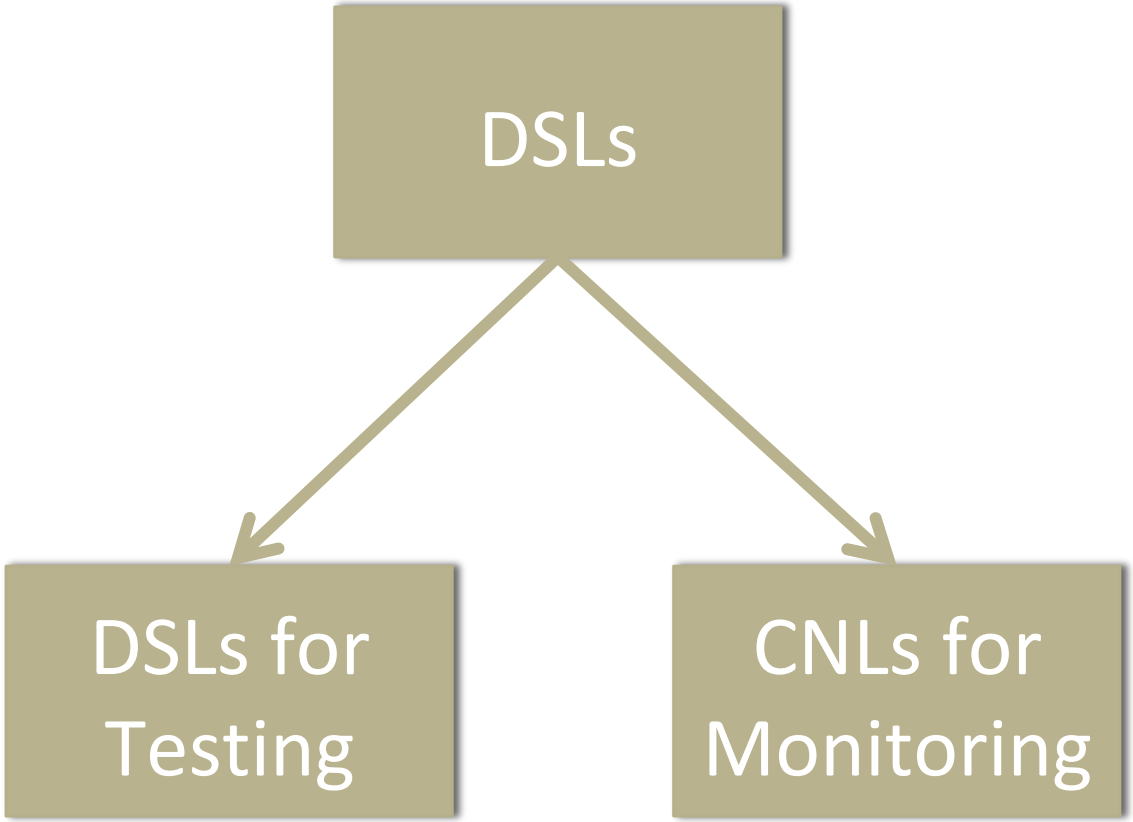
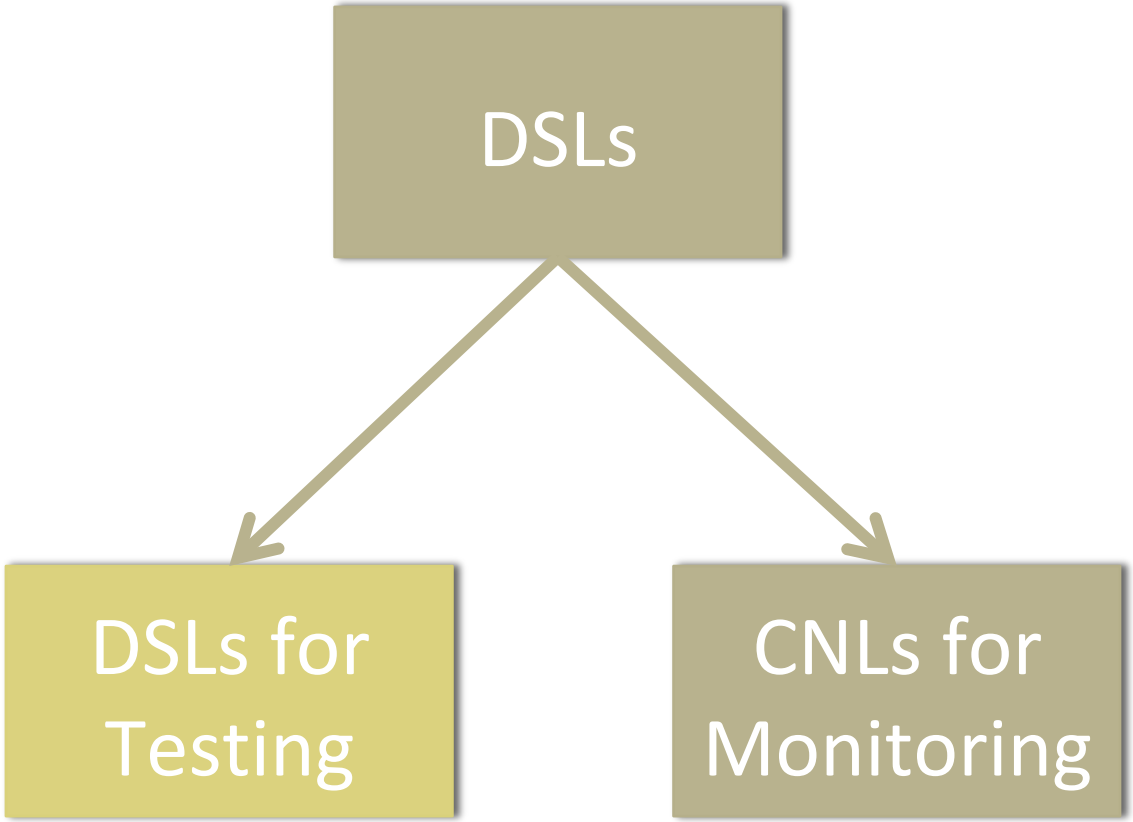
DSLs and OPE

Christian Colombo

(work with Mark Micallef and Gordon Pace)

UNIVERSITY OF MALTA
L-Università ta' Malta


DSLs
DSLs for Testing
CNLs for Monitoring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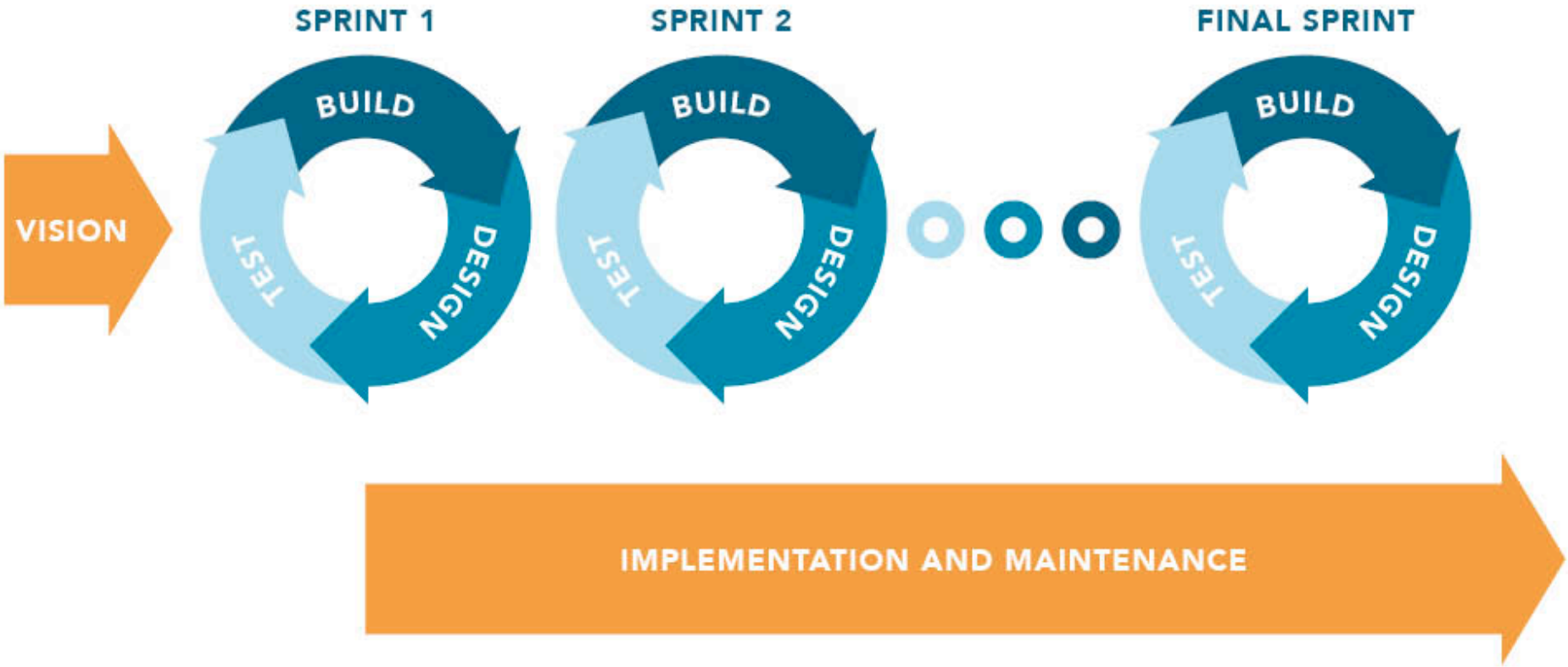
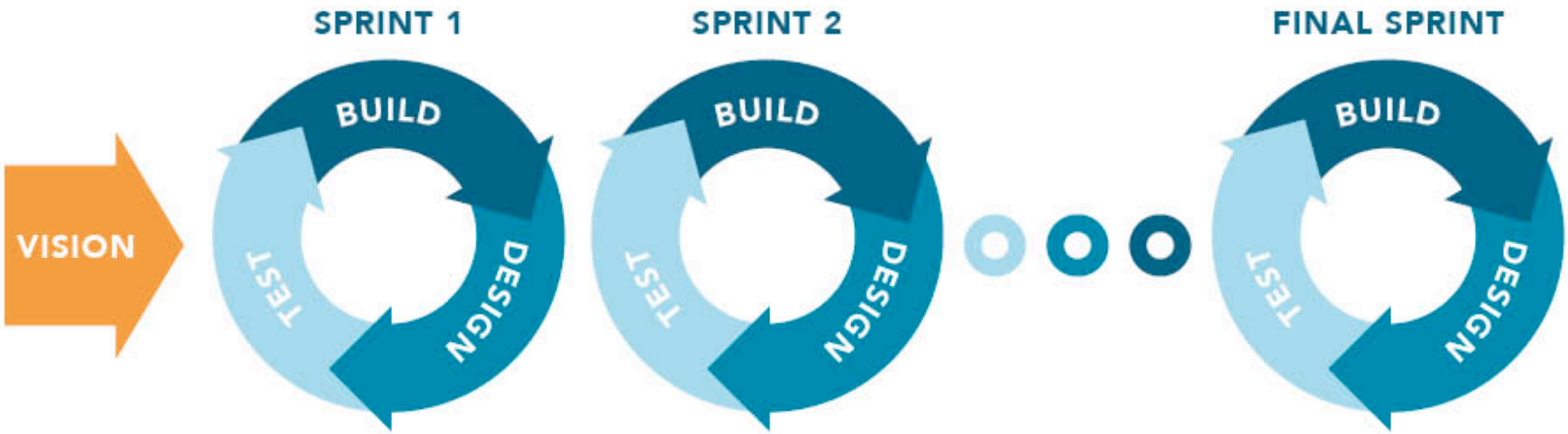
AGILE


