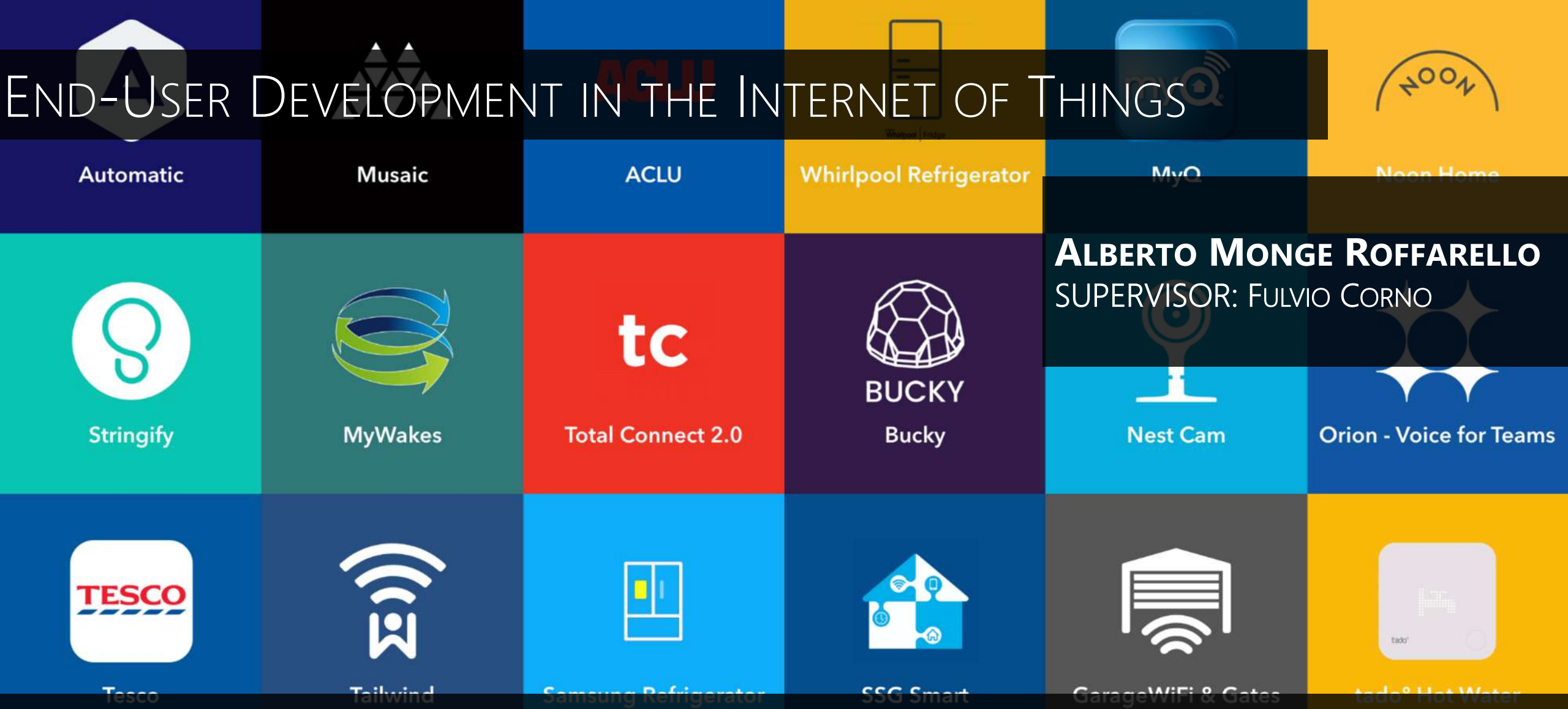
End-User Development in the Internet of Things

