Robotic Process Automation and its servitization

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SummerSOC@2025

Agenda

Friday, June 20

10:00-12:00	**Smart Services – Session Chair: Simone Agostinelli**
10:00-11:00	"Robotic Process Automation and its servitization 1", Simone Agostinelli (U of Rome)
11:00-11:15	Coffee Break
11:15-12:00	"Robotic Process Automation and its servitization 2", Simone Agostinelli (U of Rome)
12:00-15:00	Lunch Break

Tutorial Outline

RPA and its servitization (1)

- Introduction and Background to Robotic Process Automation (RPA)
- Steps to conduct a RPA project
- Automating a routine with the commercial tool UIPath

RPA and its servitization (2)

- From Robotic Process Automation to Robotic Process Mining (RPM)
- SmartRPA: A framework to realize the RPM vision
- Demonstration of SmartRPA
- Agentic Process Automation (APA)

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Robotic Process Automation

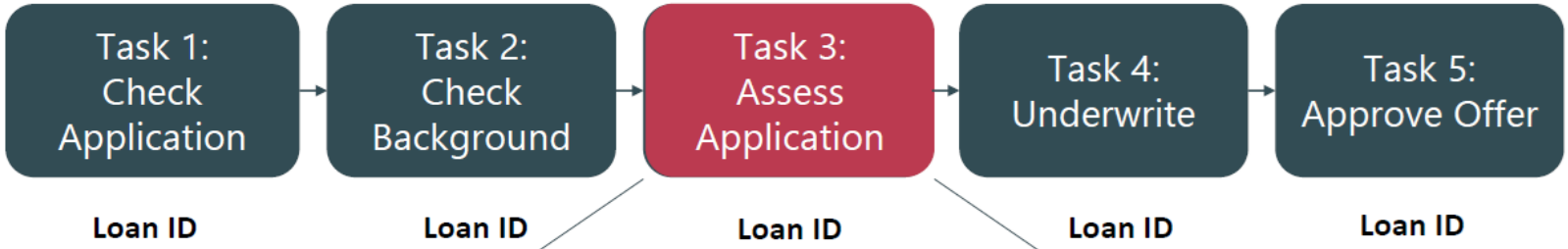
Robotic Process Automation (**RPA**) is a maturing technology, based on the notion of **software robots** (or simply **SW robots**), that allows organizations to automate high-volume **routines**.

- SW robots are mainly used to automate repetitive office operations like accounting, billing, and customer service.

- SW robots are **capable of emulating** the actions of a human worker performed on a User Interface (UI):
  - log into applications
  - connect to system APIs
  - keyboard inputs
  - mouse movements and clicks
  - copy and paste data, read and write to databases
  - open e-mail and attachments
  - fill in forms and make calculations
  - reading computer screens

Processes, Routine tasks, User Actions

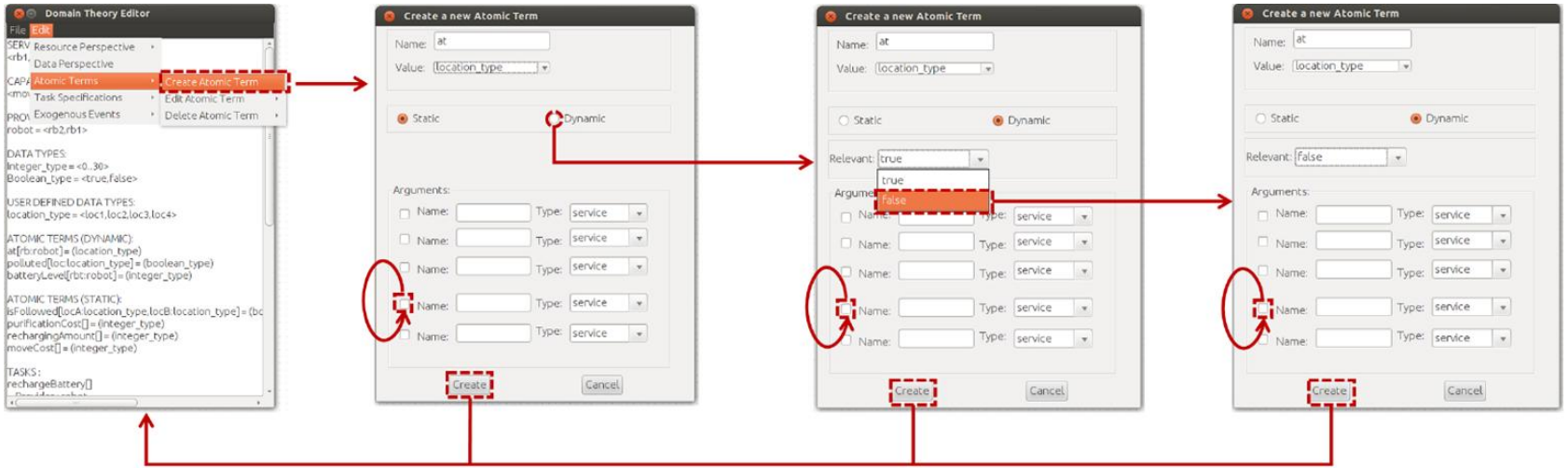
Loan origination process instance



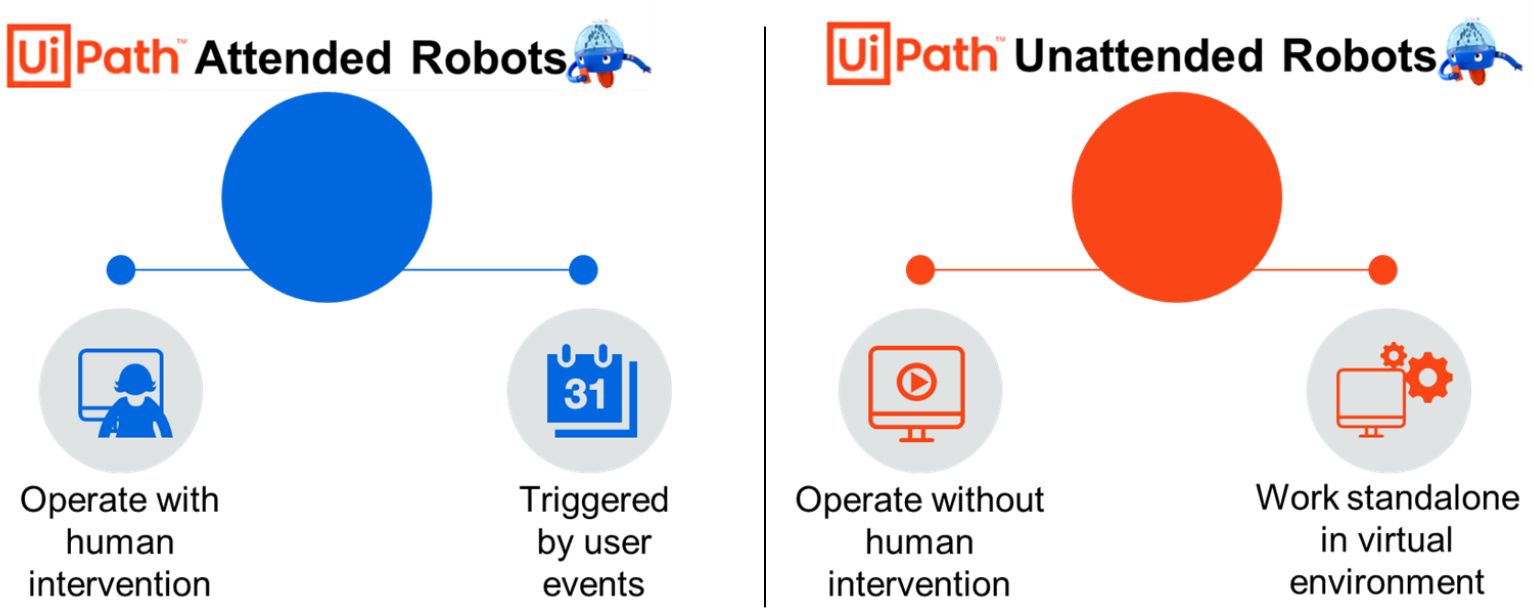
Worker's interactions with IT systems

Software (SW) Robots

A **SW robot** is a piece of software developed to capture the execution of the tasks previously performed by a human user on the UI of a computer system, and then to emulate the automation of such tasks in place of the user.



Attended vs. Unattended SW Robots



Attended SW Robots

How do they work?

Triggered by users or specific user events

What do they do?

Collaborate with a human worker for small and repetitive tasks

Where do they run?

On the same machine on which the user performs the day-to-day tasks

Unattended SW Robots

How do they work?

Controlled through Orchestrator

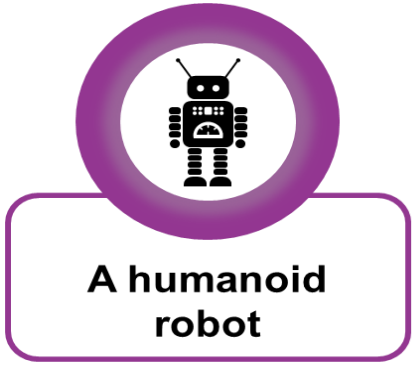
What do they do?

Run long processes or automations without human interaction

Where do they run?

Any machine connected to Orchestrator

What RPA is not



A humanoid robot

Human replacement

RPA can make individuals more efficient. A Robot will execute tasks assigned to it much faster compared to a human.

RPA can help workers become more productive and release their bandwidth so that they can focus on other aspects of their work.