SPRINT 1
SPRINT 2
FINAL SPRINT
VISION
BUILD
TEST
DESIGN
BUILD
TEST
DESIGN
BUILD
TEST
DESIGN
IMPLEMENTATION AND MAINTENANCE

AGILE



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:

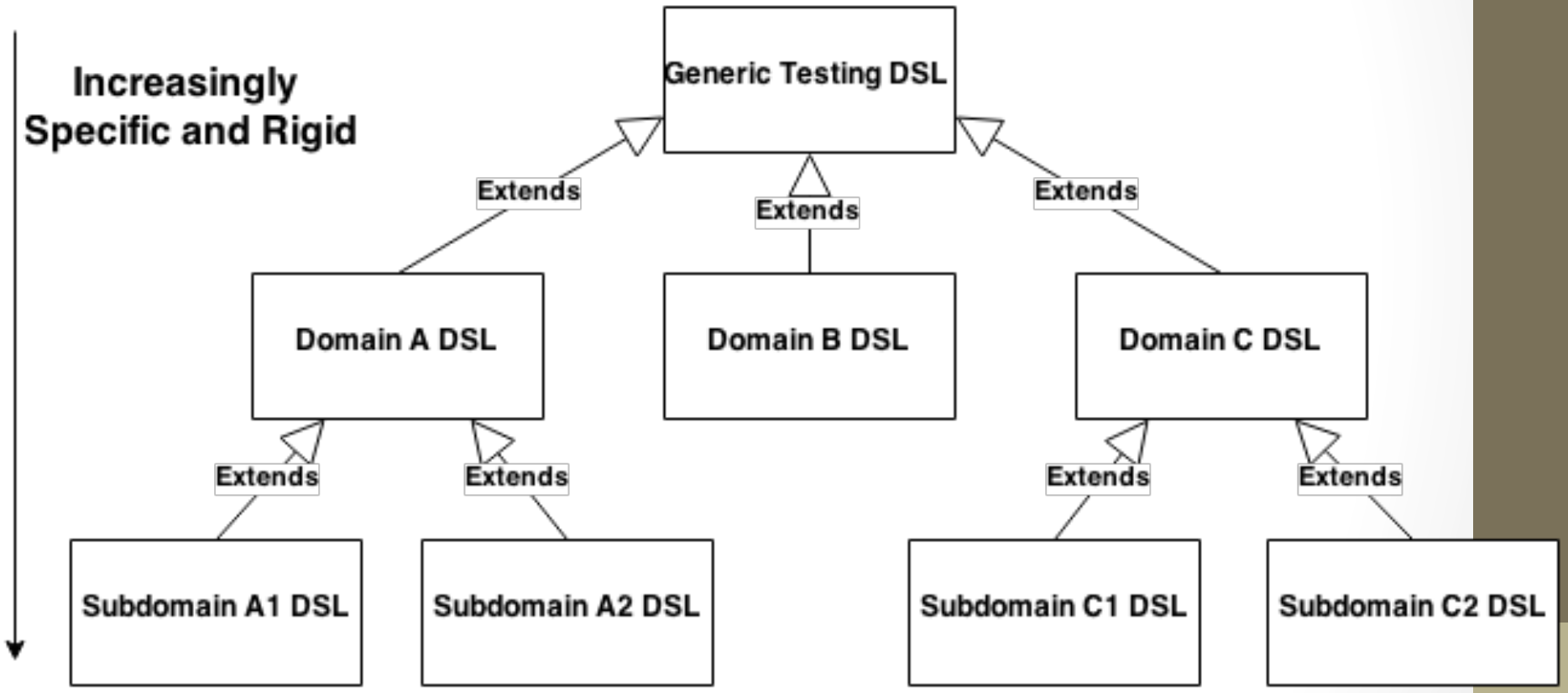
- More structured DSL
  - Easy for non skilled testers
  - Saves time

Many testing domains

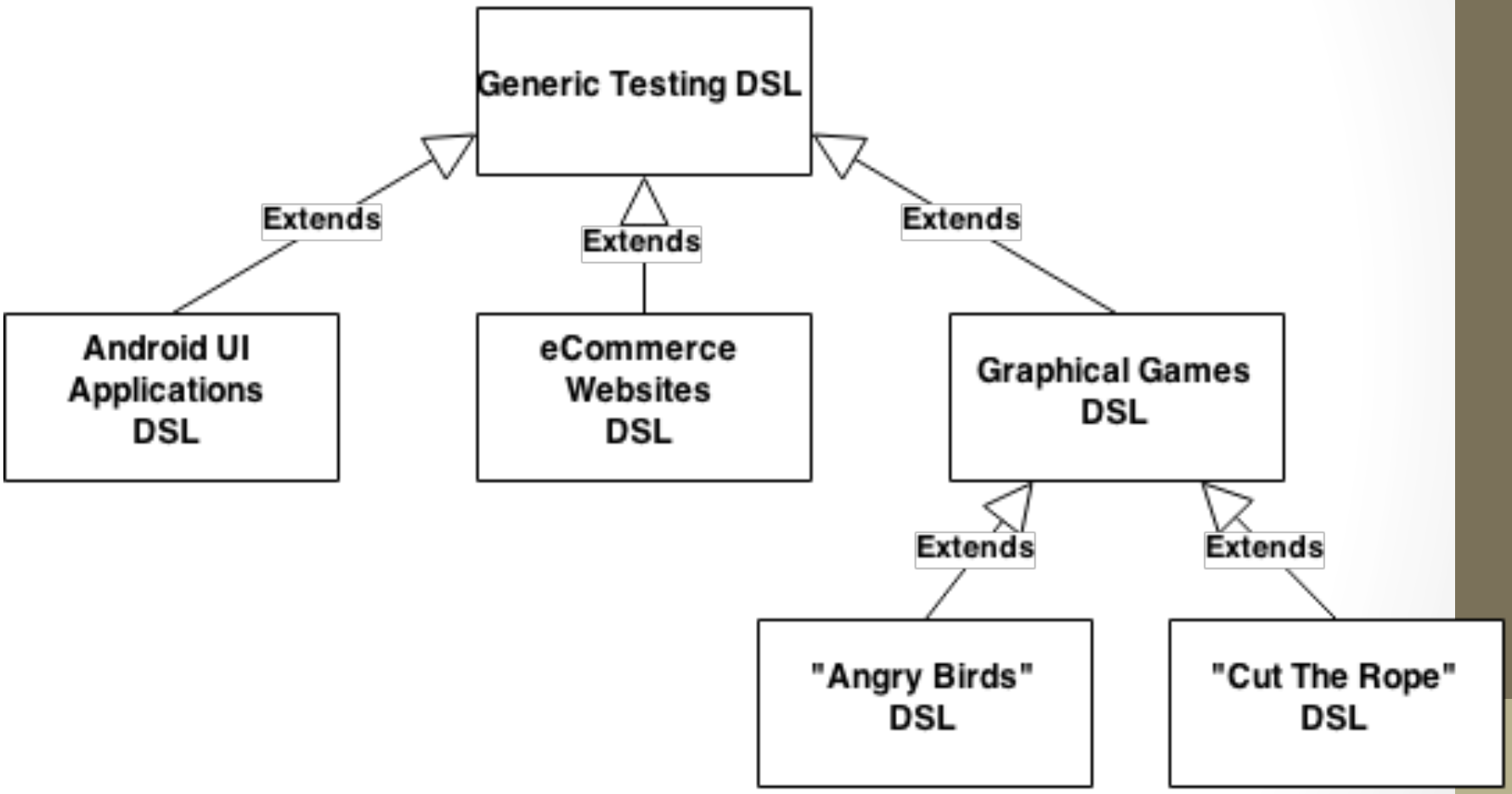
- E-commerce (cart, stock, item, buy, sell, etc)
- Games (bonus, points, bet, win, lose, etc)
- GUI apps (button, progress bar, label, tap, swipe, etc)

DSLs for testing

DSLs for testing



DSLs for testing



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

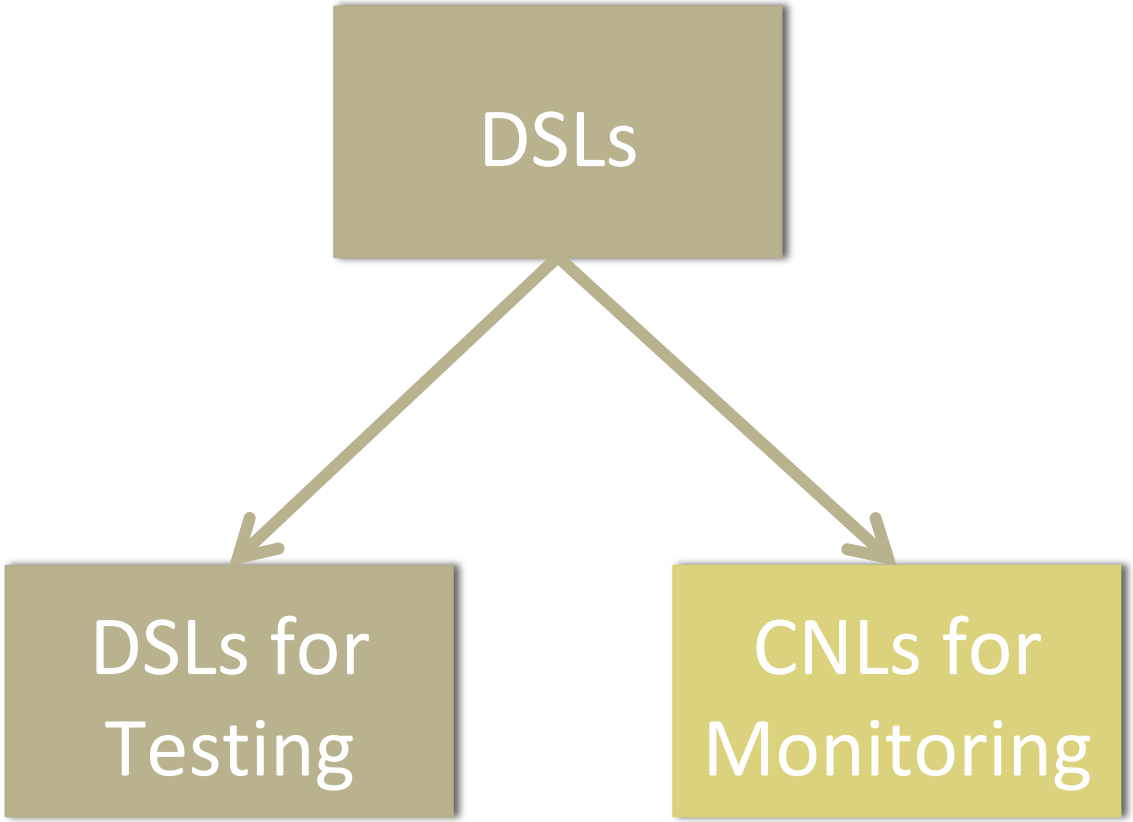
1. Easy to reach a stable language quickly with well-defined domains

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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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

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- 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”
- 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
  -

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

Auditor

1. Describe a rule

Developer

2. Rule Interpretation

3. Code

4. Report found cases

5. Review found cases

Tax fraud

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Repeat until the fraud expert is satisfied!

Tax fraud

Auditor

1. Describe a rule

Many places where this can go wrong

retation

3. Code

4. Report found cases

5. Review found cases

Developer

Repeat until the fraud expert is satisfied!

Tax fraud

Auditor

1. Describe a rule

Automatic

5. Review found cases

Solution?

