


Model Driven Development for the Internet of Things

VICENTE PELECHANO

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Agenda

- Motivation
- Problem
- Solution
- Validation
- Conclusions
- Ongoing Work

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Motivation

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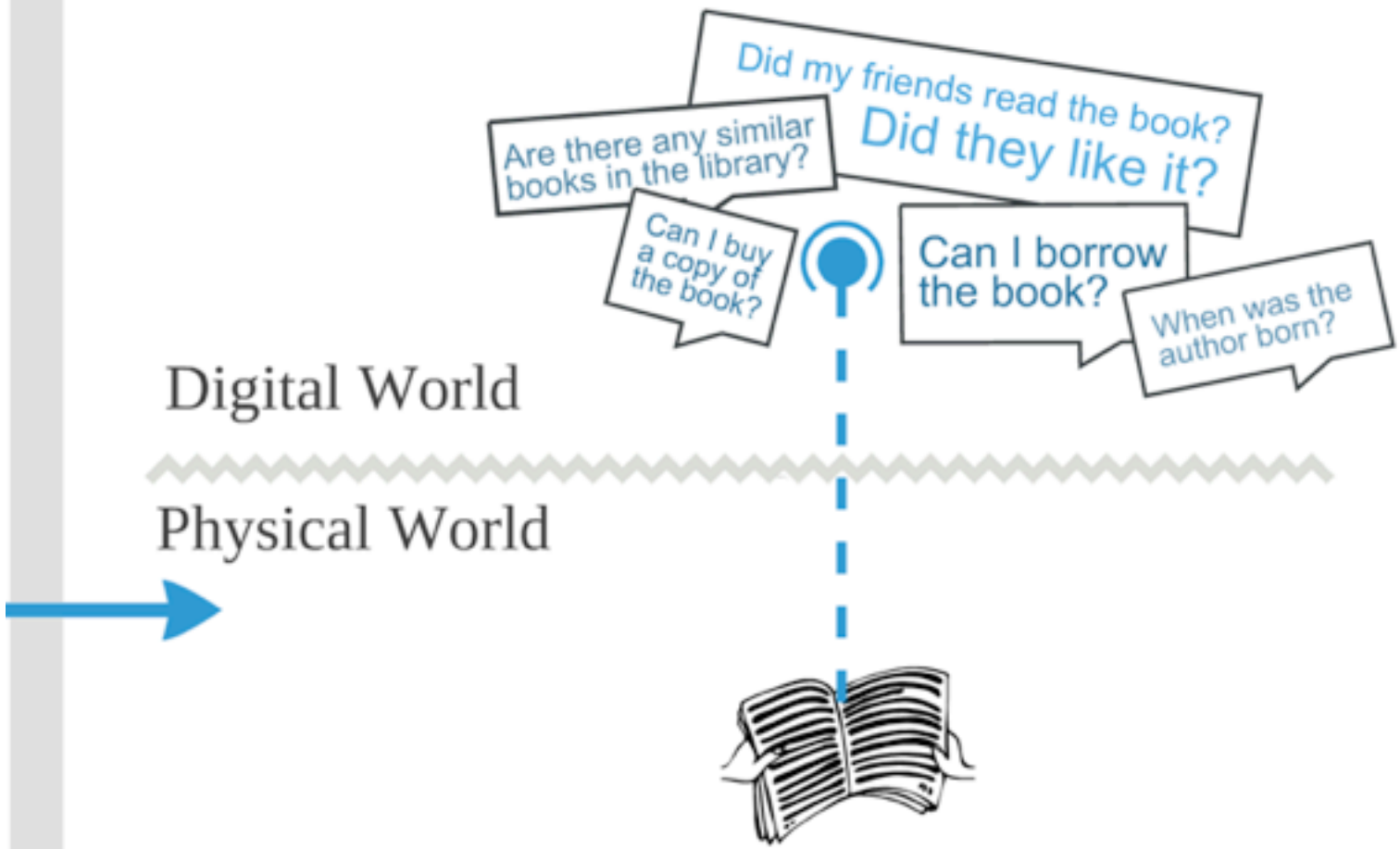
Humans need to
organize
their world


Did my friends read the book?
Did they like it?
Are there any similar books in the library?
Can I buy a copy of the book?
Can I borrow the book?
When was the author born?
Digital World
Physical World

Media breaks

Humans acting as information carriers

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Inneficient and error-prone

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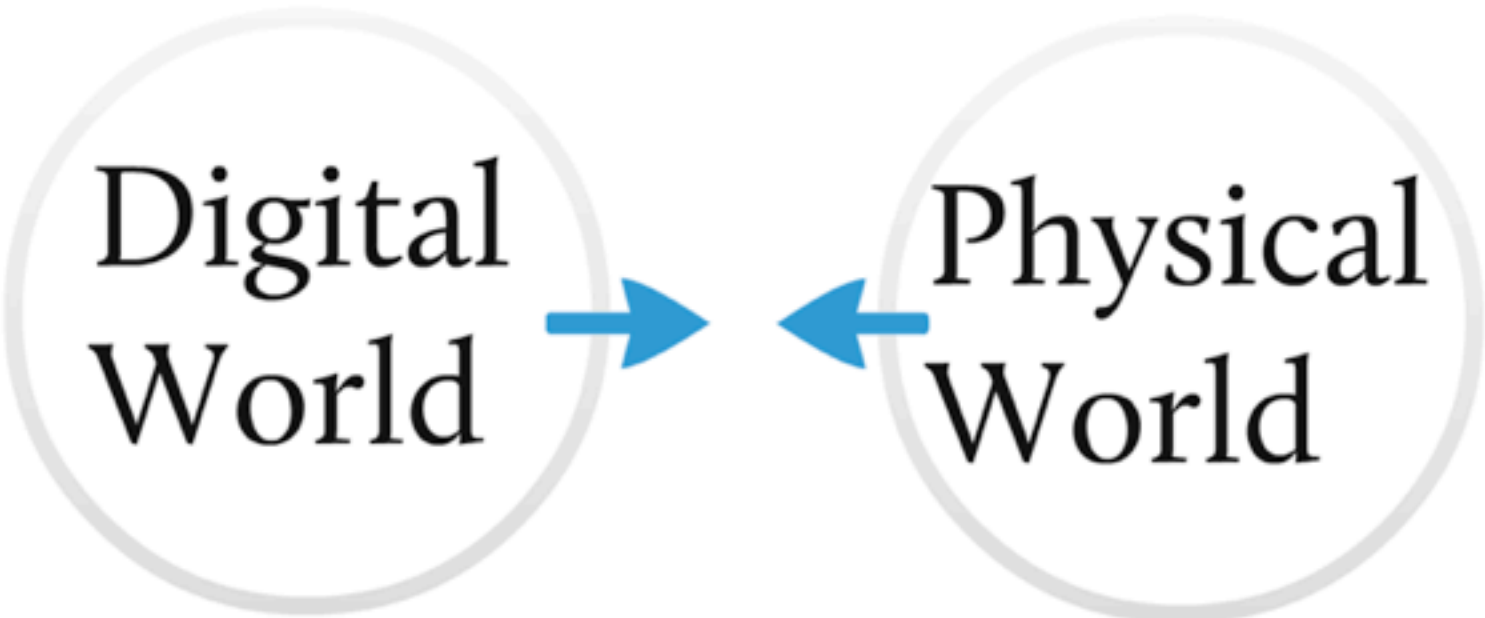
Bridge the physical-virtual gap

for users to access services right now!



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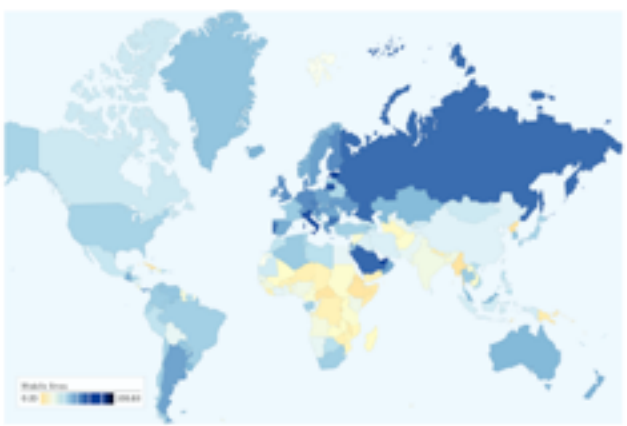
Mobile devices

services in your pocket

27 mobile phones are sold per second worldwide



Google Nexus One

Positioning
GPS-, WiFi-based

Tactile
Touch screen

Orientation
Digital compass

Movement
Accelerometer

See
Camera

Listen
Voice recognition

Speak
Text-to-speech

Advanced interaction mechanisms
with the user and the environment

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The Internet of Things

automate physical-virtual linkage

"We are talking about the everyday object, the dumbest, cheapest, most obvious thing we can buy or use. Except it has a unique digital identity, so it becomes trackable, sortable, rankable, and findable in space and time."

Bruce Sterling

Barcodes | Contact memory | Smart cards | RFID

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TIME

Time's Best Inventions of 2008

The Other 49 Best Inventions

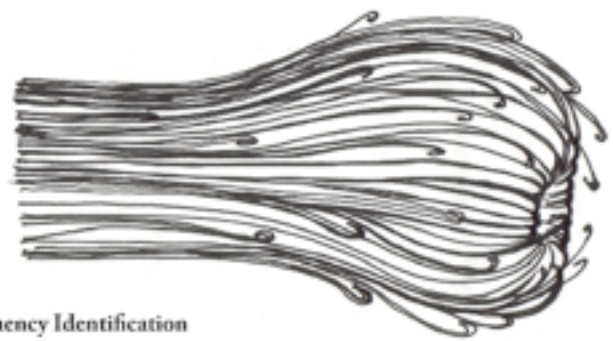
BACK NEXT

View All

30. The Internet Of Things

ILLUSTRATION FOR TIME BY CHRISTOPH NIEMANN

In September, a group of high-tech companies that includes Cisco and Sun formed the IP for Smart Objects Alliance. Simply put, the organization intends to create a new kind of network that will allow sensor-enabled physical objects — appliances in your home, products in a factory, cars in a city — to talk to one another, the same way people communicate over the Internet.



RFID - Radio Frequency Identification
Raptus Arphadus

Field: automatic identification method, using radio waves
Uses: RFID tags integrated in a product, animal, or person
Range: Passive tags 1 cm - a few meters. Many active tags have practical ranges of hundreds of meters
Capacity: from 128-bits to 2,840 bytes depending on size and activeness

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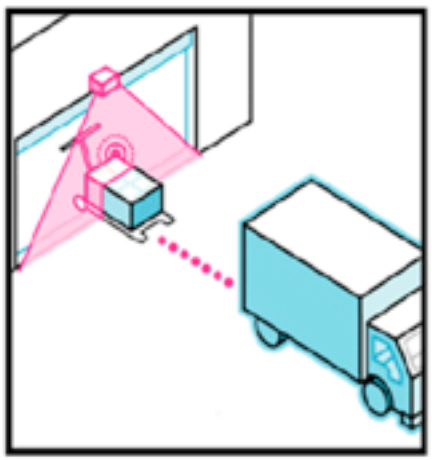
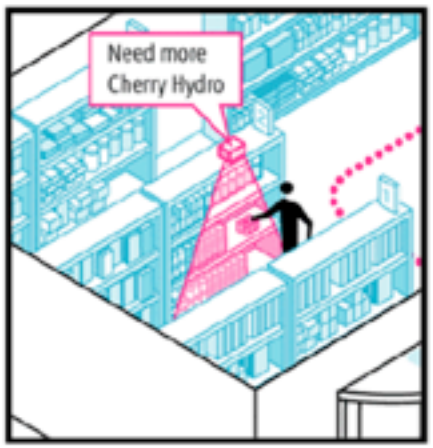
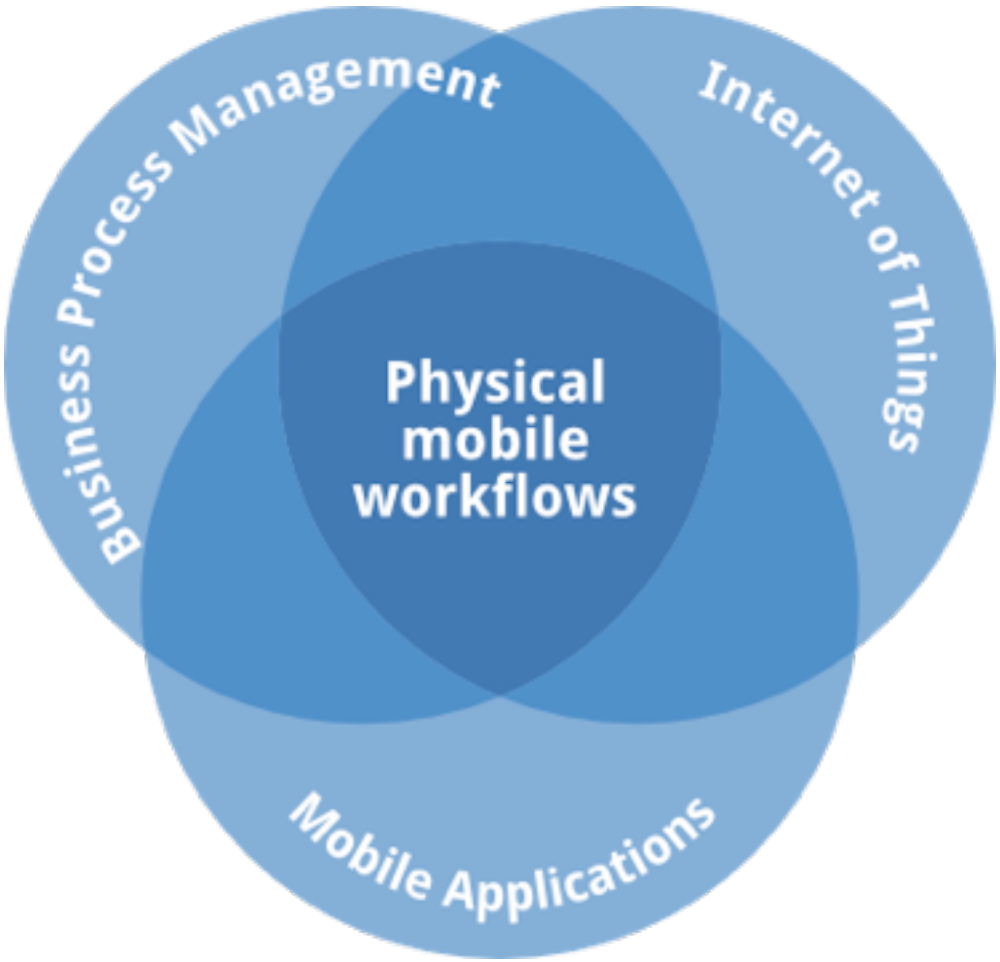
Business processes

become more fluent by automating identification





→ Different Auto-ID technologies can be used


Business Process Management
Internet of Things
Physical mobile workflows
Mobile Applications

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Problem

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How to develop Physical Mobile Workflows in a systematic manner?

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What is different in these workflows ?