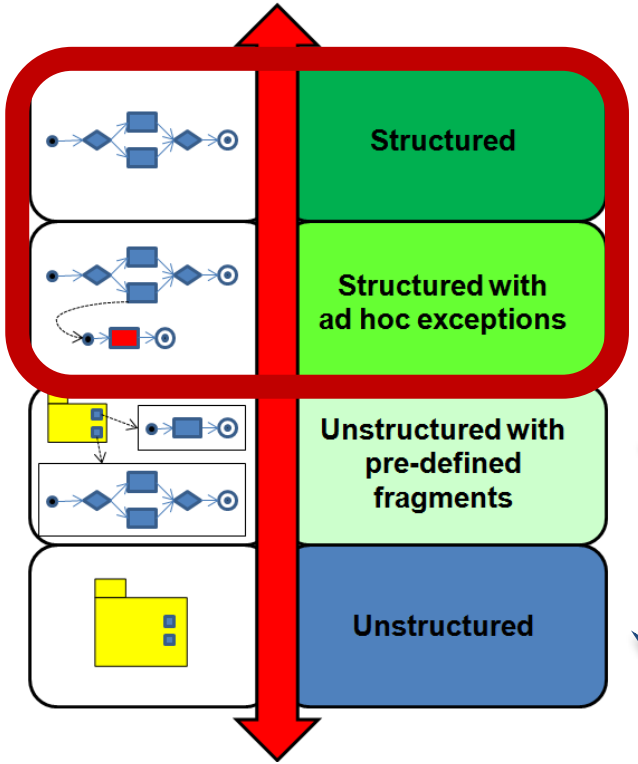
RPA can free the workers from mundane, boring repetitive tasks and they focus on tasks which involve creativity and human decisions.

Processes best-suited for RPA

Classifying RPA within the spectrum of BPM [DiCiccio-JDataSem15]

These processes are **completely predictable** and all possible paths are **well-understood.**

RPA



Unattended SW Robots

Attended SW Robots

Such processes require to be **adapted** according to **changing circumstances during the execution.**

Class of processes where **process modeling could not be completed before the execution.**

It is **impossible to define a priori the exact steps to be taken** in order to complete an assignement

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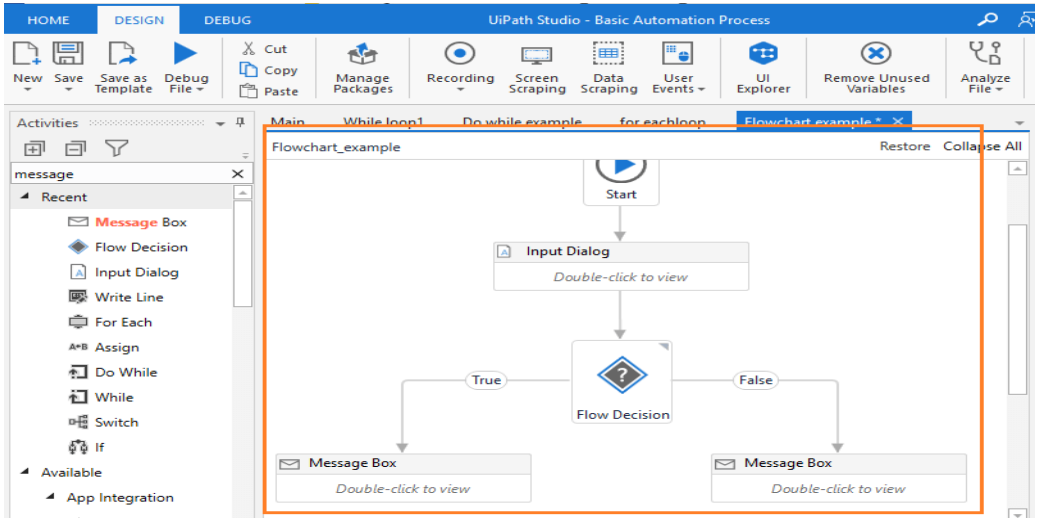
- SmartRPA: A framework to realize the RPM vision
- Hands-on session with SmartRPA
- Agentic Process Automation (APA)

How to conduct a RPA project

1. Determine which routines are good candidates to be automated.
   - This requires the support of skilled human experts that identify the candidate routines to automate by means of interviews and observation of workers conducting their daily work.

How to conduct a RPA project

1. Determine which routines are good candidates to be automated.
2. Model the selected routines in the form of flowchart diagrams that define the behavior of a SW robot.
   - The designer produces a flowchart diagram that includes the single actions to be performed by the bot on the UI to emulate a relevant task of the system.



How to conduct a RPA project

1. Determine which routines are good candidates to be automated.
2. Model the selected routines in the form of flowchart diagrams that define the behavior of a SW robot.
3. Develop each modeled routine by generating the SW code required to enact the associated SW robot on a target computer system.
   - The designer checks if the robot's behaviour during the execution of the task on the UI is capable to properly reproduce the behaviour of a human user that executes the same task.
   - If any misalignment exists, the designer adjusts the flowchart diagram to fix the identified gap.

How to conduct a RPA project

1. Determine which routines are good candidates to be automated.
2. Model the selected routines in the form of flowchart diagrams that define the behavior of a SW robot.
3. Develop each modeled routine by generating the SW code required to enact the associated SW robot on a target computer system.
4. Deploy the SW robots in their environment to perform their actions.
5. Maintain the routines over time to eventually enhance their behaviour.

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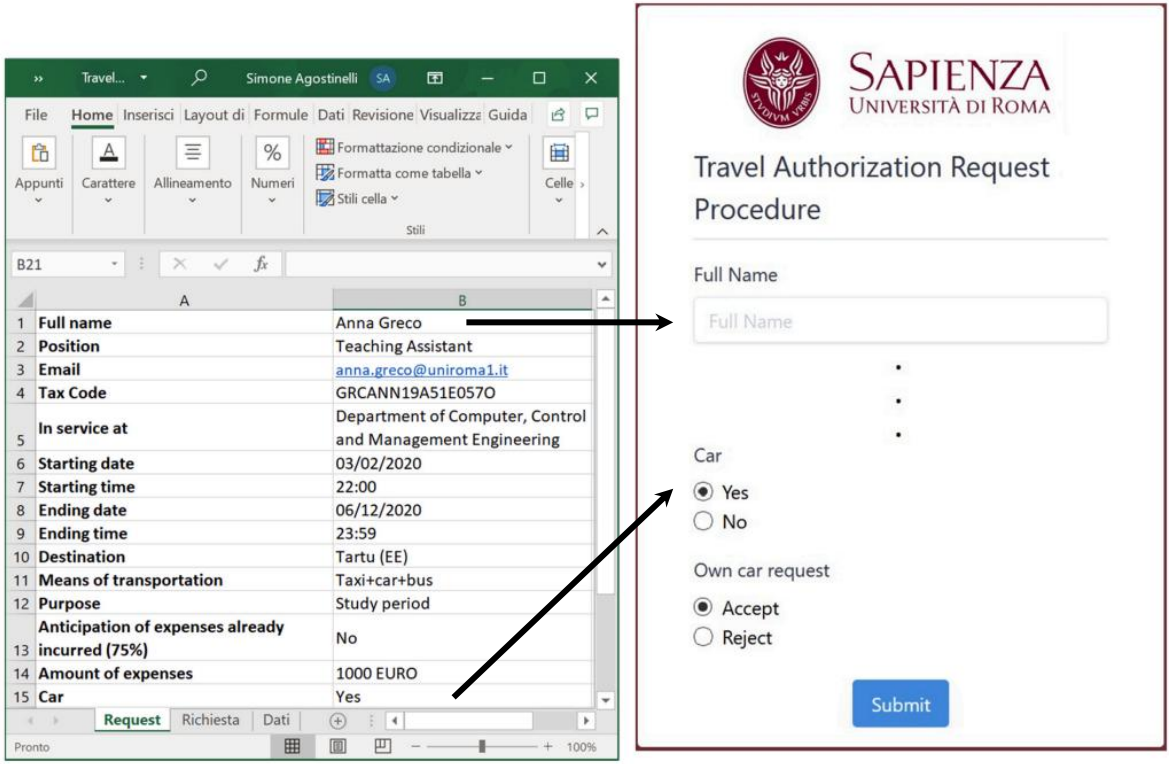
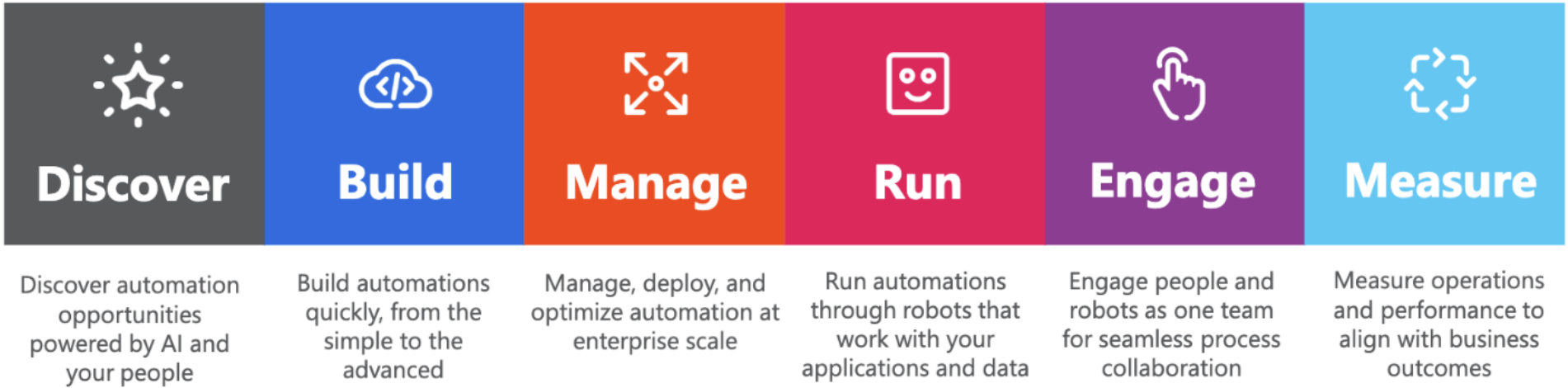
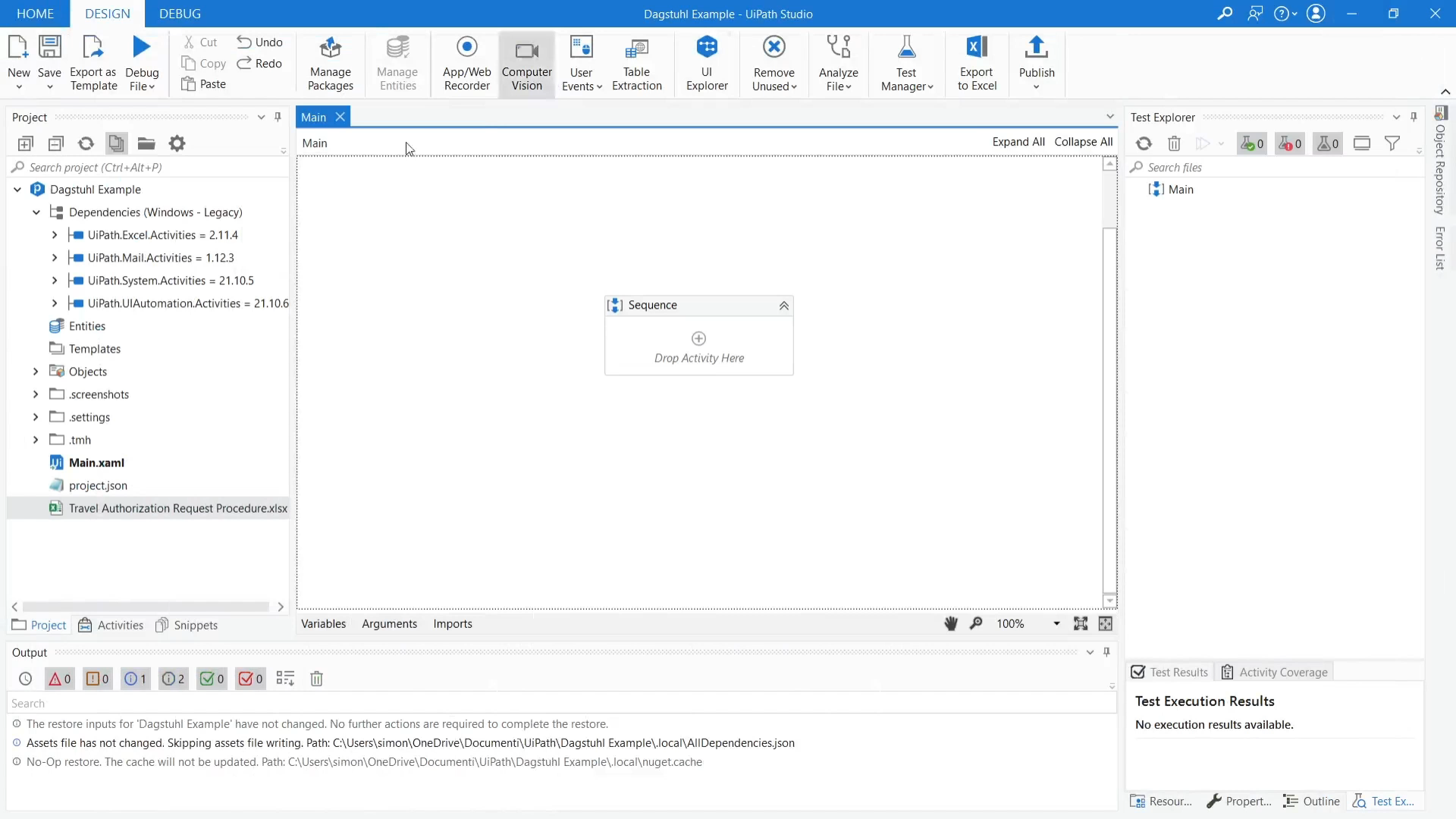
Automatable Task Example