Alberto Monge Roffarello
Supervisor: Fulvio Corno



Politecnico di Torino

e-Lite
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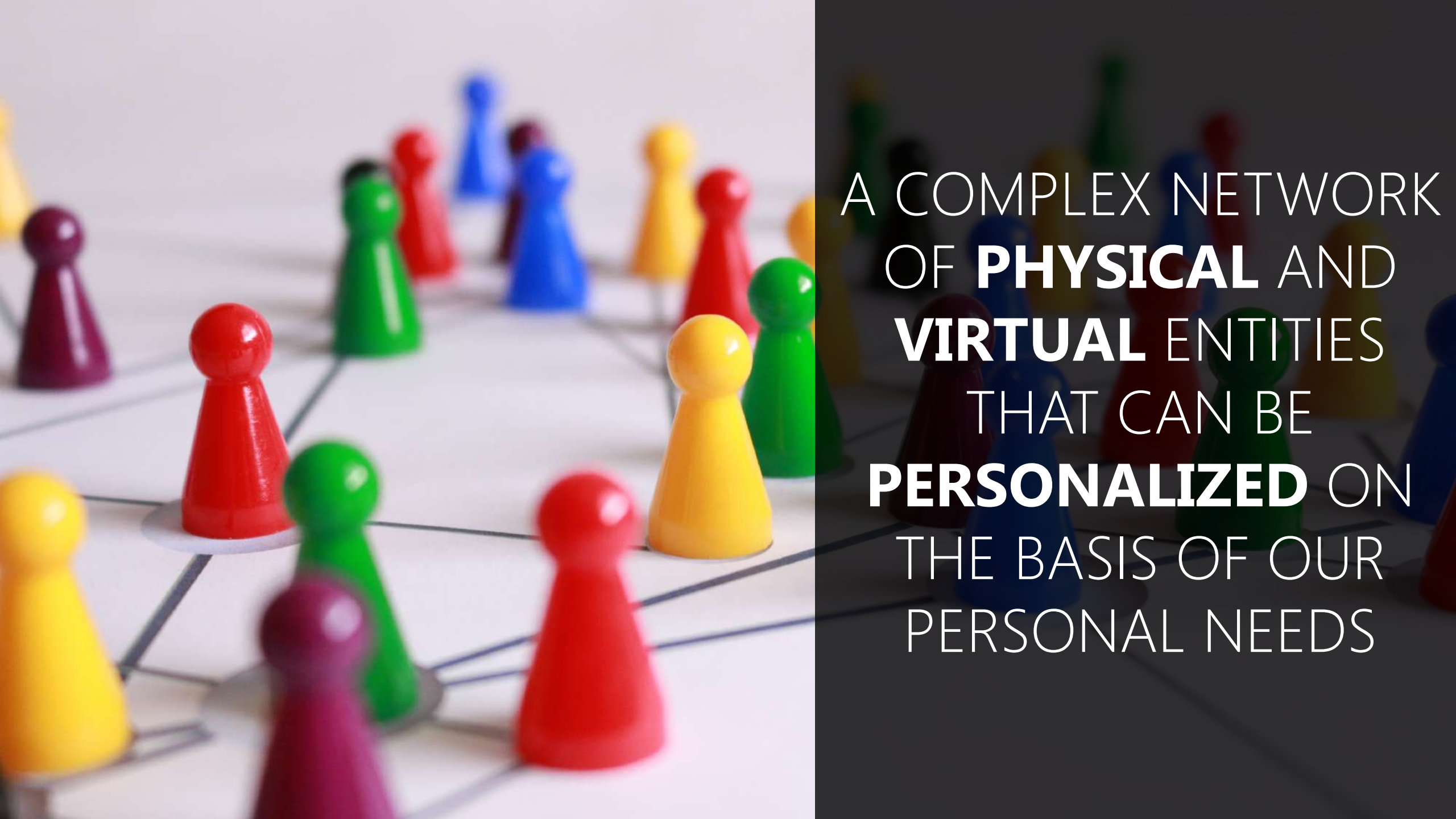
“The Internet of Things is a recognized paradigm that already helps society in many different ways, through applications ranging in scope from the individual to the planetary”

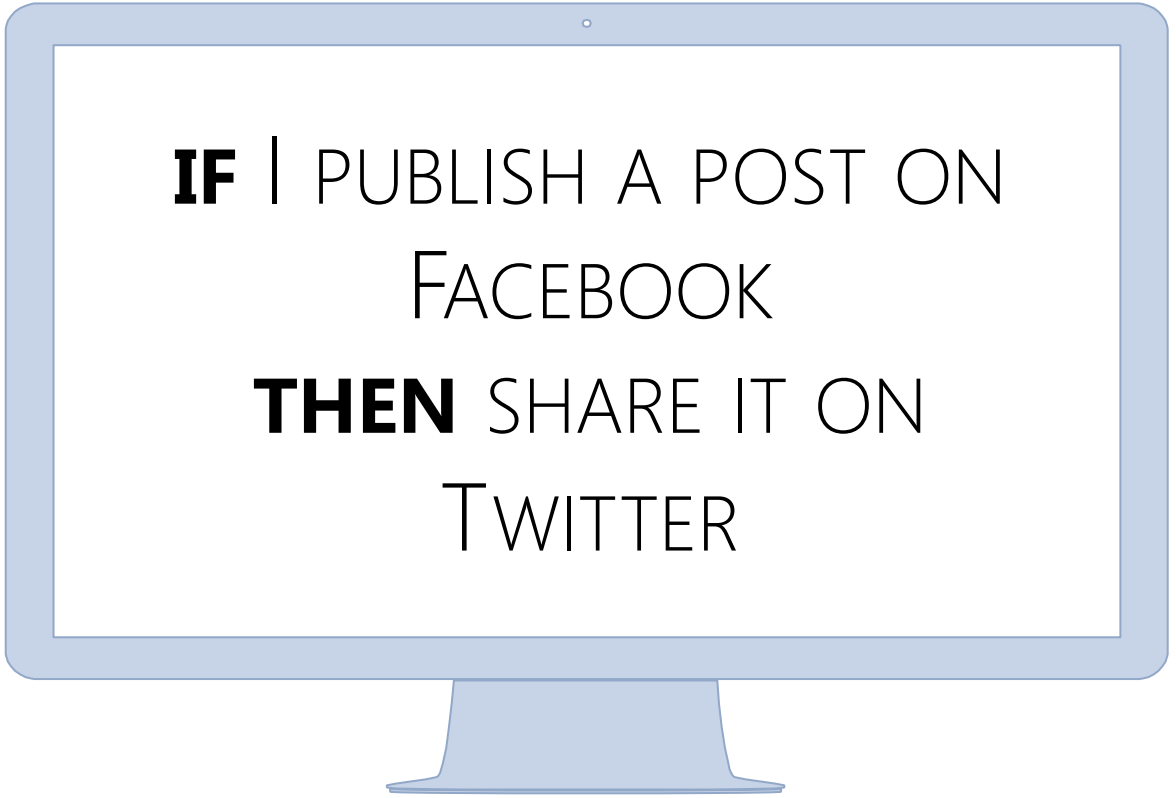
Vint Cerf and Max Senges, Google Research



A COMPLEX NETWORK OF **PHYSICAL** AND **VIRTUAL** ENTITIES THAT CAN BE **PERSONALIZED** ON THE BASIS OF OUR PERSONAL NEEDS