- CNL for domain expert

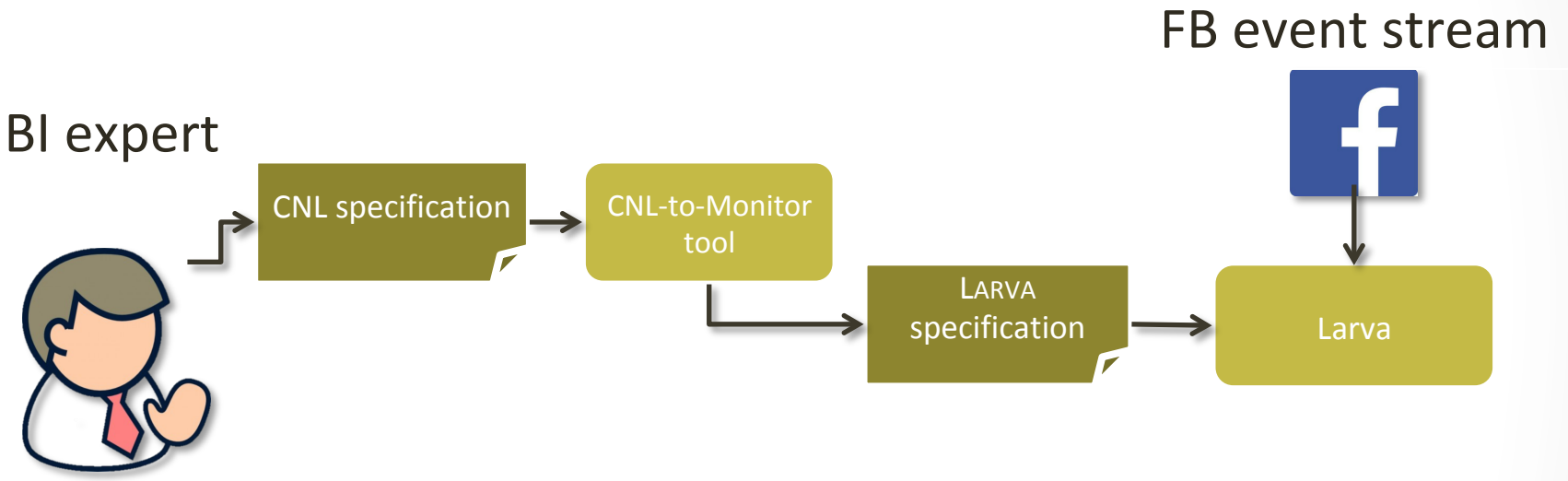
Approach: BI

FB event stream

BI expert

CNL specification

Approach: BI


FB event stream
BI expert
CNL specification
CNL-to-Monitor tool
LARVA specification
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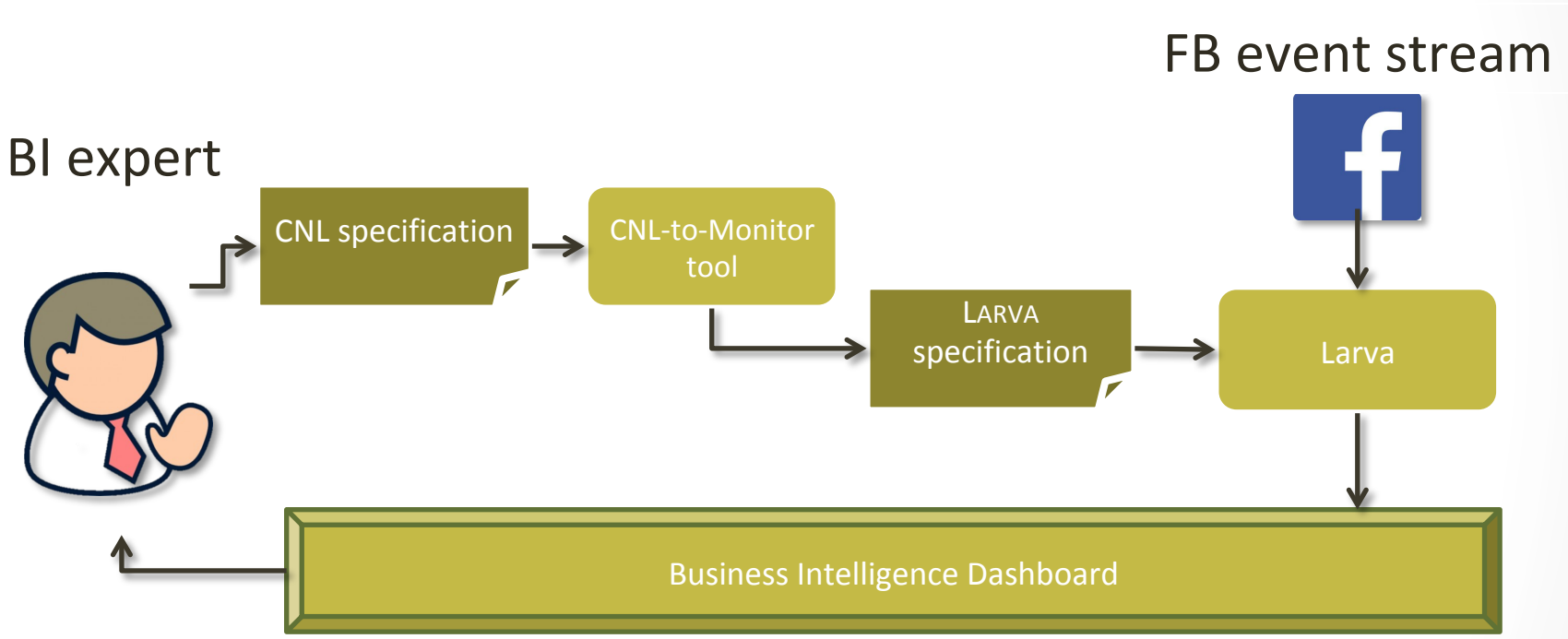
Approach: BI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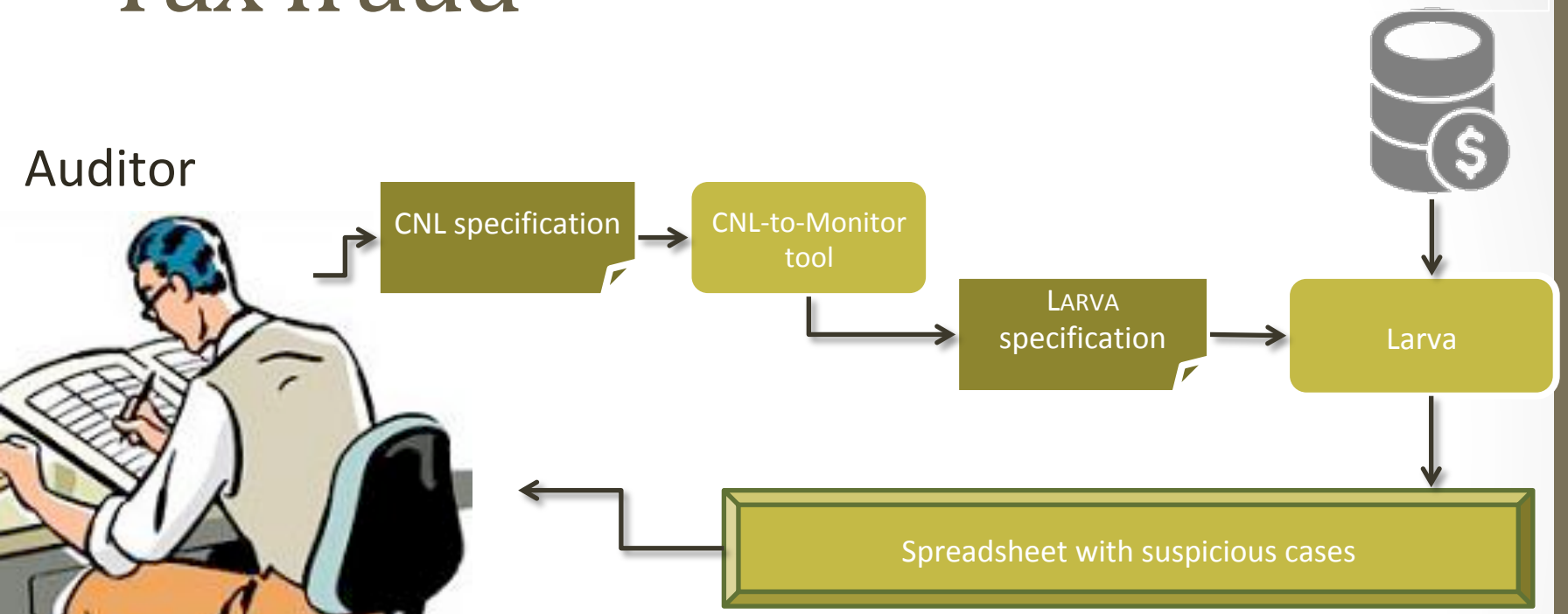
Business Intelligence Dashboard