(a) Excel spreadsheet (b) Google form

Ui Path: a tool to enact RPA projects




HOME
DESIGN
DEBUG
Dagstuhl Example - UiPath Studio
New
Save
Export as Template
Debug File
Cut
Copy
Paste
Undo
Redo
Manage Packages
Manage Entities
App/Web Recorder
Computer Vision
User Events
Table Extraction
UI Explorer
Remove Unused
Analyze File
Test Manager
Export to Excel
Publish
Project
Search project (Ctrl+Alt+P)
Dagstuhl Example
Dependencies (Windows - Legacy)
UiPath.Excel.Activities = 2.11.4
UiPath.Mail.Activities = 1.12.3
UiPath.System.Activities = 21.10.5
UiPath.UIAutomation.Activities = 21.10.6
Entities
Templates
Objects
.screenshots
.settings
.tmh
Main.xaml
project.json
Travel Authorization Request Procedure.xlsx
Project
Activities
Snippets
Main
Main
Expand All
Collapse All
Sequence
Drop Activity Here
Variables
Arguments
Imports
100%
Test Explorer
Search files
Main
Object Repository
Error List
Output
Search
The restore inputs for 'Dagstuhl Example' have not changed. No further actions are required to complete the restore.
Assets file has not changed. Skipping assets file writing. Path: C:\Users\simon\OneDrive\Documenti\UiPath\Dagstuhl Example\.local\AllDependencies.json
No-Op restore. The cache will not be updated. Path: C:\Users\simon\OneDrive\Documenti\UiPath\Dagstuhl Example\.local\nuget.cache
Test Results
Activity Coverage
Test Execution Results
No execution results available.
Resour...
Propert...
Outline
Test Ex...

UiPath Orchestrator

UiPath Orchestrator is a **centralized web platform** that allows you to **manage, monitor, and control SW robots** developed with UiPath.

Typical Use Case:

- A developer creates an RPA process in UiPath Studio.
- The automation package is uploaded to Orchestrator.
- Orchestrator deploys it to an unattended robot.
- The process is scheduled to run at a specified time.
- Orchestrator monitors the execution, records logs, and sends alerts if something fails.

Deployment Options

Aspect	On-Premise	RPA-as-a-Service (RPAaaS)
Deployment	Within organization's infrastructure	On vendor’s cloud platform
Licensing	Requires upfront software license purchase	No license purchase; subscription-based
Infrastructure	Needs server hardware, hosting, IT resources	Fully managed by the vendor
Training & Support	May require internal resources	Provided by vendor
Scalability	Limited by internal infrastructure	Easily scalable via cloud
Cost Model	High upfront costs; long-term investment	Pay-as-you-go; only pay for what you use

RPA as a Service

Concern	Details
Long-Term Costs	Subscription fees accumulate over time; can exceed upfront on-premise costs.
Data Privacy	Requires sharing sensitive data with third-party vendors: a concern for many.
Limited Vendor Choice	Fewer RPAaaS vendors available compared to broader on-premise market.
Standardization Limits	Less customization; fewer options for unique integrations, reporting, and backend access.

RPA as a Service

Choosing the Right Model

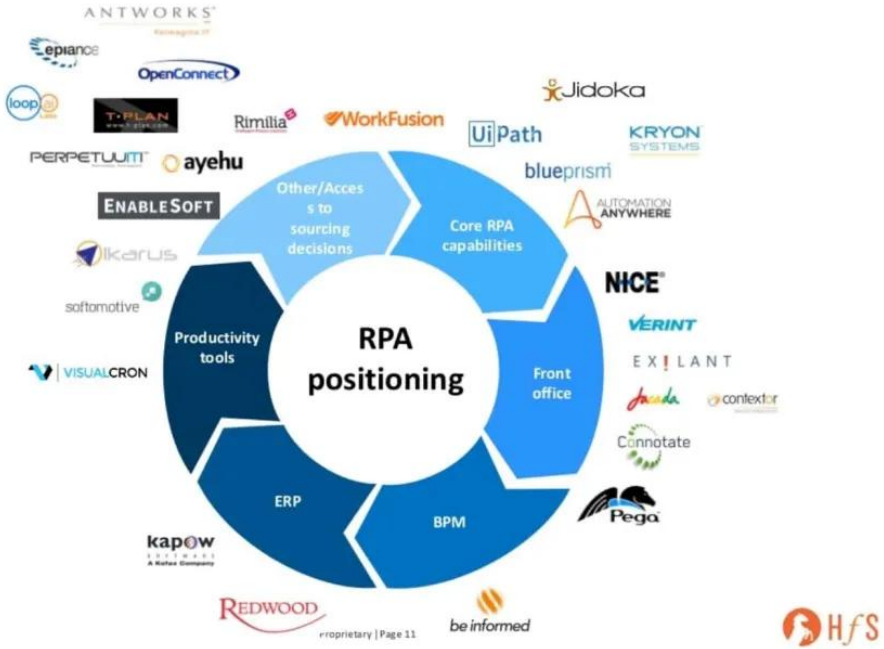
- **On-Premise RPA**: More control, flexibility, and potentially lower long-term costs.
- **RPAaaS**: Faster to deploy, lower upfront cost, minimal infrastructure burden.

Decision depends on:

- Budget
- Technical capacity
- Data policies
- Customization needs
- Stage of RPA maturity

RPA Tools: https://research.aimultiple.com/rpa-tools/

Nowadays there exist more than 50 providers offering RPA solutions with different prices and functionalities.



