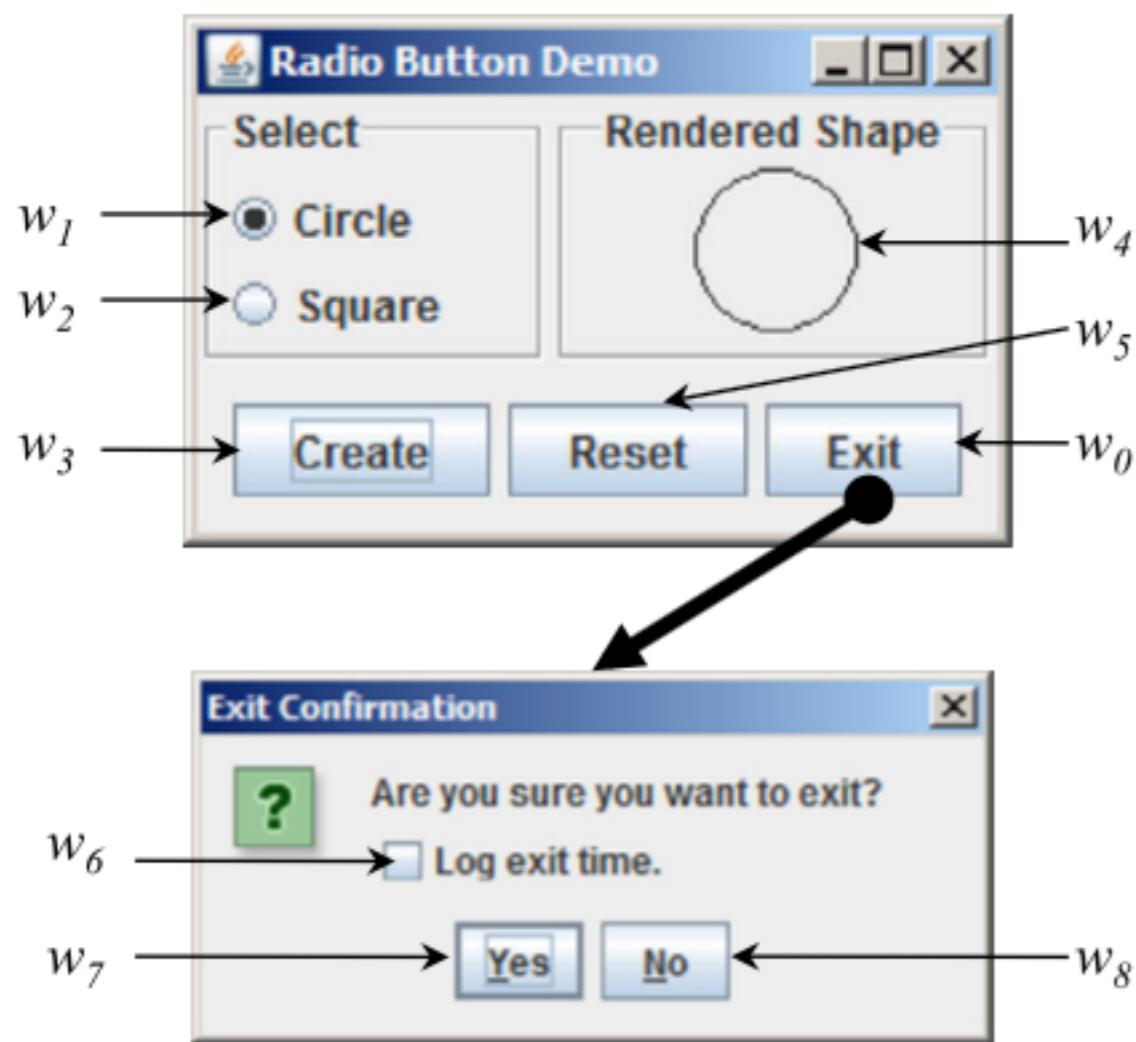
Widgets de cada componente GUI

GUI Tree

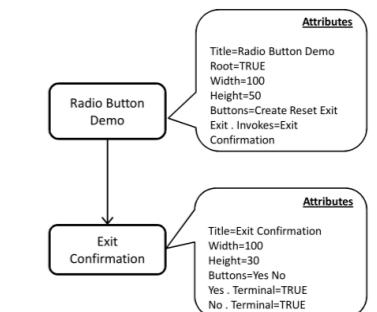
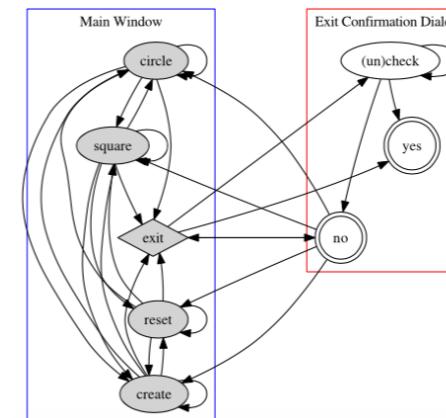
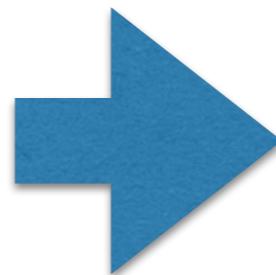
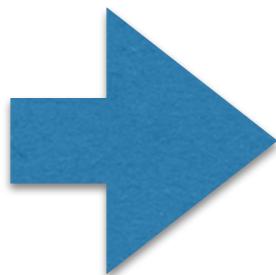
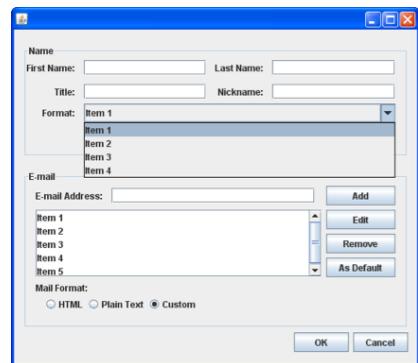
Event-flow graph (EFG)



EFG de RadioButton Demo



GUI Testing frAmewoRrk (GUITAR)



EFG

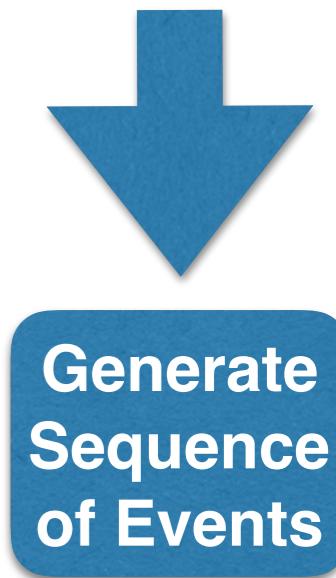
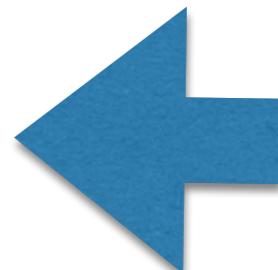
GUI Tree

Crashes?
Assertions?
Regressions?