END USERS
CAN
PROGRAM
THE IoT THROUGH
TRIGGER-ACTION
RULES


IF THE SURVEILLANCE CAMERA RECOGNIZES ME **THEN** TURN ON THE SMART THERMOSTAT


IF I PUBLISH A POST ON FACEBOOK **THEN** SHARE IT ON TWITTER

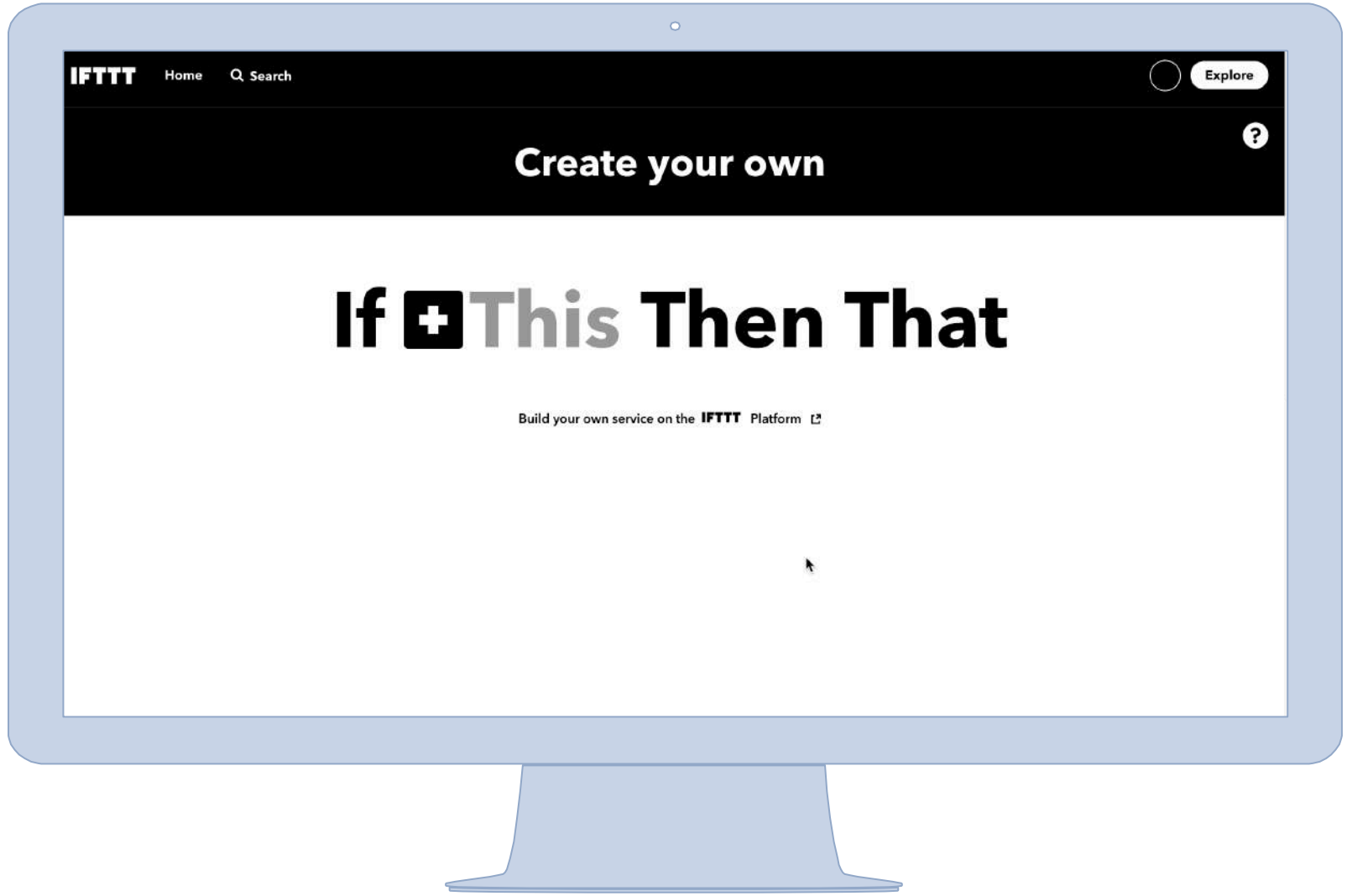
IF-THEN RULE

TRIGGER

1. Connected Entity Selection
2. Trigger Selection
3. Trigger Details

ACTION

4. Connected Entity Selection
5. Action Selection
6. Action Details



if this then that

ISSUES