RPA market expected to grow from **$4B (2024)** to **$14B (2029)** (https://www.celonis.com/blog/what-is-rpa-as-a-service/)

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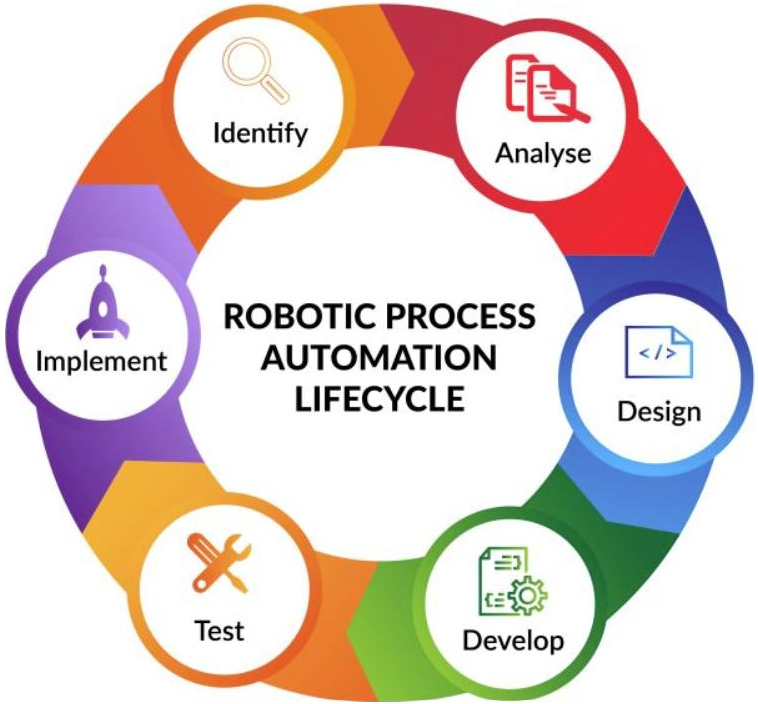
Traditional RPA lifecycle

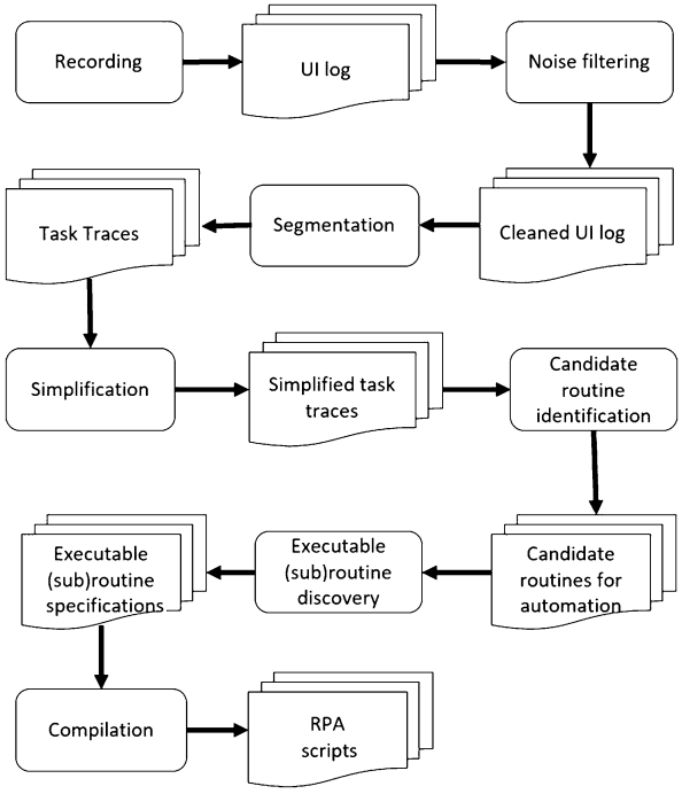


ISSUE: Trial-and-error approach repeated until success (often time consuming and error-prone) **[Jimenez-Ramirez-CAiSE19]**.

state-of-the-art RPA tools are driven by **predefined rules** and **manual configurations** made by expert users rather than automated intelligent techniques.

[Jimenerez-Ramirez-CAiSE19] Jimenez-Ramirez, Andres, et al. "**A method to improve the early stages of the robotic process automation lifecycle**." Advanced Information Systems Engineering: 31st International Conference, CAiSE 2019, Rome, Italy.

Robotic Process Mining [Leno-BISE20]



[Leno-BISE20] Leno, Volodymyr, et al. "**Robotic process mining: vision and challenges**." *Business & Information Systems Engineering* 63 (2021): 301-314.

Steps of Robotic Process Mining

- **Record the mouse/key events** that happen on the UI of the SW applications involved in a routine execution (**UI logs**).
- **Automatically determine** which routines are good candidates to be automated by analyzing the UI logs.
- **Automatically discover** from the UI log the models of the selected routines that define the behavior of a SW robot.
- **Automatically** generate the SW code to enact the SW robot related to the routine under analysis on a target computer system.

User Interaction (UI) Logs

- Detailed **event logs that record low-level interactions** between a user and the user interface of a software application.

- Events are hardware inputs like clicks and keystrokes.

  Applications: Task Mining, **Robotic Process Mining**, Software Usage Analysis, …

Case ID	UI element	Event type	Input value	Timestamp
001	user_name	click		10:23:54
001	user_name	input	"la_autor"	10:23:58
001	password	TAB		10:23:59
001	password	input	"1234567"	10:24:03
001	tick_prof_default	click	true	10:24:06
001	login_button	click		10:24:10

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SmartRPA: A framework to realize the RPM vision

Target: Automatically develop SW robots directly from **segmented** UI logs (i.e., case notion is available).

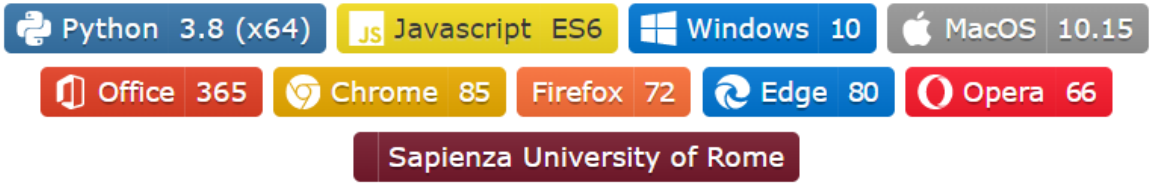
1. Train RPA routines based on observed behaviour (UI Logs) in order to automatically find the best way to perform a specific task.
2. Abstract events to a high level, thus skipping the manual modeling of the flowchart diagrams.
3. Implement and enact a SW robot emulating the most suitable routine reflecting the observed behaviour also in presence of variation points.

Agostinelli, S., Lupia, M., Marrella, A., Mecella, M. Reactive synthesis of software robots in RPA from user interface logs. Computers in Industry, vol. 142 (2022)

