DSLs and OPE

Christian Colombo
(work with Mark Micallef and Gordon Pace)
AGILE

VISION

IMPLEMENTATION AND MAINTENANCE
The need for test automation
Existing technology: Gherkin

**Given** I am a premium user

**When** I place a bet on a football match

**And** I win the bet

**Then** I will win 10% more than the advertised odds for the match
Test automation – 2 challenges

- Non skilled testers (for test automation)
- Time pressure
Proposed solution:

- More structured DSL
  - Easy for non skilled testers
  - Saves time
Many testing domains

- E-commerce (cart, stock, item, buy, sell, etc)
- Games (bonus, points, bet, win, lose, etc)
- GUI apps (button, progress bar, label, tap, swipe, etc)
DSLs for testing

- Android GUI Applications
- E-Commerce Applications
- Graphical Games

Well-Defined Domains

Undefined Domains
DSLs for testing

- Increasingly Specific and Rigid
  - Domain A DSL
    - Subdomain A1 DSL
    - Subdomain A2 DSL
  - Domain B DSL
    - Subdomain C1 DSL
  - Domain C DSL
    - Subdomain C2 DSL

- Extends
DSLs for testing

Generic Testing DSL

- Extends
  - Android UI Applications DSL
  - eCommerce Websites DSL
  - Graphical Games DSL

- Extends
  - "Angry Birds" DSL
  - "Cut The Rope" DSL
Generic testing DSL

```
define testsuite "login tests"
    define setup "setup"
        ...
    end

define teardown "teardown"
    ...
end

define test "valid login"
    ...
end
end
```
E Commerce example

define procedure "add out of stock book to cart"
    search for "Harry Potter" in "books"
    select first item from search results
    add current item to cart
end

define test "buyOutOfStockBook"
    add out of stock book to cart
    verify that the item is not added to the cart
end
Structured DSLs vs Gherkin

1. The approach works once a grammar is in place
   a. (Automatically generated) Code helpers in IDE
   b. Consistent scripts

2. More cumbersome to add new language features
   a. New features require grammar modification
   b. Notion of tagging @manual tests lost

3. Specialised skills needed for grammar definition and compilation

4. We cannot “fudge” anymore (is this good or bad?)
Defined vs Undefined domains

1. Easy to reach a stable language quickly with well-defined domains

2. You can quickly go down to the leaf node of the domain hierarchy
Questions:

• Who curates/owns the language?
• What effect will a change on the language have on existing scripts?
• How is the process of language evolution controlled?
• Who maintains code generators and how?

• Important to have management on board
DSLs

- DSLs for Testing
- CNLs for Monitoring
CNLs for data processing

- Non-technical people need to process data based on their expertise
- They cannot program – even DSLs might still feel too technical
CNLs for data processing

• Non-technical people need to process data based on their expertise
• They cannot program – even DSLs might still feel too technical

• Examples:
  • Business intelligence
Business Intelligence

• The business Facebook page
  • Fast response expected
  • “Alert me when a customer has posted a question on my page and has not been answered in an hour”
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• Reviewers’ pages
  • Bad reviews need to be damage controlled
  • “Alert me when a post on a review page mentions my business and gets more than 5 likes”
Business Intelligence

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  • Bad reviews need to be damage controlled
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• Advertising pages
  • Competitors are continually posting
  • “Alert me when a competitor posts on an advertising page and I have not posted anything today”
Business Intelligence

- The business Facebook page
  - Fast response expected
  - “Alert me when a customer has posted a question on my page and has not been answered in an hour”
- Reviewers’ pages
  - Bad reviews need to be damage controlled
  - “Alert me when a post on a review page mentions my business and gets more than 5 likes”
- Advertising pages
  - “Alert me when I haven’t posted something interesting to my competitor page and I haven’t posted anything today”

Off the shelf solutions are not so flexible

Custom solutions are expensive
CNLs for monitoring

- Non-technical people want to create monitors based on their expertise
- DSLs might still feel too technical

Examples:
- Business intelligence
- Tax fraud
Tax fraud

Auditor

“Find individuals who declared an average income of less than €3000 for any 3 sequential years”
Tax fraud

1. Describe a rule
2. Rule Interpretation
3. Code
4. Report found cases
5. Review found cases

Auditor

Developer
Tax fraud

1. Describe a rule
2. Rule Interpretation
3. Code
4. Report found cases
5. Review found cases

Repeat until the fraud expert is satisfied!
Tax fraud

1. Describe a rule
2. Rule Interpretation
3. Code
4. Report found cases
5. Review found cases

Many places where this can go wrong

Repeat until the fraud expert is satisfied!
Tax fraud

1. Describe a rule

5. Review found cases

Auditor

Automatic
Solution?