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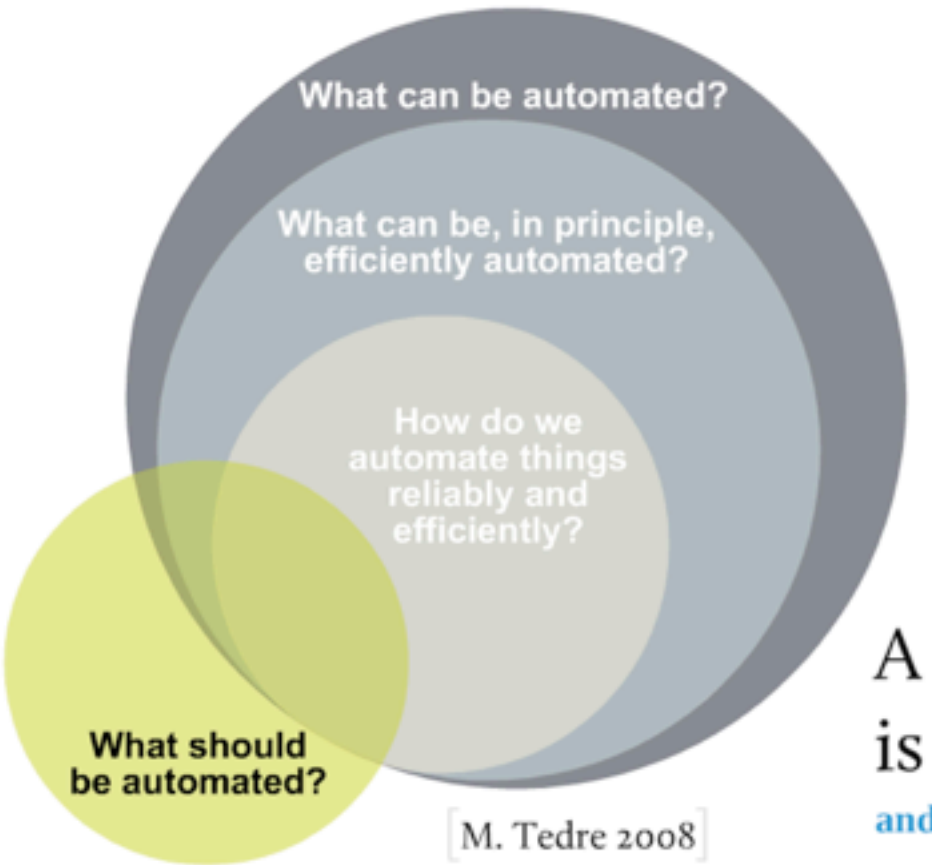
1 Options for automation



M. Tedre 2008

A specific automation degree is required for each task

and there is no one-size-fits-all solution in Auto-ID

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2 Multiple views of the world

Each participant in the workflow has a particular perspective

and is interested in different services

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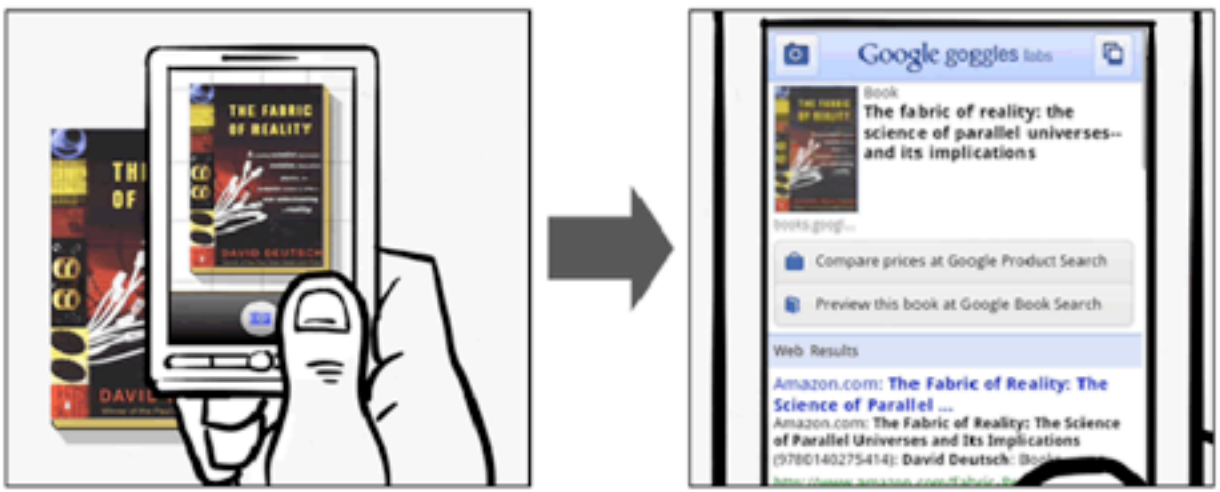
How to support these new requirements ?

From a technological perspective...

Google Goggles

use pictures to search the web



Barcode reader OCR
Image recognition
Pointing direction

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How to...

...use **other technologies** for identification?

...search books **in my library?**

...access **the services I need?**

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Consider the physical-virtual linkage during workflow development

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Solution

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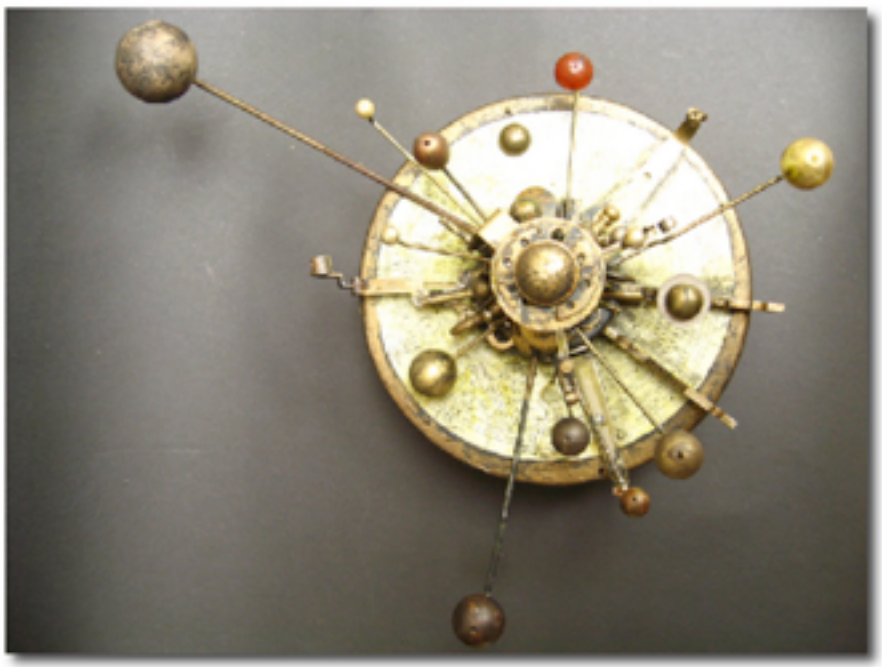
Model Driven Engineering

focus on the meaningful



Model: simplification of a system that should be able to answer questions in place of the actual system

MDE has been applied for workflow support

in the digital world

Business Process Management

Business Process Management

1. How to capture requirements about the physical-virtual linkage?

2. How to simulate the workflow in the real-world?

3. How to map requirements to technological solutions?

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Physical Mobile Workflows

A well defined business process

Explicit identification

User participation

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is our idea Original?

State of the Art

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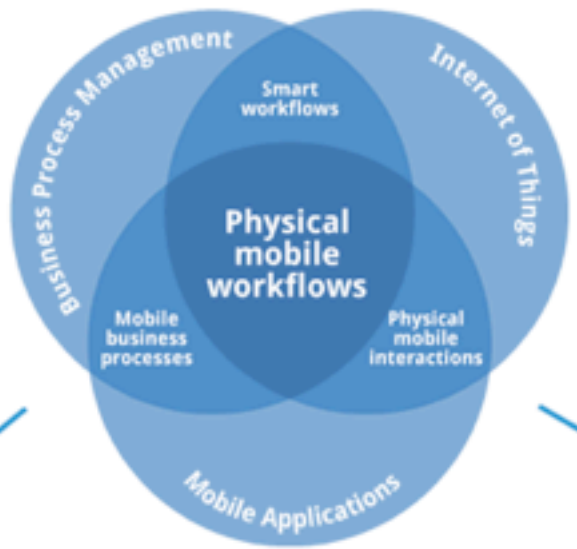
Smart workflows

12 proposals analyzed



Mobile business processes

Physical mobile interactions

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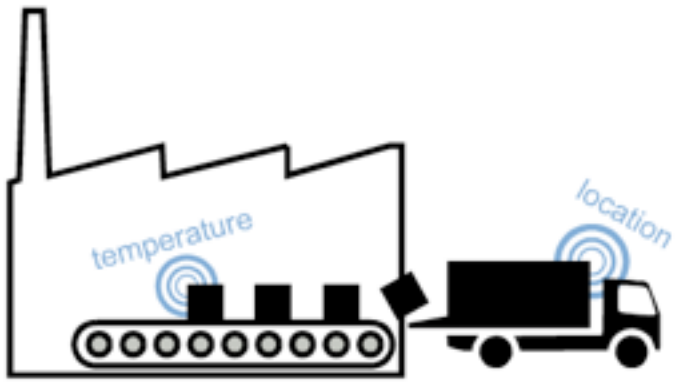
Smart workflows



They are focused on **automation**

We adapt automation level to the workflow needs

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Mobile business processes

They are focused on overcoming **technical limitations**

We focus on overcoming **human limitations** in cognitive resources

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Physical mobile interactions

They are describing **component invocation** in physical interactions

We compose physical interactions accordign to workflow requirements

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Solution

...in Detail

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The Method

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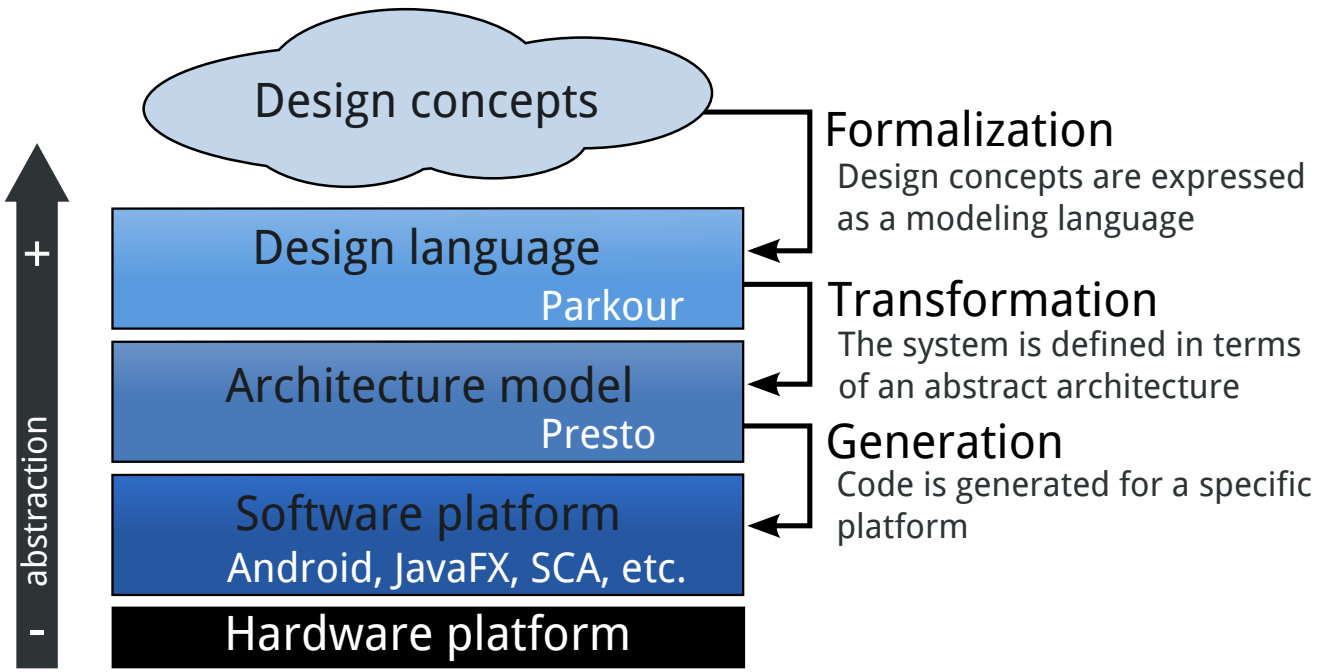
The Method



Design

Activities | Physical-virtual interaction | Technology selection | Deployment organization

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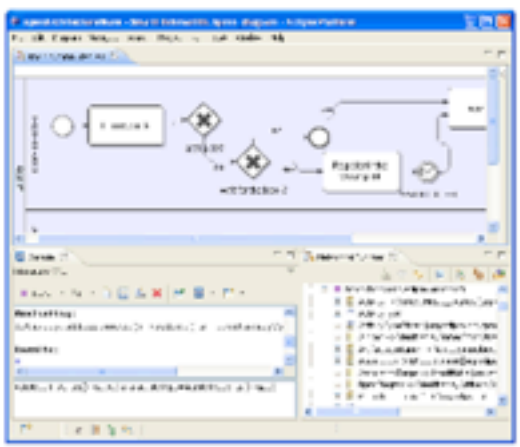
Activities

Determine which activities are performed

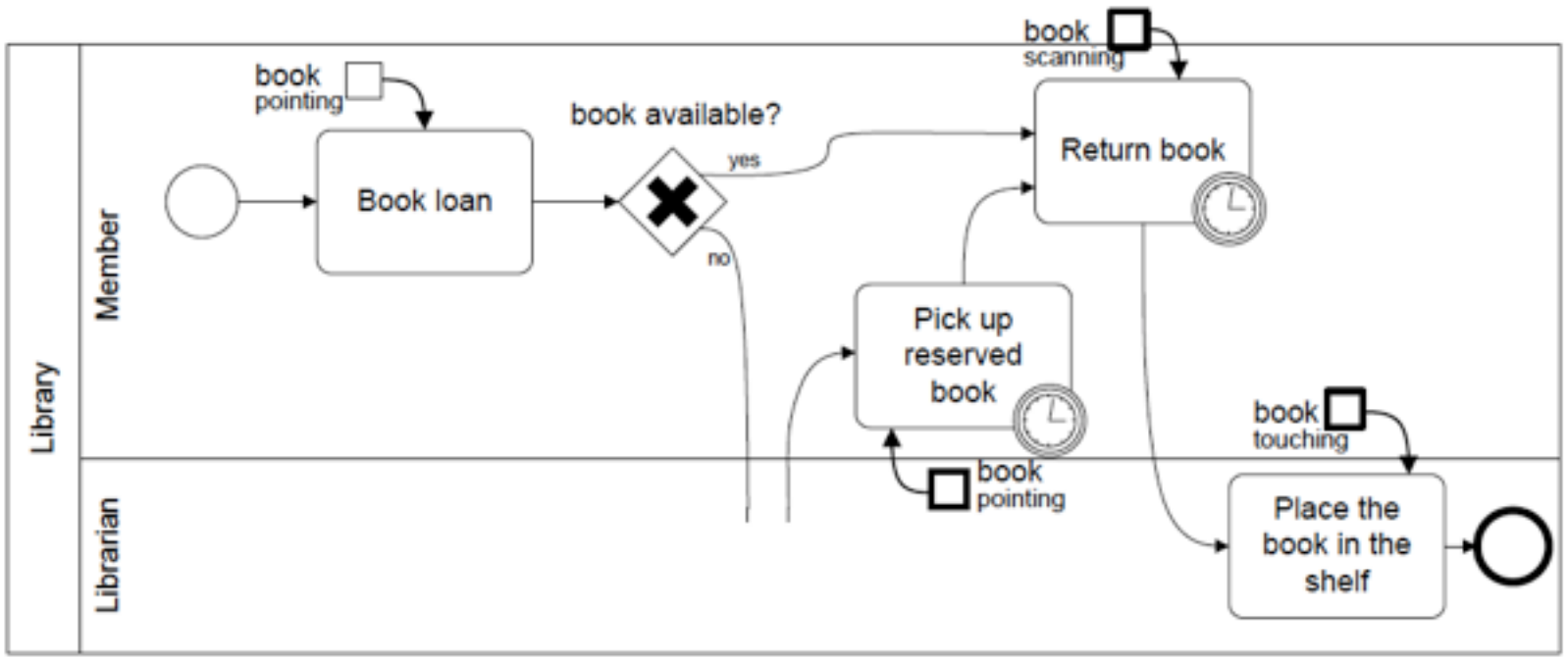
and which ones involve physical elements



Business Process Modeling Notation (BPMN)

We extended BPMN with the PhysicalObject primitive

- **Information structure**
- **Use for correlation**
- **Properties of the physical-virtual linkage...**


Library
Member
Librarian
book pointing
Book loan
book available?
yes
no
book scanning
Return book
Pick up reserved book
book pointing
book touching
Place the book in the shelf