SmartRPA

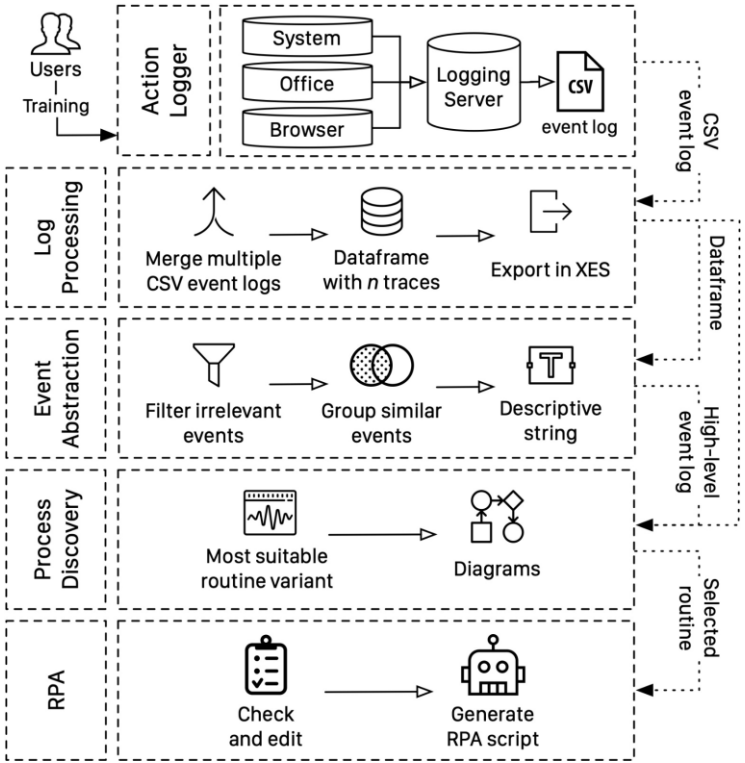
SmartRPA

Logging and RPA training

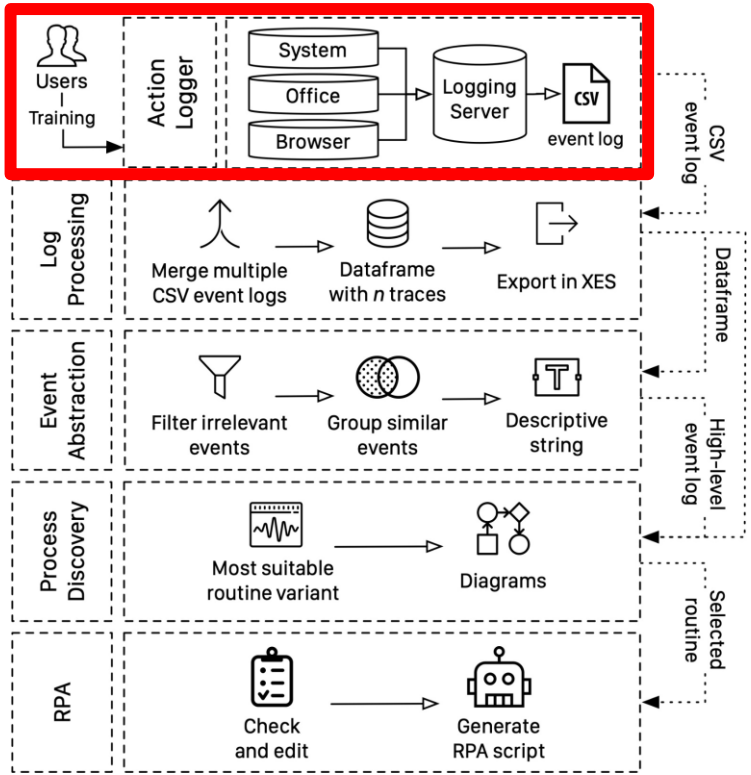


https://github.com/bpm-diag/smartRPA

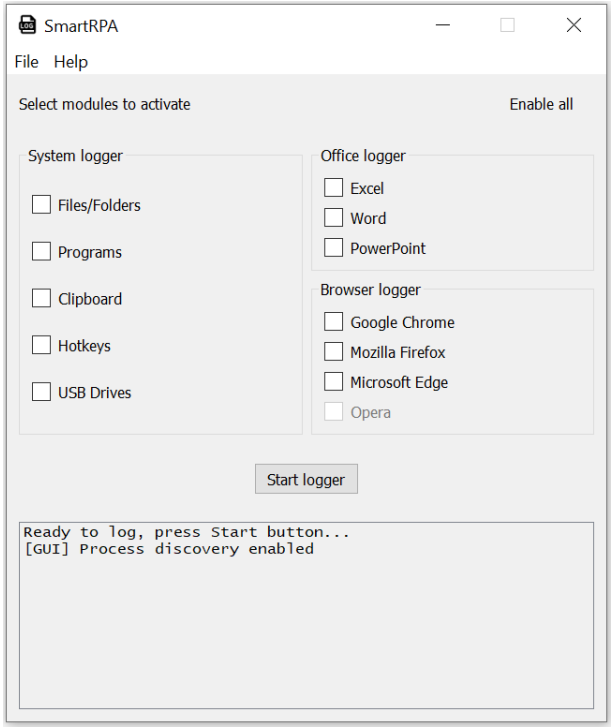
SmartRPA Conceptual Architecture

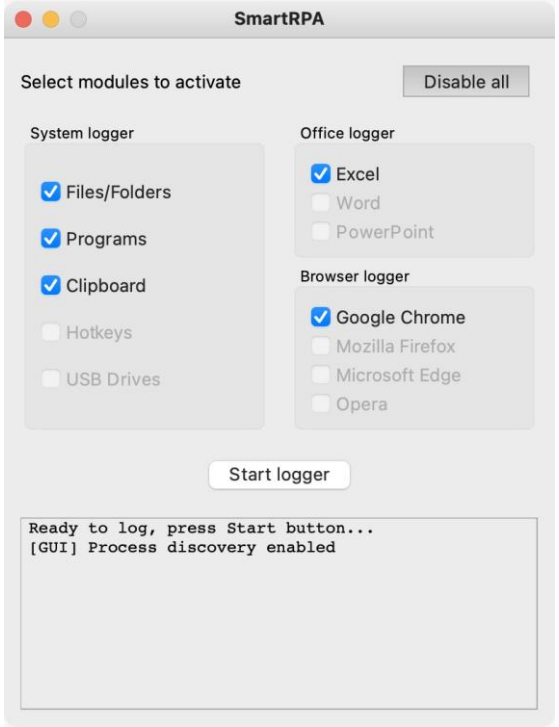


Action Logger



Action Logger





Action Logger

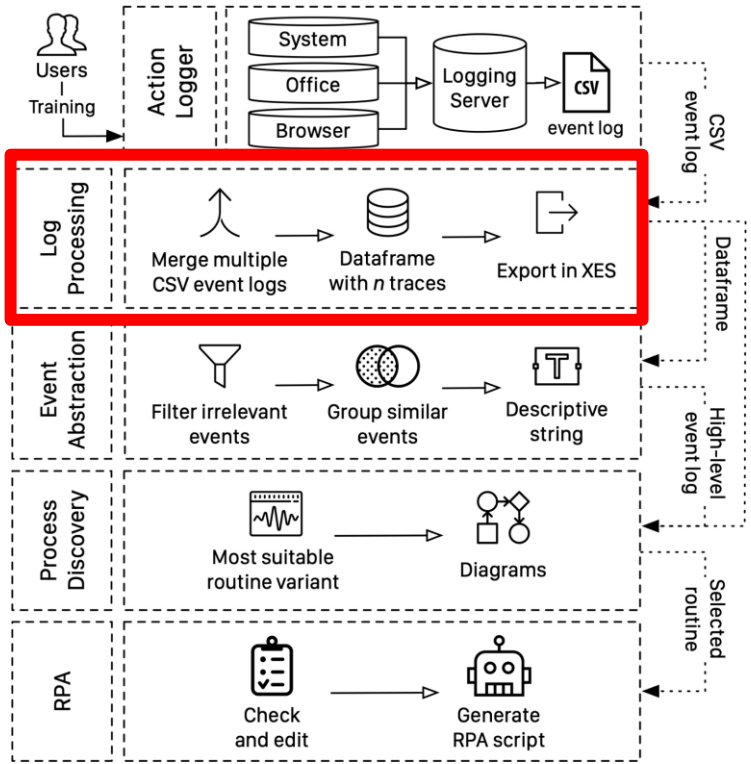
Logging modules

1. System Logger
    1. Native OS APIs
2. Office Logger
    1. Native APIs (Windows)
    2. JavaScript APIs (MacOS)
3. Browser Logger
    1. JavaScript extension

