

Pragmatic Model-Based Testing

Dealing with complexity in software

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

About the author

Aleksandar Karamfilov



- Co-Owner/Founder/Trainer at
- Misery generator since 2008
- Red wine/api consumer/producer
- Helping young people get “rich”



СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Content

- Why Testing Must Be Model-Based?
- What is a Model?
- Modeling System State
- State Machines and Directed Graphs
- GraphWalker Library
- Using GraphWalker in Test Automation
- Demo

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](https://dev.bg/qa)

Models

A Little Theory

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](#)

Why Testing Must Be Model-Based?

Testing can be viewed as search problem. We are looking for those few input and state combinations that will reach, trigger and propagate bugs out of trillions and trillions which won't. Brute force is impotent at this scale. Testing by poking around is a waste of time that leads to unwarranted confidence.

Instead, our search must be systematic, focused and automated.

What is Reach, Trigger, Propagate!?



СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](https://dev.bg/qa)

The Ideal Fault Conditions(Fault => Failure)

- Reachability Condition
 - Reach the faulty source code
- Necessity Condition
 - Make it return wrong result
- Propagation Condition
 - Propagate it high enough so tester can see it

What is a Model?

- A model is **description** of system behavior
- Models are **simpler** than the system they describe
- Models help us **understand** and predict the system's behavior

Elements of Model

- Subject
 - A model must have a well-defined subject. Example: building, bridge
- Point of view
 - A model must be based on a frame of reference and principles that can guide identification of relevant issues and information
- Representation
 - A modeling technique must have a means to express a model (equations, CAD model)
- Technique
 - Models are complex artifacts and skills of modeler matters

Availability of Different Models

- Tables
- Combination Sets
- Diagrams
- Graphs
- Checklists

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Modeling System State

State Machine

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](#)

What is a State Machine?

A **state machine** is a system whose output is determined by both current and past input. The effect of previous inputs is represented by a state.



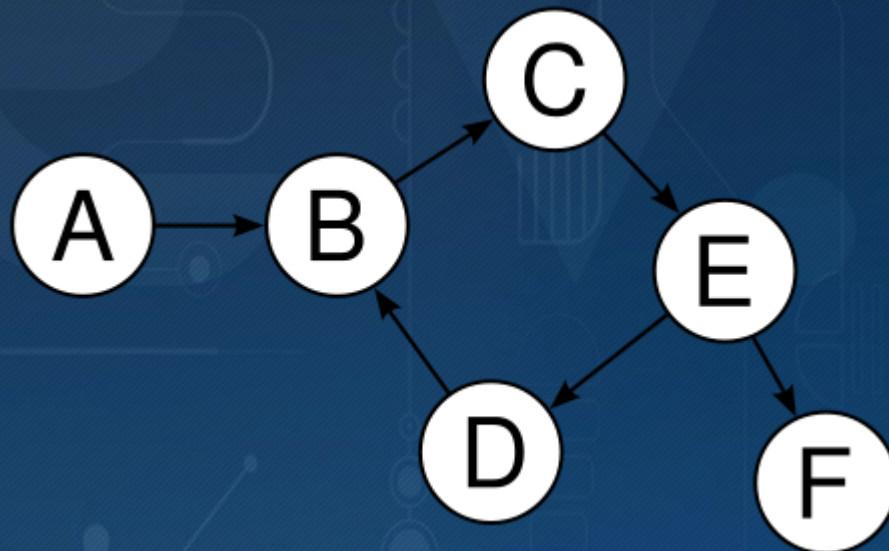
СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](https://dev.bg/qa)

State Machine Building Blocks

- State
 - An abstraction that summarizes the information concerning past inputs that is needed to determine the behavior of the system on subsequent inputs
- Transition
 - An allowable two-state sequence. A transition is caused by event.
- Event
 - An input or an interval of time
- Action
 - The result or output that follows an event

What is a Directed Graph?

Directed graph (or **digraph**) is a graph that is a set of vertices connected by edges, where the edges have a direction associated with them.



Using GraphWalker

Automated Switch Coverage

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](https://dev.bg/qa)

GraphWalker

GraphWalker is an open-source Model-based testing tool for test automation. It is designed to make it easy to design your tests using directed graphs.