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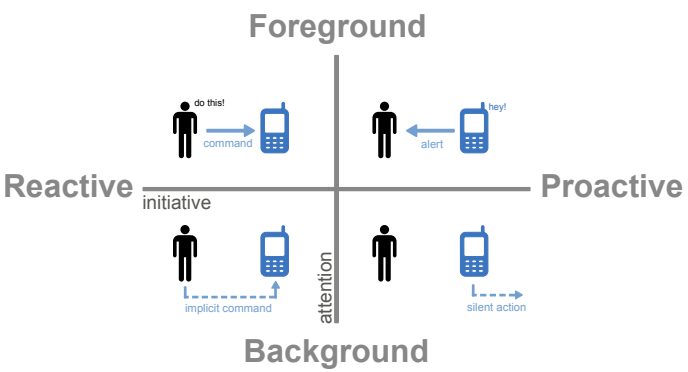
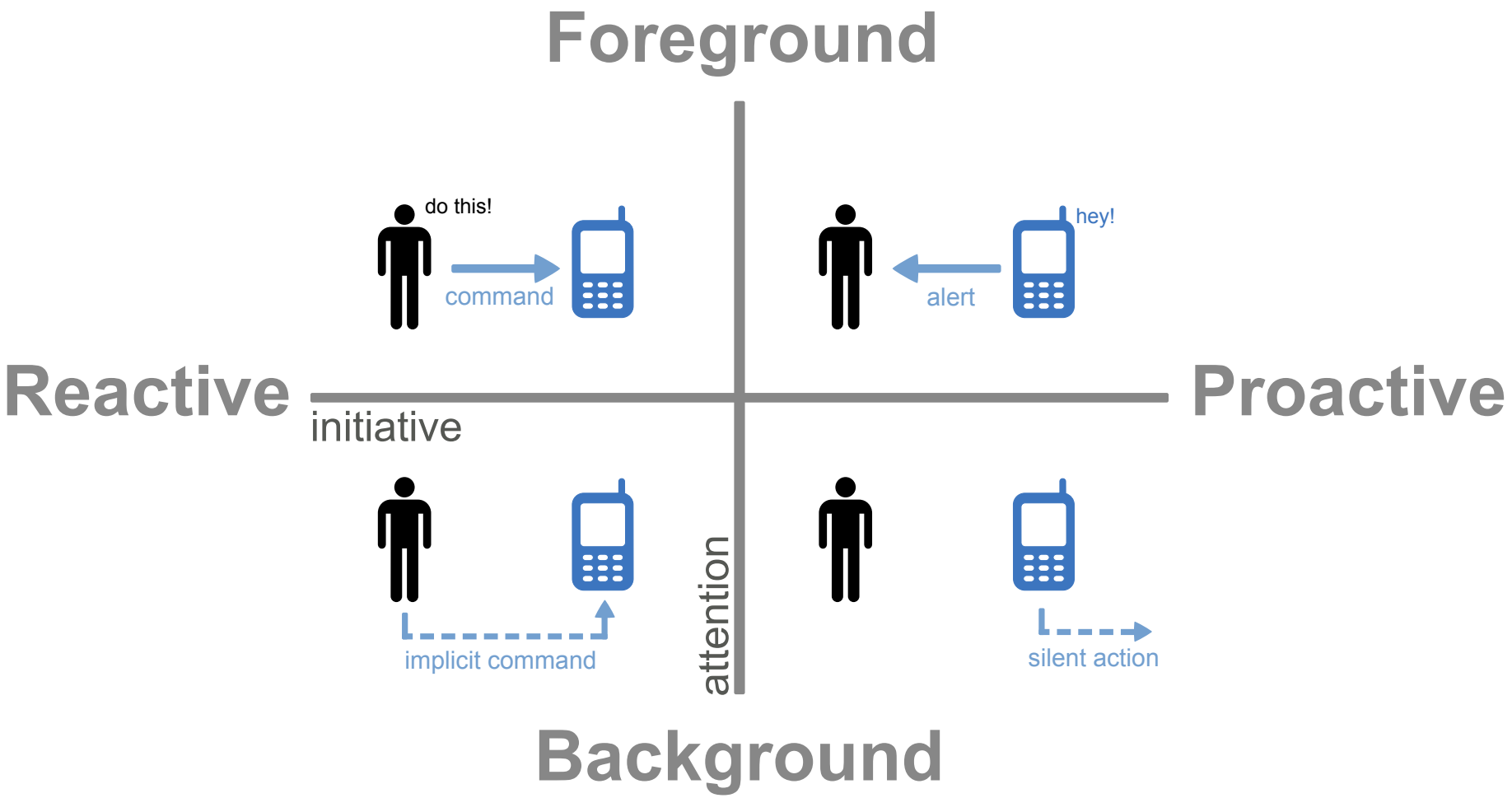
Physical-virtual interaction



Implicit Interaction


Foreground
Reactive
Proactive
initiative
attention
Background
do this!
command
hey!
alert
implicit command
silent action

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Implicit Interaction

Physical-virtual interaction can happen at different obtrusiveness levels

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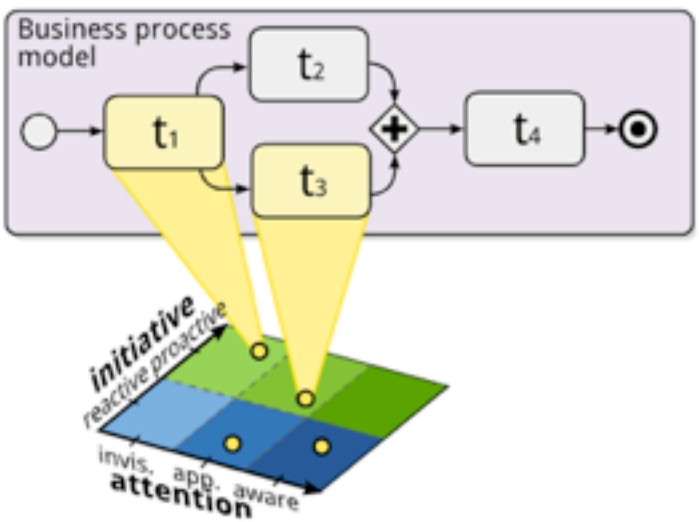
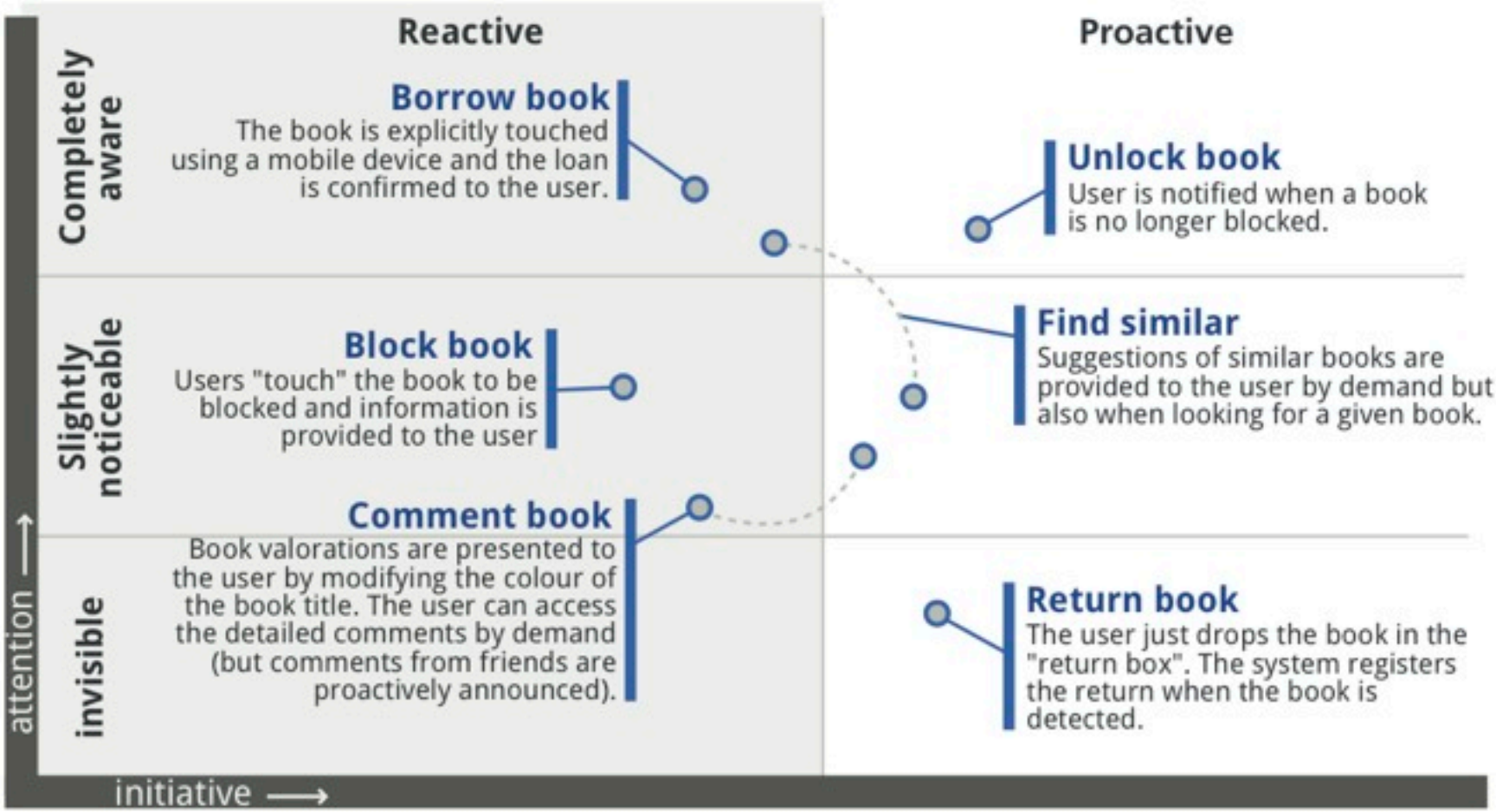
At which obtrusiveness level is performed each task?




Reactive
Proactive
Completely aware
Slightly noticeable
invisible
attention
initiative
Borrow book
The book is explicitly touched using a mobile device and the loan is confirmed to the user.
Unlock book
User is notified when a book is no longer blocked.
Block book
Users "touch" the book to be blocked and information is provided to the user
Find similar
Suggestions of similar books are provided to the user by demand but also when looking for a given book.
Comment book
Book valorations are presented to the user by modifying the colour of the book title. The user can access the detailed comments by demand (but comments from friends are proactively announced).
Return book
The user just drops the book in the "return box". The system registers the return when the book is detected.

Which interaction mechanisms can be supported?

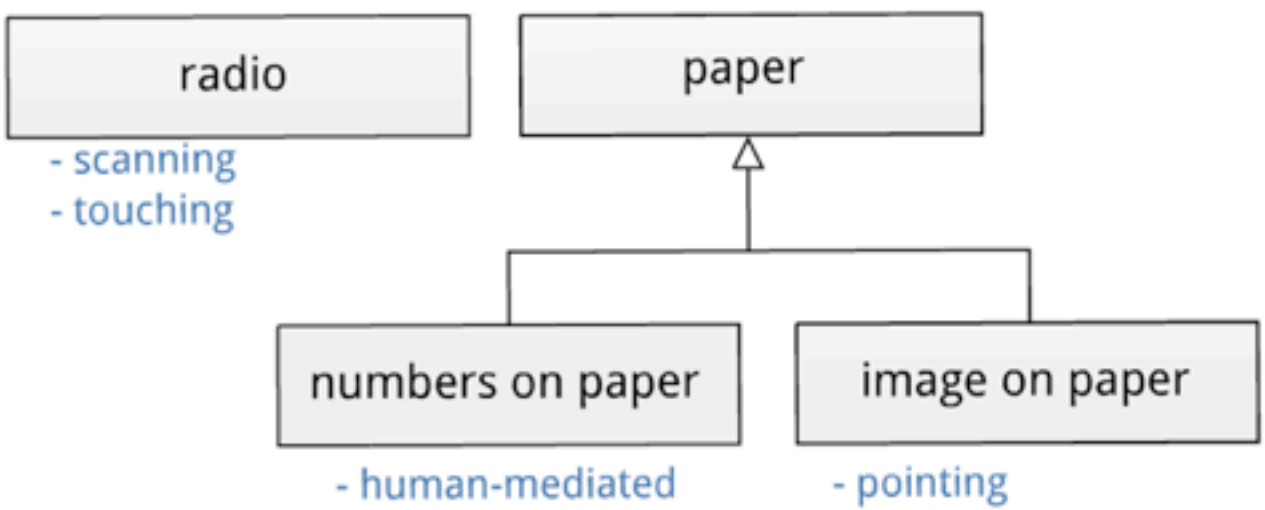
Pointing

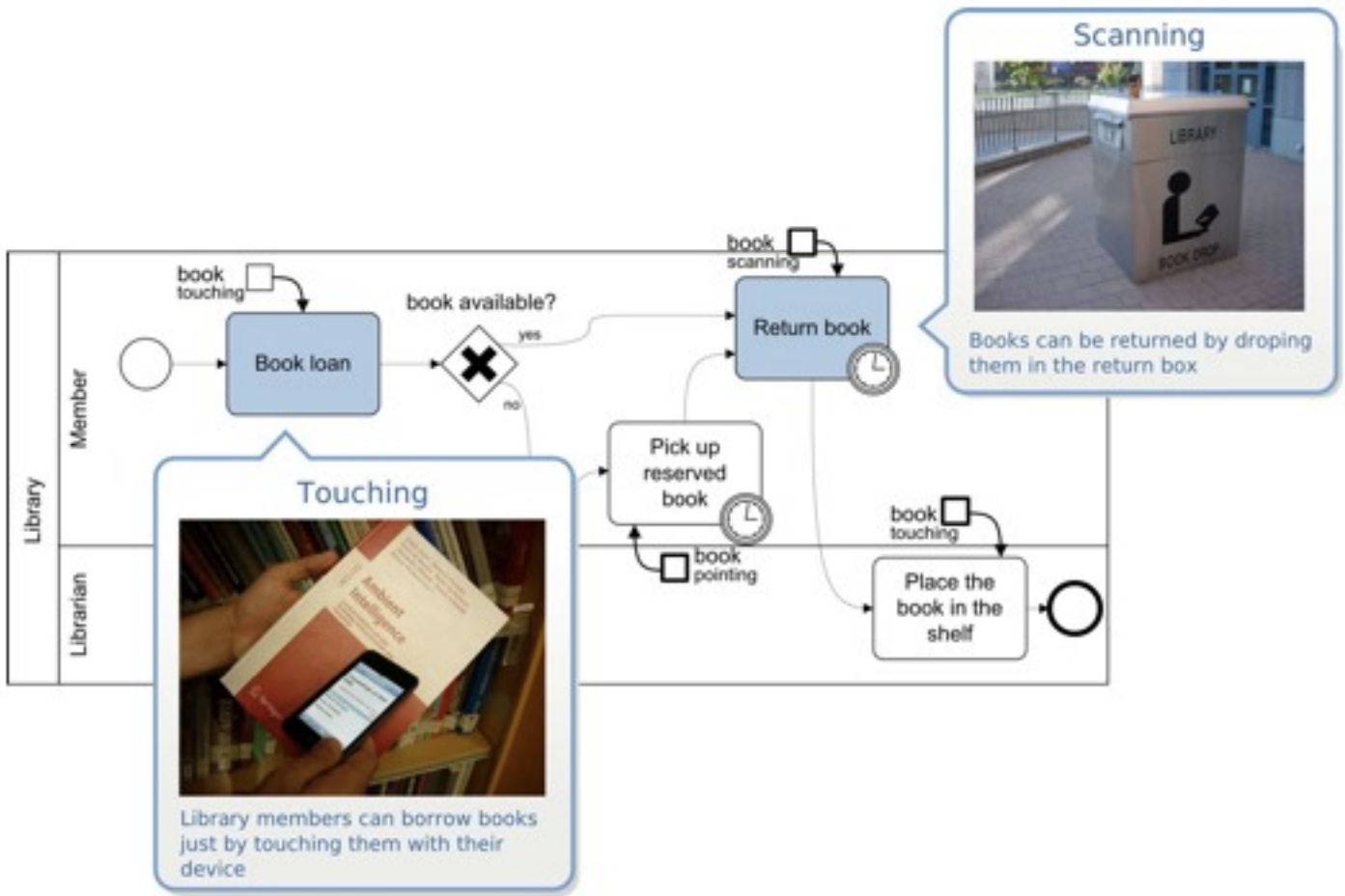
Touching

Scanning

User mediated interaction

The MEDIUM Concept




Scanning
Books can be returned by droping them in the return box
Library
Member
Librarian
book touching
Book loan
book available?
yes
no
book scanning
Return book
Pick up reserved book
book pointing
book touching
Place the book in the shelf
Touching
Library members can borrow books just by touching them with their device

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Technology selection

technology + medium + interaction

RFID

radio

QR Code

paper

Text label

paper

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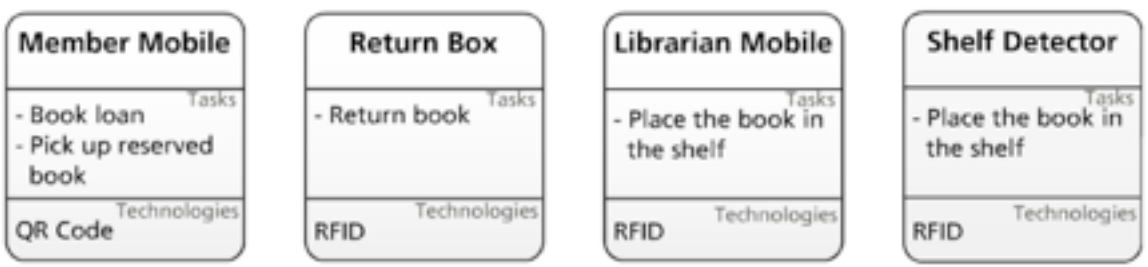
Deployment organization

- device + tasks + technologies



Member Mobile	Return Box	Librarian Mobile	Shelf Detector
Tasks - Book loan - Pick up reserved book	Tasks - Return book	Tasks - Place the book in the shelf	Tasks - Place the book in the shelf
Technologies QR Code	Technologies RFID	Technologies RFID	Technologies RFID

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and ...
The Models...