ISSUES

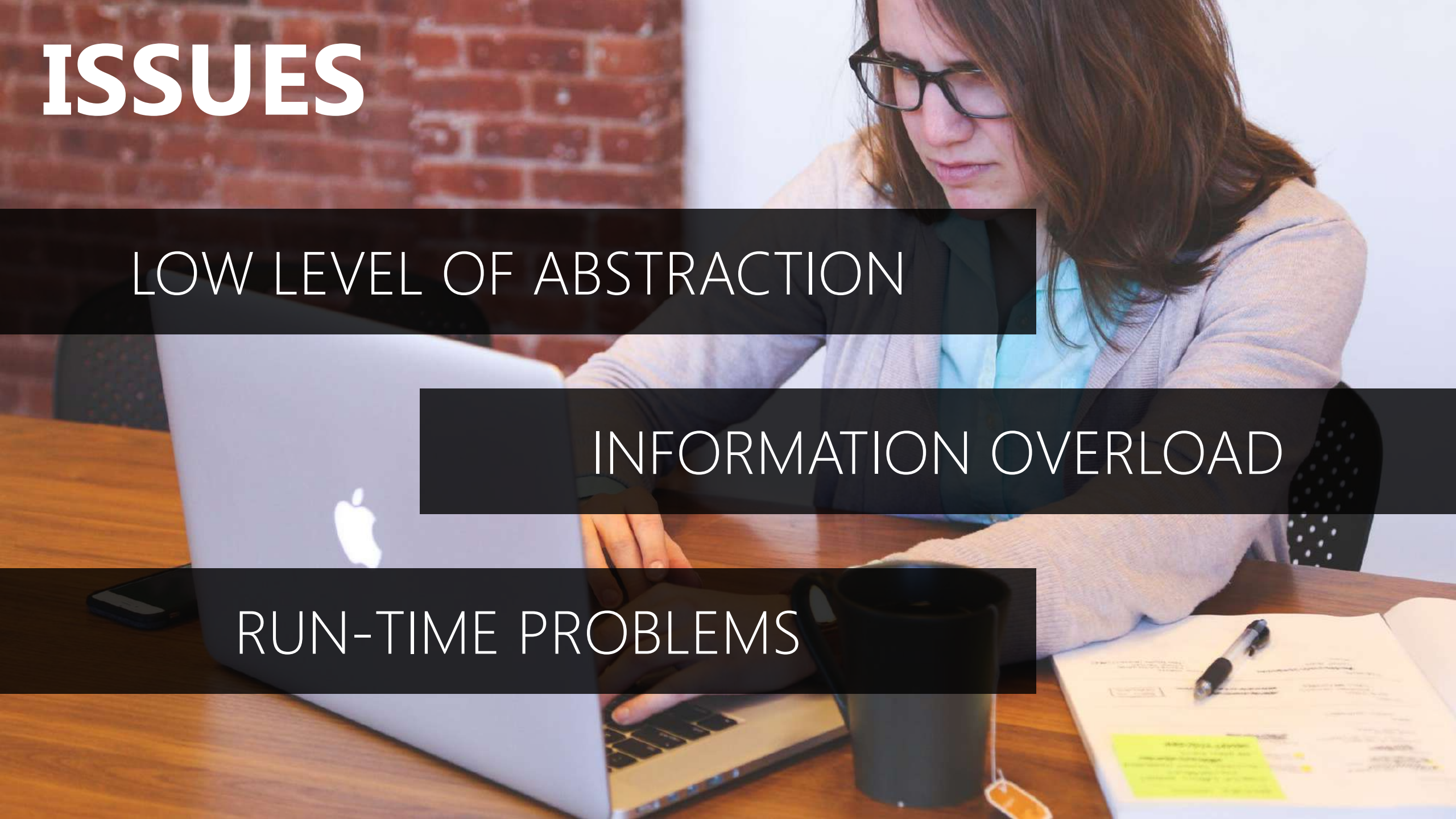
LOW LEVEL OF ABSTRACTION

ISSUES

LOW LEVEL OF ABSTRACTION

INFORMATION OVERLOAD

ISSUES



LOW LEVEL OF ABSTRACTION

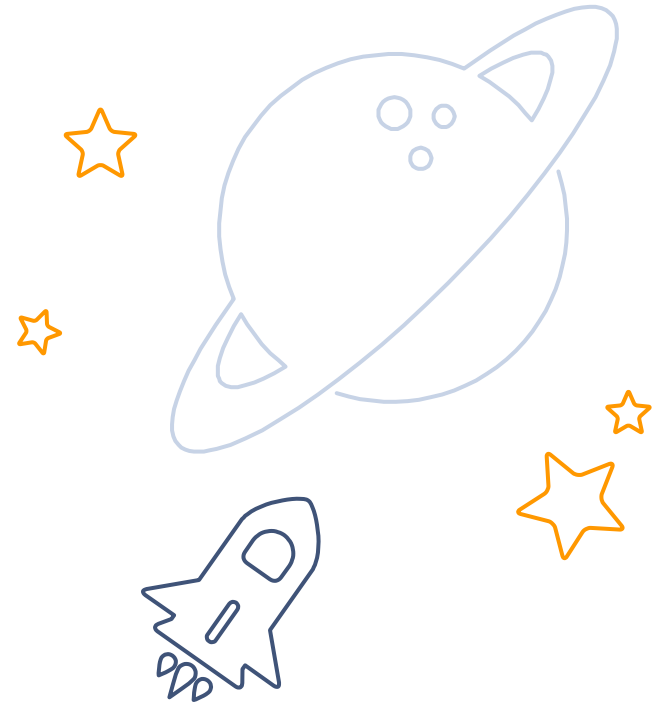
INFORMATION OVERLOAD

RUN-TIME PROBLEMS

RESEARCH GOAL

Assisting end users in easily and efficiently **personalizing** the **functionality** of their connected entities.

The main goal is to simplify the **definition** of IF-THEN rules.