- CNL for domain expert
Approach: BI

BI expert

CNL specification

FB event stream
Approach: BI

BI expert

CNL specification

CNL-to-Monitor tool

LARVA specification

Larva

FB event stream
Approach: BI

BI expert

CNL specification → CNL-to-Monitor tool

LARVA specification → Larva

FB event stream

Business Intelligence Dashboard
Tax fraud

Auditor

- CNL specification
- CNL-to-Monitor tool
- LARVA specification
- Larva
- Spreadsheet with suspicious cases

Tax data stream
Tax fraud

Auditor

CNL specification

CNL-to-Monitor tool

LARVA specification

Larva

Spreadsheet with suspicious cases

In the long term monitoring is faster than database query
Lessons learnt

- Users found it quite easy to express themselves in CNL
  - Some examples were enough to get them going

- Good UI support makes a great difference

- Tax fraud domain was much more difficult to capture
  - Contains more jargon
  - Can express (very) complex rules
Open Payments Ecosystem

Horizon 2020 project

Shaun Azzopardi, Christian Colombo, Gordon J Pace, and Brian Vella
Travel Agency

- Corporate Customers
- Travel Agent
- Payments
- Airlines, Hotels, etc.
Using corporate credit cards

- Flights
- Hotel
- Transport
Using corporate credit cards

- Flights
- Hotel
- Transport

Reconciliation
One-shot cards
One-shot cards

Flights

Easy reconciliation
Payment programme setup costs

- Implementing card processes
- Agreement with bank
- Compliance to legislation
- Auditing
- Dispute resolution
- ...
Building a payment application

Travel Agent
Building a payment application
Building a payment application
Building a payment application
Building a payment application
Open Payments Ecosystem
Open Payments Ecosystem

- Corporates
- Customers
- Payment applications
- Programme managers
- Service providers
- Developers
- Execution environment
Open Payments Ecosystem
Process gives rise to issues

- Is the application legal?
Process gives rise to issues

• Is the application legal?

• Which Service Provider would be willing and able to run it?
Process gives rise to issues

- Is the application legal?
- Which Service Provider would be willing and able to run it?
- Can application violate regulations at runtime?
Open Payments Ecosystem + Compliance
Compliance

1. Checking compliance to regulations
Compliance

1. Checking compliance to regulations
2. Matching service provider capabilities
Compliance

1. Checking compliance to regulations
2. Matching service provider capabilities
3. Limiting risk for service providers
Example

UK e-money regulations state that funds on financial instruments should be redeemable at par value.
Example

1. Is the jurisdiction the UK?

UK e-money regulations state that funds on financial instruments should be redeemable at par value.

- Compliance to regulations
- Capability checking
- Risk mitigation
Example

UK e-money regulations state that funds on financial instruments should be redeemable at par value.

1. Does the application fall under the definition of e-money?
Example

UK e-money regulations state that funds on financial instruments should be redeemable at par value.

1. Are funds redeemable through the application?
Example

2. Can service provider support e-money applications?

UK e-money regulations state that funds on financial instruments should be redeemable at par value.
Example

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1. Is correct value given to the user

1. Compliance to regulations
2. Capability checking
3. Risk mitigation
Example

UK e-money regulations state that funds on financial instruments should be redeemable at par value.

1. Compliance to regulations
2. Capability checking
3. Risk mitigation

3. How many funds are allowed on instruments?
Open Payments Ecosystem + Compliance

Compliance upfront?

- Corporates
- Customers
- Development Environment
- Service Providers
- Payment applications
- Program managers
Compliance Challenges

- Not all properties are checkable upfront

Implication: SA not enough
Compliance Challenges

- Not all properties are checkable upfront
- Not all information is available – only the model of the application

Implication: SA not enough

Implication: SA can only be done on model
Compliance Challenges

- Not all properties are checkable upfront
- Not all information is available – only the model of the application
- We cannot trust the application (it is run by third party)

Implication: SA not enough
Implication: SA can only be done on model
Implication: We have to verify model adherence at runtime
Model

Developer submits model of application rather than implementation.
Model

Developer submits model of application rather than implementation.

Static check the model.
Model - Implementation

Runtime check implementation against model
Runtime verification

Runtime check implementation against model

Implementation

Runtime verify remaining checks, eg: limits, at par value, delays
Example

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1. Is the jurisdiction the UK?

2. Can service provider support e-money applications?

1. Does the application fall under the definition of e-money?

1. Are funds redeemable through the application?

Static check the model
Example

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3. How many funds are allowed on instruments?

Runtime verify remaining checks, eg: limits, at par value, delays
What about the maths?
Combining Static and Dynamic Analysis

\[ \pi = \pi_1 \land \pi_2 \]

\[ \frac{SA \quad P \vdash \pi_1 \quad RV \quad P \vdash \pi_2}{P \vdash \pi} \]
Combining Static and Dynamic Analysis

\[ \text{SA}(P, \pi) \xrightarrow{\text{RV}} P \vdash \pi_1 \xrightarrow{\text{RV}} P \vdash \pi/\pi_1 \xrightarrow{\text{RV}} P \vdash \pi \]

Quotient operator

\( \alpha/\beta \) is taken to be the least quotient of \( \alpha \) by \( \beta \) w.r.t. conjunction:

- It is a quotient: \( \beta \land (\alpha/\beta) \Rightarrow \alpha \)
- It is the least such quotient: for any \( \gamma \) such that \( \beta \land \gamma \Rightarrow \alpha \), then \( \gamma \Rightarrow \alpha/\beta \).
Integrating the model

\[
\text{SA}(M, \pi) \quad \text{RV} \quad P \subseteq M
\]

\[
\frac{M \vdash \pi}{P \vdash \pi}
\]
Integrating the model

\[
\frac{SA(M, \pi)}{M \vdash \pi} \quad \frac{RV}{P \subseteq M} \quad \frac{P \vdash \pi}{P \vdash \pi}
\]

\[
\frac{SA(M, \pi)}{M \vdash \pi_1} \quad \frac{RV}{P \subseteq M} \quad \frac{RV}{P \vdash \pi/\pi_1} \quad \frac{P \vdash \pi}{P \vdash \pi}
\]
Quotient operator on the model
Conclusions

• Loads of work ahead!!