Parkour DSL

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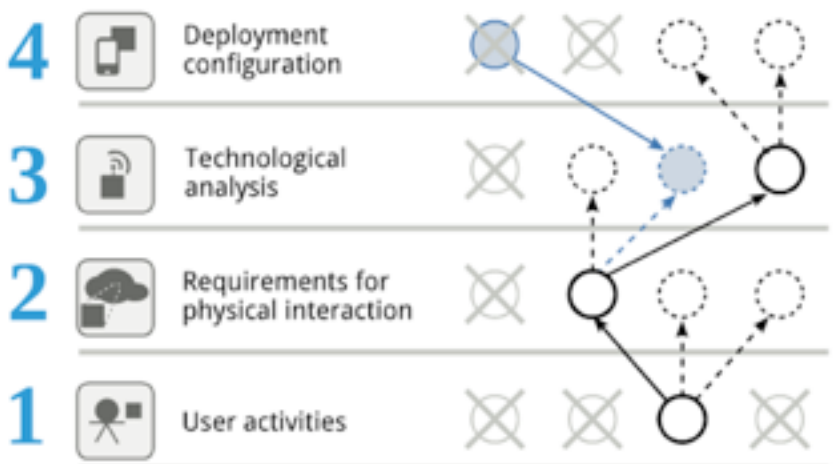
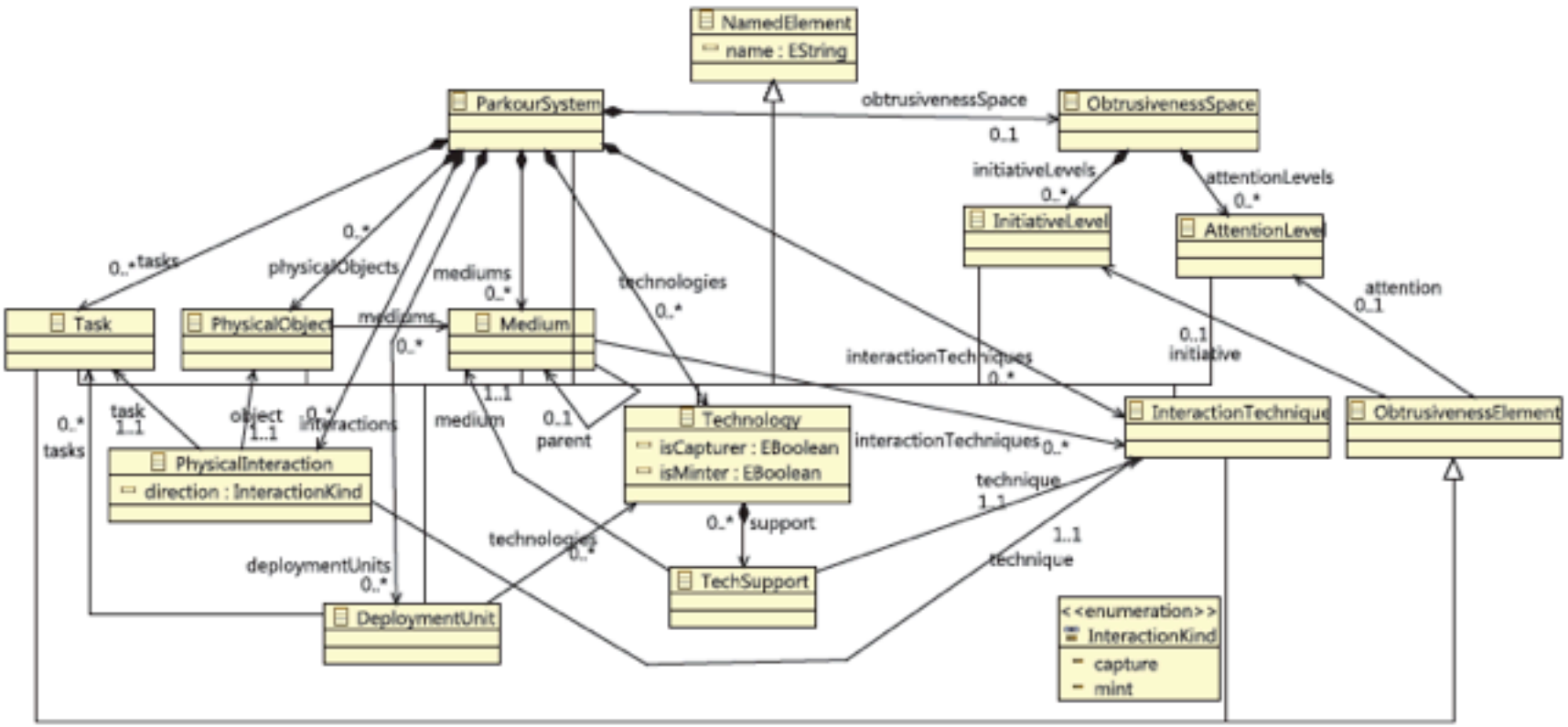
Formalize

The Parkour metamodel formalizes the concepts used for design



Parkour Metamodel



Keep the design consistent

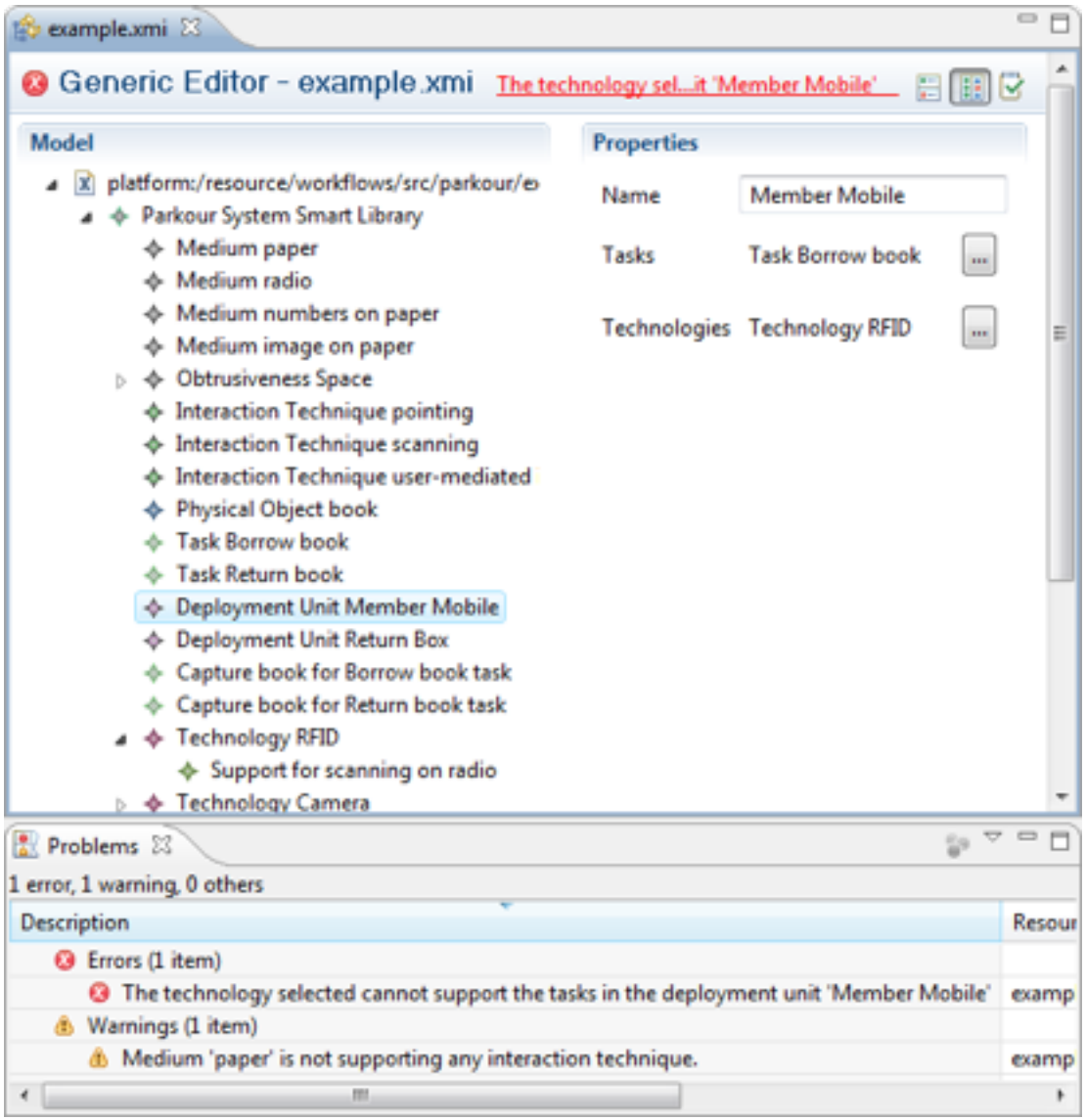
which interaction techniques supports?

Can RFID be used by library members to borrow books by pointing at them?

which medium is used for labeling the books?

at which obtrusiveness level is interaction produced?

Model-based Validation



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Simulate

How to put the workflow in the real world before it is developed?

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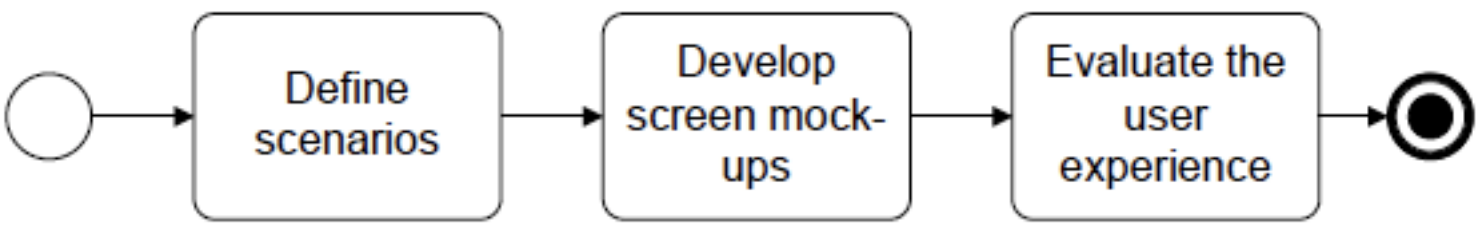
How to put the workflow in the real world before it is developed?

We need to support...

- **Fast evolution**
  Business processes are fast-changing → **HTML prototypes + Wizard of Oz**
- **A concurrent environment**
  Users are involved in many tasks at a time → **Predefined script**
- **The user and the process**
  User experience and process efficiency matter → **MoBiS-Q questionnaire**


Define scenarios
Develop screen mock-ups
Evaluate the user experience

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The operator triggers context changes

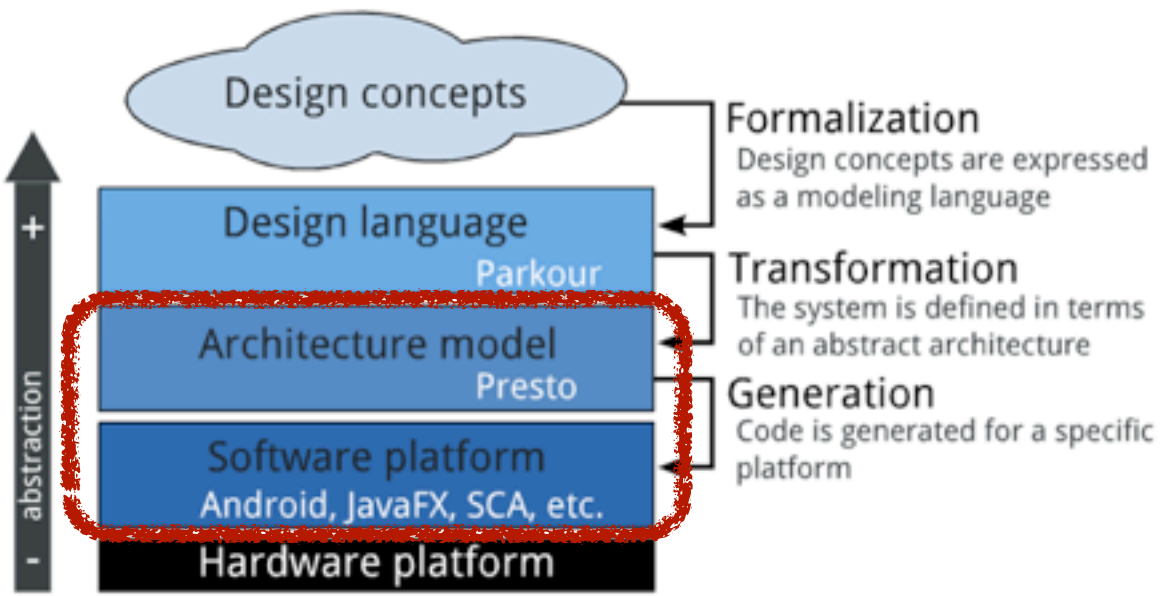
The user follows the process according to a script

Execute

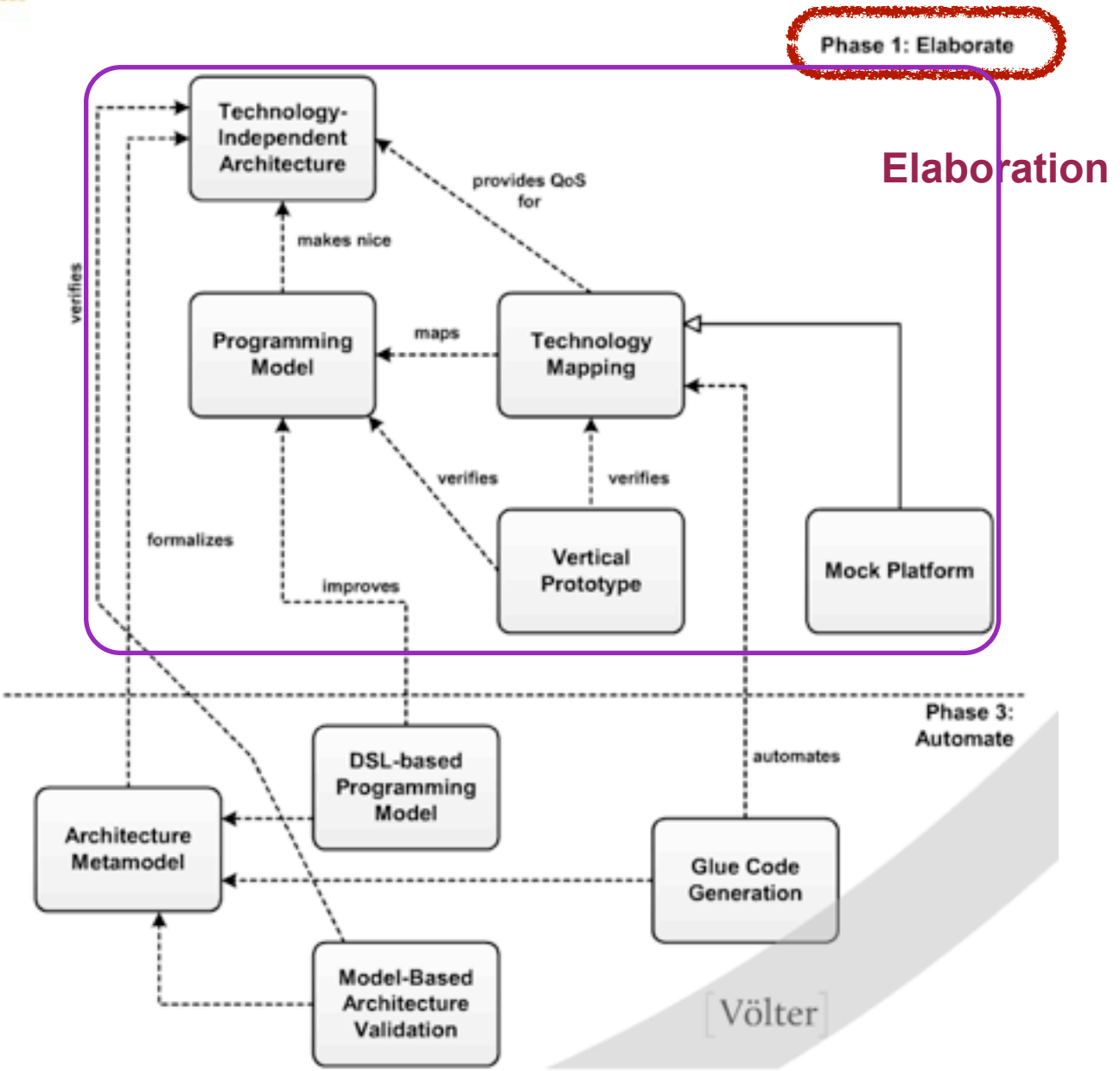
How to provide a software solution?