1 MOVING TOWARDS A **HIGH-LEVEL** OF **ABSTRACTION**

EUPont

2 **DISCOVERING** IF-THEN RULES AND **FUNCTIONALITY**

EUDoptmizer RecRules

3 **DEBUGGING** IF-THEN RULES AT **DEFINITION TIME**

SCPN EUDebug My IoT Puzzle

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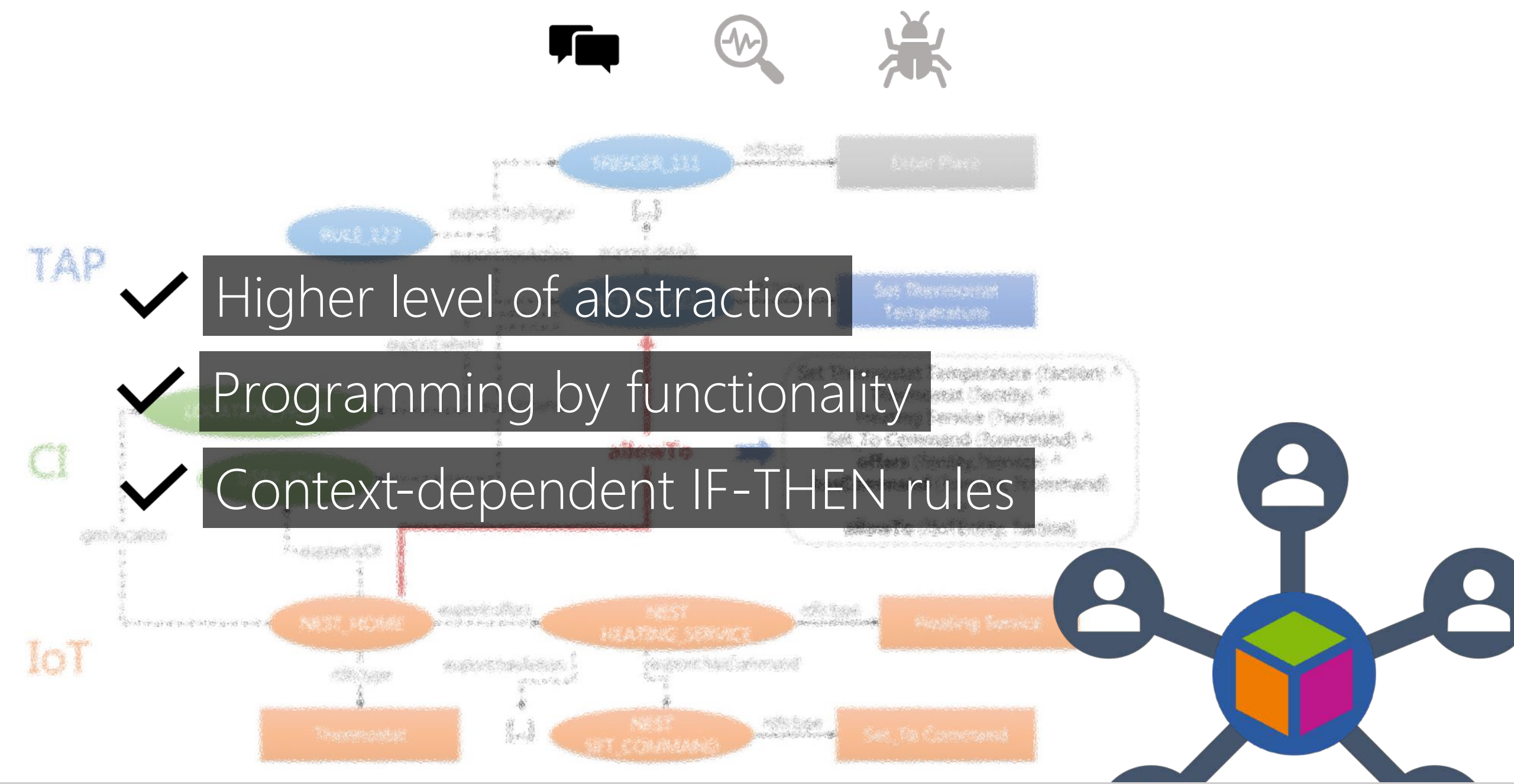

TAP
CI
IoT
Higher level of abstraction
Programming by functionality
Context-dependent IF-THEN rules