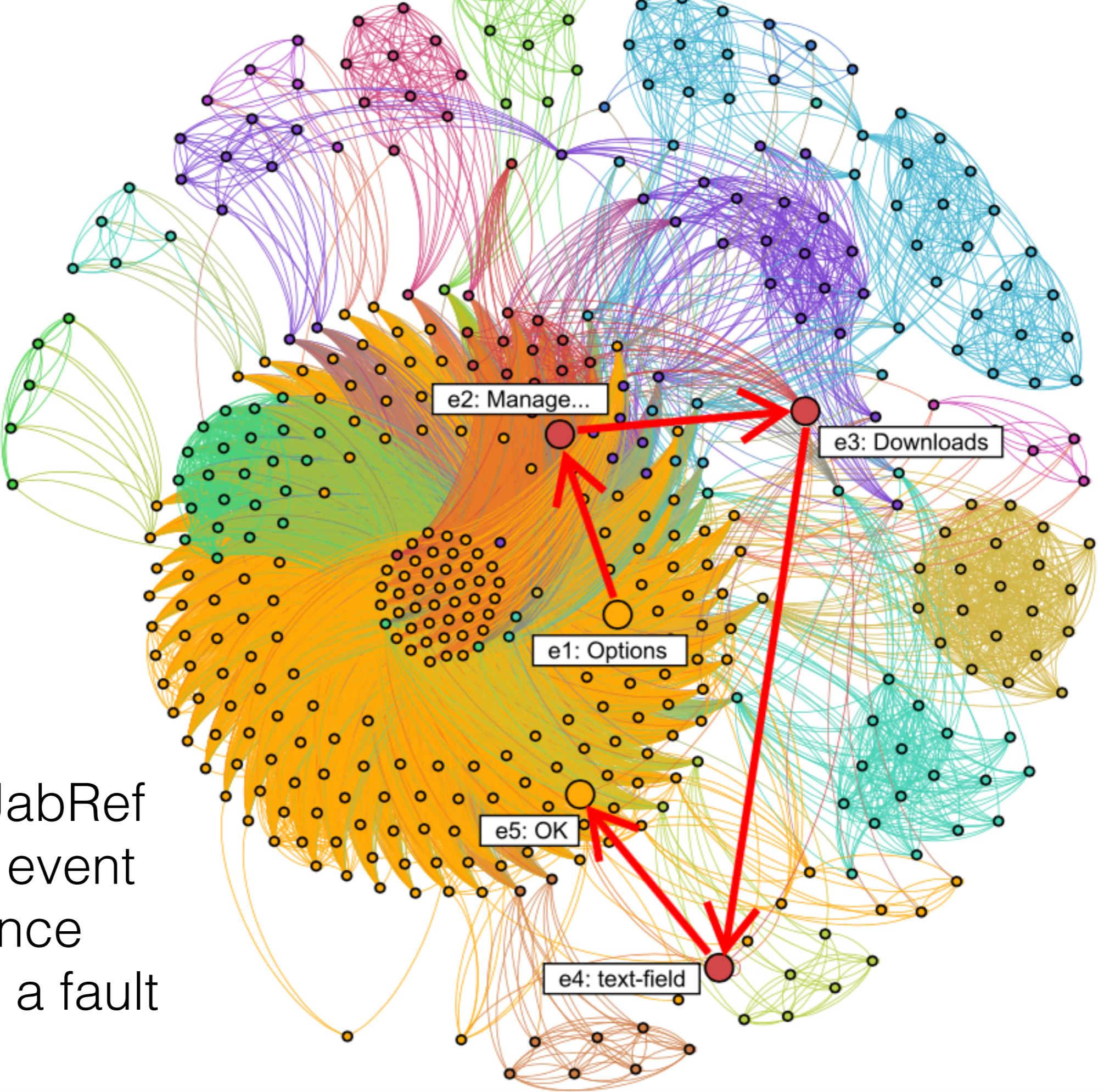


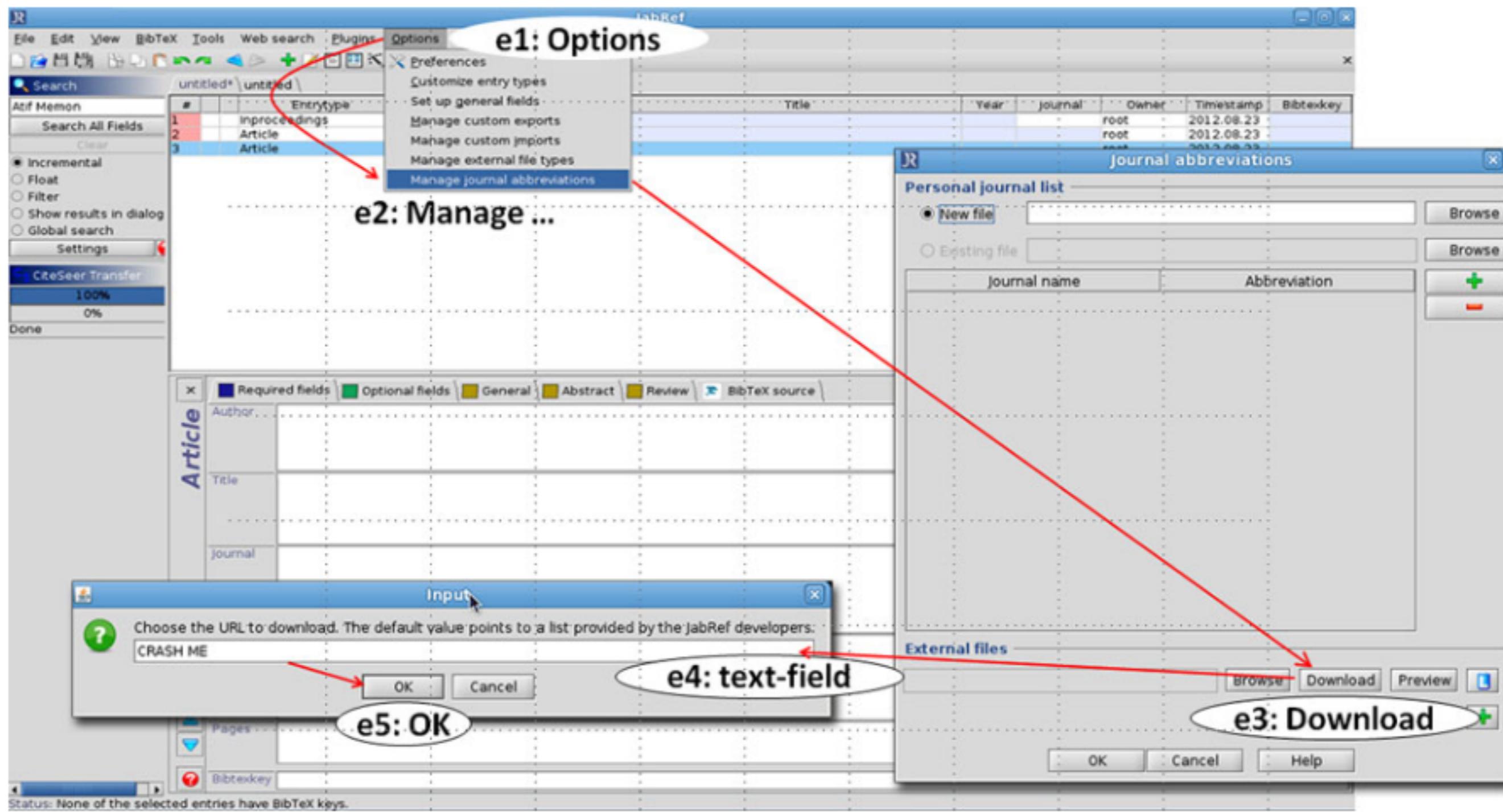
<click,New>
<click,Open>
<keyDown,"A">
<keyDown,"B">
<click,OK>

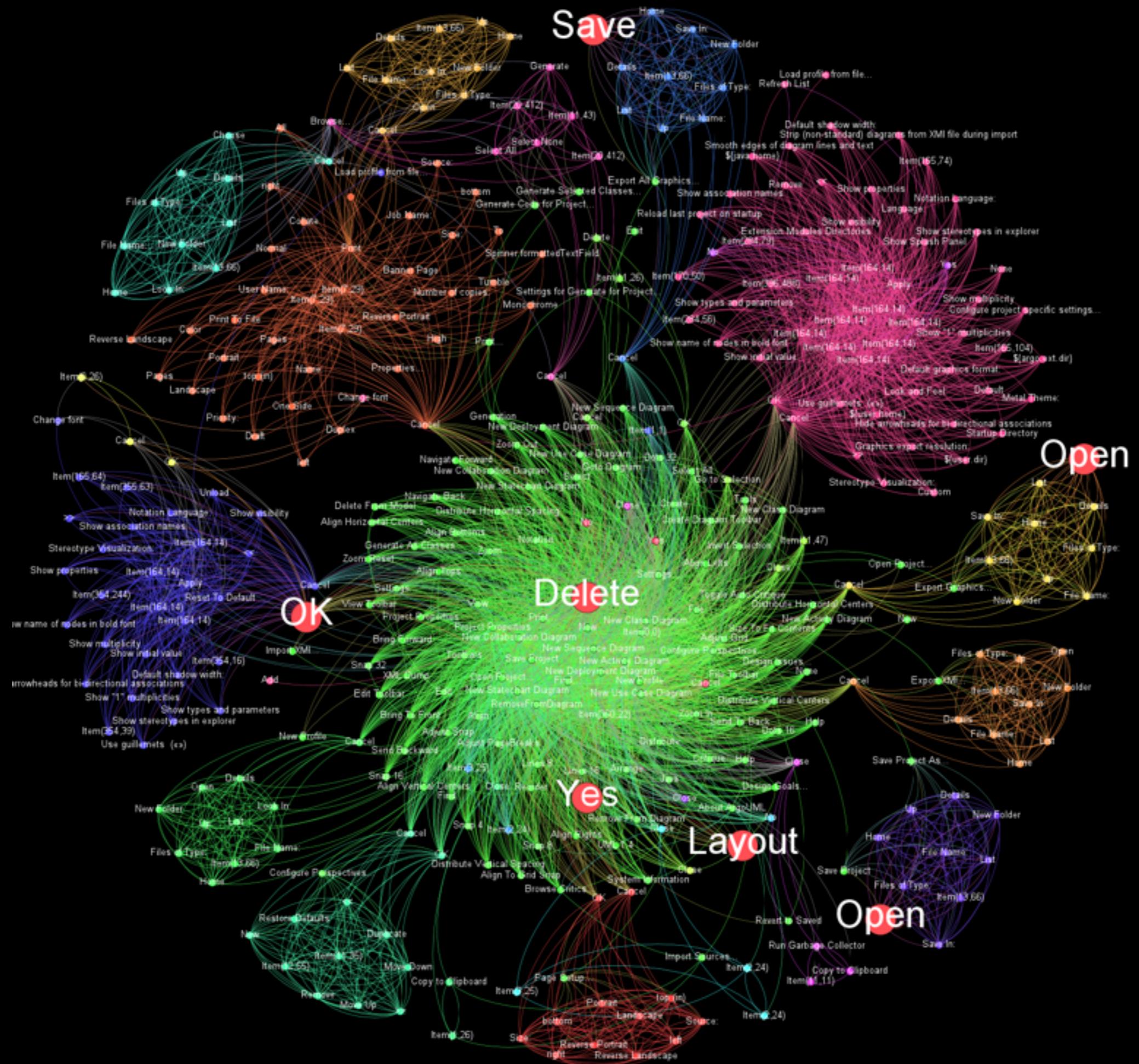
...



EFG for JabRef
with one event
sequence
triggering a fault







GUI Testing frAmewoRrk (GUITAR)

- <https://sourceforge.net/projects/guitar/>
- Construye un **modelo inicial** (que no es modificado con las observaciones)
- Genera **aleatoriamente** secuencias para explorar nuevos caminos del EFG
- Sólo utiliza los atributos del estado para chequear **regresiones** o verifica la ausencia de **crashes**

EXSyst

- EXSyst: **Exploration of Systems**
- Utiliza un **algoritmo genético** para evolucionar los test suites
 - Maximiza **code coverage**
 - El modelo (EFG) es usado para definir cuáles son las acciones posibles y reducir el espacio de búsqueda
 - Se actualiza a medida que se observa nuevos estados y acciones posibles



Address Book

New contact

New category

First name	Last name	E-mail	Phone	Mobile

All

Category name:
eO*I already exists

Abbrechen OK

Apply

First name

Last name

Second e-mail

Phone

URL

Mobile

Notes

GUI Testing

- Mayormente manual (ejecución y oráculo)
- La mayoría de los frameworks de GUI Testing son propietarios (pagos)
- A nivel técnico, la tecnología utilizada (swing/awt/etc) puede ser determinante de la herramienta elegida

The Web



GUI vs. Web

- Hay una tendencia cada vez más marcada de reemplazar aplicaciones GUI por aplicaciones Web
 - GoogleDocs
 - Colaboración
 - Stats,
 - Etc.