Tax fraud

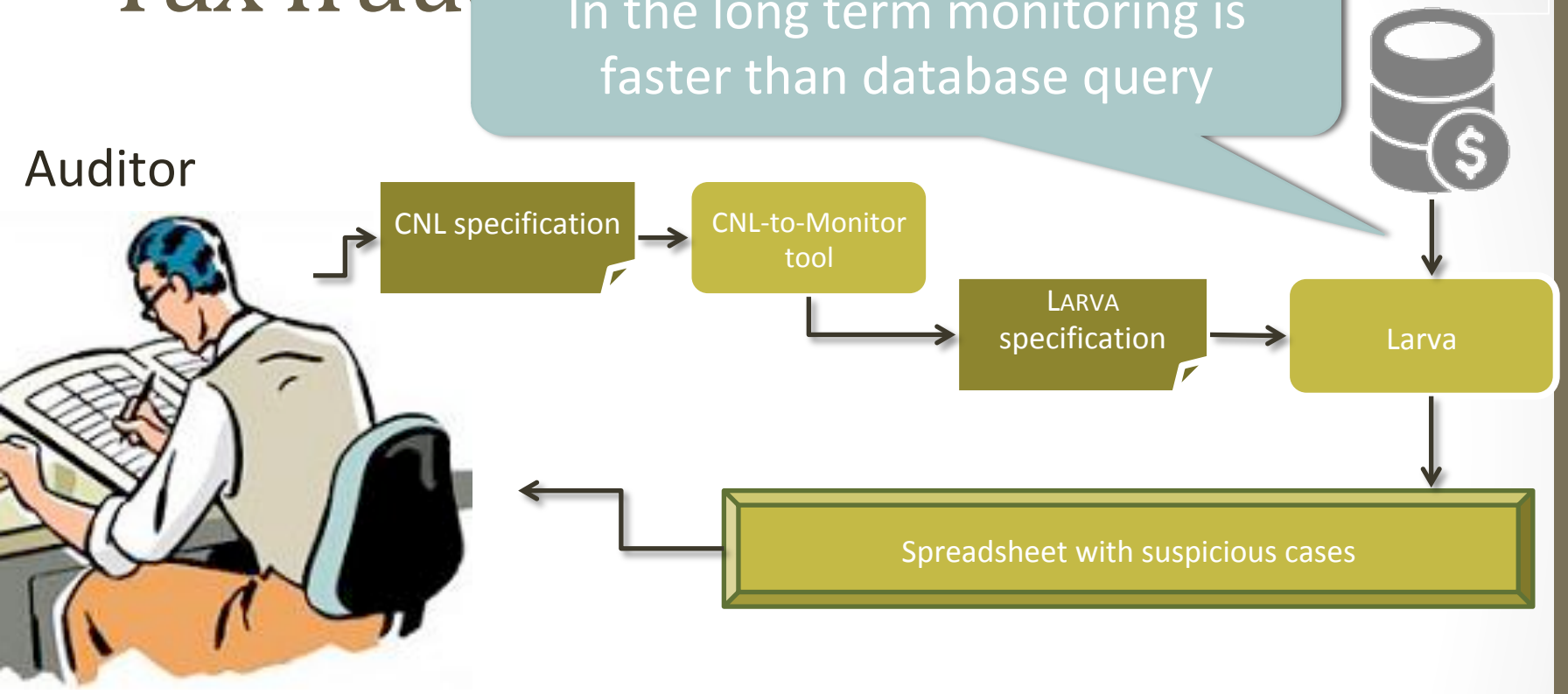
Tax data stream



Tax frau

a stream

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

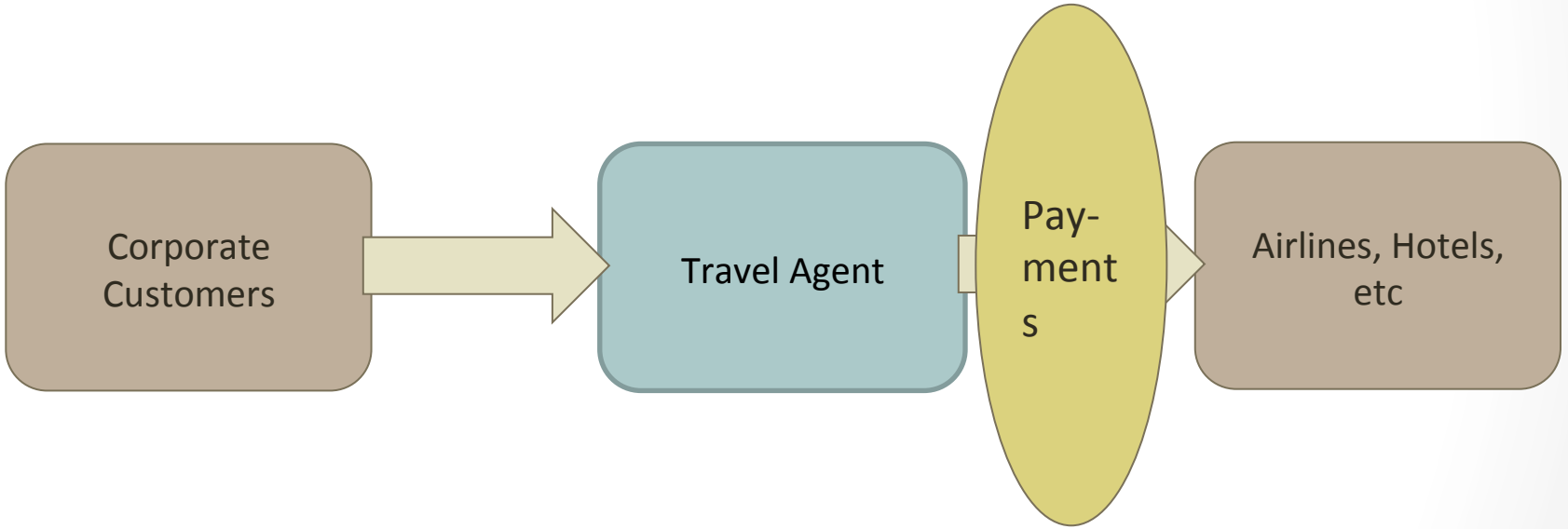
Open Payments Ecosystem

Horizon 2020 project

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

Travel Agency

Travel Agency

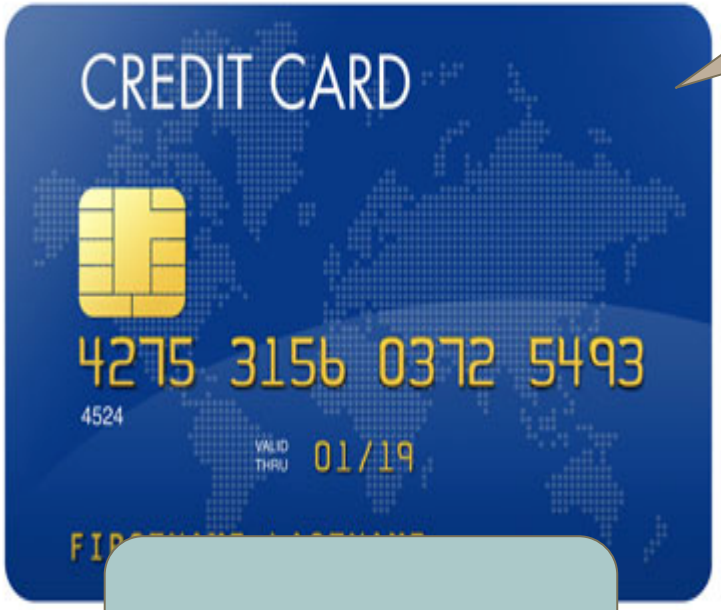


Using corporate credit cards

Using corporate credit cards

One-shot cards

One-shot cards



Flights

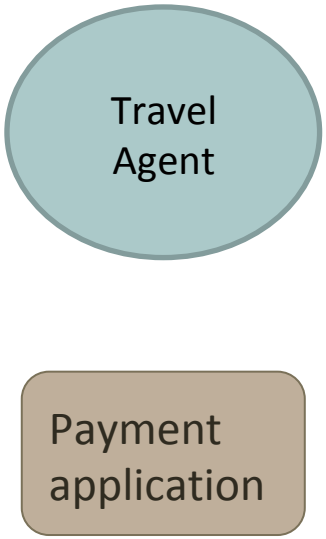
Easy reconciliation

Payment programme setup costs

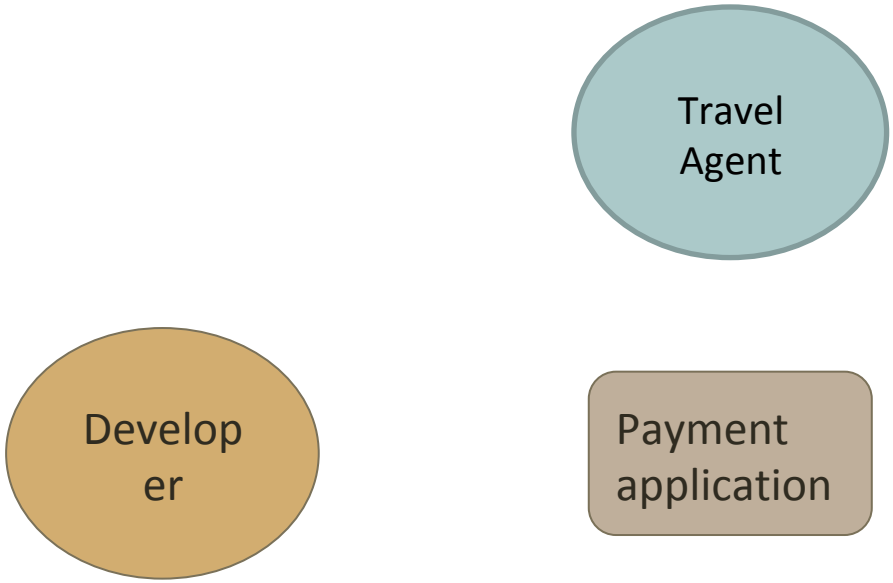
- Implementing card processes
- Agreement with bank
- Compliance to legislation
- Auditing
- Dispute resolution
- …

Building a payment application

Building a payment application



Building a payment application



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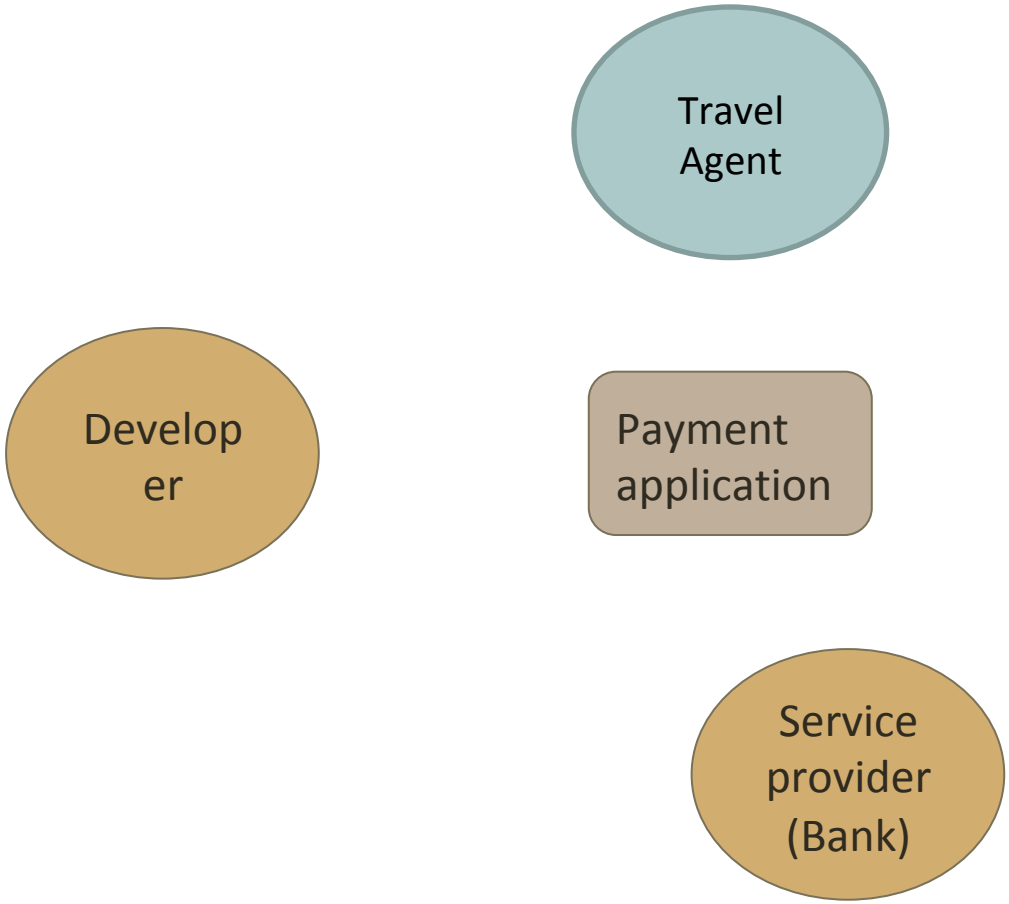