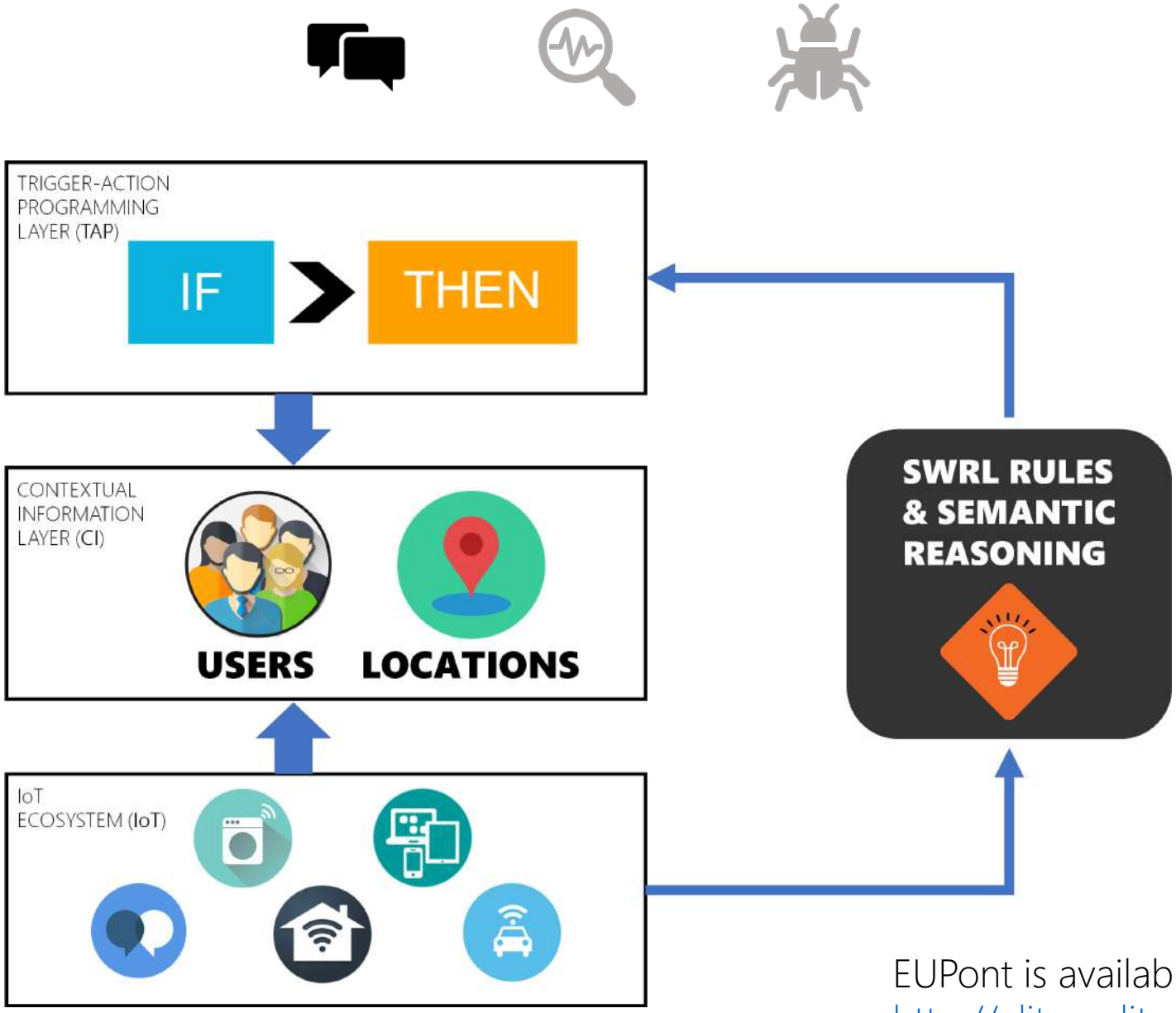


IF

I enter an indoor location,

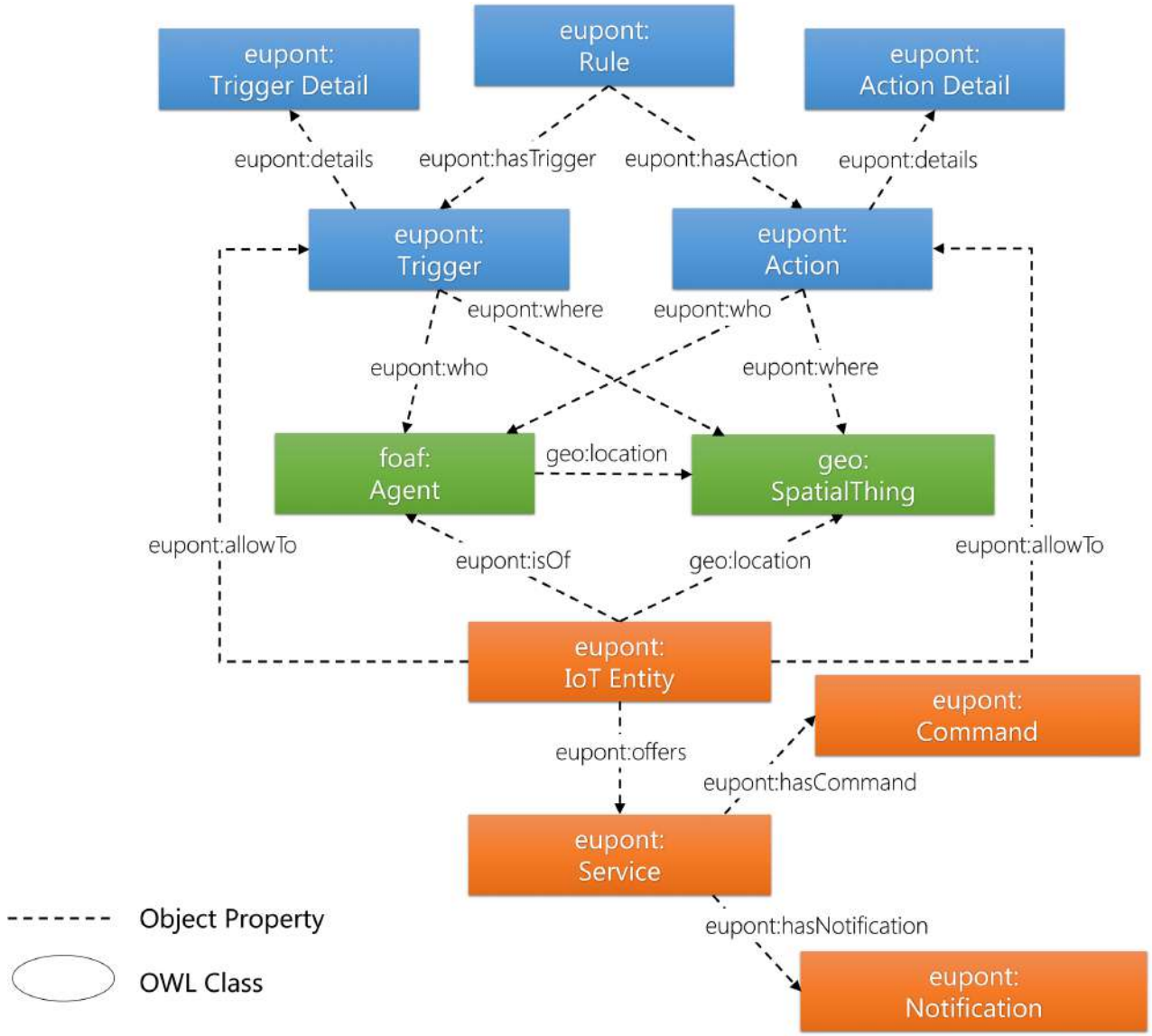
THEN

set its temperature to 20 Celsius degree



EUPont is available at
http://elite.polito.it/ontologies/eupont.owl

EUPont



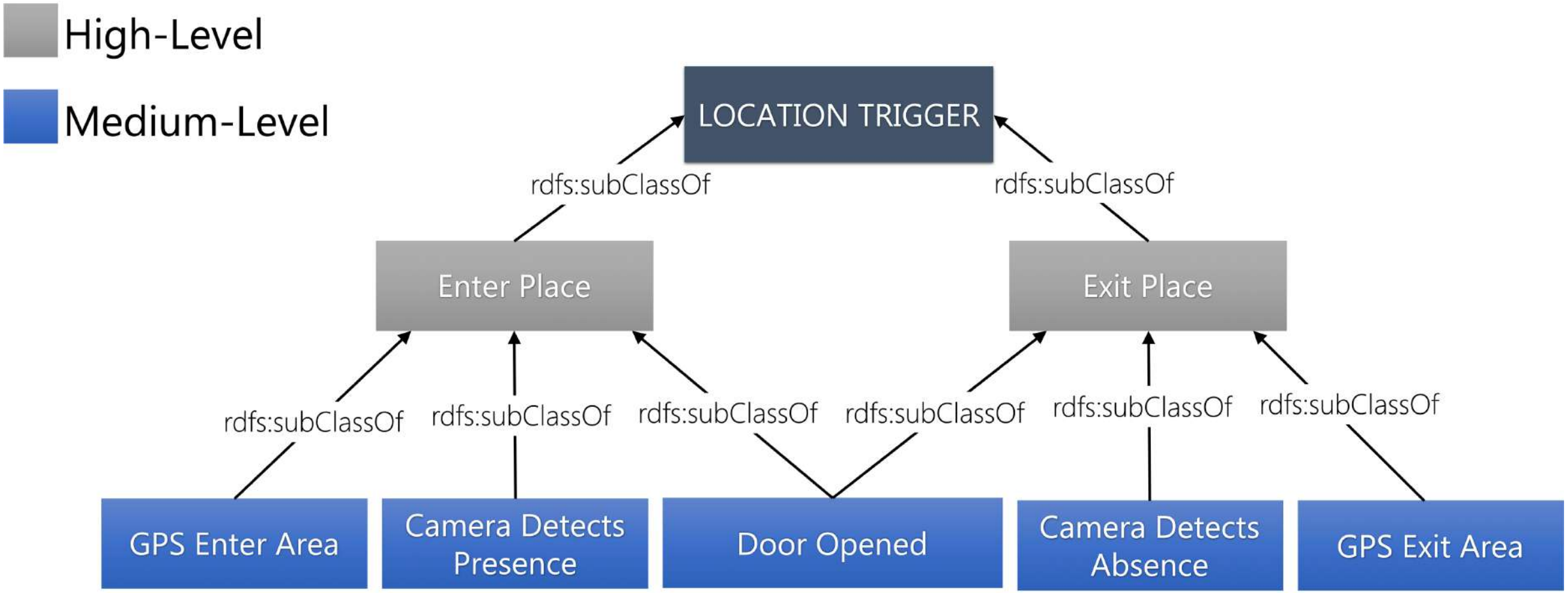
TRIGGER-ACTION PROGRAMMING
LAYER

CONTEXTUAL INFORMATION
LAYER

INTERNET OF THINGS
LAYER