Selenium



```
Webdriver driver = new FirefoxDriver();

Wait<WebDriver> wait = new
WebDriverWait(driver, 30);

driver.get("http://www.google.com/");

//type search query

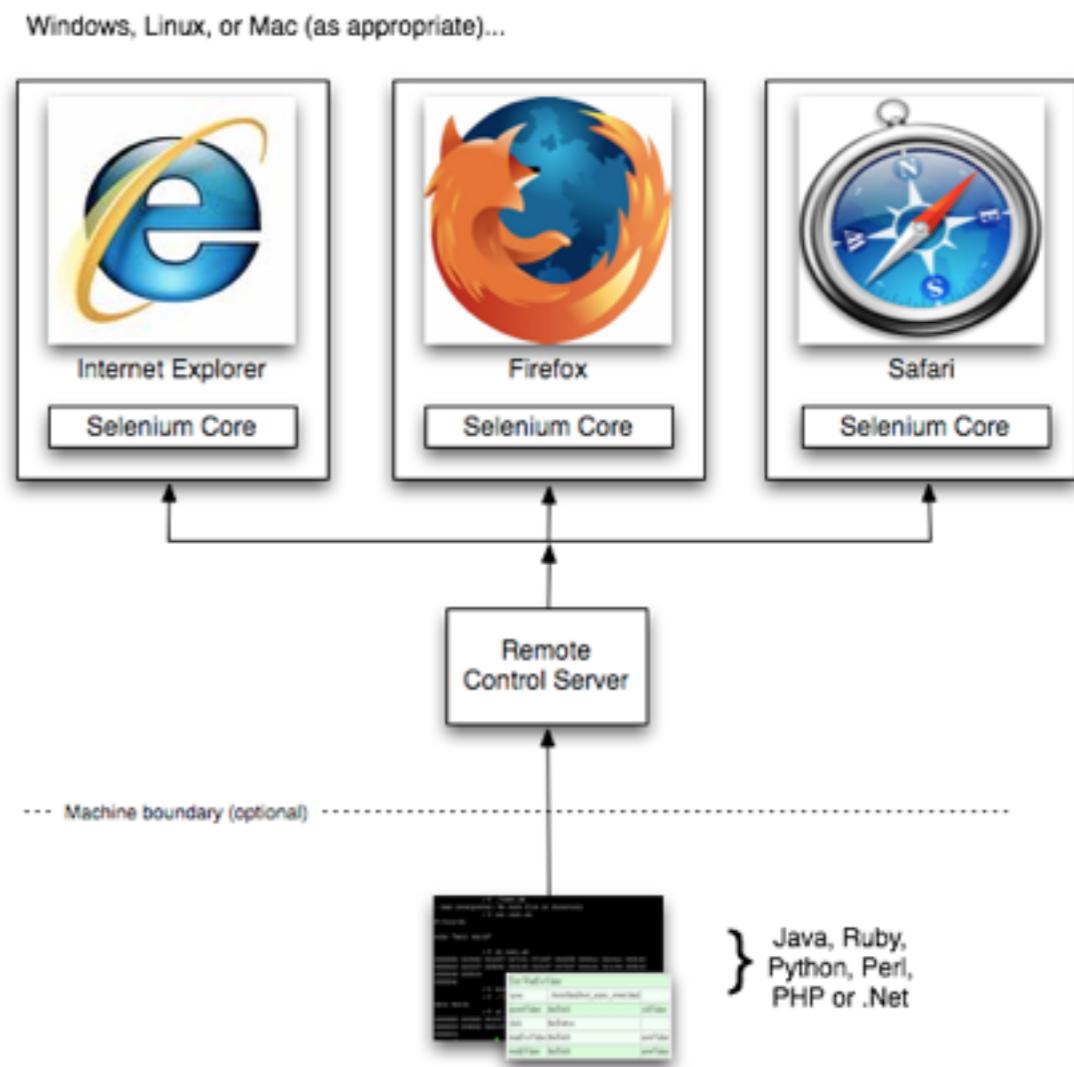
driver.findElement(By.name("q")).sendKeys(
"qa automation\n");

// click search

driver.findElement(By.name("btnG")).click();

// check result

assertTrue(driver.findElement(By.tagName("body"))
).getText().contains("qaautomation.net"));
```



Capture & Replay

The screenshot shows a Mozilla Firefox browser window with the title "2.6.x on HSQLDB : Gateway : Welcome - Mozilla Firefox". The address bar displays "http://nightly2.sakaiproject.org:8087/portal". The main content area shows the "Welcome" page of the Sakai project, featuring links for "Training", "Acknowledgments", "New Account", and "Help". A sidebar on the left contains options like "Toolbars", "Firebug", "Status Bar", and "Sidebar". The "Sidebar" option is expanded, showing "Adblock Plus: Blockable Items", "Stop", "Reload", "Zoom", "Page Style", "Character Encoding", "Page Source", and "Full Screen".

A Selenium IDE extension is installed in the browser. A context menu is open over the Selenium IDE interface, with options "Play Suite" and "Play Single Test" highlighted by red arrows. The Selenium IDE interface itself has tabs for "Table" and "Source". It displays a list of recorded test steps:

Command	Target	Value
type	eid	admin
type	pw	admin
clickAndWait	//input[@value='submit']	
click	//input[@id='joinable']	ai-sit...
select	joinerRole	label=Student

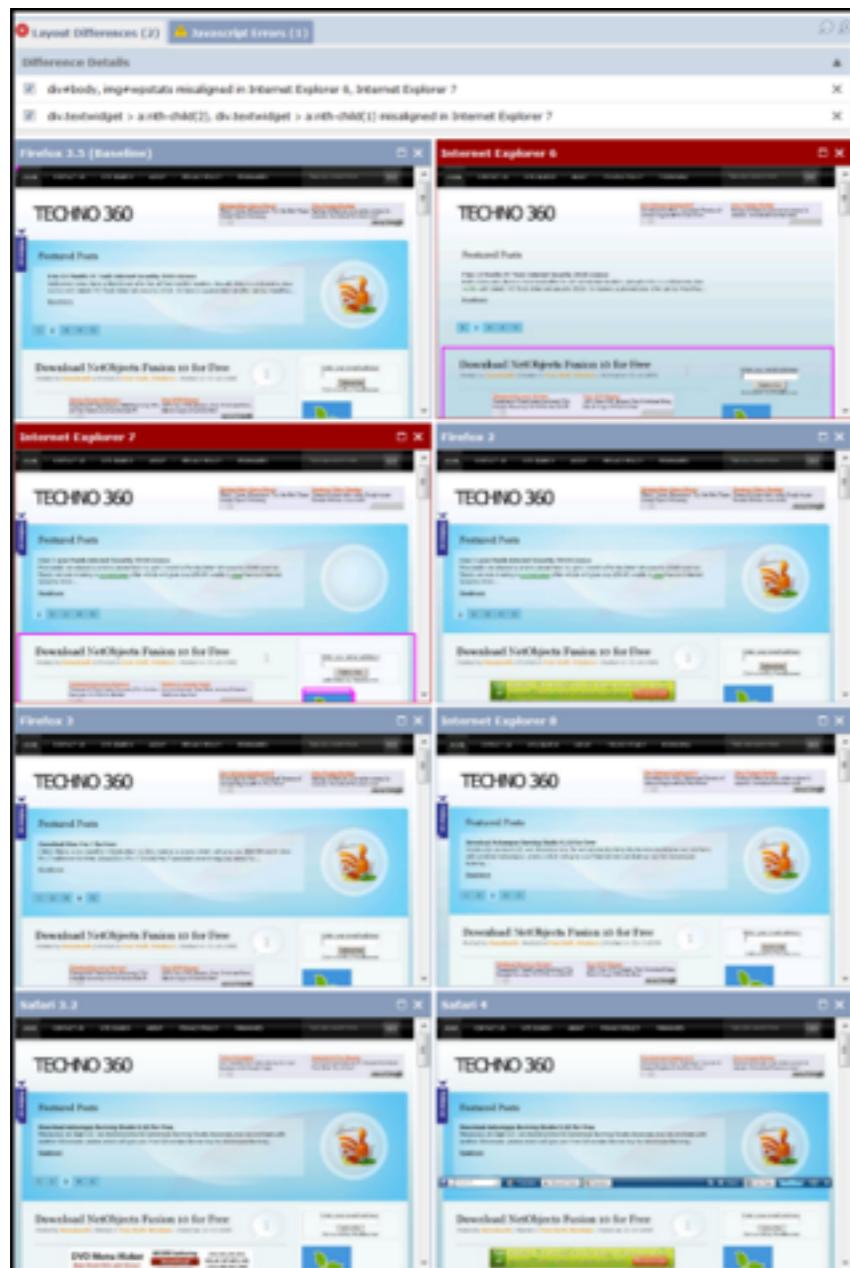
At the bottom of the Selenium IDE interface, there are buttons for "Log", "Reference", "UI-Element", "Rollup", "Info", and "Clear". The status bar at the bottom of the browser window also shows the Selenium IDE interface.

The right side of the image shows a detailed view of the Selenium IDE interface, focusing on the recorded steps. Red arrows point from the "Record" button in the context menu to the "Record" button in the Selenium IDE toolbar, and from the "Play Suite" button to the "Play Suite" button in the Selenium IDE toolbar. The recorded steps are listed in a table with columns "Command", "Target", and "Value".

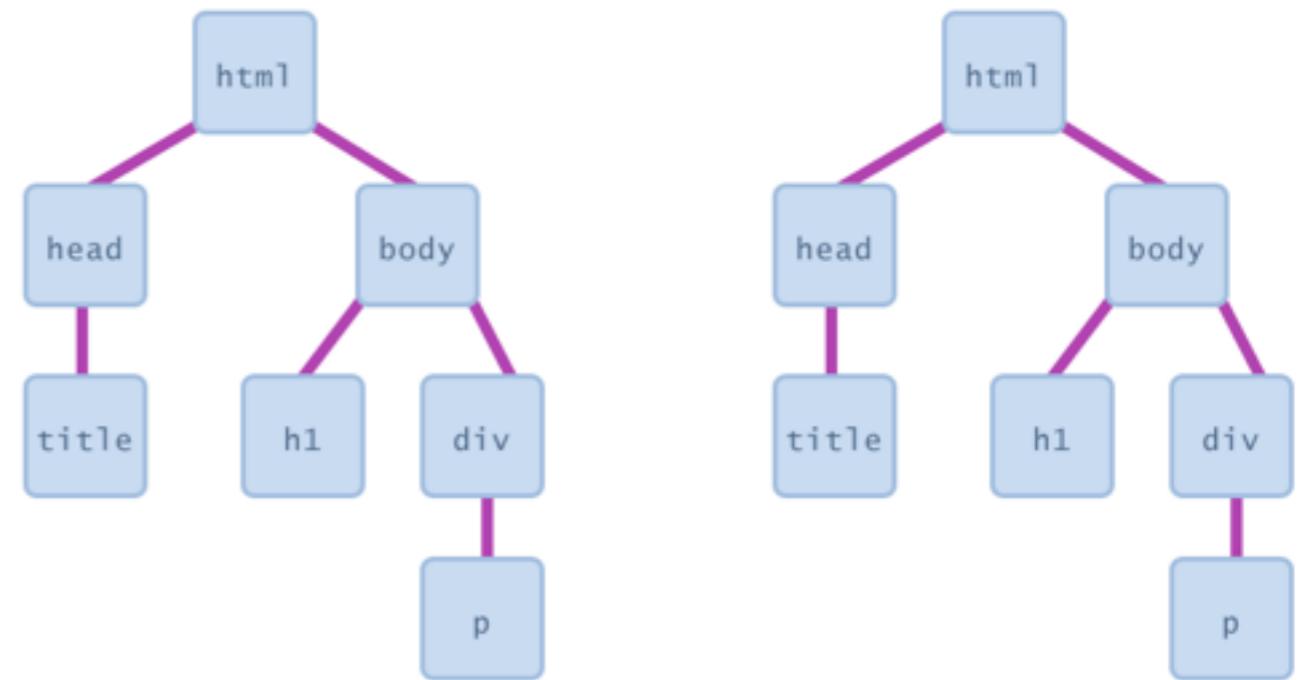
Command	Target	Value
type	eid	admin
type	pw	admin
clickAndWait	//input[@value='submit']	
click	//input[@id='joinable']	ai-sit...
select	joinerRole	label=Student

The status bar at the bottom of the Selenium IDE interface shows log entries: "[info] Executing: |type | pw | admin |" and "[info] Executing: |type | eid | admin |".