Automation

supporting multiple technologies



The Architectural Proces

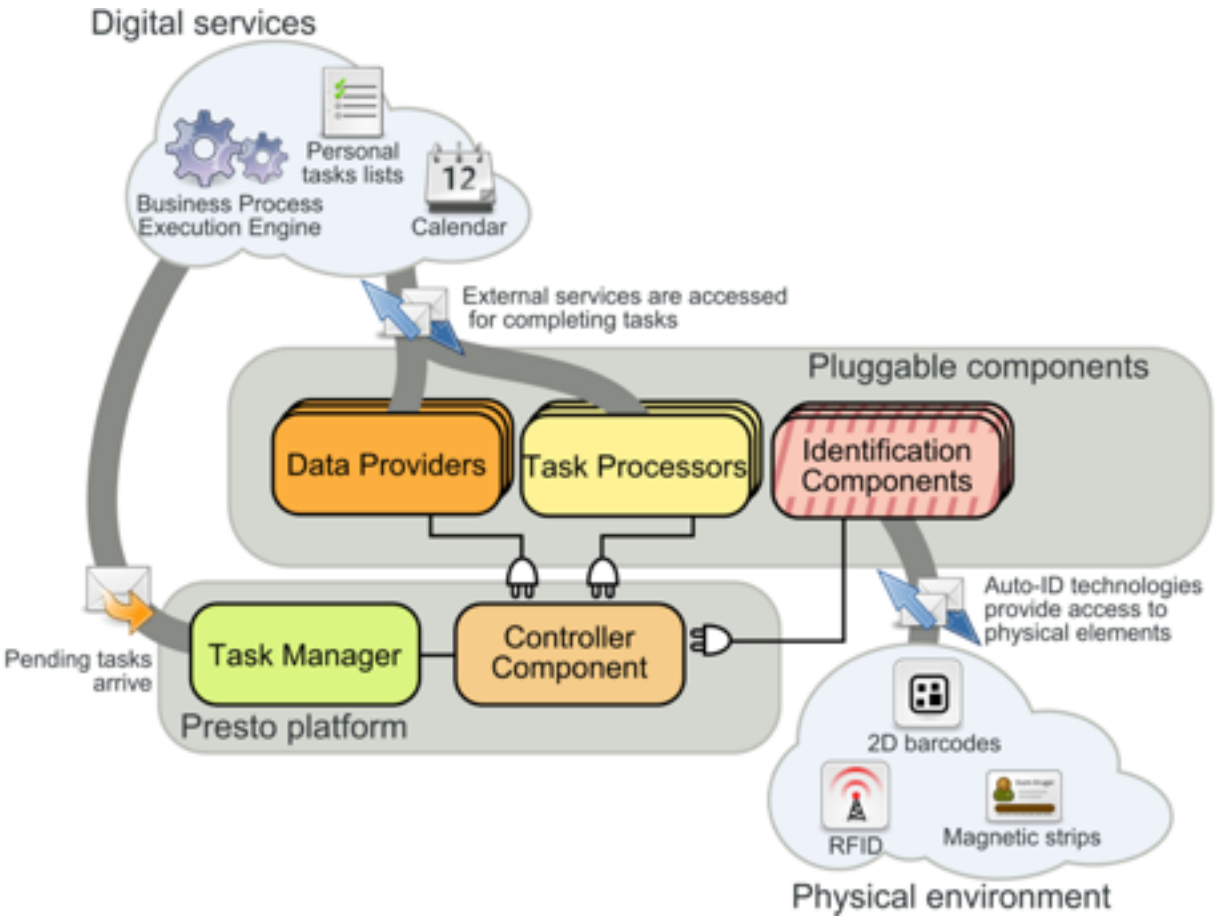


Elaboration

Technology Independent Architecture

Presto

a pluggable architecture



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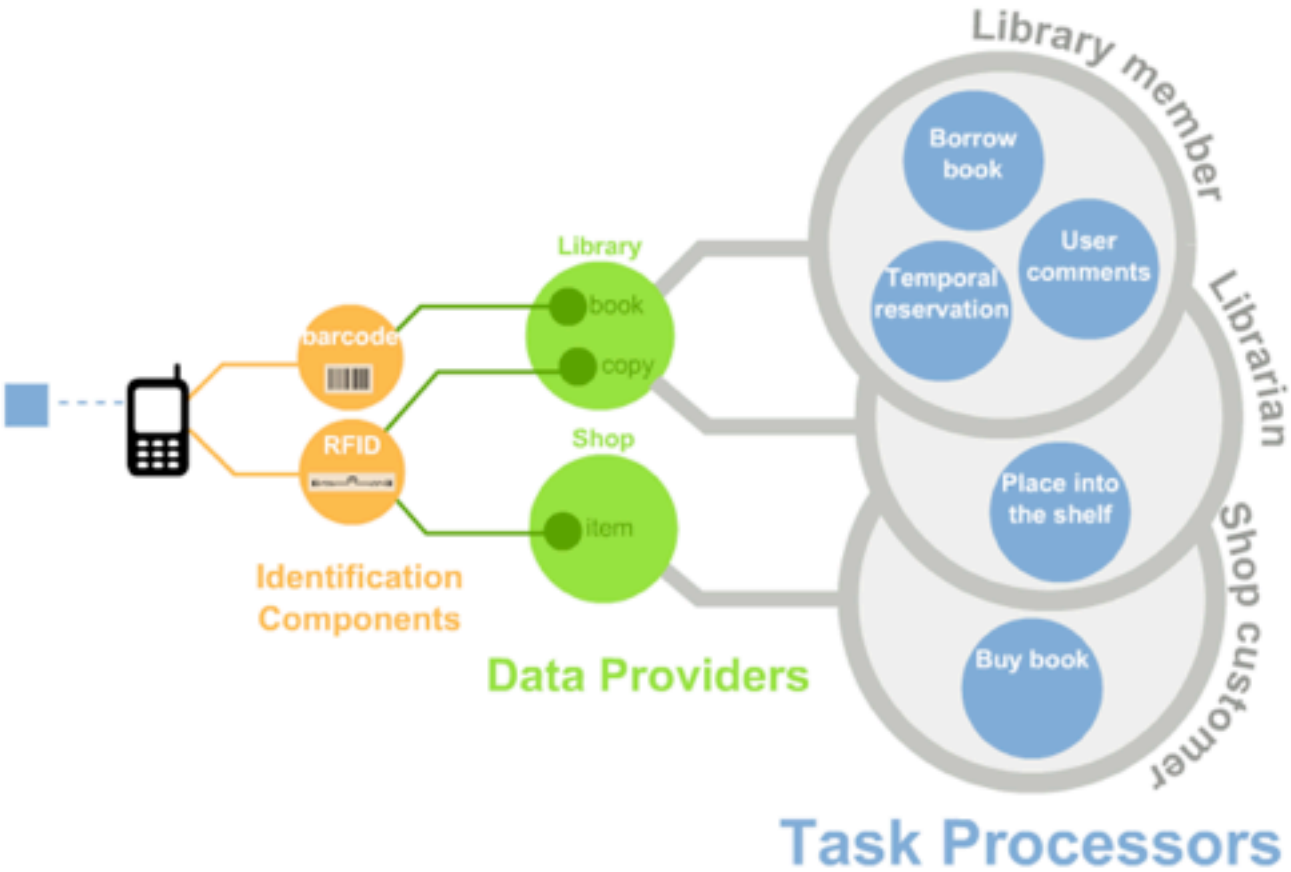
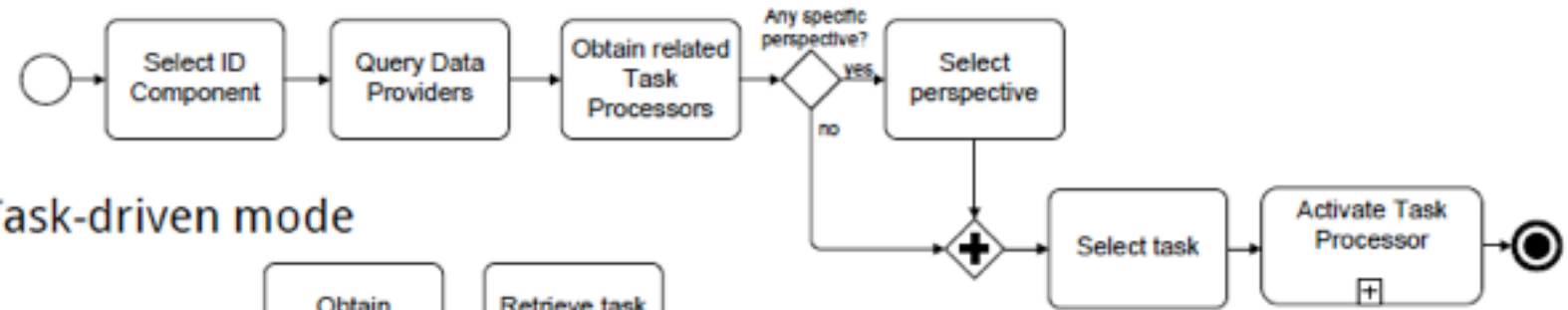
Flexible physical-virtual linkage

supporting multiple user perspectives

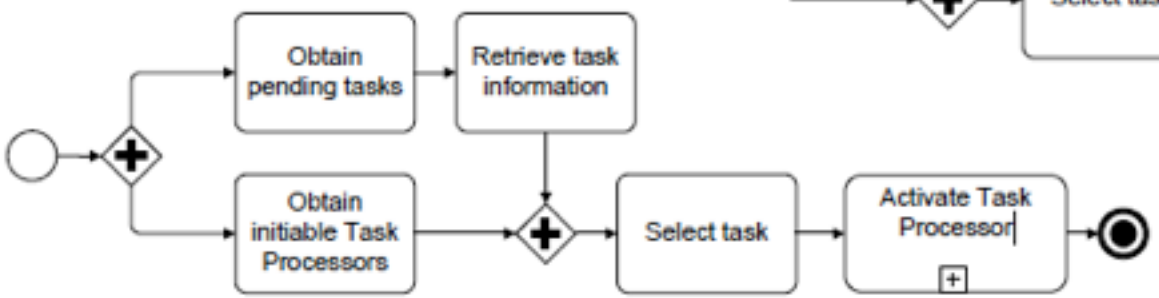


Programming Model

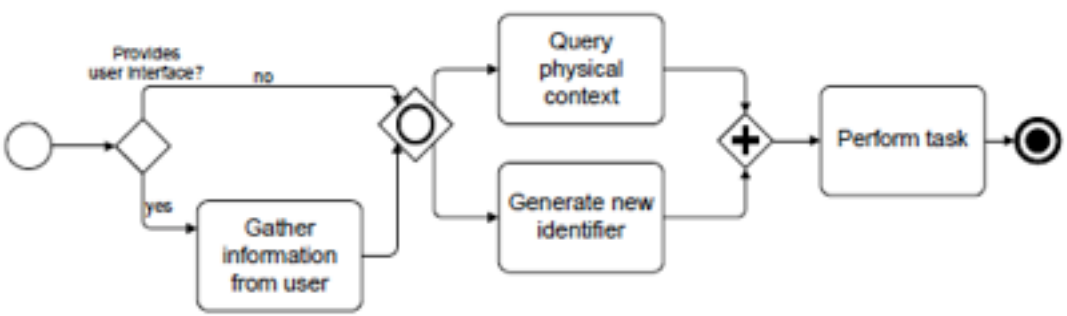
Object-driven mode



Task-driven mode

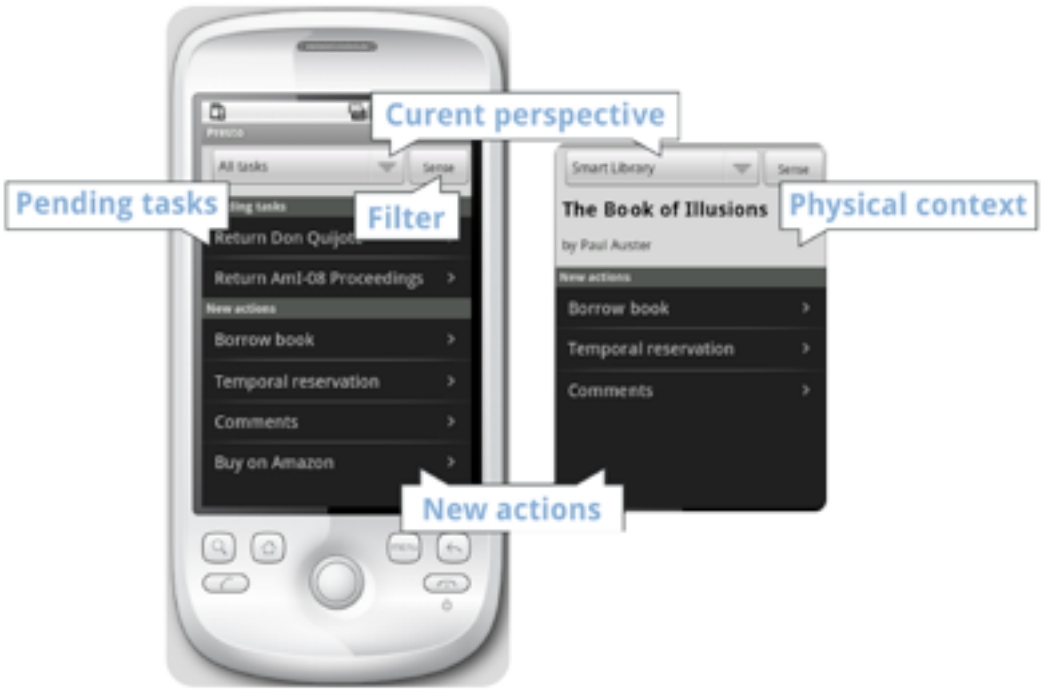


Activate Task Processor



Programming Model

- Defining Task Processors
  - Pending Tasks
  - New Actions



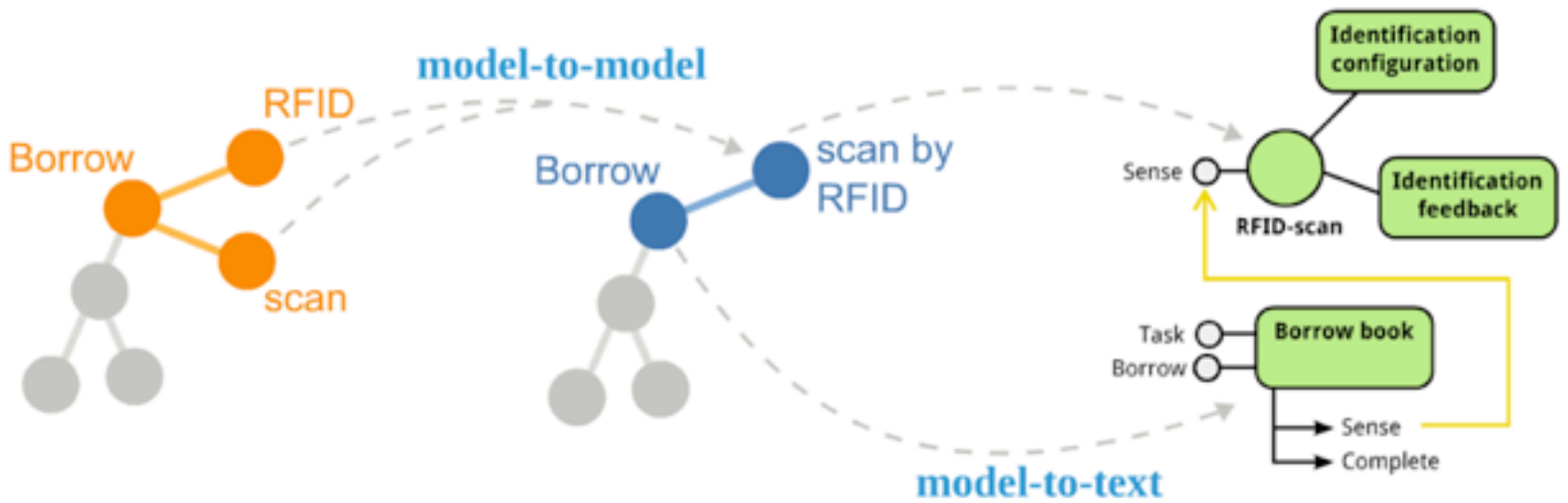
Programming Model

- Defining Identification Components
  - Capturers
  - Minters
- Defining Data Providers
  - Matching Identifiers and Objects
  - Providing Info about the Object (Physical Element)