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](https://dev.bg/qa)

Preconditions

- JDK 8+
- Maven 3+
- IntelliJ/Eclipse
- Time 😊

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Step 1

Generate Maven project from archetype

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Generate Maven project from archetype

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

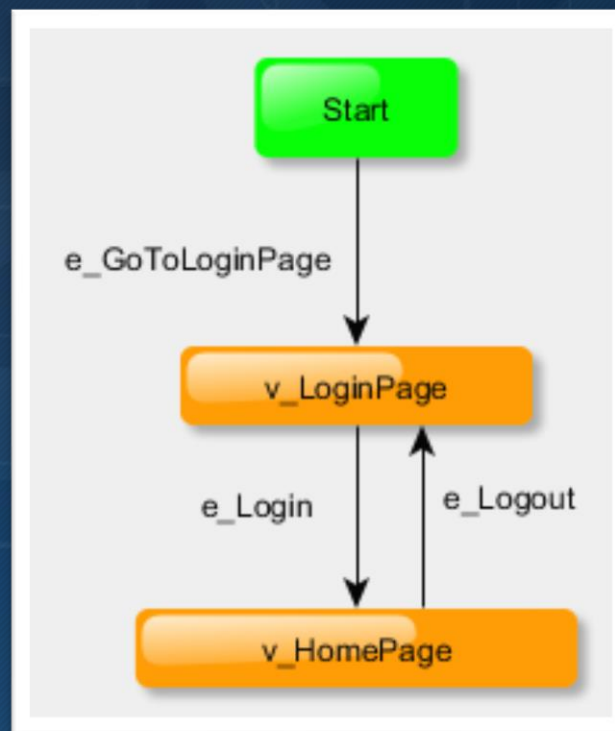
СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Step 2

Create model/graph using yEd editor

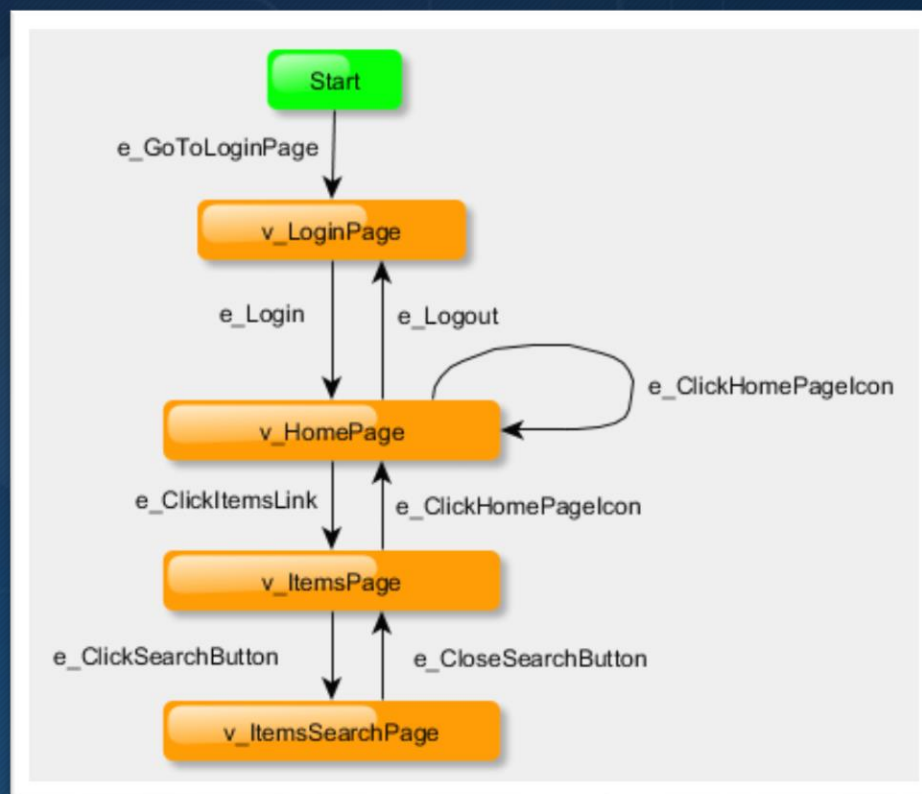
СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Start simple