Una página



Screenshot



Document Object Model (DOM)

Document Object Models

- Una representación lógica de que es un documento web (HTML/XML)
- Una API para acceder y manipular Documentos Web
- Un documento es un DOM tree o DOM forest (conjunto de DOM Trees)

CrawlJax

- Explorar aplicaciones AJAX
- Opensource:<http://crawljax.com>
- Estado: DOM Tree
- Eventos: click, mouseover, dblclick... sobre HTML elements
- Compara el DOM Tree **antes** y **después** de cada evento (Levenshtein edit distance)

Invariantes

- Sobre un único estado (DOM tree)
 - Validación del DOM, Mensajes de error, accesibilidad,
- Entre estados
 - Back-Button consistente, No clicks “muertos”
- User-defined:
 - Escribir un predicado que se evalúa en cada nuevo estado visitado

Crossbrowser Compatibility



Internet Explorer



Firefox



Safari



Google Chrome



Opera



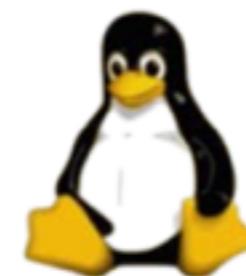
Internet Explorer 6



Firefox 3.5



Internet Explorer 7



Diferencia de Layout

The image shows two side-by-side screenshots of a Microsoft advertisement for Windows 7. Both screenshots feature the same layout and content, but they are displayed in different web browsers.

Left Screenshot (Mozilla Firefox):

- Header:** It's a pleasure to buy and own.
- Section 1:** We'll help you shop.
Visit any Apple Retail Store, and you'll get expert advice, custom computer consulting, or instant Mac support for free. Visit www.apple.com/macbook for appointment details for a Personal Consulting Appointment.
- Section 2:** It's a pleasure to buy and own! The Apple MacBook Air is fast, expressive, and it's designed just for the screen. If you need more, just add accessories.
- Section 3:** We'll help you move.
Buy a Mac or an Apple iMac, and it comes with integrated all-in-one floor protection and customization for your needs. If you're not sure if it's right for you, visit apple.com/ibuy or speak with a friendly Apple Store employee.
- Section 4:** We'll give you support.
Every Mac comes with award-winning support. Get you connected to the AppleCare Protection Plan for most parts of your Mac, and have quick access to support available at apple.com/techsupport.
- Section 5:** We'll help you learn.
It's easy to learn how to use Mac OS X and Mac OS X Server on a Windows PC, even if you've never been before. Start getting started. Luckily, we offer various ways of learning. One recommended book by O'Reilly, *Learn Mac OS X*, is available online. Other hundreds of resources on Apple.com. Visit apple.com/learn.
- Image:** A large Firefox logo with a globe and a fox.

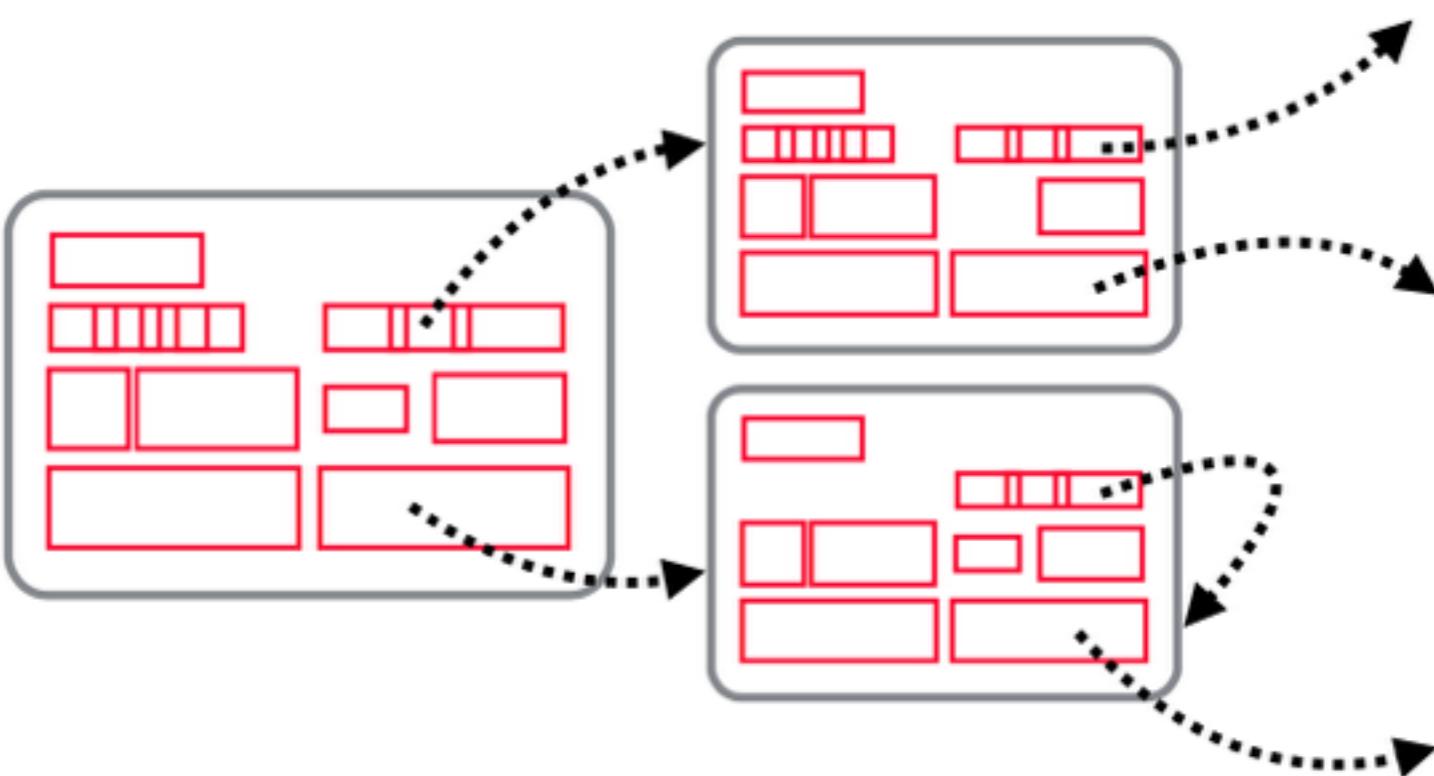
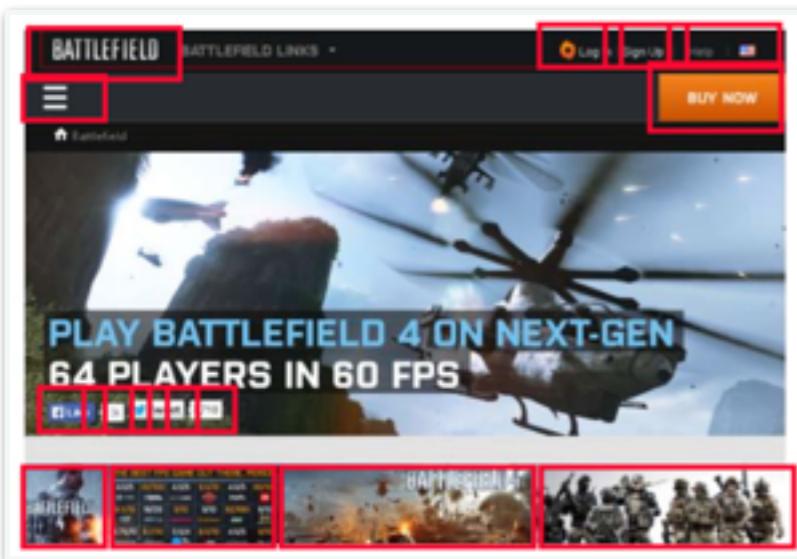
Right Screenshot (Internet Explorer):

- Header:** It's a pleasure to buy and own.
- Section 1:** We'll help you shop.
Visit any Apple Retail Store, and you'll get expert advice, custom computer consulting, or instant Mac support for free. Visit www.apple.com/macbook for appointment details for a Personal Consulting Appointment.
- Section 2:** It's a pleasure to buy and own! The Apple MacBook Air is fast, expressive, and it's designed just for the screen. If you need more, just add accessories.
- Section 3:** We'll help you move.
Buy a Mac or an Apple iMac, and it comes with integrated all-in-one floor protection and customization for your needs. If you're not sure if it's right for you, visit apple.com/ibuy or speak with a friendly Apple Store employee.
- Section 4:** We'll give you support.
Every Mac comes with award-winning support. Get you connected to the AppleCare Protection Plan for most parts of your Mac, and have quick access to support available at apple.com/techsupport.
- Section 5:** We'll help you learn.
It's easy to learn how to use Mac OS X and Mac OS X Server on a Windows PC, even if you've never been before. Start getting started. Luckily, we offer various ways of learning. One recommended book by O'Reilly, *Learn Mac OS X*, is available online. Other hundreds of resources on Apple.com. Visit apple.com/learn.
- Image:** A large Internet Explorer logo with a blue 'e' inside a yellow oval.