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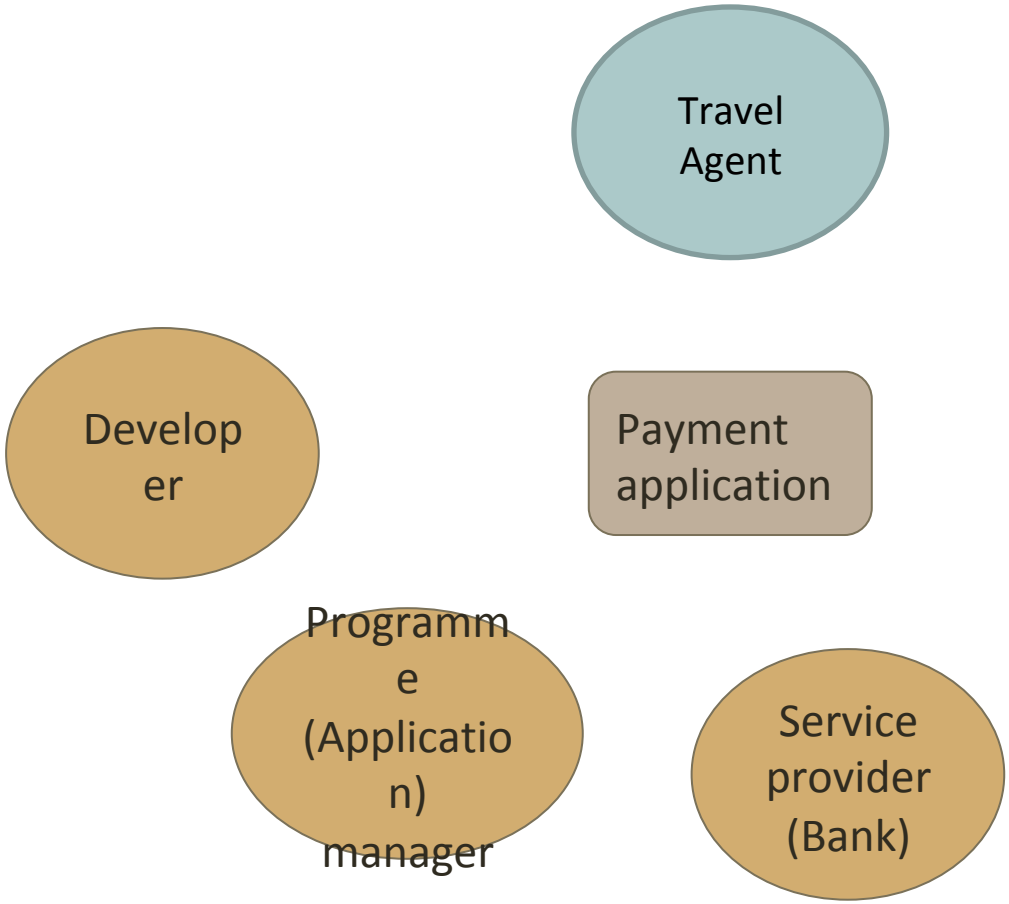
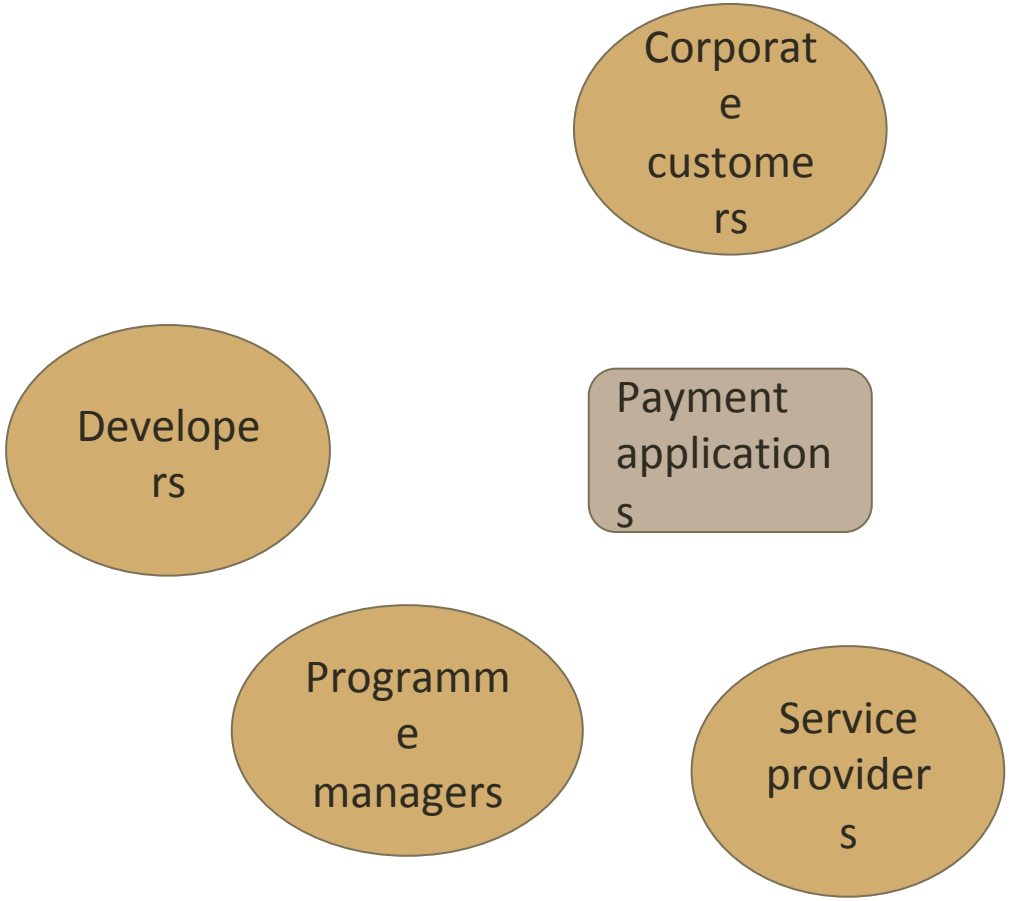


Open Payments Ecosystem



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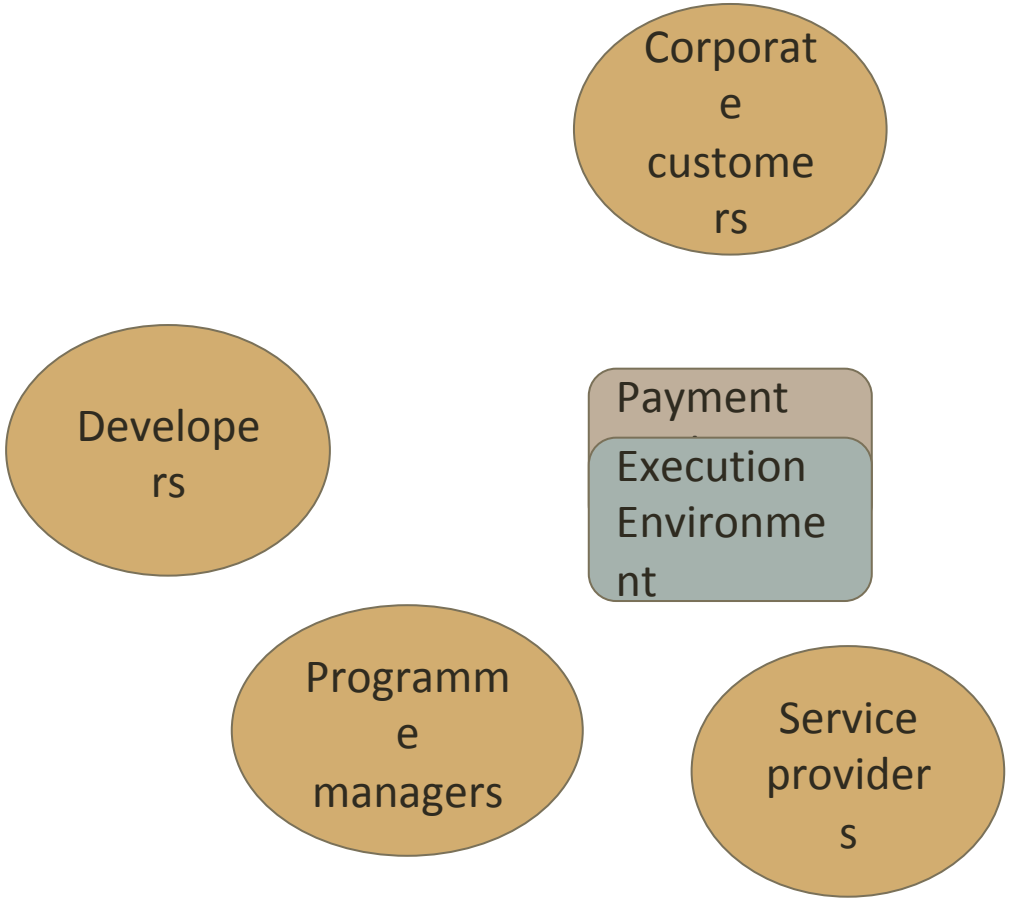

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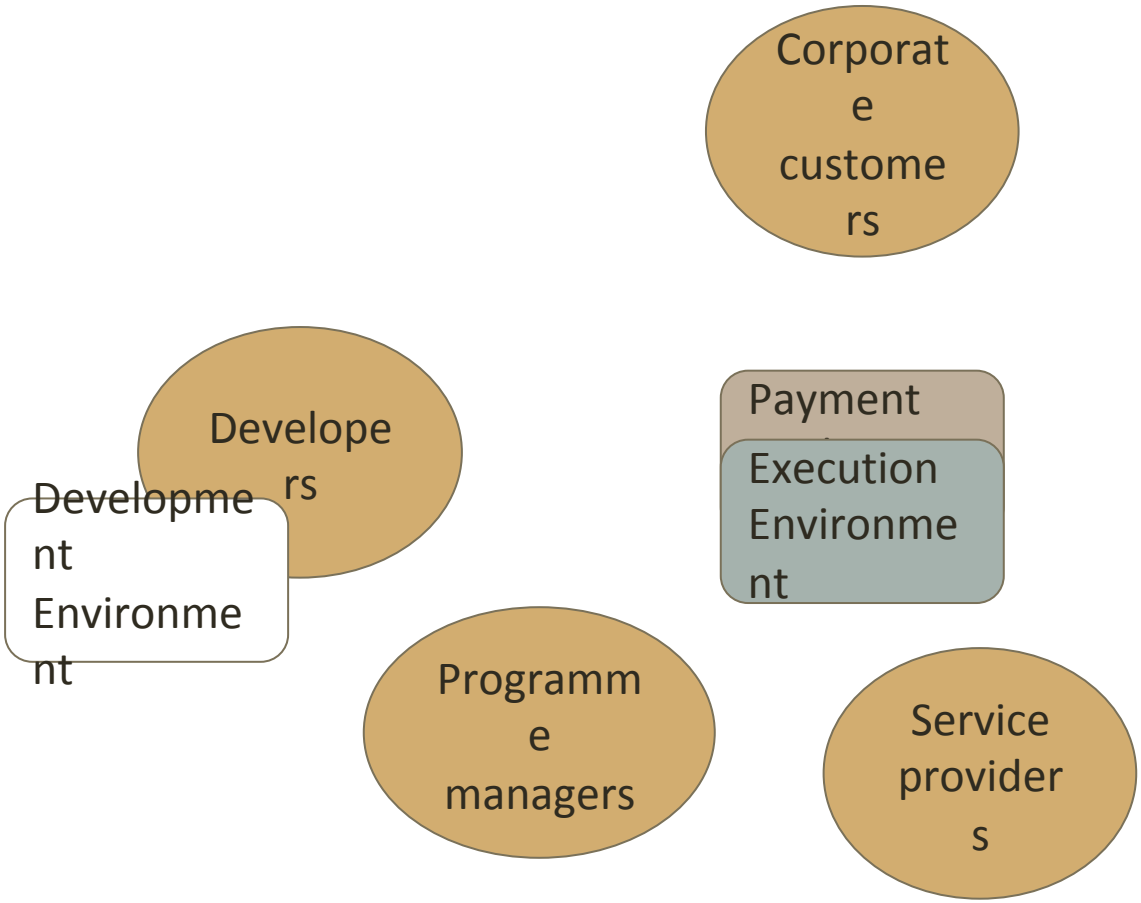

Process gives rise to issues

- Is the application legal?