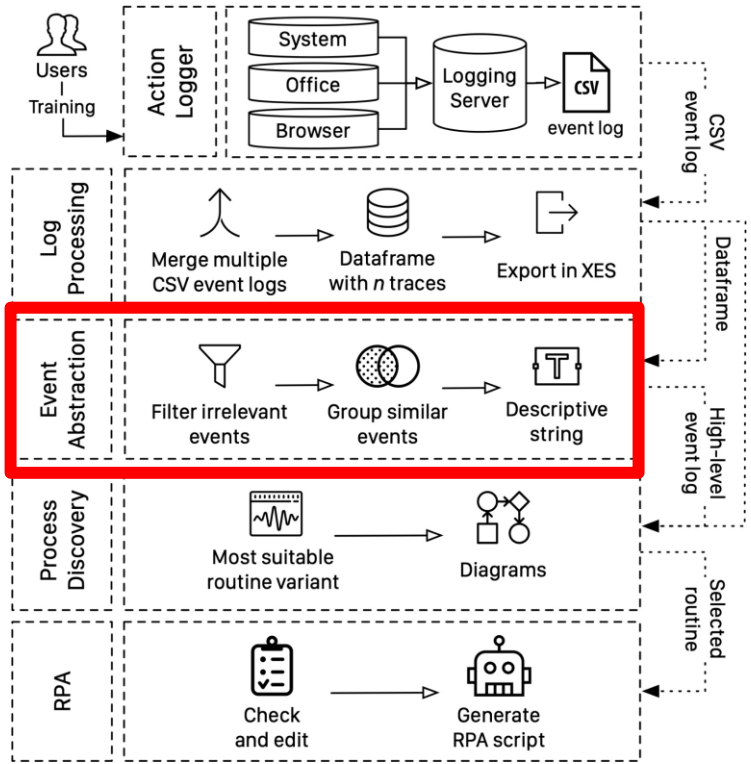
Logging server

- built with Flask
- store UI actions
- organize them into CSV event logs

Log Processing



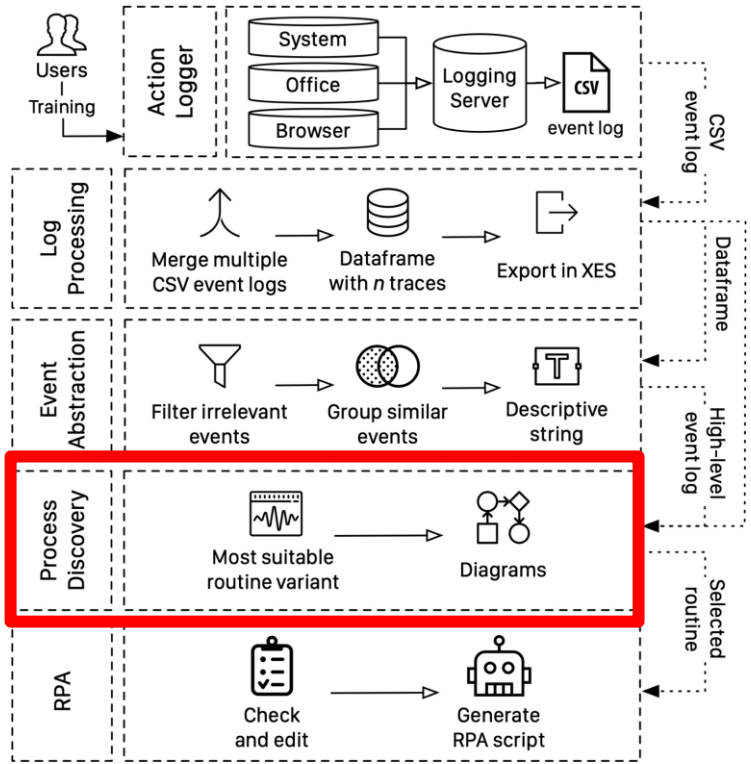
Event Abstraction



Event Abstraction

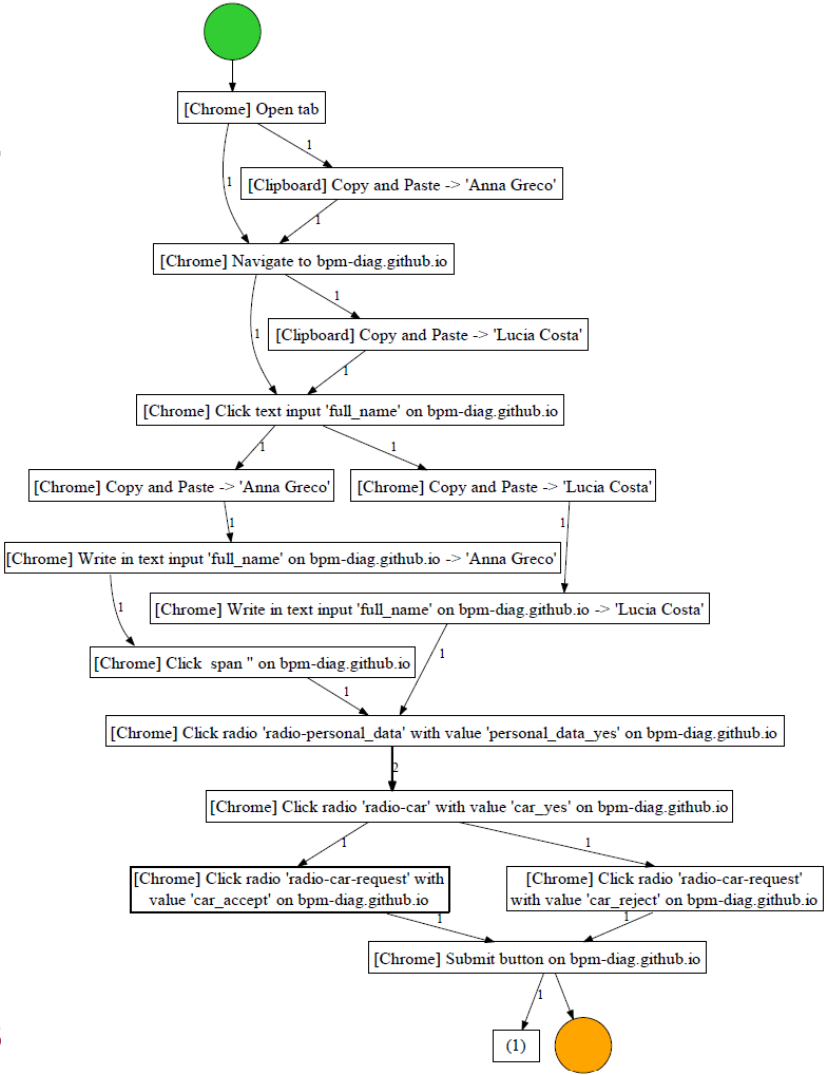
Low-level		High-level
`editCell`	→	Edit cell B12 on Sheet2 with value “test”
`clickButton`	→	Click submit button “Send form” on uniroma1.it
`hotkey`	→	Press “CTRL+C” hotkey (copy)

Process Discovery

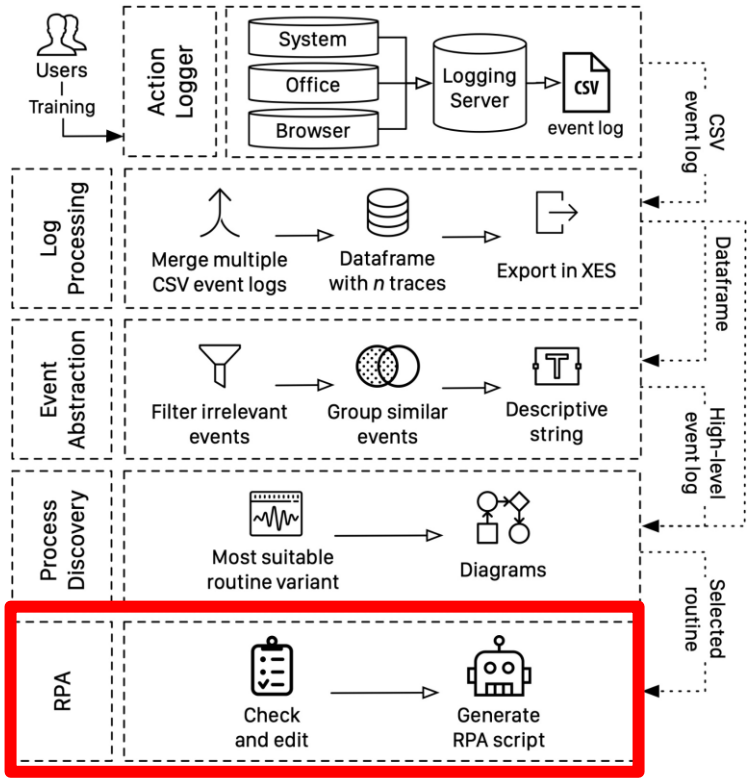


Process Discovery

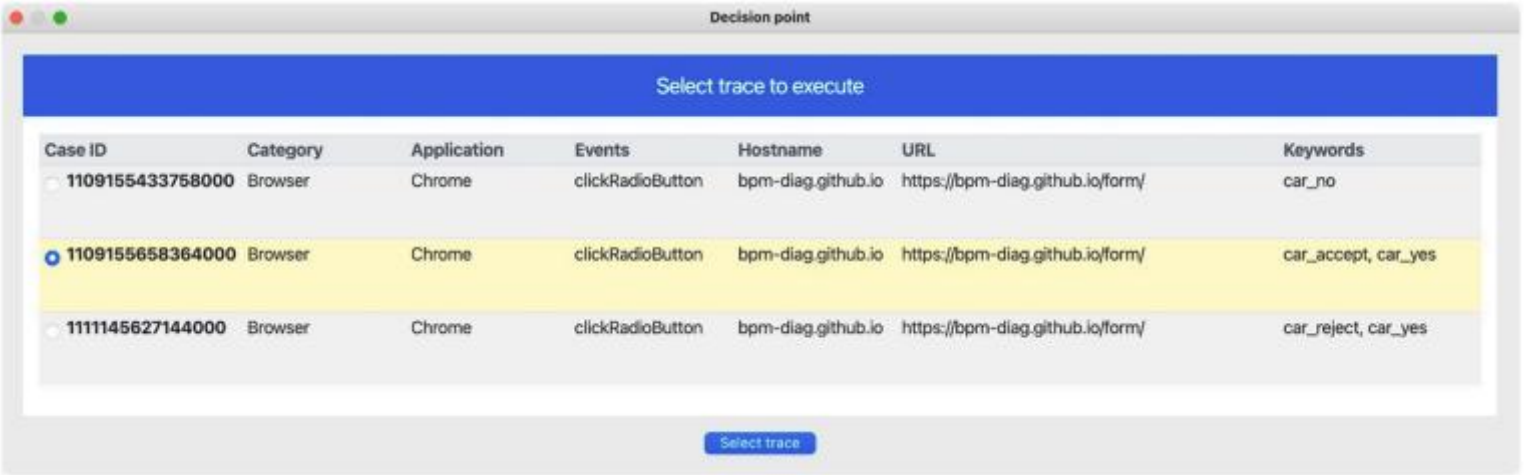
1. Applies the heuristic miner algorithm implemented in **PM4PY**.
2. Derives the high-level workflow describing the overall users' observed behavior as a Directly-Follows Graph (**DFG**).



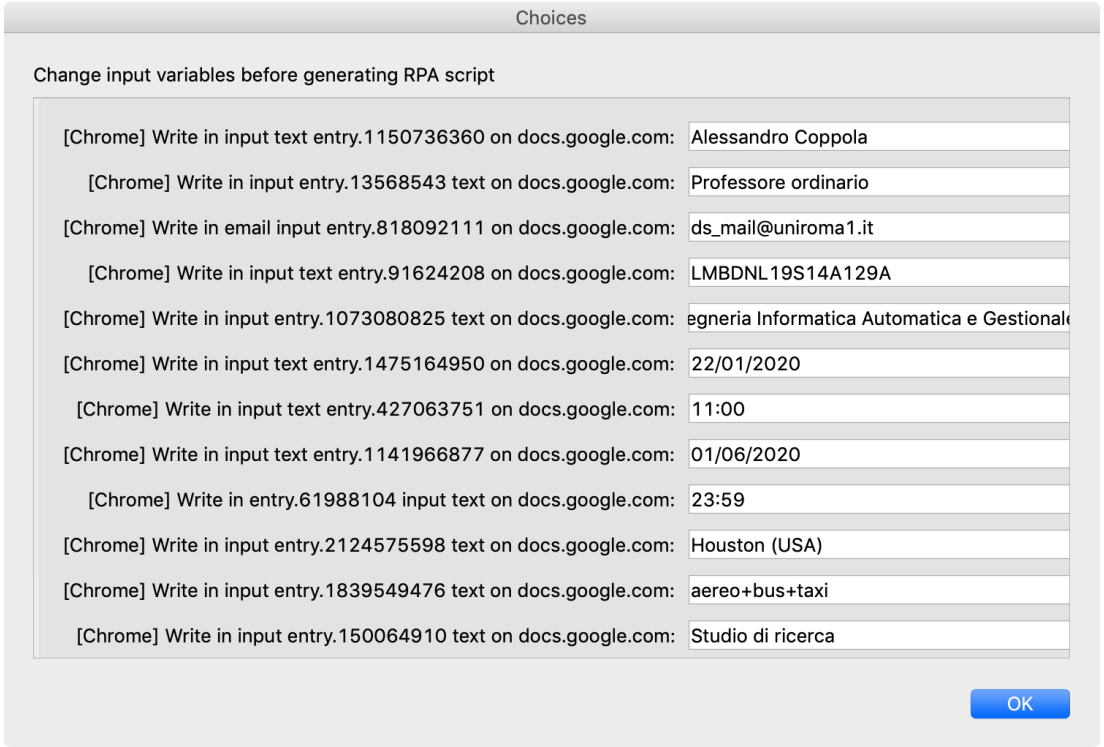
RPA (Scripts Generation)