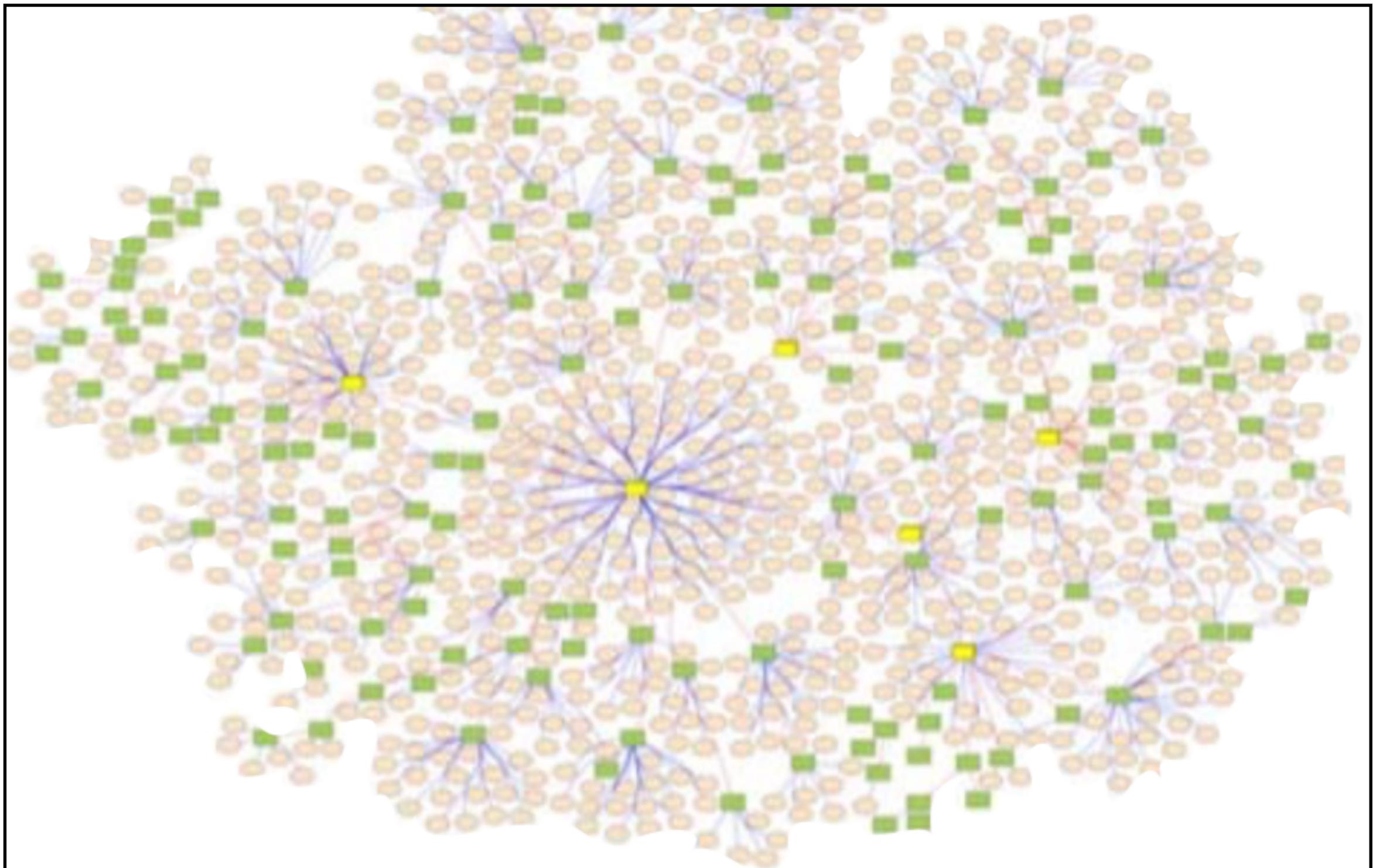
Webmate

- Target: crossbrowser compatibility de web apps
 - *¿La página se ve igual en todos los browsers?*
- Inspirado en Typestates enriquecidos

Webmate



Webmate



Crossbrowser Checking

Dashboard / Test: <http://www.battlefield.com/> / State: e7b5f462538c372 / Issue: 50135

Incorrect Dimensions: //div[@id='gus-wrapper']/div[1]/div
(<http://www.battlefield.com/> / e7b5f462538c372)

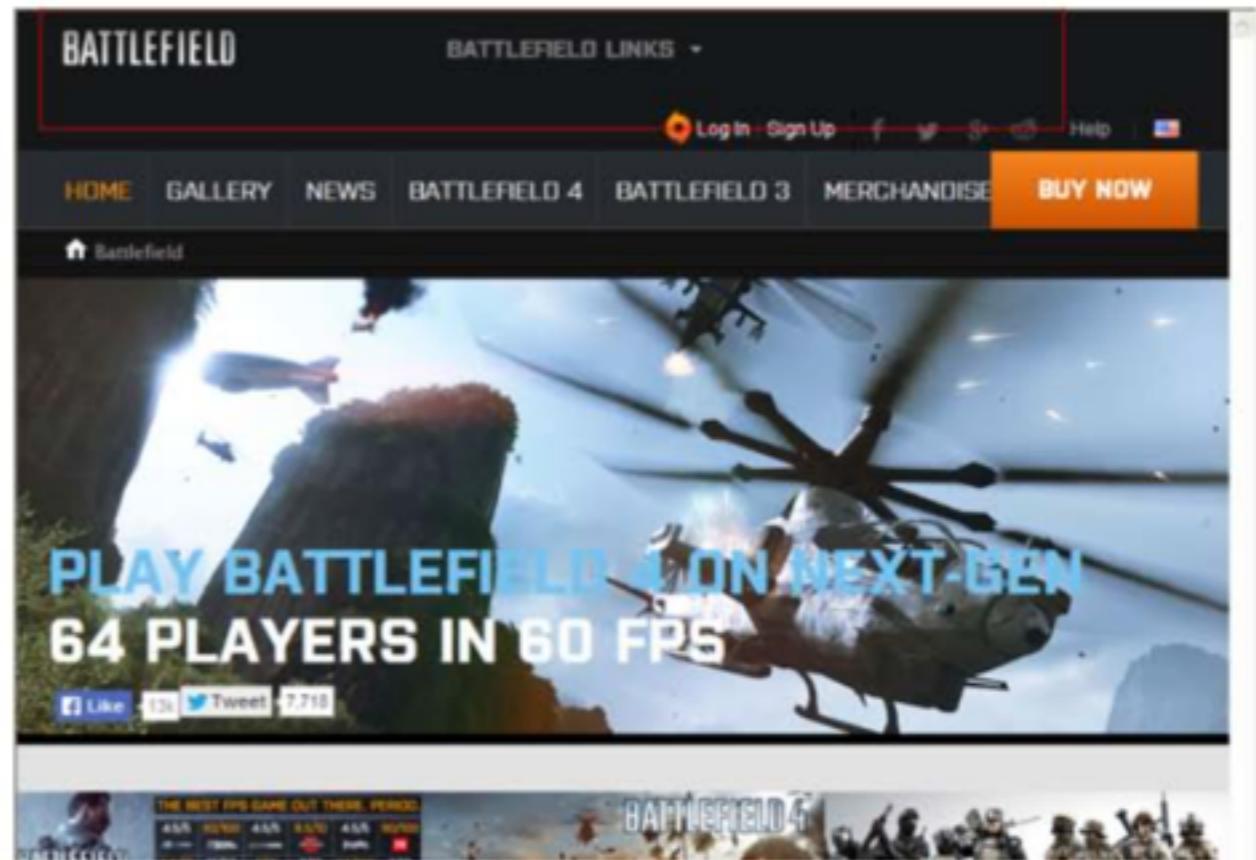
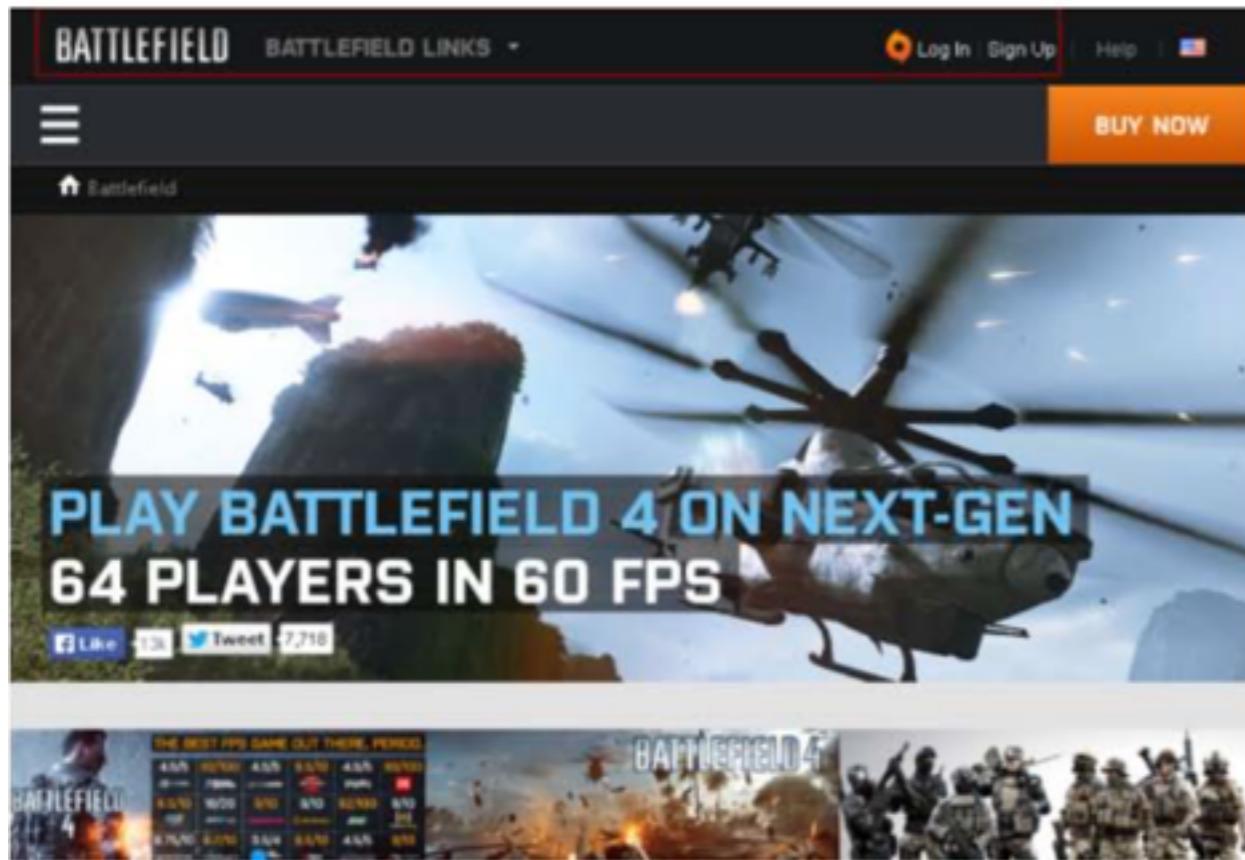
Reference Browser

Mozilla Firefox 17 / Windows XP

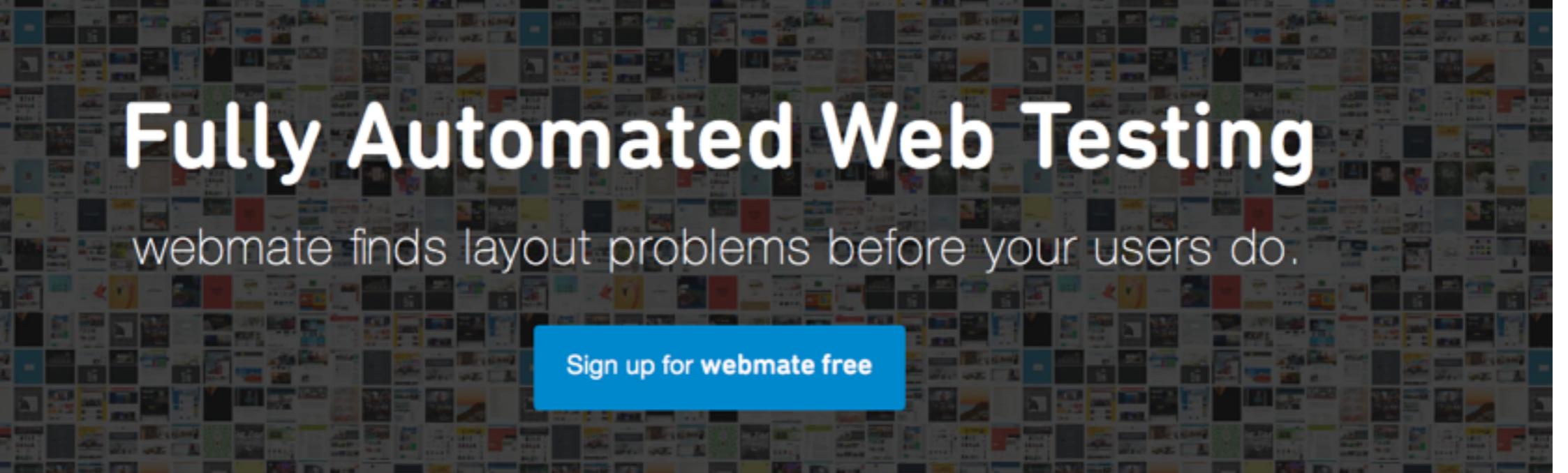


X-Browser

Internet Explorer 8 / Windows 7



<http://webmate.io>



Fully Automated Web Testing

webmate finds layout problems before your users do.