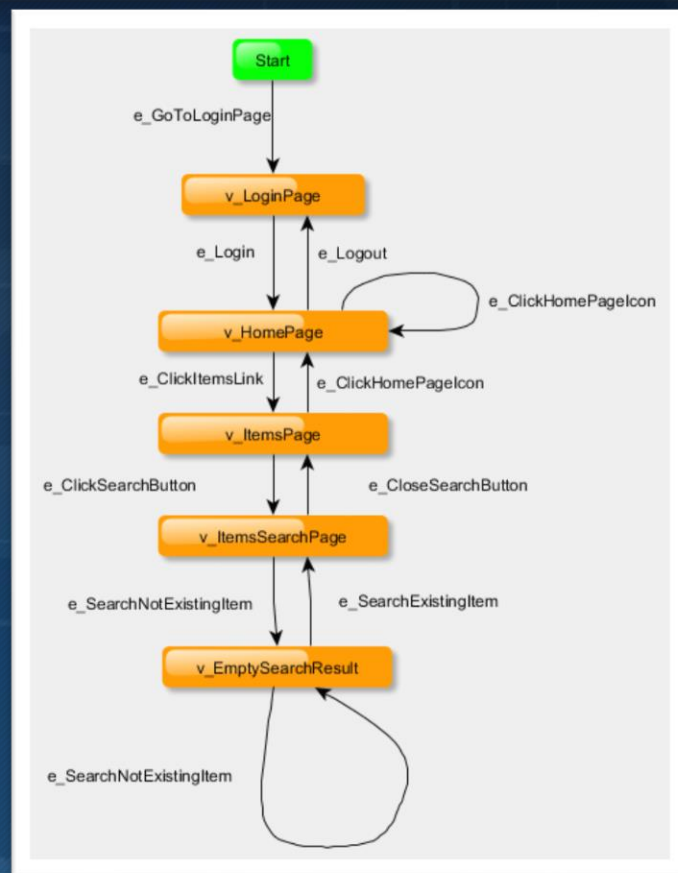
СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Add more edges/vertices



СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Finish it



СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Generate graphml file using yEd editor

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<graphml xmlns="http://graphml.graphdrawing.org/xmlns" xmlns:java="http://www.yworks.com/xml/yfiles-common/1.0/java" xmlns:sys="http://www.yworks.com/xml/yfiles-common/markup/primitives" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://graphml.graphdrawing.org/xmlns http://graphml.graphdrawing.org/xmlns/1.0/graphml.xsd">
  <!--Created by yEd 3.18.1.1-->
  <key attr.name="Description" attr.type="string" for="graph" id="d0"/>
  <key for="port" id="d1" yfiles.type="portgraphics"/>
  <key for="port" id="d2" yfiles.type="portgeometry"/>
  <key for="port" id="d3" yfiles.type="portuserdata"/>
  <key attr.name="url" attr.type="string" for="node" id="d4"/>
  <key attr.name="description" attr.type="string" for="node" id="d5"/>
  <key for="node" id="d6" yfiles.type="nodegraphics"/>
  <key for="graphml" id="d7" yfiles.type="resources"/>
  <key attr.name="url" attr.type="string" for="edge" id="d8"/>
  <key attr.name="description" attr.type="string" for="edge" id="d9"/>
  <key for="edge" id="d10" yfiles.type="edgegraphics"/>
  <graph edgedefault="directed" id="G">
    <data key="d0" xml:space="preserve"/>
    <node id="n0">
      <data key="d6">
        <y:GenericNode configuration="ShinyPlateNode3">
          <y:Geometry height="30.0" width="43.314453125" x="128.3427734375" y="-15.0"/>
          <y:Fill color="#00FF00" transparent="false"/>
          <y:BorderStyle hasColor="false" type="line" width="1.0"/>
          <y:NodeLabel alignment="center" autoSizePolicy="content" fontFamily="Dialog" fontSize="12" fontStyle="plain" hasBackgroundColor="false" hasLineColor="false" height="18.75" text="n0" width="43.314453125" x="128.3427734375" y="-15.0"/>
        </y:GenericNode>
      </data>
    </node>
    <node id="n1">
      <data key="d6">
        <y:GenericNode configuration="ShinyPlateNode3">
          <y:Geometry height="30.0" width="134.111328125" x="82.9443359375" y="60.0"/>
          <y:Fill color="#FF9900" transparent="false"/>
          <y:BorderStyle hasColor="false" type="line" width="1.0"/>
          <y:NodeLabel alignment="center" autoSizePolicy="content" fontFamily="Dialog" fontSize="12" fontStyle="plain" hasBackgroundColor="false" hasLineColor="false" height="18.75" text="n1" width="134.111328125" x="82.9443359375" y="60.0"/>
        </y:GenericNode>
      </data>
    </node>
    <node id="n2">
      <data key="d6">
        <y:GenericNode configuration="ShinyPlateNode3">
          <y:Geometry height="30.0" width="168.18359375" x="65.908203125" y="160.0"/>
          <y:Fill color="#FF9900" transparent="false"/>
          <y:BorderStyle hasColor="false" type="line" width="1.0"/>
          <y:NodeLabel alignment="center" autoSizePolicy="content" fontFamily="Dialog" fontSize="12" fontStyle="plain" hasBackgroundColor="false" hasLineColor="false" height="18.75" text="n2" width="168.18359375" x="65.908203125" y="160.0"/>
        </y:GenericNode>
      </data>
    </node>
```

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Step 3

Generate interface

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Generate interface from the model