Technological mapping

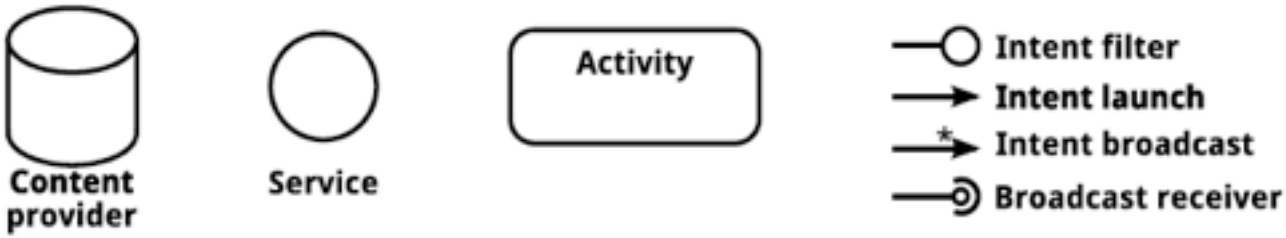
code generation techniques

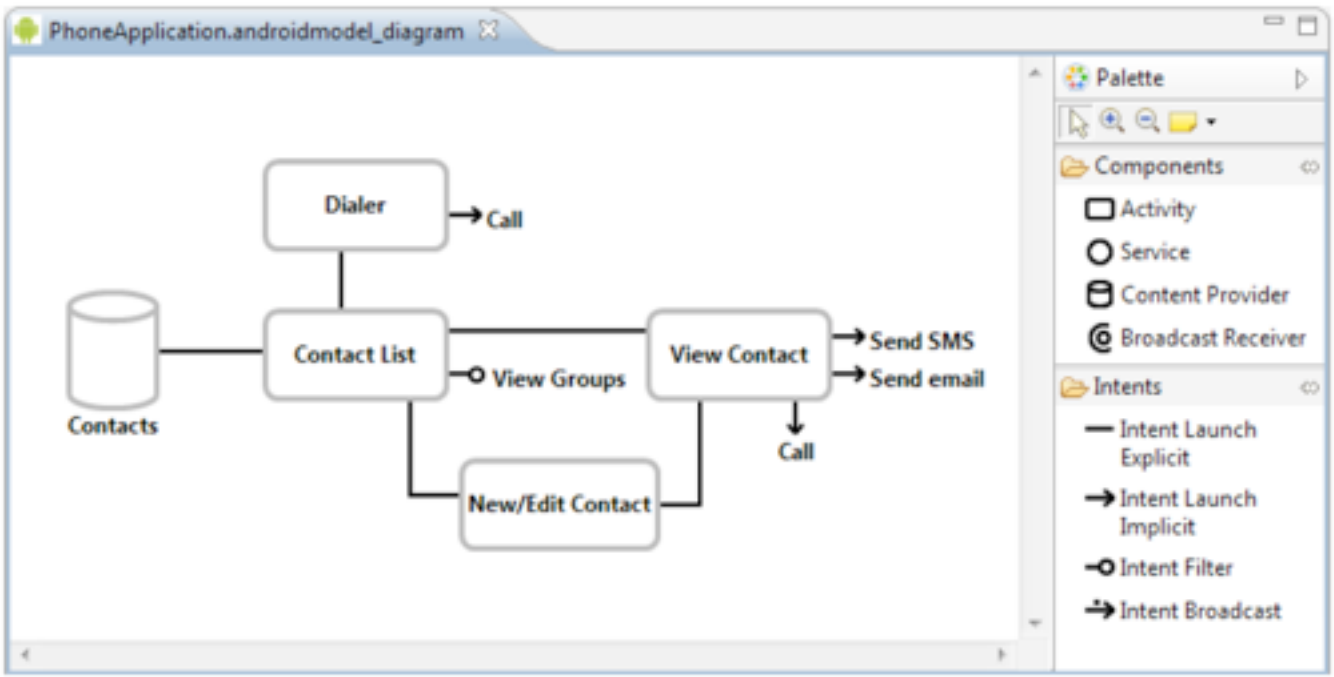
Parkour Presto Android



Technology Mapping

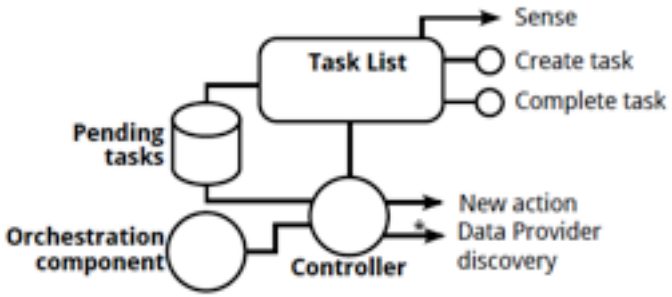
PRESTO – Android



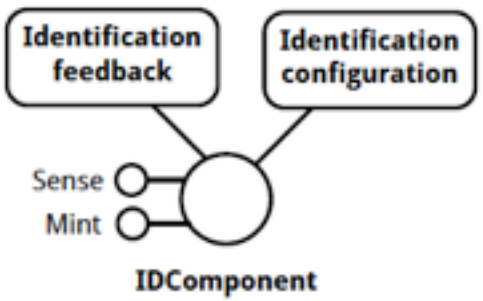


Technology Mapping

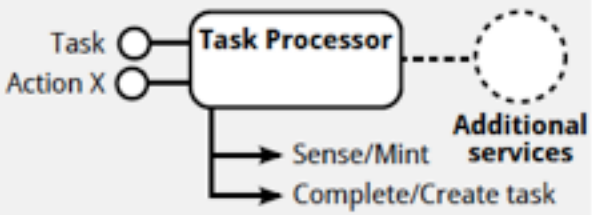
PRESTO – Android



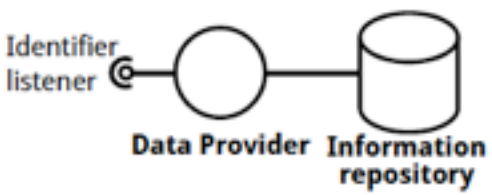
Identification Components



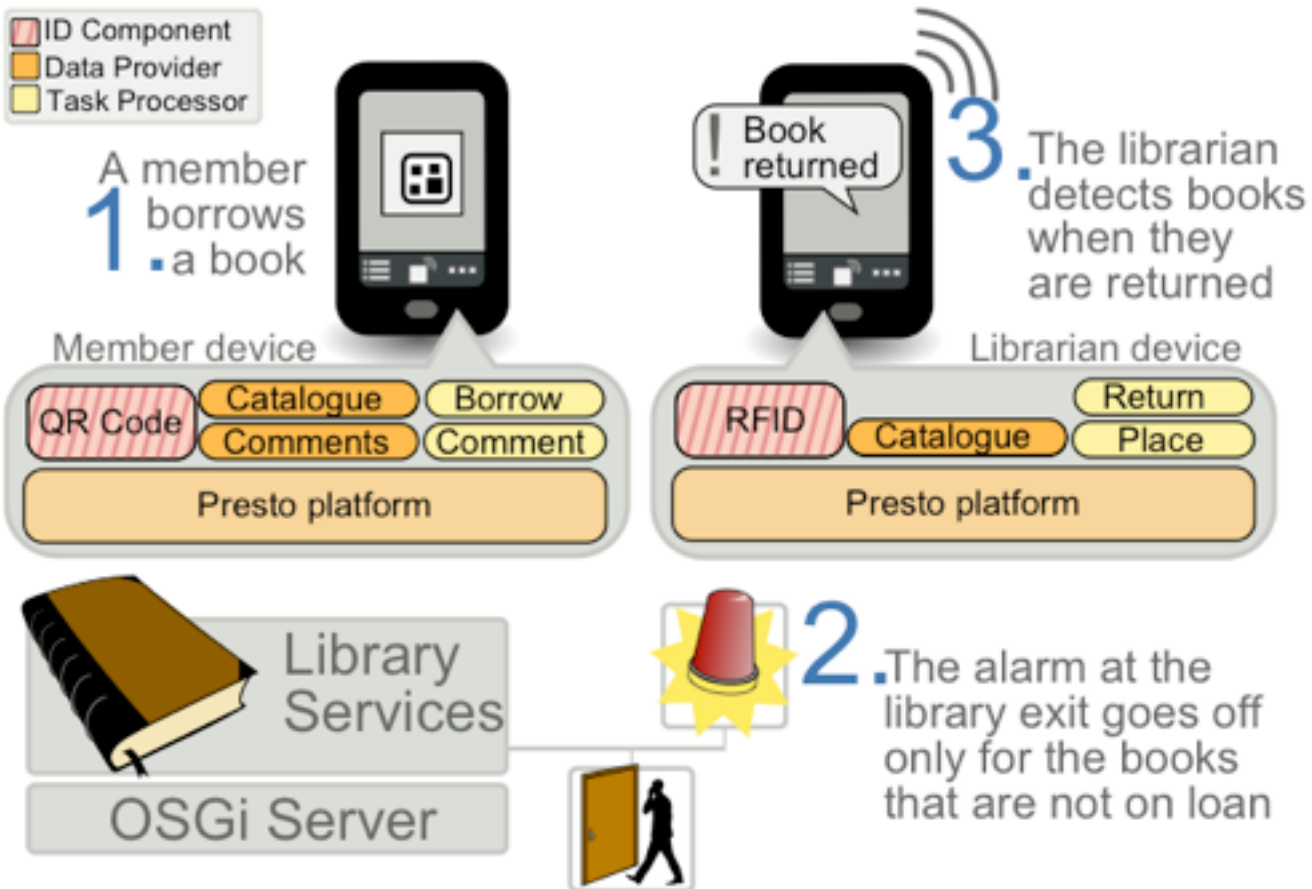
Task Processors



Data Providers



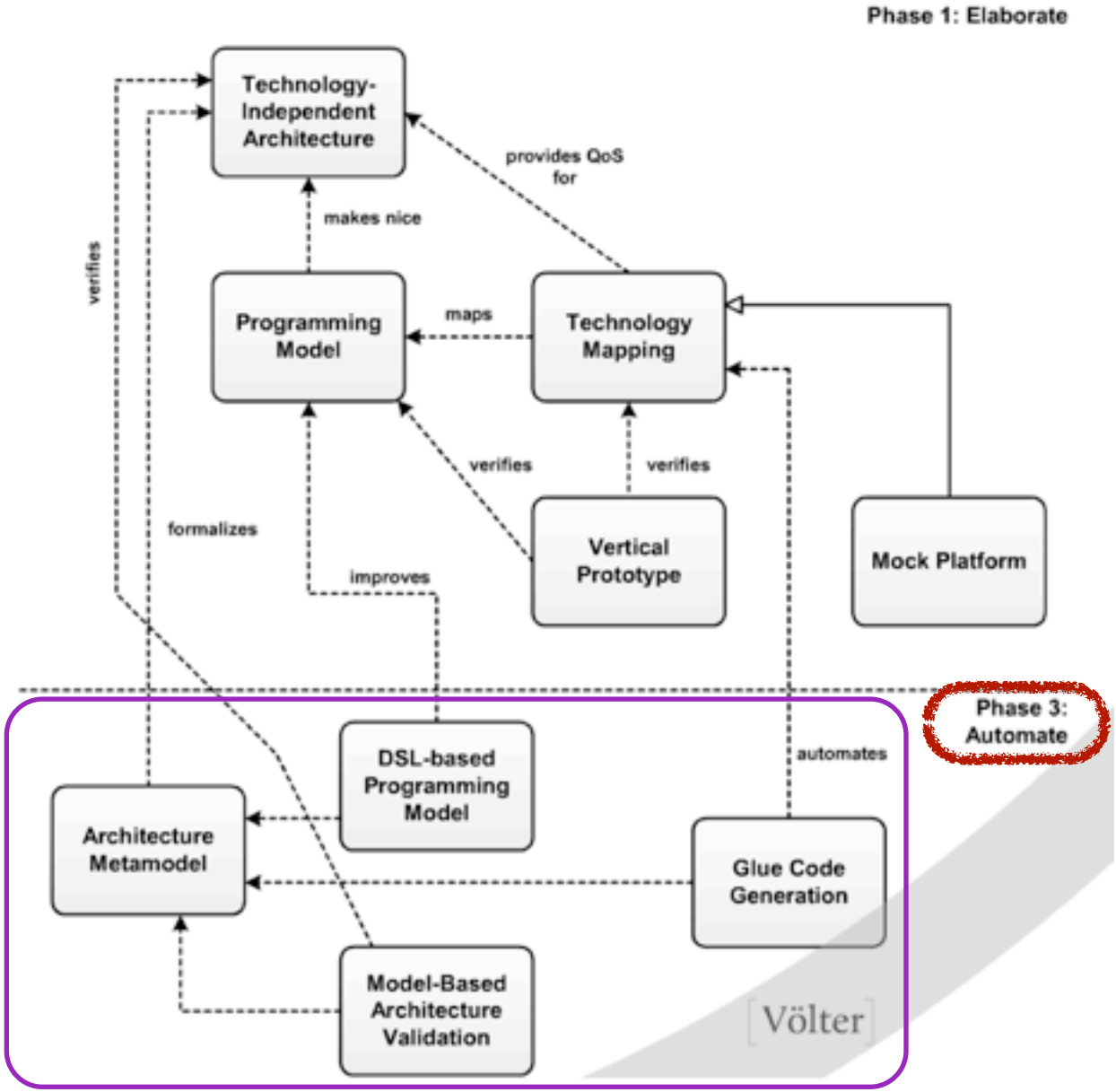
Mock Platform & Vertical Prototype



Mock Platform & Vertical Prototype

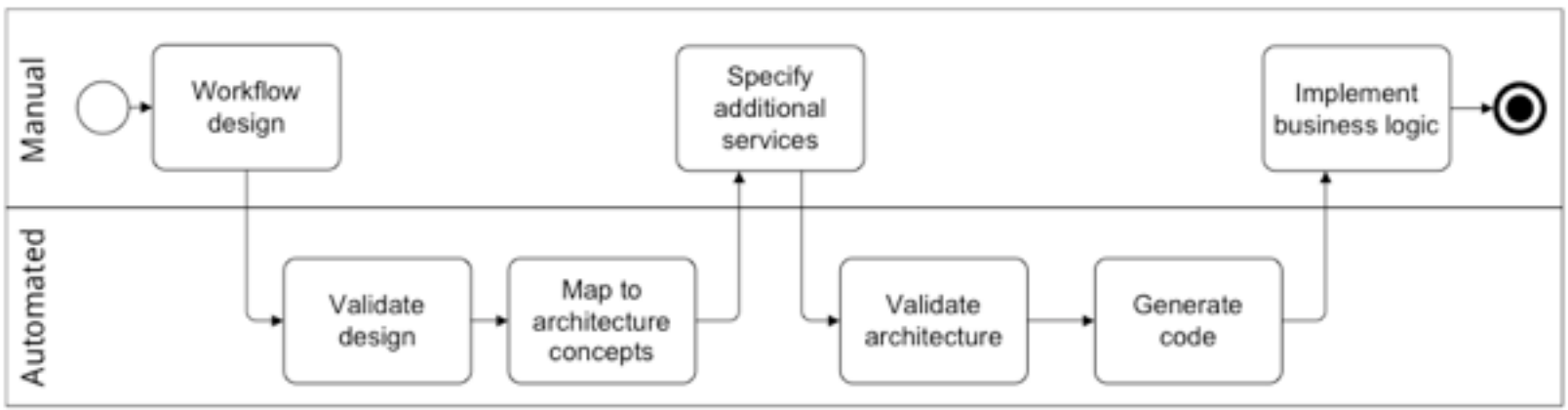
The process is supported at the automation level defined