[Sign up for webmate free](#)



webmate Live Testing

For debugging, access to live systems is indispensable. webmate provides live access to virtual machines, directly in your browser (no plugin necessary).

webmate Live Testing is Testing Infrastructure as a Service with over 300 browser installations available and many tools that make testing and development easier. Read more about webmate Live Testing (formerly known as "Browser Fleet") on our [blog](#).

Free your IT department from maintaining your testing infrastructure! webmate Live Testing can be used **free of charge** for up to 15 minutes per day.

[Sign up for webmate free](#)



STATE DIAGNOSIS

TEST OVERVIEW

WORKBENCH

Dr. Juan Pablo Galeotti - University

3 Differences detected:

Additional 3 ^

...div[1]/div[1]/div[8]/div[1]

...div[1]/div[1]/div[5]/div[1]

...div[1]/div[1]/div[4]/div[1]

Selected Cross B

IE 10 / Win 7

Launch
Quick TestAdd
New TestCreate
Issue FilterAccess
Filters

Reference Browser

Chrome 43 / Win 7 64



The screenshot shows a complex web page with multiple sections: "About Me" (including a photo and bio), "My Publications" (with several links), "My Teaching" (with course descriptions), "My Research" (with grants and publications), "My Awards" (with a list of awards), "My Patients" (with a list of names), "My Classes" (with course descriptions), "My Books" (with a list of books), "My Videos" (with a list of video links), and "My Groups" (with a list of groups). A sidebar on the right contains "LATEST NEWS" and "ARCHITECTURE". At the bottom, there's a "USER LOGIN" section.

The screenshot shows the same website structure in IE 10. A red box highlights a difference in the "LATEST NEWS" section of the sidebar. A callout box provides details about this difference.

XPath: //*[
 @id="block-
 views-news-
 list-block-
 1"]/div[1]/div[
 1]/div[1]/div[
 4]/div[1]

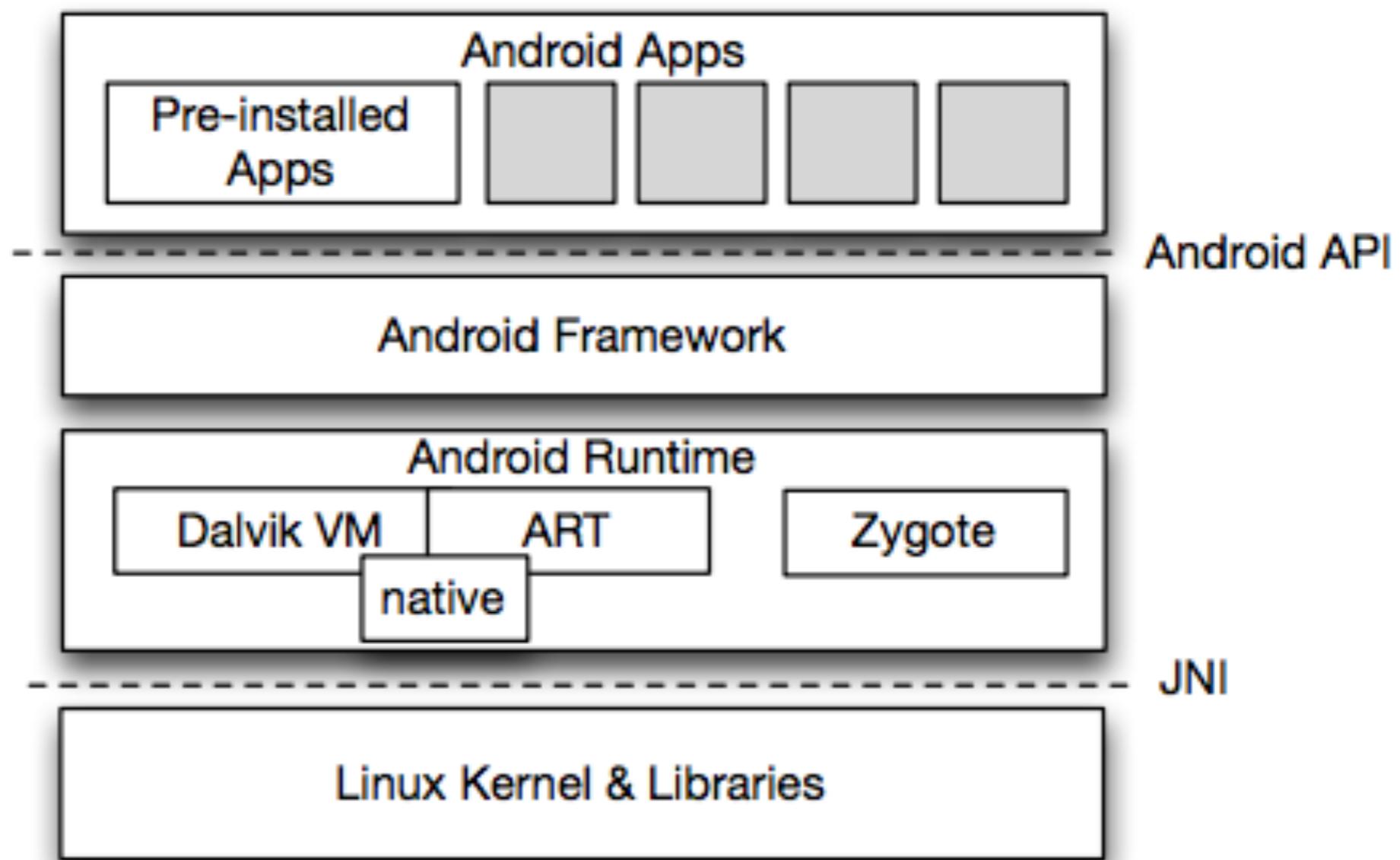
Details: Additional
Element -
Could not
find element
in reference
browser

Filter: Hide Difference for Run
 Exclude DOM Element

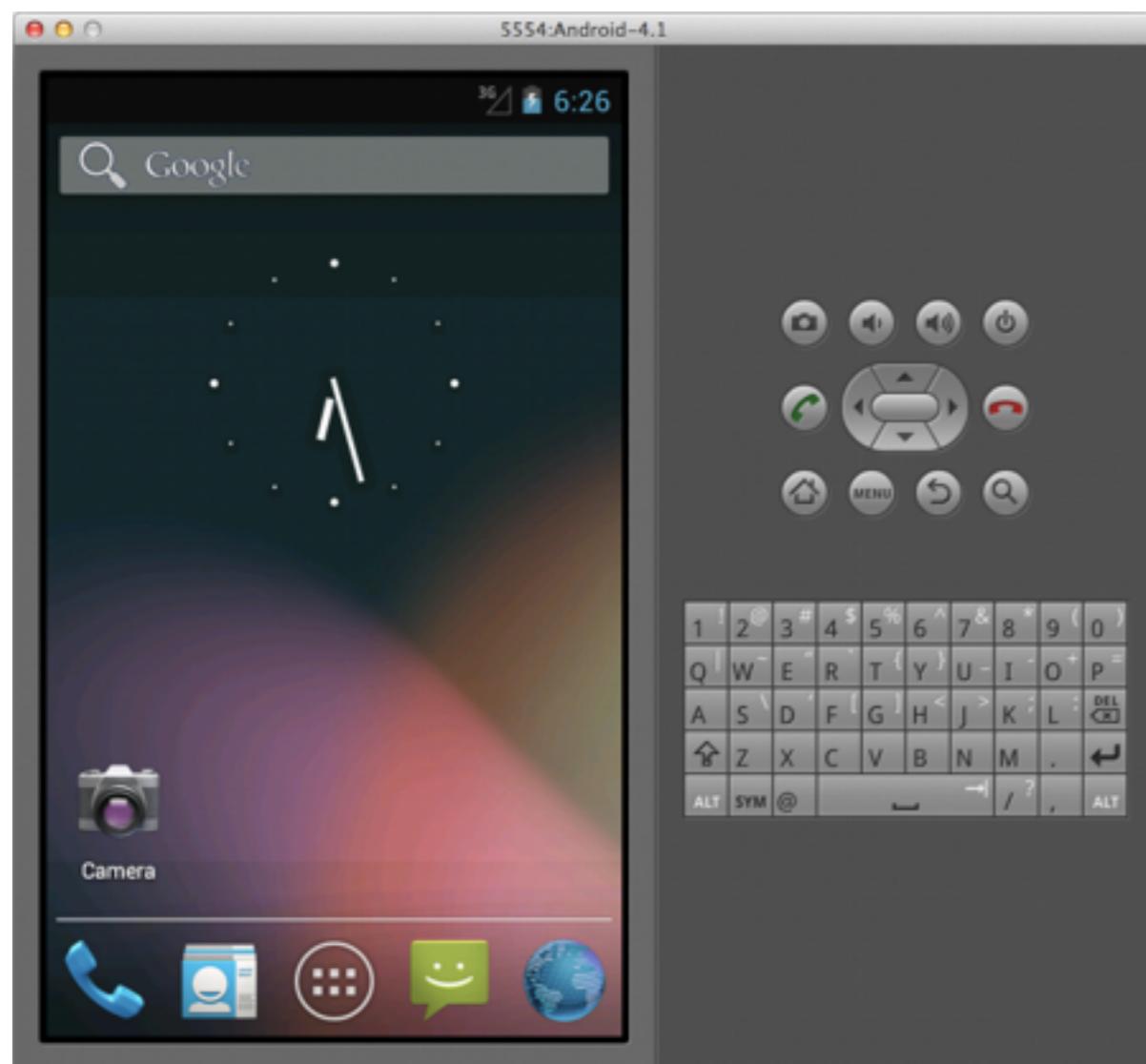
Android



Arquitectura Android



Ejecución de Tests



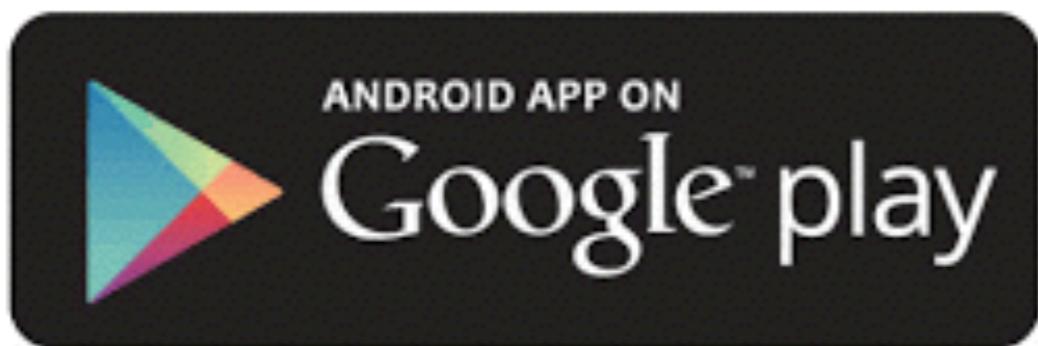
Emulador

VS.