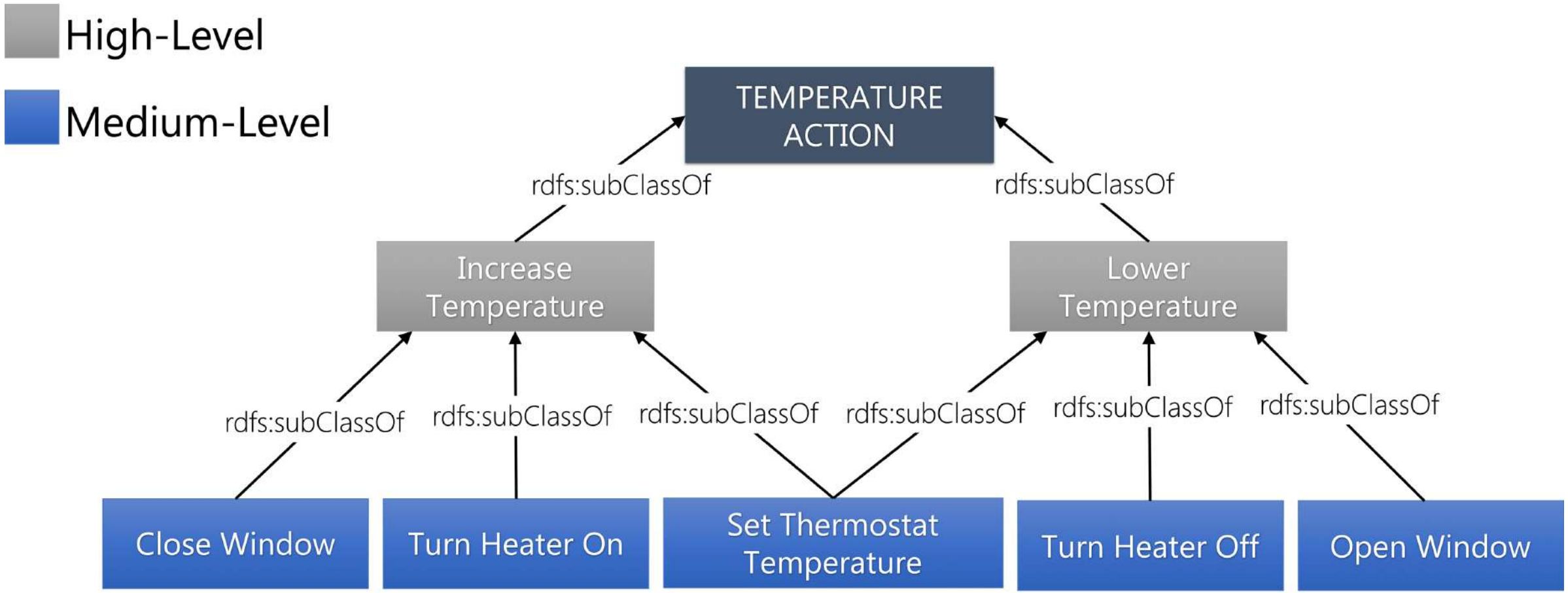
TRIGGER-ACTION PROGRAMMING

LAYER

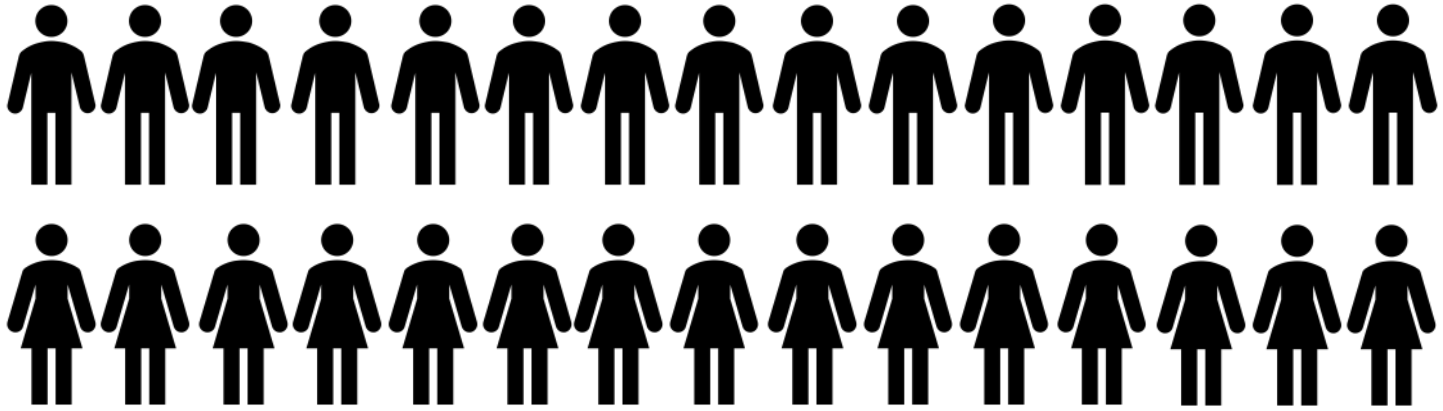


TRIGGER-ACTION PROGRAMMING

LAYER



USER STUDY



15 males

15 females

University students
Different backgrounds
22.23 mean **age**



USER STUDY

Does the **EUPont** representation help users **define** their IF-THEN rules more **effectively** and **efficiently** compared with the IFTTT representation?