```
mvn graphwalker:generate-sources
```

```
@Model(file = "com/company/ForgottenPassword.graphml")
public interface ForgottenPassword {

    @Edge()
    void e_ClickForgottenPasswordLink();

    @Edge()
    void e_SubmitInvalidEmail();

    @Vertex()
    void v_ResetPasswordPage();

    @Vertex()
    void v_WrongEmailErrorMessage();

    @Edge()
    void e_ClickReturnToLoginPageLink();

    @Edge()
    void e_SubmitWrongEmail();
}
```

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Step 4

Implement interface

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Implementation

```
@GraphWalker(value = "random(edge_coverage(100))", start = "e_GoToLoginPage")
public class InvMainNavigationTest extends ExecutionContext implements InvModel {
    private Inv inv;

    public InvMainNavigationTest() {
        inv = new Inv();
        inv.startBrowser("chrome");
    }

    @Override
    public void v_LoginPage() {
        Assertions.assertEquals("QA Ground", inv.loginPage().getCompanyName());
    }

    @Override
    public void v_HomePage() {
        Assertions.assertEquals("karamfilovs@gmail.com",
inv.homePage().getUserPanelText());
    }

    @Override
    public void e_ClickHomePageIcon() {
        inv.homePage().clickCompanyLogo();
    }
}
```

```
@Override
public void e_ClickForgottenPasswordLink() {
    inv.loginPage().clickForgottenPasswordLink();
}

@Override
public void e_SubmitInvalidEmail() {
    inv.resetPasswordPage().enterEmail("al@pragmatic");
    inv.resetPasswordPage().clickSendButton();
}

@Override
public void v_ResetPasswordPage() {
    Assertions.assertEquals("Възстановяване на парола",
inv.resetPasswordPage().getPageHeaderText());
}
```

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Step 5

Execute tests

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Execute tests

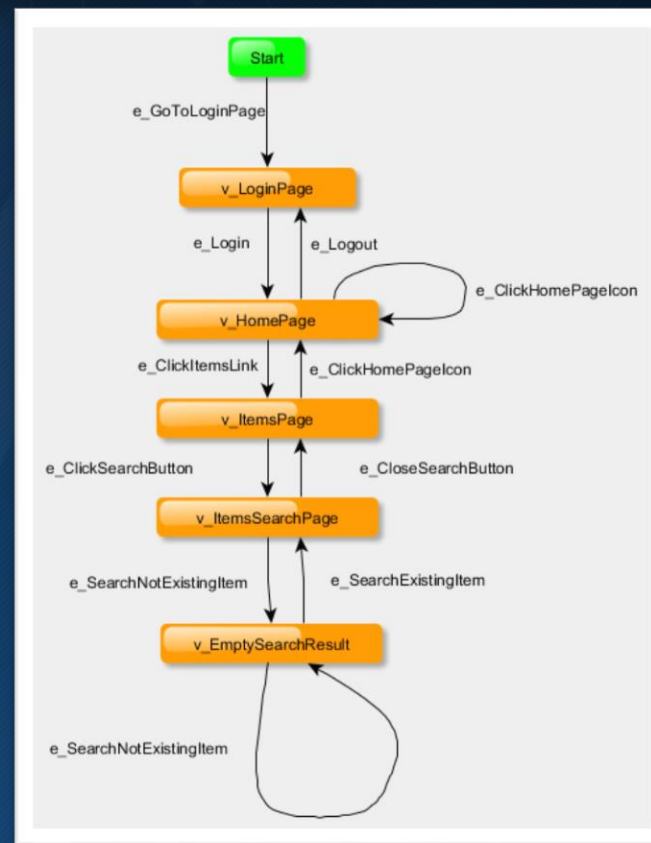
```
mvn graphwalker:test
```