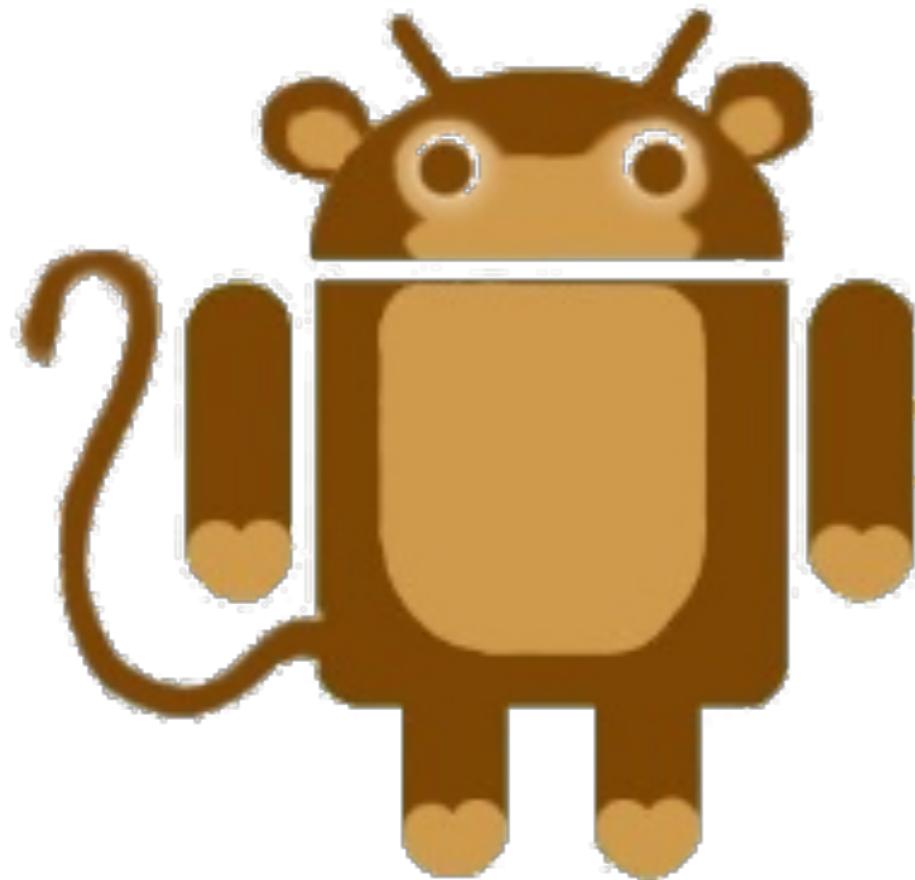


Dispositivo

App Stores



Monkey



- Parte del Android SDK
- **Black-box**
- Genera eventos UI al **azar**.
- El usuario indica el **tamaño** de la secuencia de eventos antes de un restart
- Solamente eventos UI

DynoDroid

- <http://www.cis.upenn.edu/~mhnaik/dynodroid.html>
- Eventos Soportados:
 - **UI events**: LongTap(245, 310), Drag(0, 0, 245, 310), etc.
 - **System events**: BatteryLow, SmsReceived("hello"), etc.
- Es una Virtual Machine. No instrumenta la app.
- Oráculo: **Crashes**

Observe-Select-Execute Algorithm

Algorithm 1 Overall algorithm of Dynodroid.

INPUT: Number $n > 0$ of events to generate.

OUTPUT: List L of n events.

$L :=$ empty list

$e :=$ event to install and start app under test

$s :=$ initial program state

for i from 1 to n **do**

 append e to L

 // Execute event e in current state s to yield updated state.

$s := \text{EXECUTOR}(e, s)$

 // Compute set E of all events relevant in current state s .

$E := \text{OBSERVER}(s)$

 // Select an event $e \in E$ to execute in next iteration.

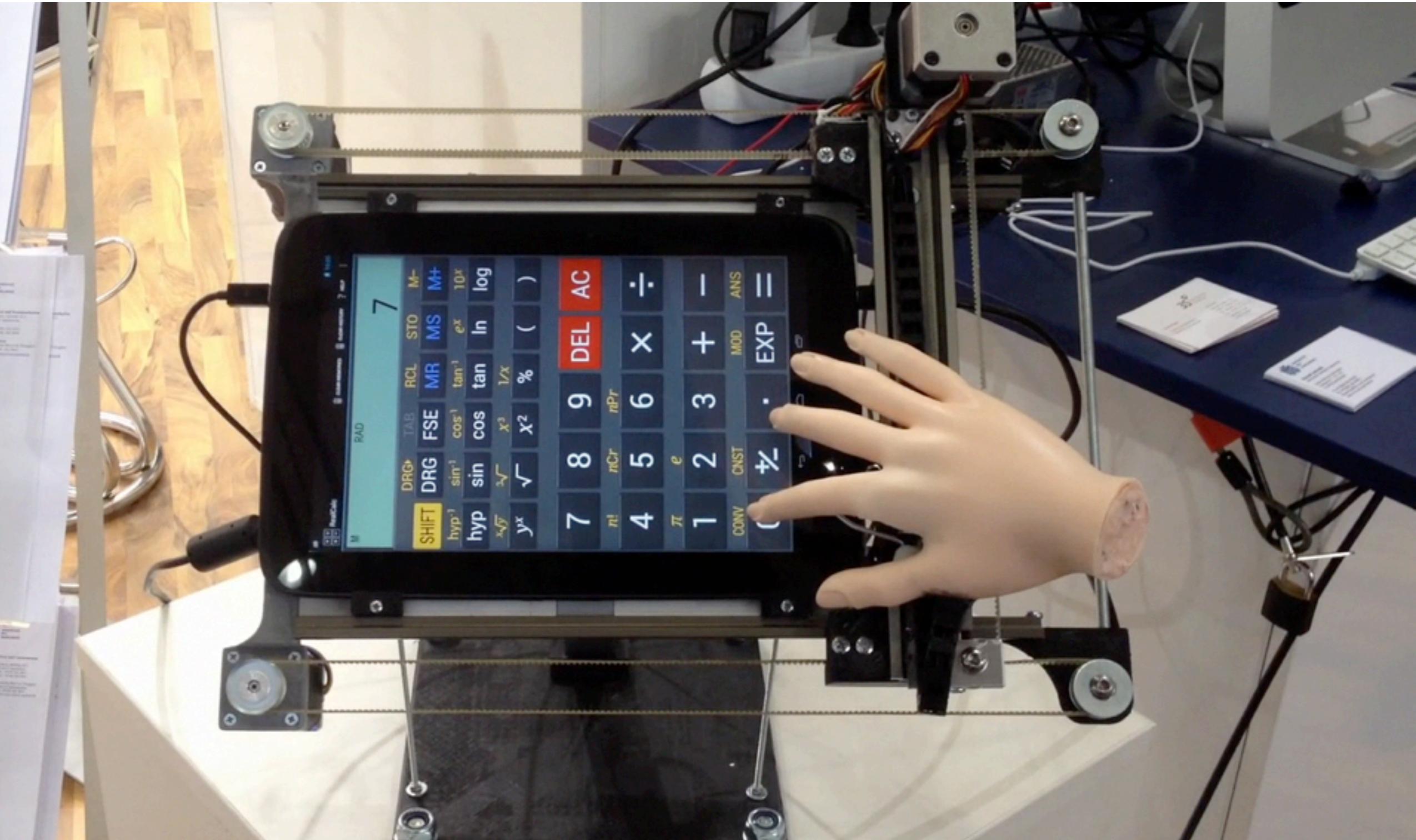
$e := \text{SELECTOR}(E)$

end for

Event Selection

- Frequency
 - Selects event that has been selected least often
 - **Drawback:** deterministic => unfair
- UniformRandom
 - Selects event uniformly at random
 - **Drawback:** does not consider domain knowledge; no distinction of UI vs. system events, contexts in which event occurs, frequent vs. rare events
- BiasedRandom
 - Combines both