Untangling the variation points



RPA - Custom dialog



RPA – SW Robot (Python)

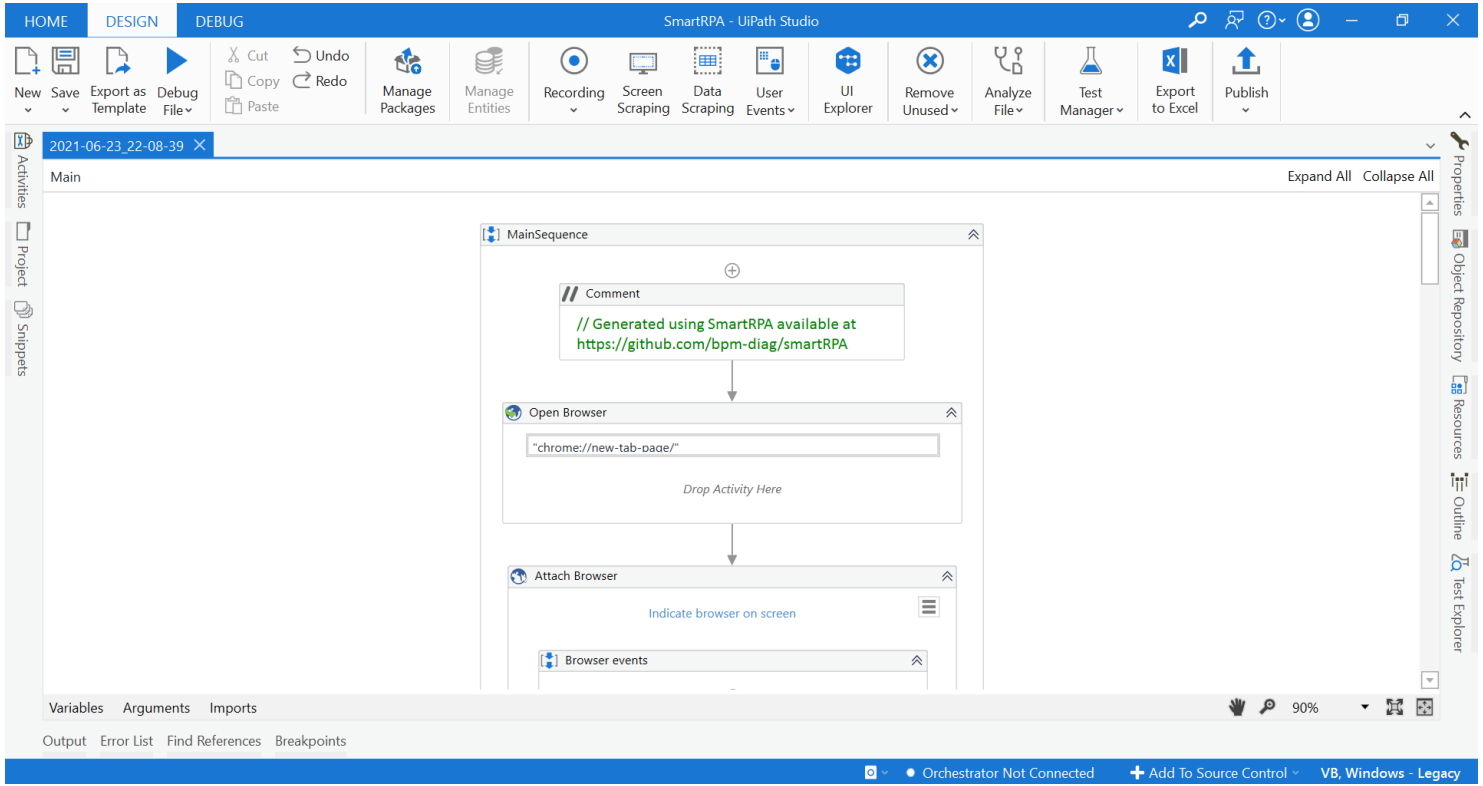
2021-06-23_22-08-39_RPA.py - C:\Users\simon\Desktop\smartRPA\RPA\2021-06-23_22-08-39\SW_Robot\2021-06-23_22-08-39_RPA.py (3.8.1)

File Edit Format Run Options Window Help

```
# -*- coding: utf-8 -*-
# This file was auto generated based on C:/Users/simon/Desktop/smartRPA/RPA/2021-06-23_22-08-39/event_log/2021-06-23_22-08-39_combined.csv
import sys, os
from time import sleep
import pyperclip
try:
    from automagica import *
except ImportError as e:
    print("Please install 'automagica' module running 'pip3 install libraries/Automagica-2.0.25-py3-none-any.whl'")
    print("If you get errors check here https://github.com/bpm-diag/smartRPA#1-automagica")
    sys.exit()


try:
    import importlib
    from selenium import webdriver
    import chromedriver_binary  # Adds chromedriver binary to path
    from selenium.common.exceptions import *
    from selenium.webdriver.common.keys import Keys
    from selenium.webdriver.common.action_chains import ActionChains
    from selenium.webdriver.support.ui import Select
    from selenium.webdriver.support.ui import WebDriverWait
    from selenium.webdriver.support import expected_conditions
    from selenium.webdriver.common.by import By
    print("Opening Chrome...")
    browser = webdriver.Chrome()
    browser.get('about:blank')
except WebDriverException as e:
    print(e)
    sys.exit()

from win32gui import GetForegroundWindow, GetWindowText

# 2021-06-23T15:54:01.704 typed
sleep(0.2)
print('Loading link https://bpm-diag.github.io/form/')
browser.get('https://bpm-diag.github.io/form/')

try:
    WebDriverWait(browser, 2).until(expected_conditions.presence_of_element_located((By.TAG_NAME, 'body')))
except selenium.common.exceptions.TimeoutException:
```

Ln: 1 Col: 0

RPA – SW Robot (UiPath)



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Tool Demonstration

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- **Agentic Process Automation (APA)**

What is Agentic Process Automation?

- Agentic Process Automation (APA) uses **AI agents** to build **flexible workflows** that complete tasks **without human intervention**.
- Represents the next evolution in **Intelligent Automation**.
- APA enables **autonomous** execution of complex, multi-step processes involving planning and decision-making.

AxRPA 2025

1st International Workshop

Agents, the Replacement of Robotic Process Automation?

This workshop is organized within the **7th International Conference on Process Mining (ICPM 2025)** in Montevideo, Uruguay, 20 October - 24 October 2025.

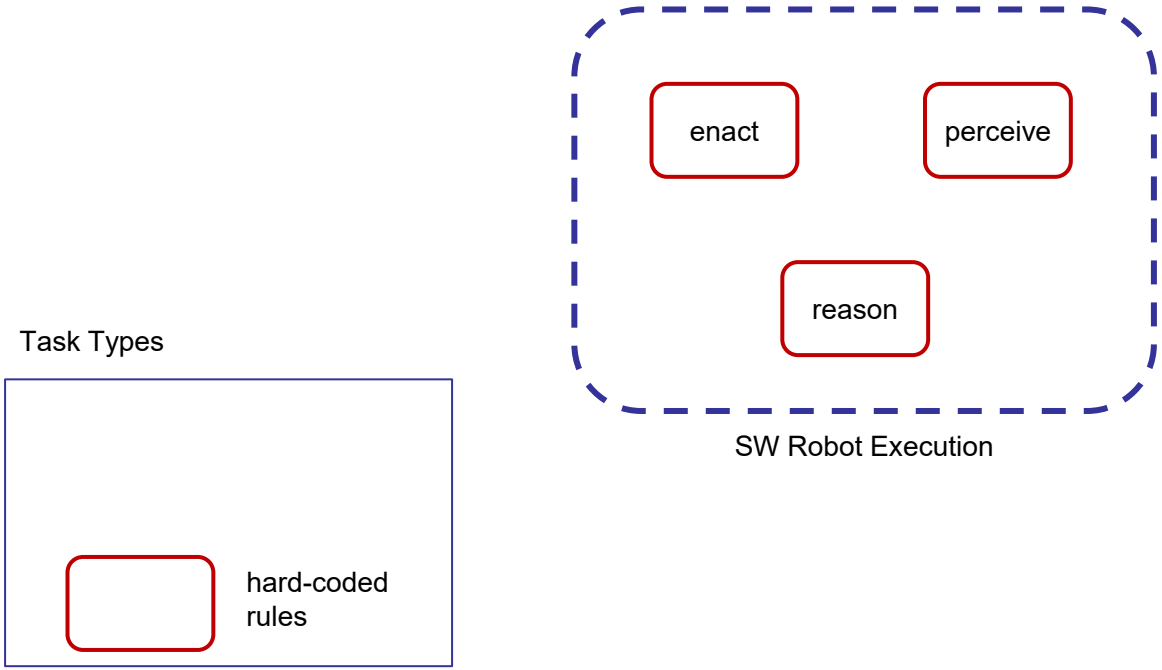
The **AxRPA** workshop explores the transformative potential of *AI agents* in reshaping traditional *Robotic Process Automation (RPA)* and their integration with *Task Mining* under the broader scope of *Process Science*. As advancements in *Large Language Models (LLMs)* enable AI agents to execute goal-oriented tasks beyond static workflows, new challenges arise such as defining autonomy, ensuring seamless collaboration with existing systems, and addressing ethical implications. The workshop bridges academia and industry to discuss topics such as dynamic adaptability of agents, synergy between Process Mining and RPA, and human-agent collaboration.

Activities include paper presentations and a panel discussion ("AI Agents vs. RPA: Bridging the Gap Between Autonomy and Robotic Process Automation"), featuring experts from both fields. Aimed at researchers and practitioners in BPM, AI, and RPA, the workshop seeks to foster innovation, share best practices, and chart the future of intelligent RPA. Join us to explore cutting-edge research, practical insights, and collaborative opportunities in this evolving domain.