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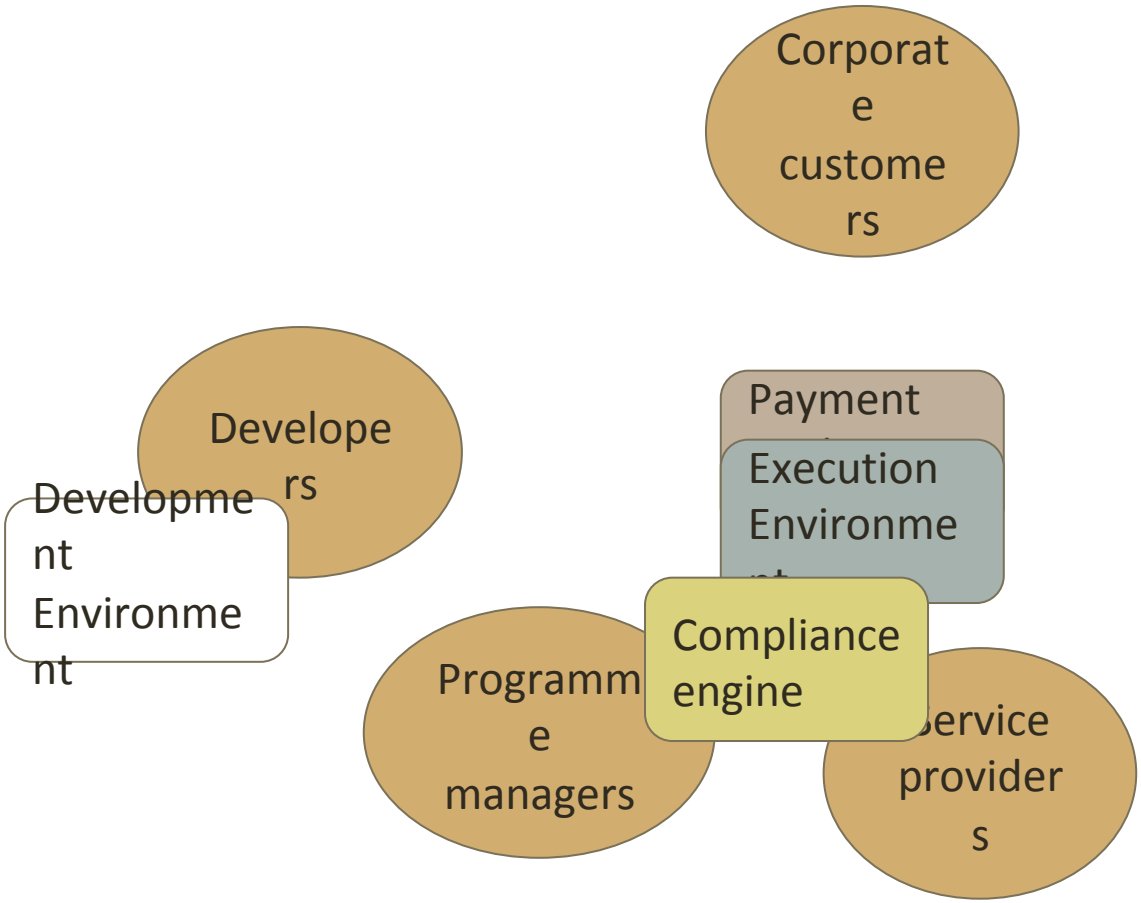
- Is the application legal?
- Which Service Provider would be willing and able to run it?

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.

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

Exampl

1. Is the jurisdiction the UK?

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

Example

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

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

1. Compliance to regulations
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Example

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

1. Are funds redeemable through the application?

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

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.

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. Is correct value given to the user

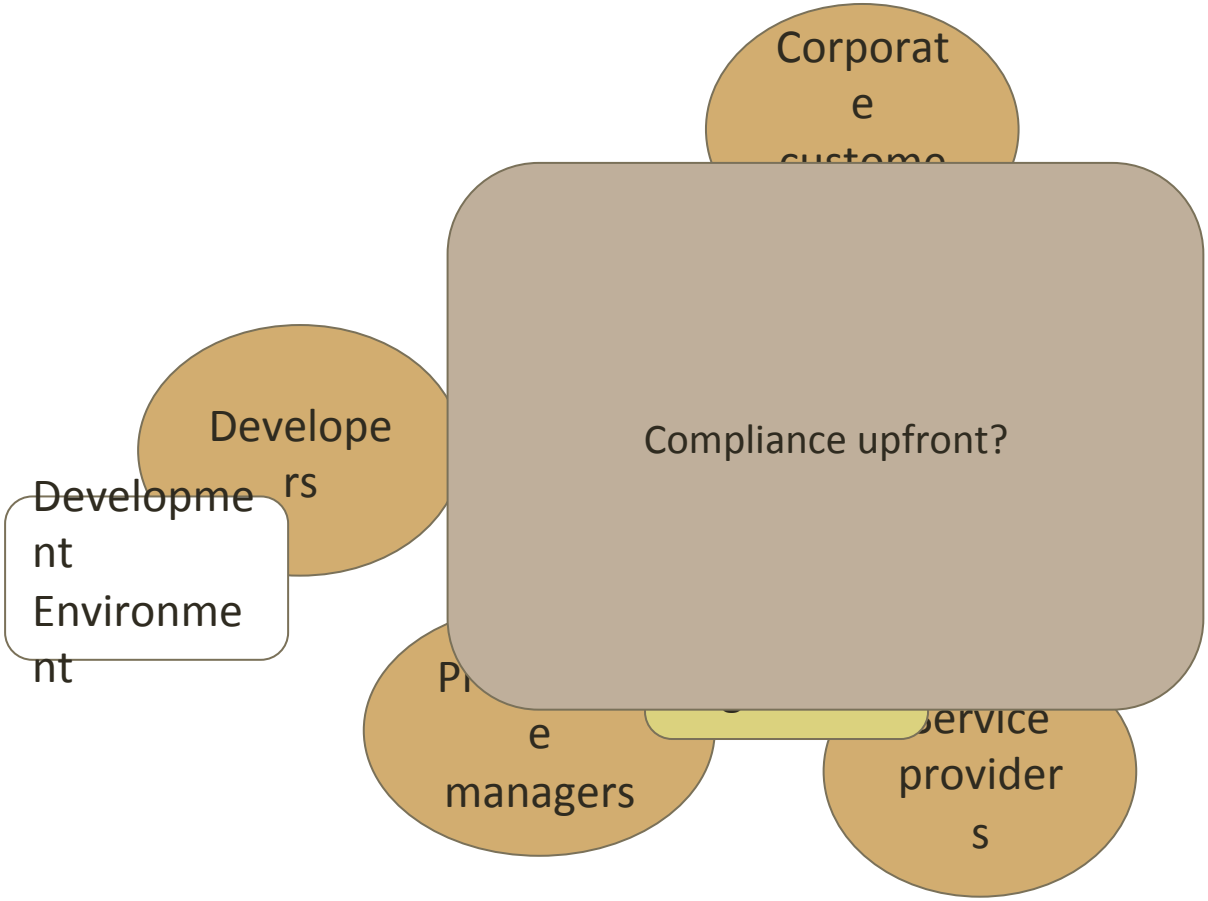
1. Compliance to regulations
2. Capability checking
3. Risk mitigation

Example

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

3. How many funds are allowed on instruments?

Open Payments Ecosystem + Compliance



Compliance Challenges

- Not all properties are checkable upfront

Implication: SA not enough

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- 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 [illegible])