The Architectural Proces

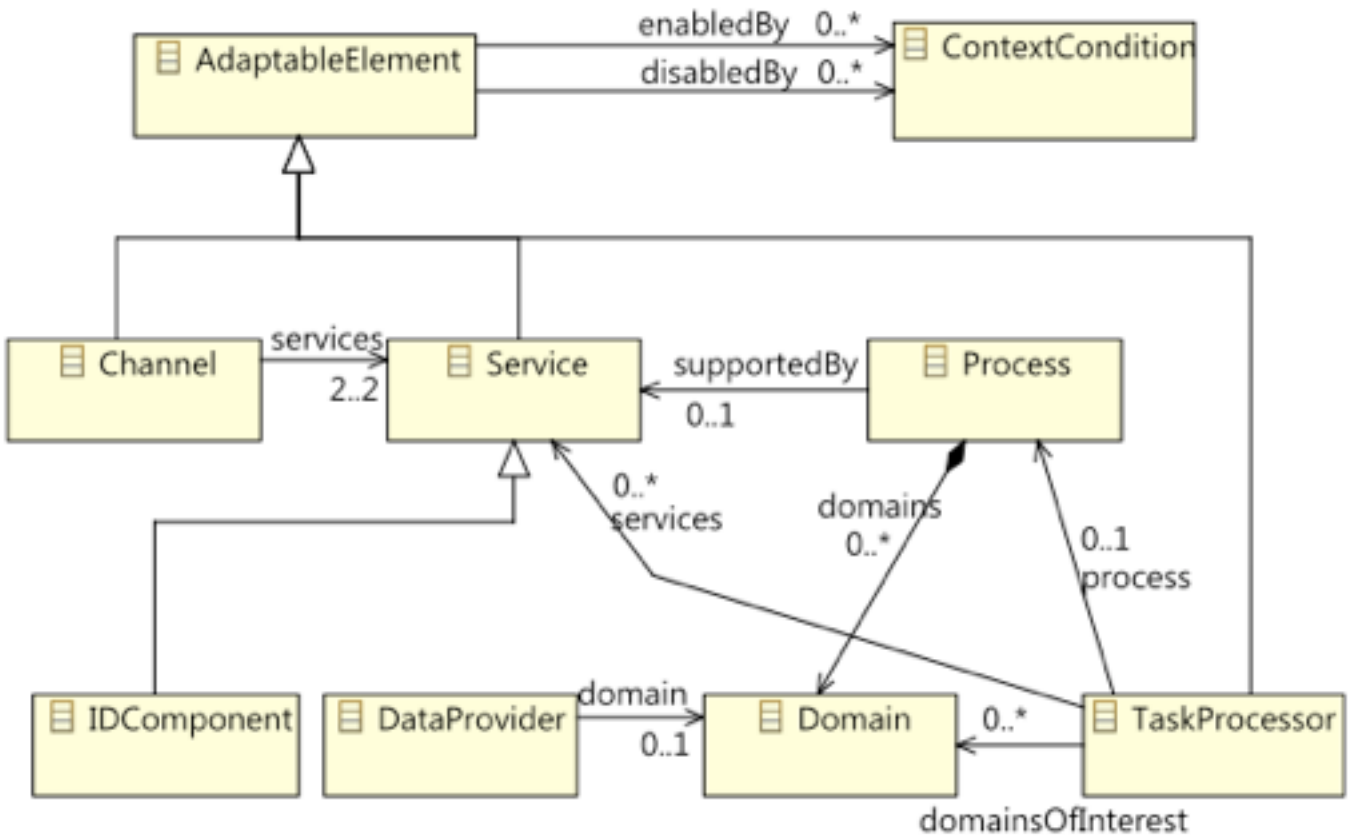


Automation

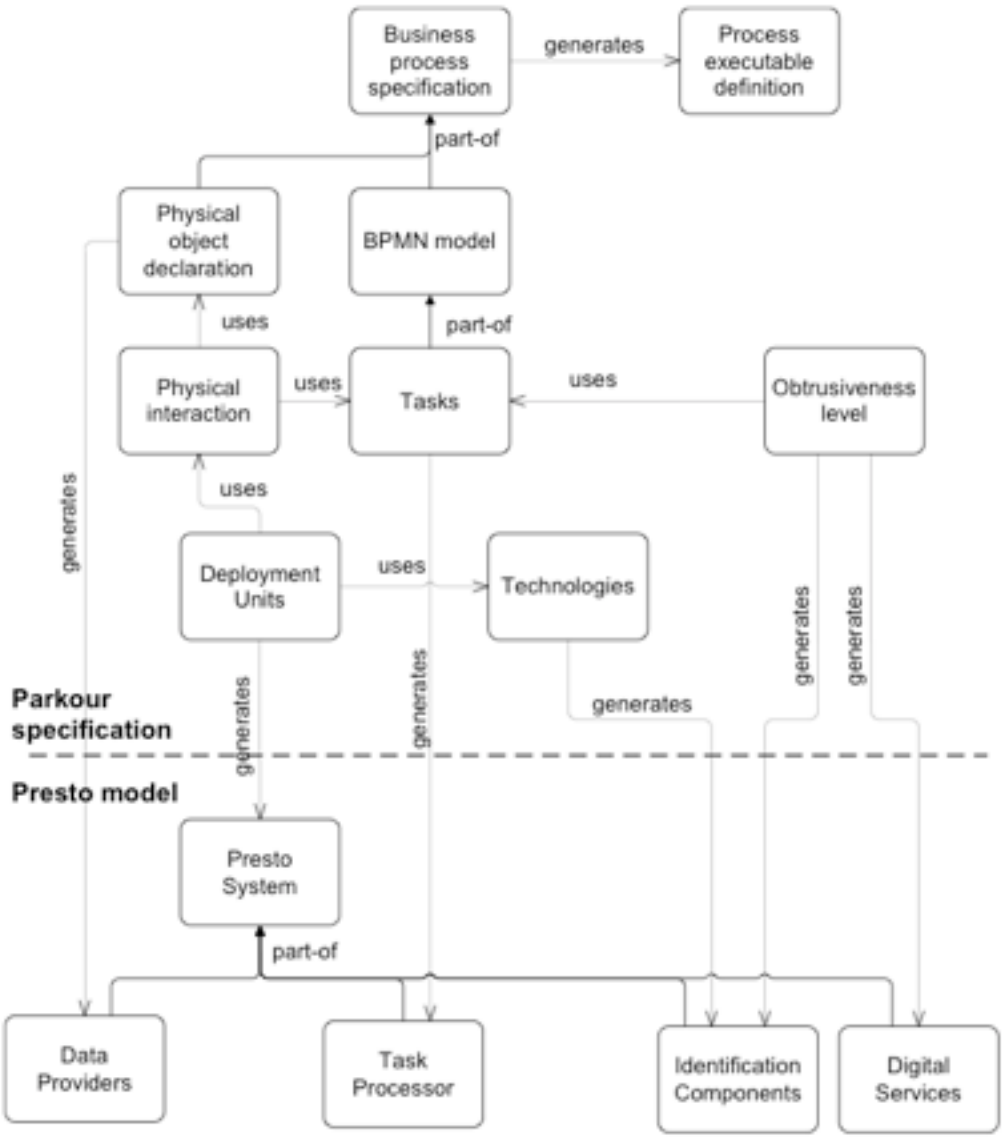
Automated and Manual Steps



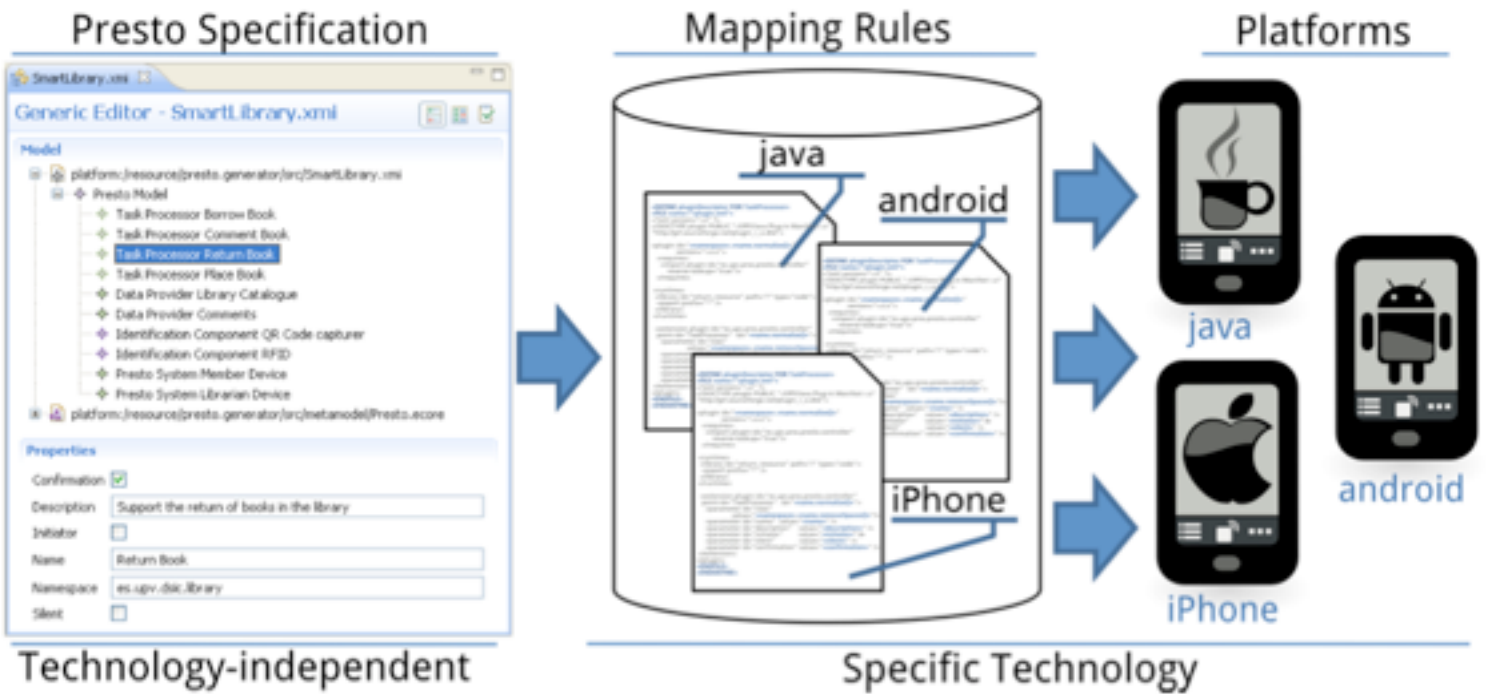
PRESTO Architecture Metamodel



Mapping between Concepts and Architecture Components



Glue Code Generation



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What is generated?

Component descriptors and code skeleton

Infrastrucutre for the physical-virtual linkage

Developers can focus on business logic

Without dealing with the underlying application framework

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Can we determine the obtrusiveness level for a given task at design?

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Validation

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We applied the approach to different case studies

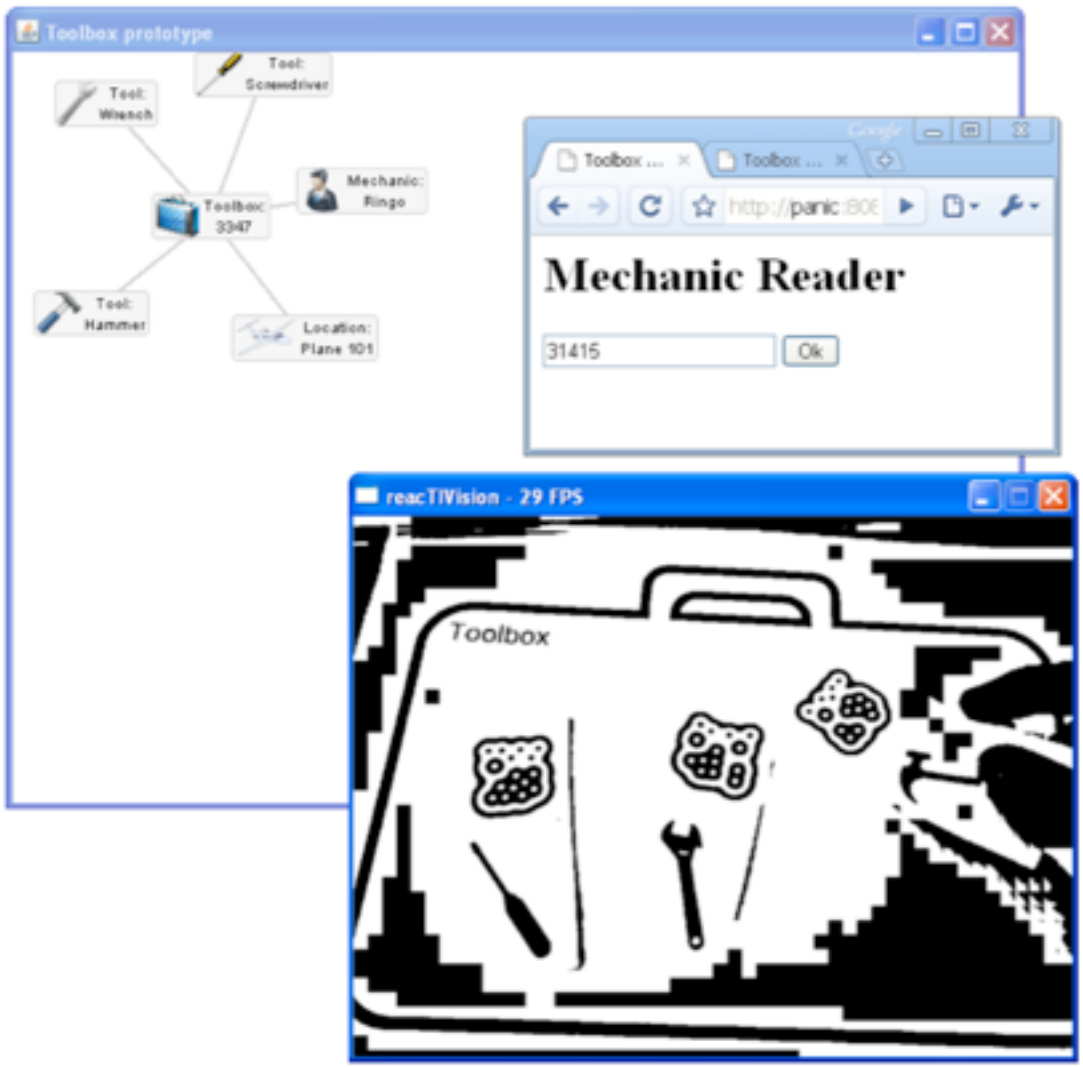
To validate that...