```
mvn graphwalker:test
[INFO] Scanning for projects...
[INFO] -----< bg.inv:model-
based-testing >-----
[INFO] Building Graphwalker Example 1.0-SNAPSHOT
[INFO] -----[ jar ]-----
[INFO]
[INFO] >>> graphwalker-maven-plugin:3.4.2:test
(default-cli) > [graphwalker]test-compile @
model-based-testing >>>
[INFO]
[INFO] --- graphwalker-maven-
plugin:3.4.2:validate-models (default-cli) @
model-based-testing ---
[INFO]
[INFO] --- graphwalker-maven-
plugin:3.4.2:generate-sources (default-cli) @
model-based-testing ---
```

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Execution Report

```
[INFO] {  
  "totalFailedNumberOfModels": 0,  
  "totalNotExecutedNumberOfModels": 0,  
  "totalNumberOfUnvisitedVertices": 0,  
  "verticesNotVisited": [],  
  "totalNumberOfModels": 1,  
  "totalCompletedNumberOfModels": 1,  
  "totalNumberOfVisitedEdges": 19,  
  "totalIncompleteNumberOfModels": 0,  
  "edgesNotVisited": [],  
  "vertexCoverage": 100,  
  "totalNumberOfEdges": 19,  
  "totalNumberOfVisitedVertices": 5,  
  "edgeCoverage": 100,  
  "totalNumberOfVertices": 5,  
  "totalNumberOfUnvisitedEdges": 0  
}
```



СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Differences with Traditional Approach

```
@Test
@DisplayName("Can login successfully with valid credentials")
@Tag("high")
public void canLoginSuccessfullyWithValidCredentials() {
    inv.loginPage().gotoPage();
    Assertions.assertEquals(COMPANY_NAME,
inv.loginPage().getCompanyName());
    inv.loginPage().enterEmail(EMAIL);
    inv.loginPage().enterPassword(PASSWORD);
    inv.loginPage().clickLoginButton();
    Assertions.assertEquals(EMAIL, inv.homePage().getUserPanelText());
}
```

```
@Test
@DisplayName("Cant reset password with invalid email")
public void cantResetPasswordWithInvalidEmail() {
    inv.loginPage().gotoPage();
    Assertions.assertEquals(COMPANY_NAME,
inv.loginPage().getCompanyName());
    inv.loginPage().clickForgottenPasswordLink();
    inv.resetPasswordPage().enterEmail("invalid@email");
    inv.resetPasswordPage().clickSendButton();
    Assertions.assertEquals("Въведеният имейл е невалиден",
inv.resetPasswordPage().getInvalidEmailErrorMessage());
}
```

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA

Benefits of Model-Based Testing

- Easy test case maintenance
- Reduced cost
- Early bug detection
- Increased bug count
- Time savings
- Can be used for Web/Mobile/Web Services

Obstacles to Model-Based Testing

- Comfort factor
 - This is not your parents test automation
- Skill sets
 - Need testers who can design
- Expectations
 - Models can be significant upfront investment
 - Will never catch all the bugs
- Different metrics
 - In model-based testing we use different metrics (coverage)

Questions?



СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА [DEV.BG/QA](https://dev.bg/qa)

Thank you!

Contacts:



LinkedIn: <https://www.linkedin.com/in/akaramfilov>

GitHub: <https://github.com/karamfilovs>

Demo: <https://github.com/karamfilovs/devbg>

GraphWalker: <https://graphwalker.github.io>

Next event:

Security testing - OWASP

СЛЕДИ КАКВО ПРЕДСТОИ В ГРУПАТА НА DEV.BG/QA