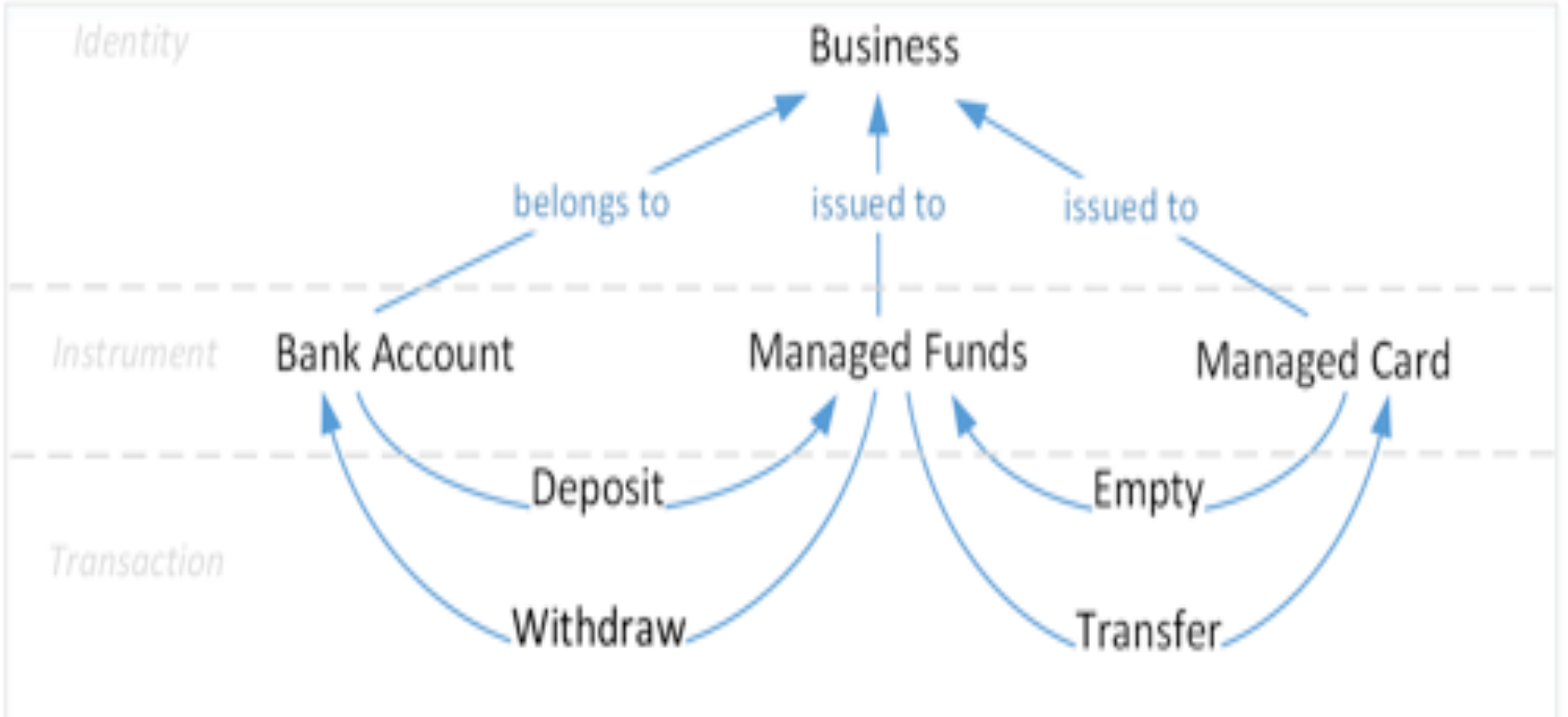
Implication: SA not enough

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



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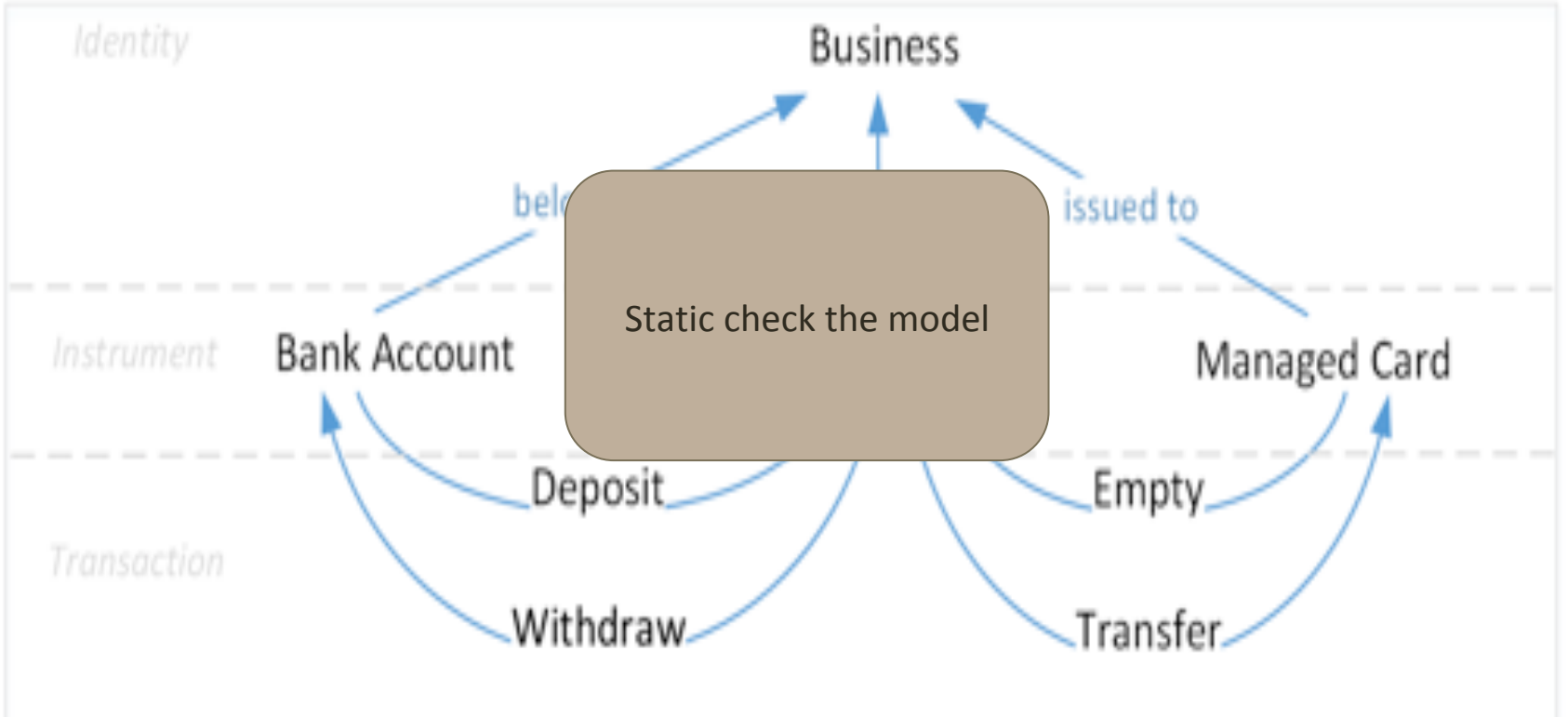
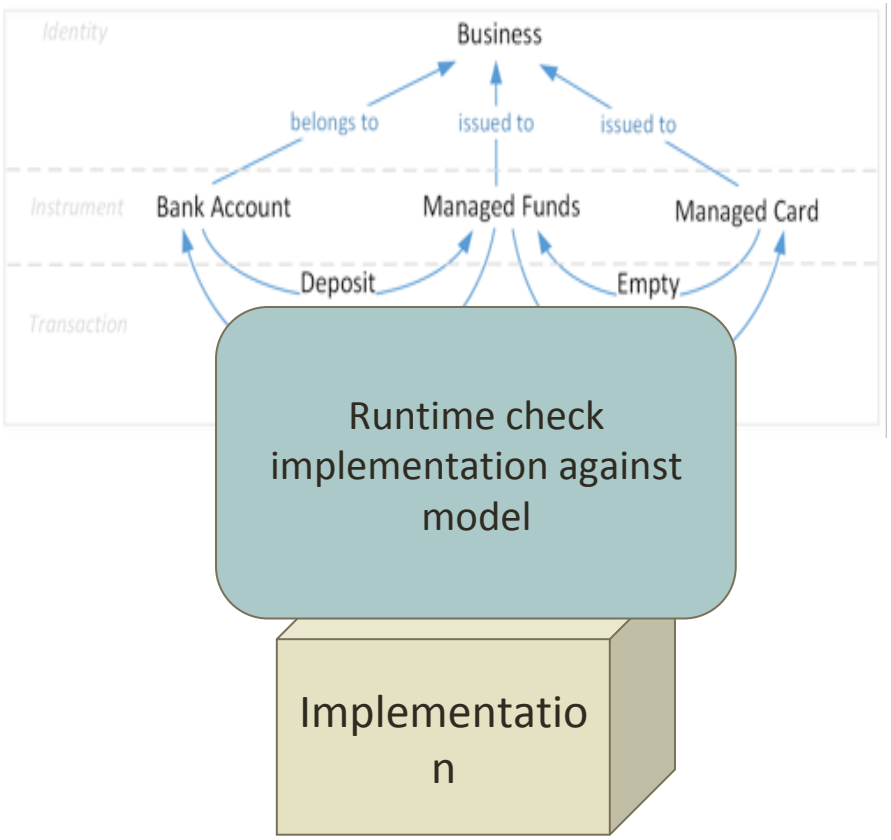
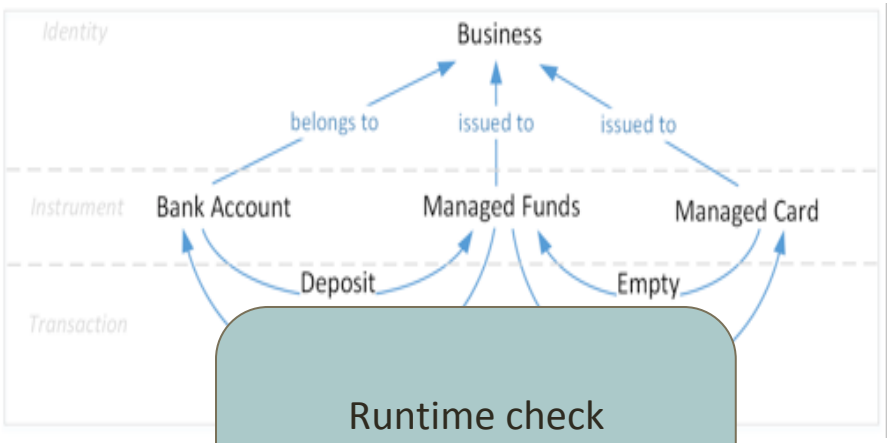


Model - Implementation



Runtime verification



Runtime check implementation against model

Implementation

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

Example

Static check the model

1. Is the jurisdiction the UK?

2. Can service provider support e-money applications?

UK e-money regula ...on financial instruments should be redeer

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

1. Are funds redeemable through the application?

Runtime check implementation against model

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

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

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

1. Is correct value given to the user

3. How many funds are allowed on instruments?

What about the maths?

Combining Static and Dynamic Analysis

$$\frac{\pi = \pi_1 \wedge \pi_2 \quad \overset{\text{SA}}{\dfrac{}{P \vdash \pi_1}} \quad \overset{\text{RV}}{\dfrac{}{P \vdash \pi_2}}}{P \vdash \pi}$$

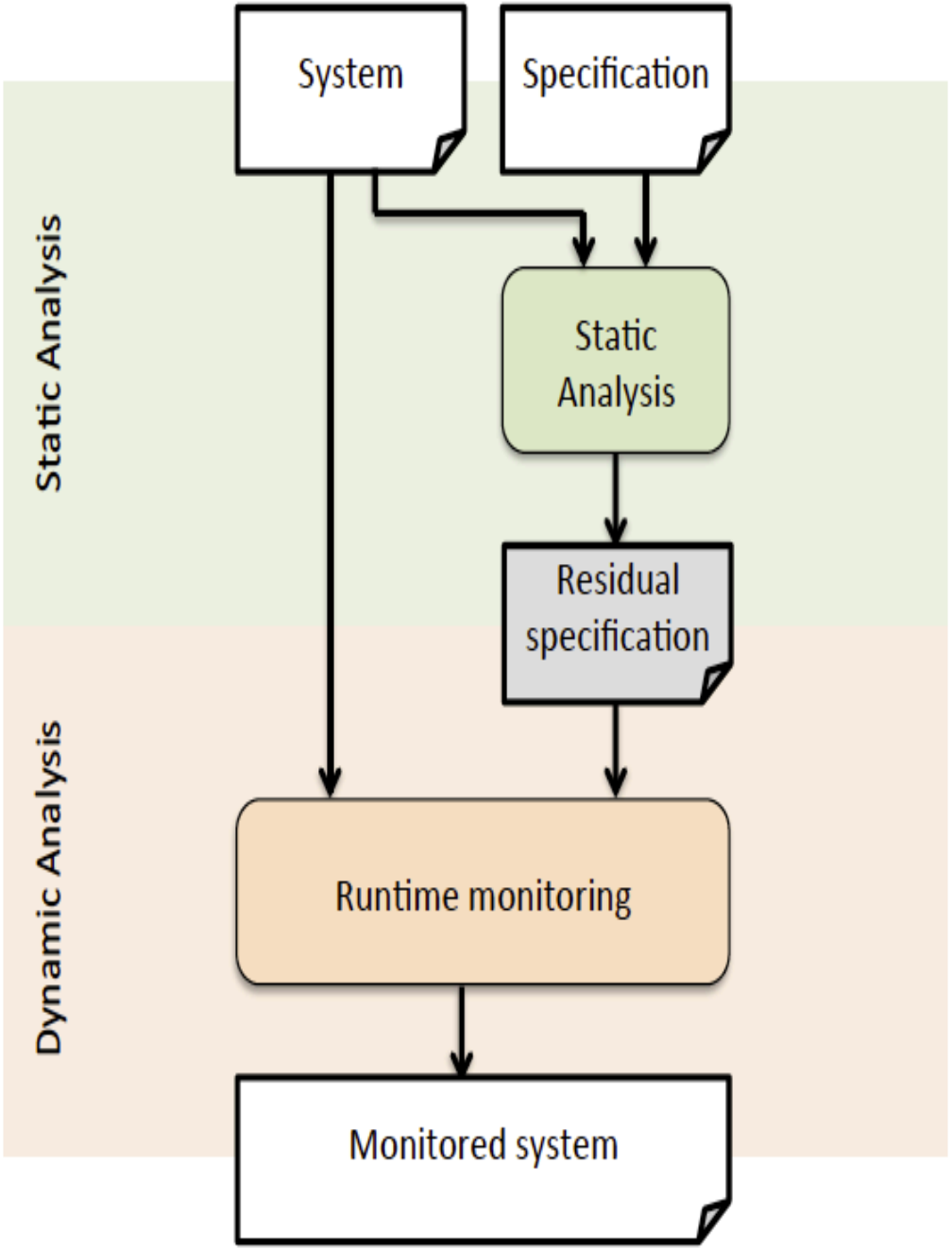
Combining Static and Dynamic Analysis

$$\mathrm{SA}(P,\pi)\ \frac{}{P \vdash \pi_1}\ \mathrm{RV}\ \frac{}{P \vdash \pi/\pi_1}\ \frac{}{P \vdash \pi}$$

Quotient operator

α/β is taken to be the least quotient of α by β w.r.t. conjunction:

- It is a quotient: $\beta \wedge (\alpha/\beta) \implies \alpha$
- It is the the least such quotient: for any γ such that $\beta \wedge \gamma \implies \alpha$, then $\gamma \implies \alpha/\beta$.