Architecture concepts can be mapped to different platforms

The approach can support representative systems

Developers can handle the concepts and tools proposed

Smart Toolbox



T-Guide


T-Guide
Detalles
Tareas Pendientes
PRESTAMO DE LIBROS
Filtrar Fecha
Contexto
Nueva Tarea
Todos
Actividades
GUIADO
REPARACIONES
Tareas Disponibles
GUIADO UTILIZANDO QRCODES
GUIADO UTILIZANDO RFID
Ubicaciones
AULA 2
AULA 3
CENTRO DE COMPUTO
DOCUMENTACION
LABORATORIO DE INGENIERIA DE SOFTWARE
LABORATORIO DE INTELIGENCIA ARTIFICIAL
Proceso de guiado
Lab. S.D
Mnto.
Computo
Aula 1
Aula 2
Lab. I.A.
Primer piso computación
Lab. I.S.
Ha llegado al destino solicitado 'CENTRO DE COMPUTO'.
Cerrar
Lectura
Salir

Video

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What about end-users?

34 users
participated in
an experiment

MoBiS-Q questionnaire was used

Perceived usability of a mobile business service

easy to learn, quick enough, ease of navigation

Fit for mobile working context

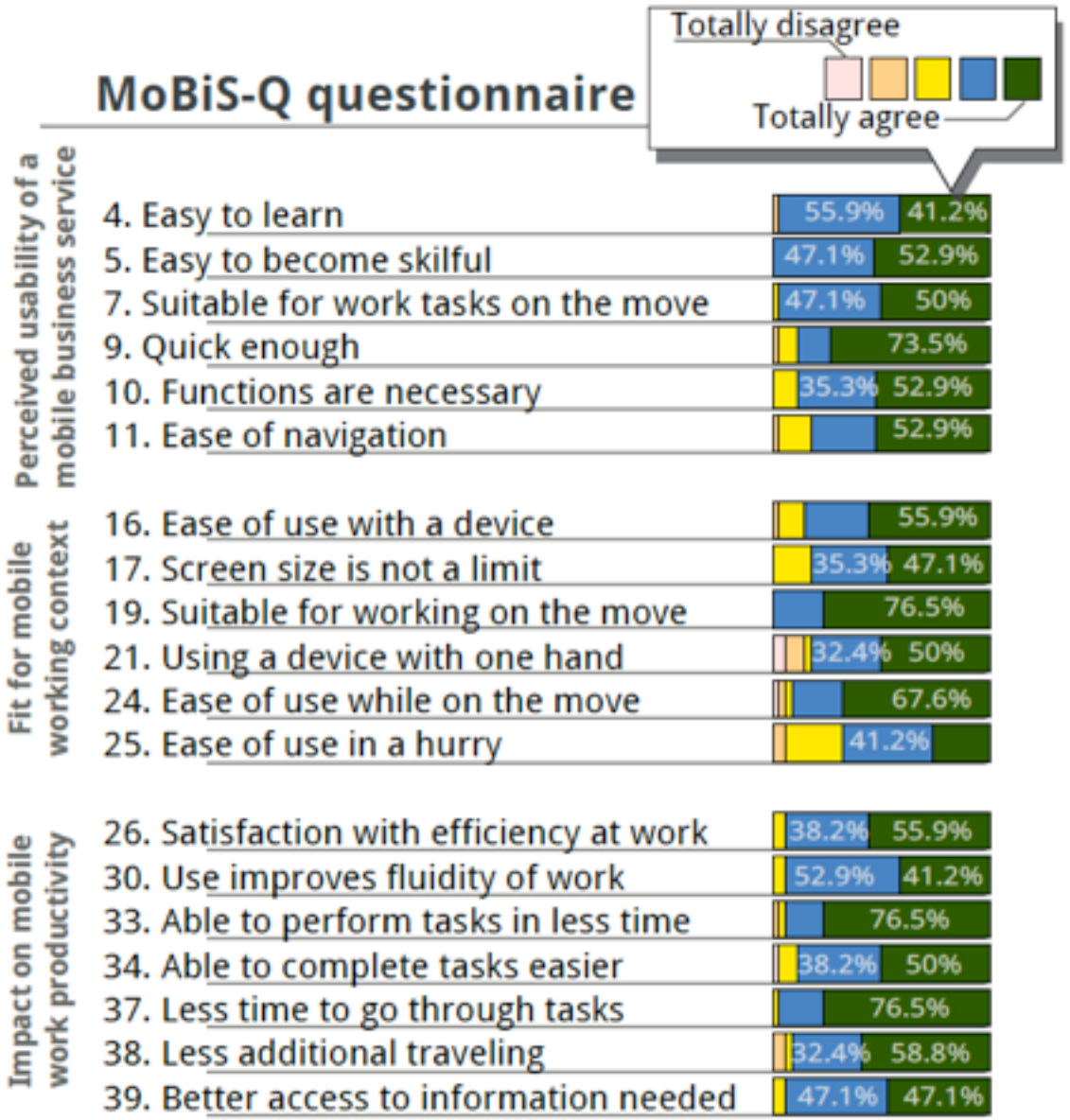
easy of use while on the move, with one hand, in a hurry

Perceived impact on mobile work productivity

complete tasks in less time, easier, with less additional traveling

80%

of the users at least agreed in each topic considered


MoBiS-Q questionnaire
Totally disagree
Totally agree
Perceived usability of a mobile business service
4. Easy to learn 55.9% 41.2%
5. Easy to become skilful 47.1% 52.9%
7. Suitable for work tasks on the move 47.1% 50%
9. Quick enough 73.5%
10. Functions are necessary 35.3% 52.9%
11. Ease of navigation 52.9%
Fit for mobile working context
16. Ease of use with a device 55.9%
17. Screen size is not a limit 35.3% 47.1%
19. Suitable for working on the move 76.5%
21. Using a device with one hand 32.4% 50%
24. Ease of use while on the move 67.6%
25. Ease of use in a hurry 41.2%
Impact on mobile work productivity
26. Satisfaction with efficiency at work 38.2% 55.9%
30. Use improves fluidity of work 52.9% 41.2%
33. Able to perform tasks in less time 76.5%
34. Able to complete tasks easier 38.2% 50%
37. Less time to go through tasks 76.5%
38. Less additional traveling 32.4% 58.8%
39. Better access to information needed 47.1% 47.1%

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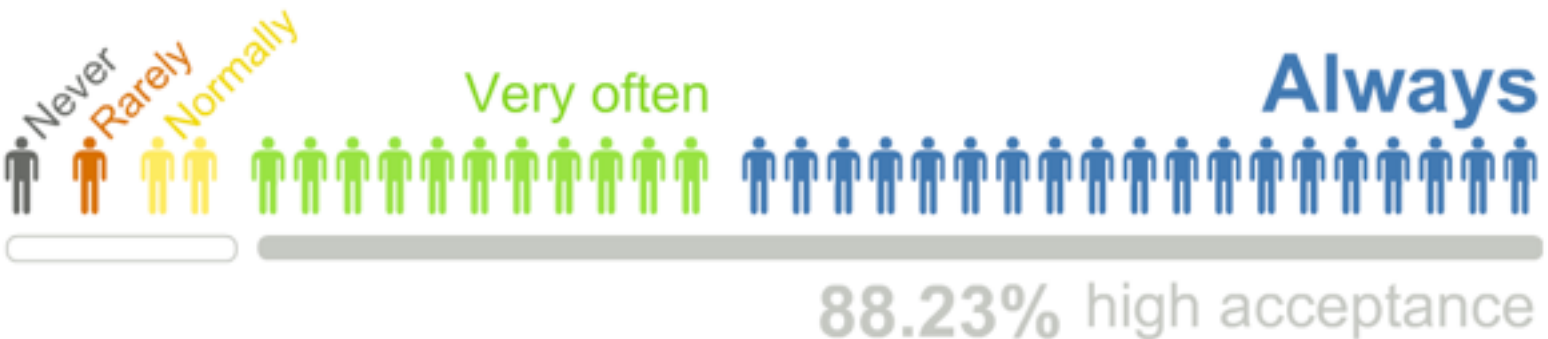
How often would you use the service?



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Conclusions

A good tool is an invisible tool

"By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool. Eyeglasses are a good tool -you look at the world, not the eyeglasses.

Mark Weiser

Concepts

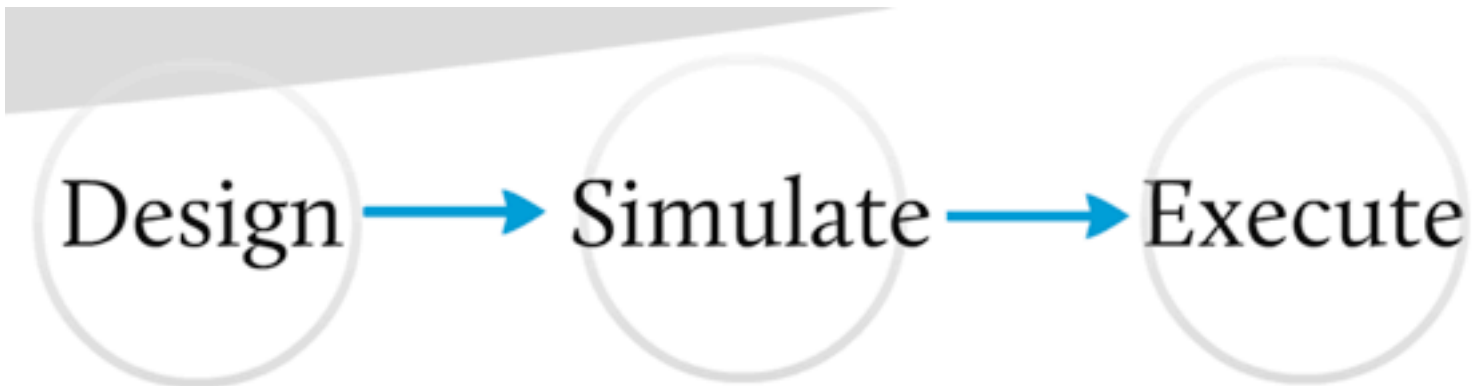
for the design of physical mobile workflows

Architecture

based on models to automate development

Steps

to apply Business Process Management considering the physical world



Concepts for modeling...

Guidelines for fast-prototyping...

Model-based architecture for executing...

...workflows that involve physical elements

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New into the community

We were unknown

and following a different approach

Methodologies were overlooked

although they recognize the need for them

Focus on the user

experimenting with users was a must


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Automating the development of Physical Mobile Workflows

a Model Driven Engineering approach

Pau Giner

Supervisor: Dr. Vicente Pelechano
Universidad Politécnica de Valencia

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Ongoing Work

- In this kind of systems where ***components disappear***, the way in which the system ***interact with users*** is a very challenging topic
- ***Adapting*** *Workflows* and *User Interfaces* taking into account the ***Context***
- The ***Obstrusiveness Framework*** can guide the Adaptation

Adaptive Interactions

Context-aware interfaces use the **context** in which interactions take place to provide more relevant services to the user, but …

… there is a need to adapt the degree to which interaction intrudes on **user attention** to avoid an annoying environment

Refining Interaction Designs through SIMPLICITY

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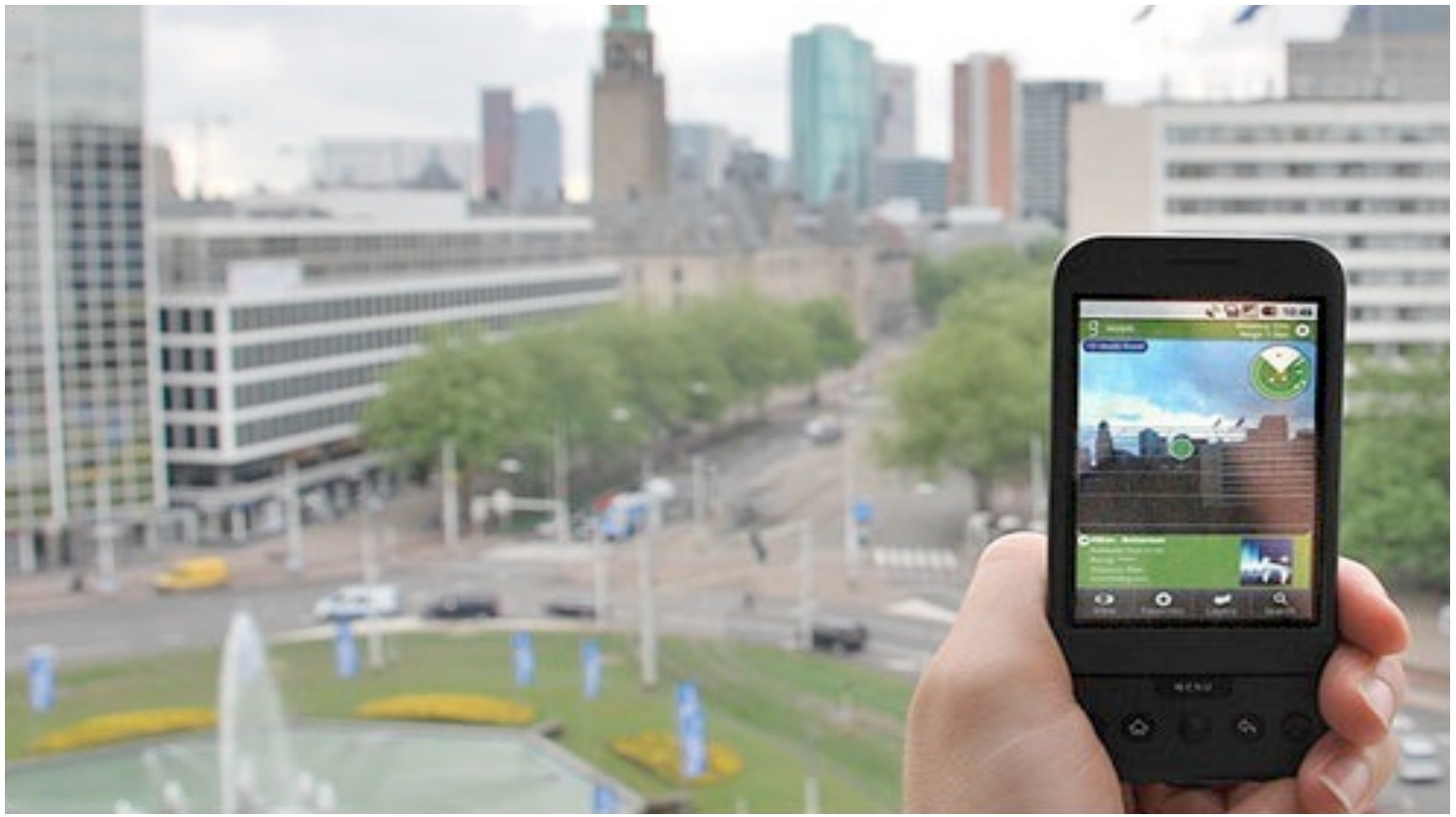
Refining Interaction Designs through SIMPLICITY



...and they provide more and more digital services and mobile applications

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Refining Interaction Designs through SIMPLICITY

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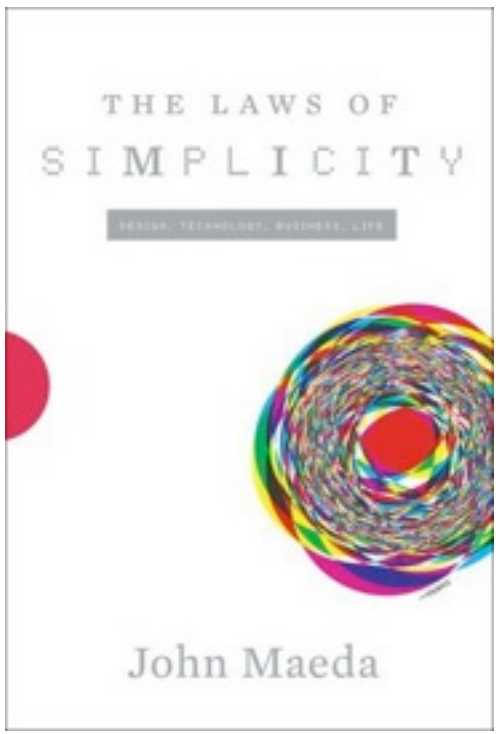
People appreciate **simplicity** in designs



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de Producción de Software

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