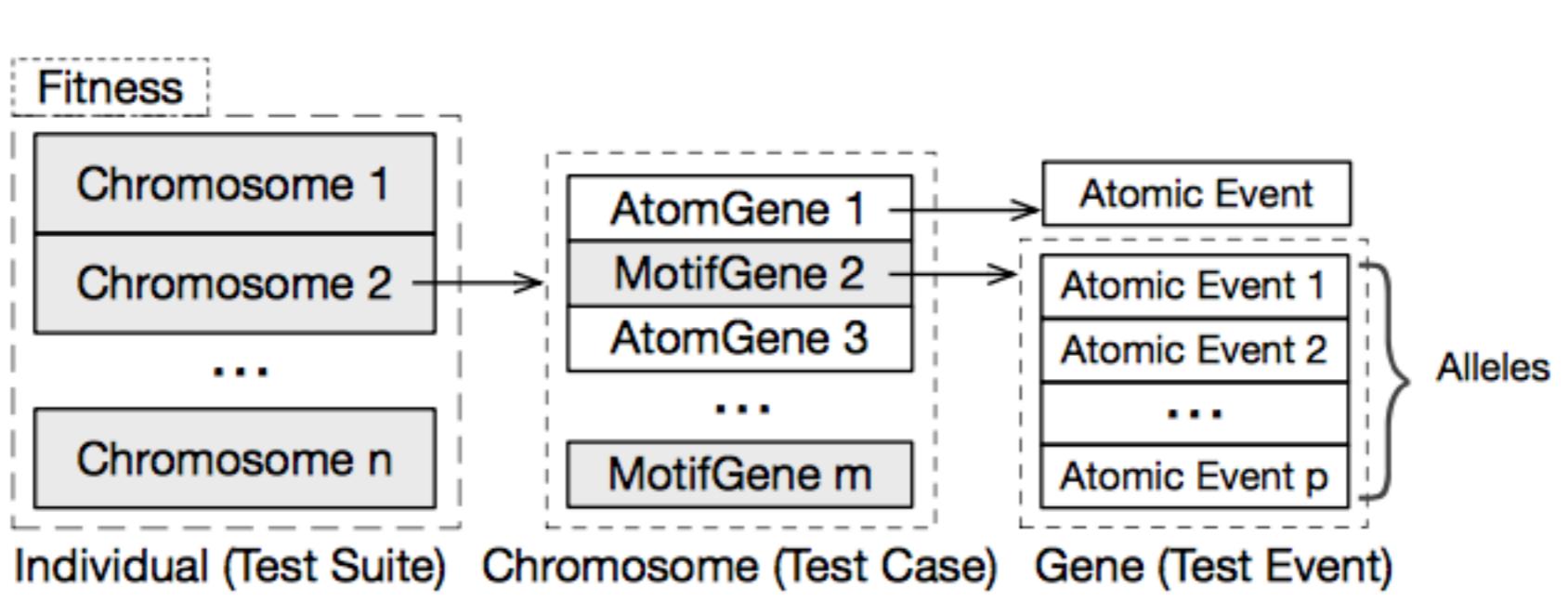
DroidMate



Sapienz

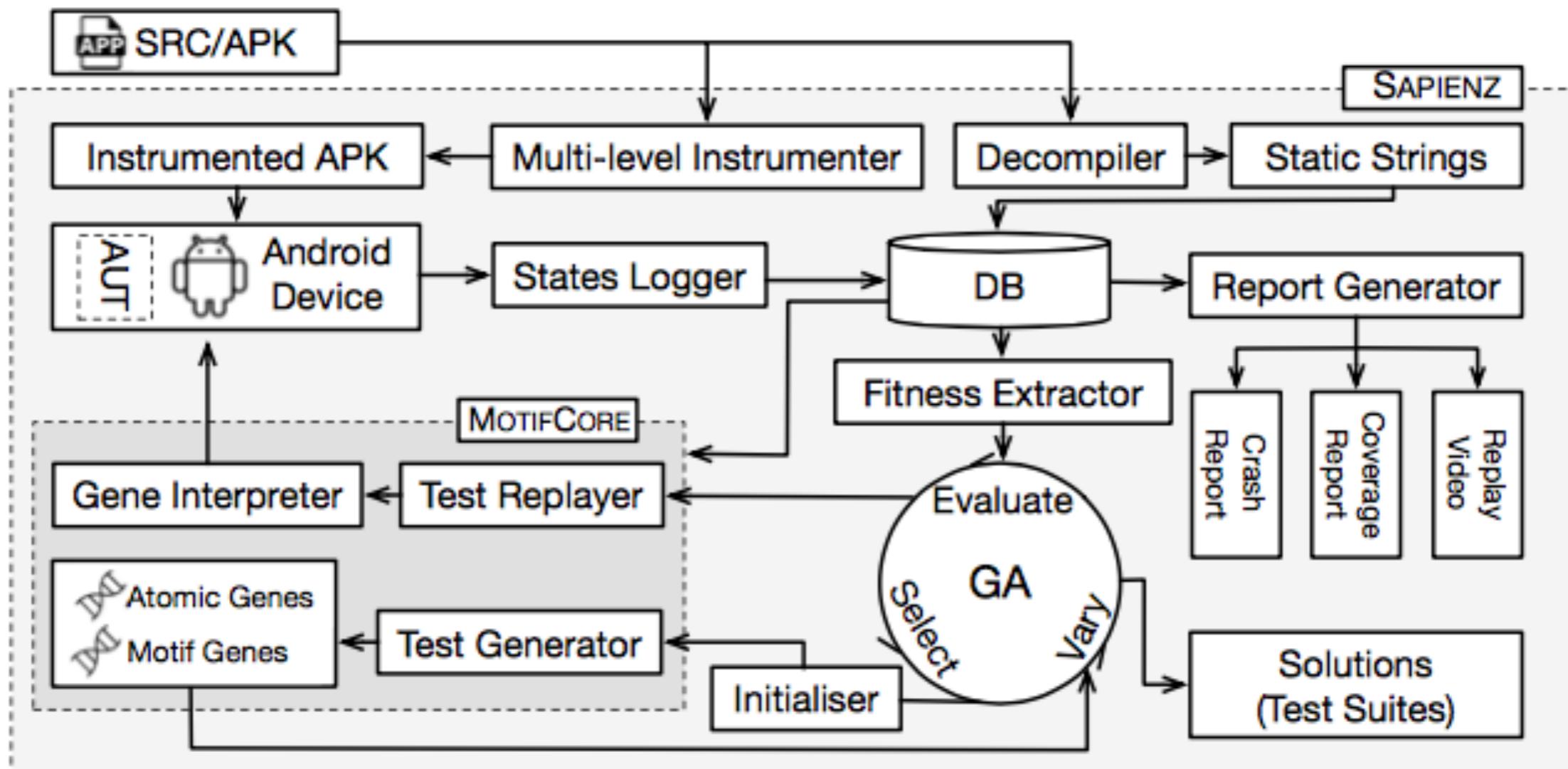
- <http://sapienz.tk>
- <https://github.com/Rhapsod/sapienz>
- Multi-Objective (coverage, length of test, #crashes)
- Algoritmo Genético: NSGA-II
 - **Nondominated Sorting Genetic Algorithm**
- Parallel Fitness Evaluation

Sapienz - Individuos



- Atom Gene: Es una acción atómica que no puede ser descompuesta (click, downKey, etc)
- Motif Gene: Secuencia predefinida de acciones atómicas (*DNA motif is a short sequence pattern that has a biological function*)

Sapienz - Workflow



Algorithm 1: Overall algorithm of SAPIENZ.

Input: AUT A , crossover probability p , mutation probability q ,
max generation g_{max} , execution time t

Output: UI model M , Pareto front PF , test reports C

$M \leftarrow K_0$; $PF \leftarrow \emptyset$; $C \leftarrow \emptyset$; ▷ initialisation

generation $g \leftarrow 0$;

boot up devices D ; ▷ prepare app exerciser

inject MOTIFCORE into D ; ▷ for hybrid exploration (see §3.2)

static analysis on A ; ▷ for string seeding (see §3.3)

instrument and install A ;

initialise population P ; ▷ hybrid of random and motif genes

evaluate P with MOTIFCORE and update (M, PF, C) ;

while $g < g_{max}$ and $\neg \text{timeout}(t)$ **do**

$g \leftarrow g+1$;

$Q \leftarrow \text{wholeTestSuiteVariation}(P, p, q)$; ▷ see Algorithm 2

evaluate Q with MOTIFCORE and update (M, PF, C) ;

$\mathcal{F} \leftarrow \emptyset$; ▷ non-dominated fronts

$\mathcal{F} \leftarrow \text{sortNonDominated}(P \cup Q, |P|)$;

$P' \leftarrow \emptyset$; ▷ non-dominated individuals

for each front F in \mathcal{F} **do**

if $|P'| \geq |P|$ **then** break;

calculate crowding distance for F ;

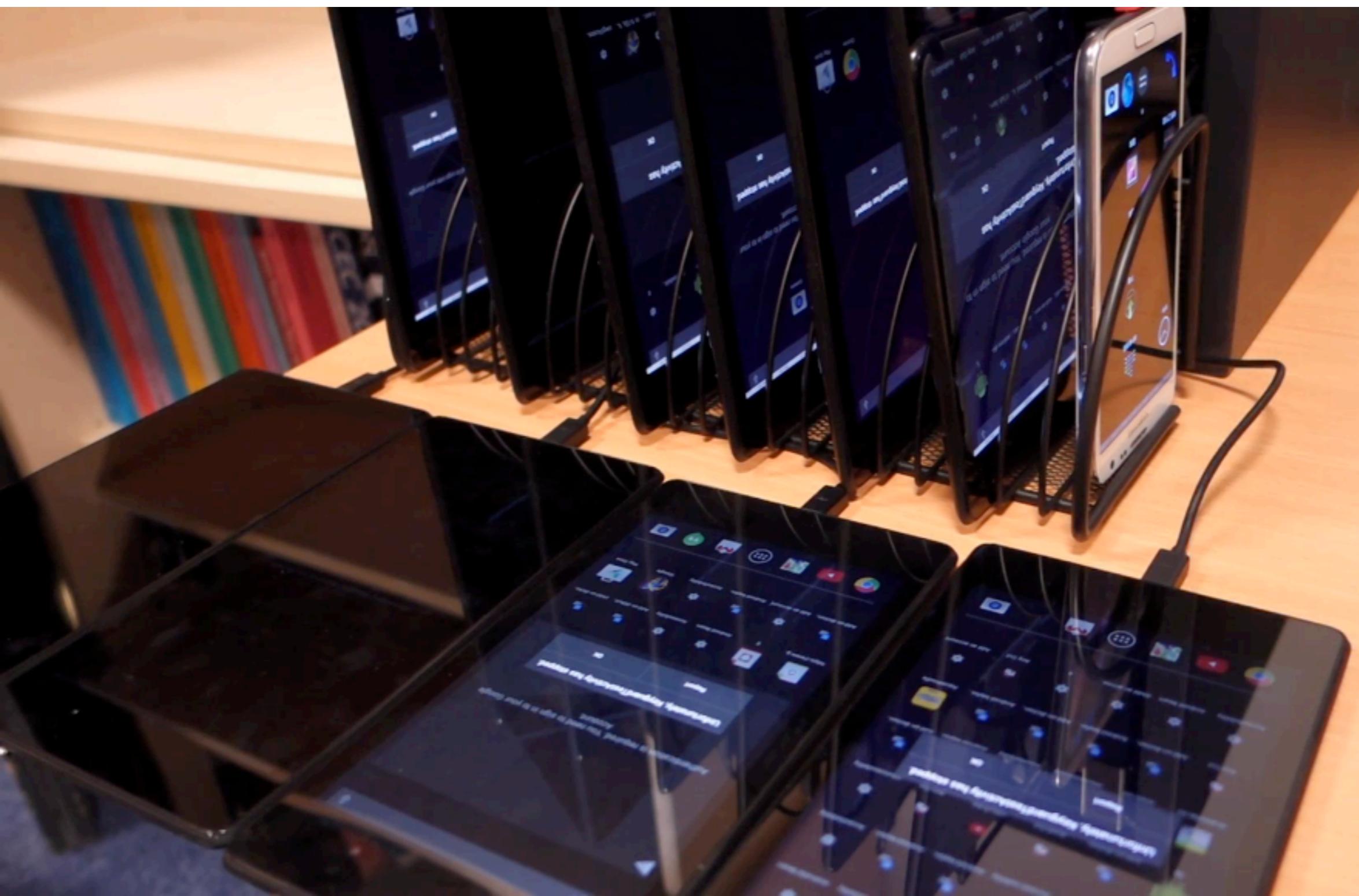
for each individual f in F **do**

$P' \leftarrow P' \cup f$;

$P' \leftarrow \text{sorted}(P', \prec_c)$; ▷ see equation 3 for operator \prec_c

$P \leftarrow P'[0 : |P|]$; ▷ new population

return (M, PF, C) ;



Event-Based Testing