System
Specification
Static Analysis
Static Analysis
Residual specification
Dynamic Analysis
Runtime monitoring
Monitored system

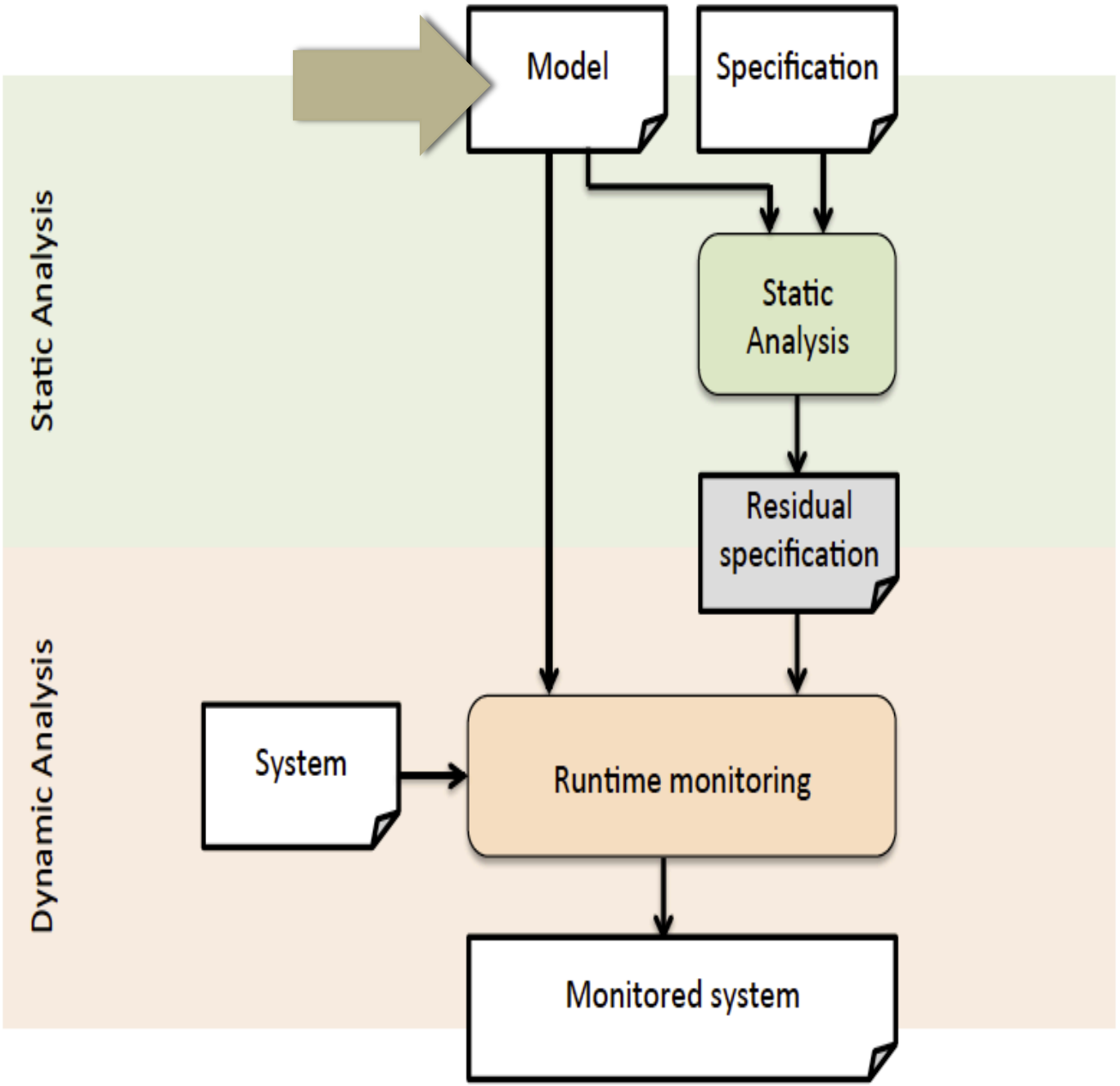
Integrating the model

$$\mathrm{SA}(M,\pi)\ \frac{}{M \vdash \pi}\ \mathrm{RV}\ \frac{}{P \sqsubseteq M} \qquad \frac{}{P \vdash \pi}$$

Integrating the model

$$\mathrm{SA}(M,\pi)\ \frac{}{M \vdash \pi}\ \mathrm{RV}\ \frac{}{P \sqsubseteq M}\ \frac{}{P \vdash \pi}$$

$$\mathrm{SA}(M,\pi)\ \frac{}{M \vdash \pi_1}\ \mathrm{RV}\ \frac{}{P \sqsubseteq M}\ \mathrm{RV}\ \frac{}{P \vdash \pi/\pi_1}\ \frac{}{P \vdash \pi}$$


Static Analysis
Dynamic Analysis
Model
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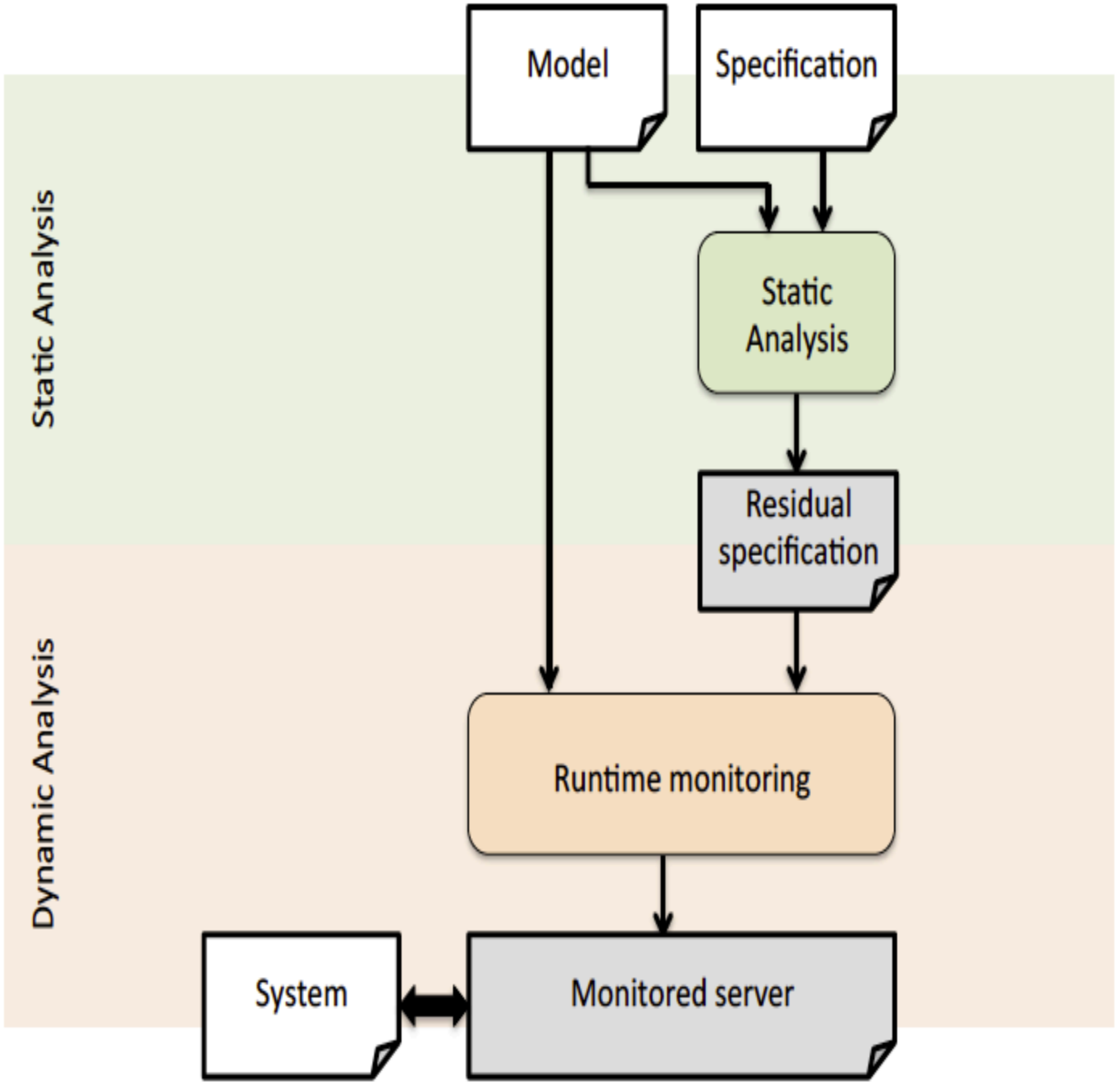
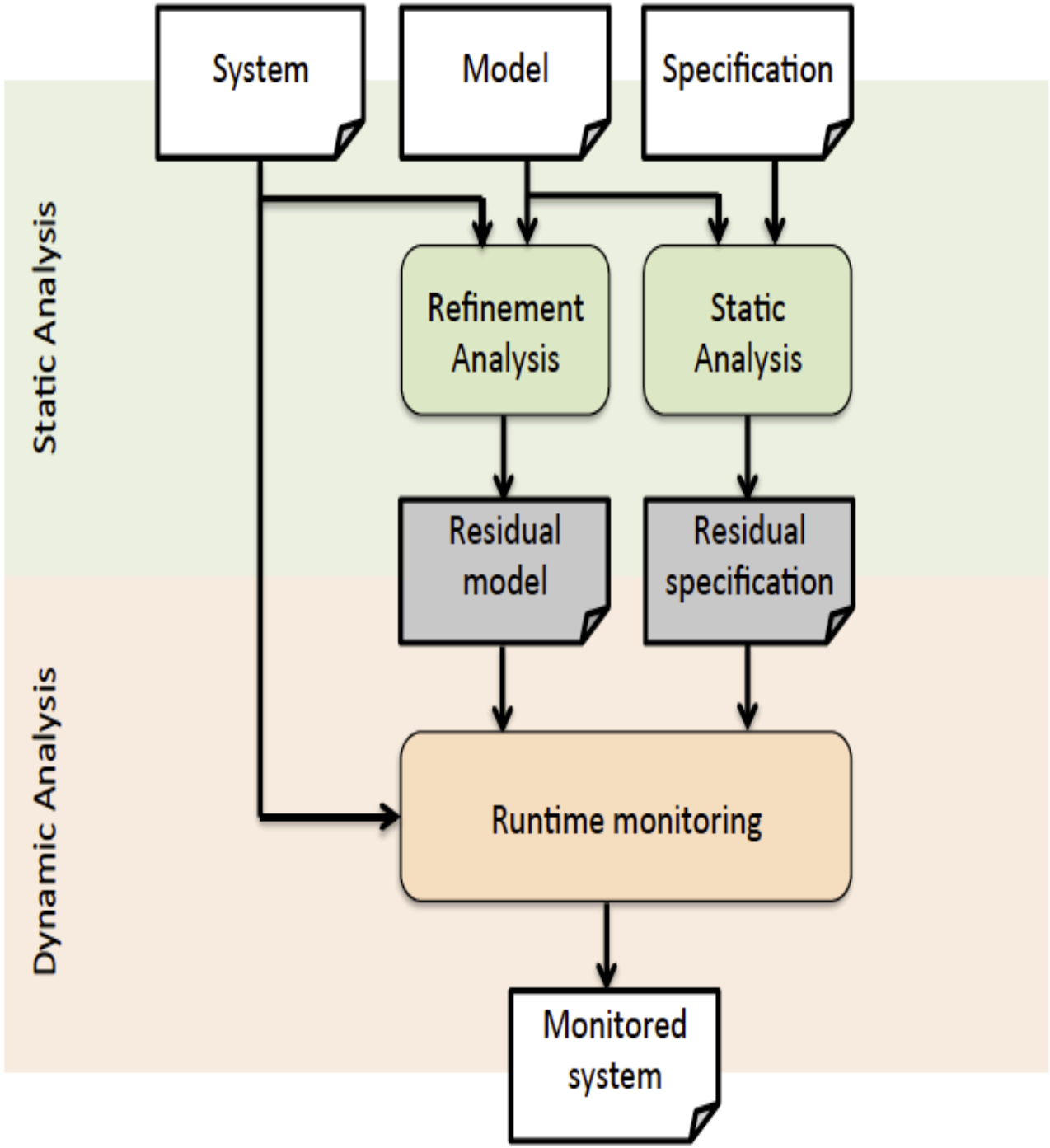
System
Runtime monitoring
Monitored system


Static Analysis
Dynamic Analysis
Model
Specification
Static Analysis
Residual specification
Runtime monitoring
System
Monitored server

Quotient operator on the model

$$\mathrm{SA}(P,M)\ \frac{}{P \sqsubseteq M_1}\ \mathrm{SA}(M,\pi)\ \frac{}{M \vdash \pi_1}\ \mathrm{RV}\ \frac{}{P \sqsubseteq M/M_1}\ \mathrm{RV}\ \frac{}{P \vdash \pi/\pi_1}$$
$$\frac{}{P \vdash \pi}$$


System
Model
Specification
Static Analysis
Refinement Analysis
Static Analysis
Residual model
Residual specification
Dynamic Analysis
Runtime monitoring
Monitored system

Conclusions

- Loads of work ahead!!