How does it work?

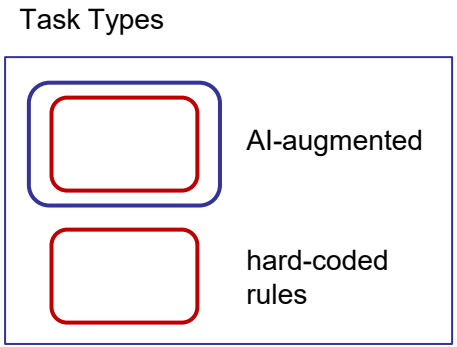
- **AI agents** manage tasks and decisions.
- Uses **LLMs & generative AI**.
- **Ingests real-time data** via ML and NLP.
- Complements existing **ERP**, **CRM**, **API systems**.
- Orchestrates workflows across apps and systems.
- Works alongside RPA, not against it.

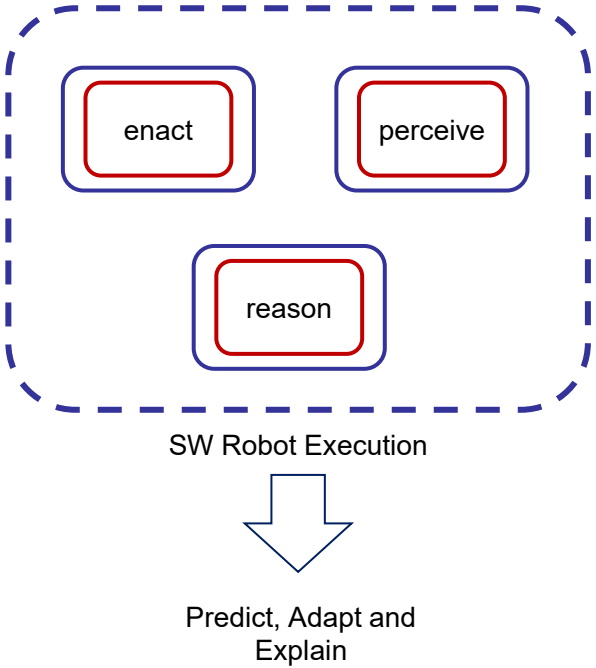
Traditional SW Robots



Proactive SW Robots [Dumas-ACMTrans23]

[Dumas-ACMTrans23] Dumas, Marlon, et al. "**AI-augmented business process management systems: a research manifesto.**" *ACM Transactions on Management Information Systems* 14.1 (2023): 1-19.





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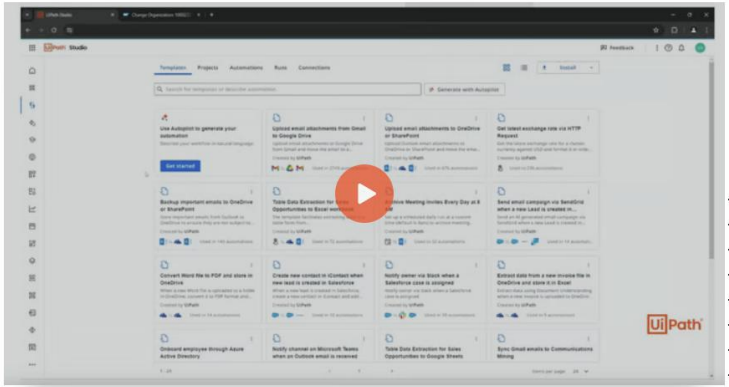
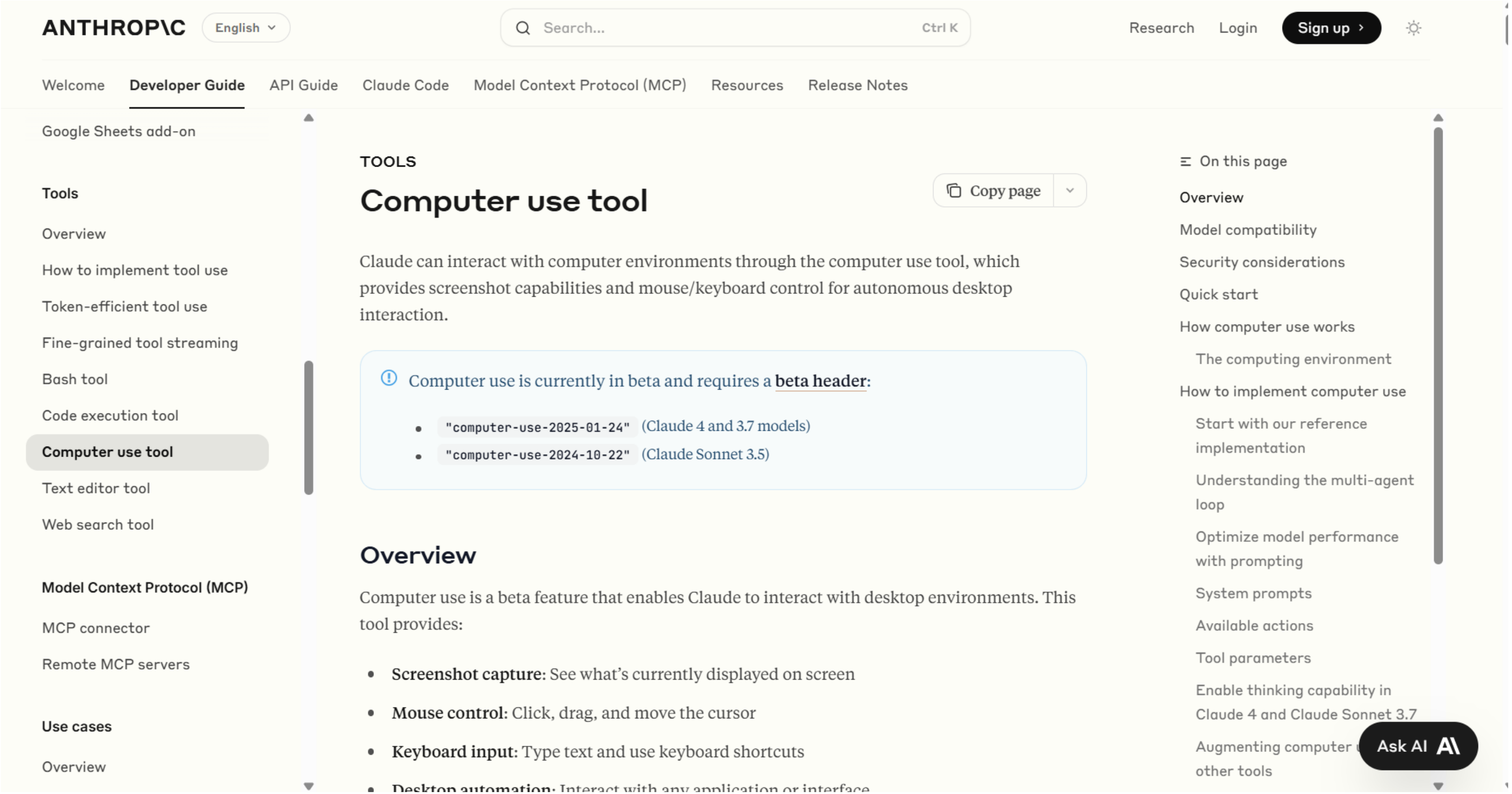
Autopilot for Studio enhances productivity for developers of all kinds.

- 'Text to workflow' transforms descriptions easily into automation workflows, reducing complexity particularly for non-technical users.
- 'Text to expressions' generates expressions using natural language descriptions allowing developers to focus on the problem at hand rather than syntax.
- 'Automated code generation' directly transforms descriptions into code-based automations.



GPT Operator

Claude (Anthropic)



ANTHROP\C English

Search... Ctrl K

Research Login Sign up

Welcome | Developer Guide | API Guide | Claude Code | Model Context Protocol (MCP) | Resources | Release Notes

Google Sheets add-on

Tools

- Overview
- How to implement tool use
- Token-efficient tool use
- Fine-grained tool streaming
- Bash tool
- Code execution tool
- Computer use tool
- Text editor tool
- Web search tool

Model Context Protocol (MCP)

- MCP connector
- Remote MCP servers

Use cases

- Overview

TOOLS

Computer use tool

Copy page

Claude can interact with computer environments through the computer use tool, which provides screenshot capabilities and mouse/keyboard control for autonomous desktop interaction.

Computer use is currently in beta and requires a **beta header**:

- `"computer-use-2025-01-24"` (Claude 4 and 3.7 models)
- `"computer-use-2024-10-22"` (Claude Sonnet 3.5)

Overview

Computer use is a beta feature that enables Claude to interact with desktop environments. This tool provides:

- **Screenshot capture:** See what's currently displayed on screen
- **Mouse control:** Click, drag, and move the cursor
- **Keyboard input:** Type text and use keyboard shortcuts
- **Desktop automation:** Interact with any application or interface

On this page

- Overview
- Model compatibility
- Security considerations
- Quick start
- How computer use works
  - The computing environment
- How to implement computer use
  - Start with our reference implementation
  - Understanding the multi-agent loop
  - Optimize model performance with prompting
  - System prompts
  - Available actions
  - Tool parameters
  - Enable thinking capability in Claude 4 and Claude Sonnet 3.7
  - Augmenting computer [...] other tools

Ask AI

… And many more

- Automation Anywhere Co-Pilot
- Microsoft Co-Pilot for Power Automate
- IBM watsonx Orchestrate
- Etc…

Final Overview

Criteria	Traditional RPA	RPM	APA
Adaptability	Low	Medium	High
Task Complexity	Low	Medium	High
Intelligence	Low	Medium	High
Scalability	Medium	High	High

RPA and its servitization

Thank you for the attention!

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