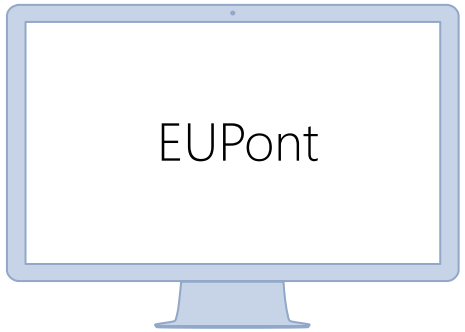


USER STUDY

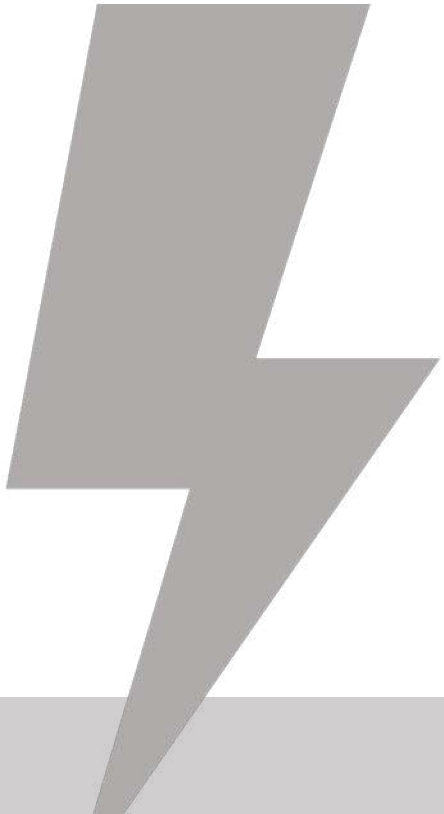
5 TASKS: Scenario + Goal

2 INTERFACES

vs.

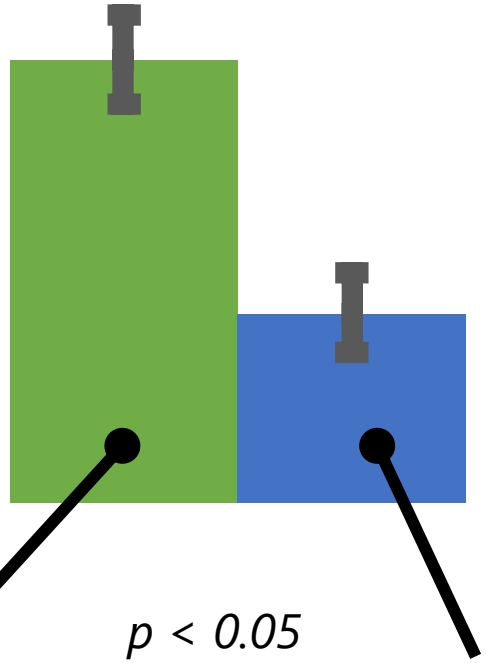


ADVANTAGES



The **EUPont** representation allows end users to avoid **errors** and to **reduce** the **time** needed to define their IF-THEN rules.

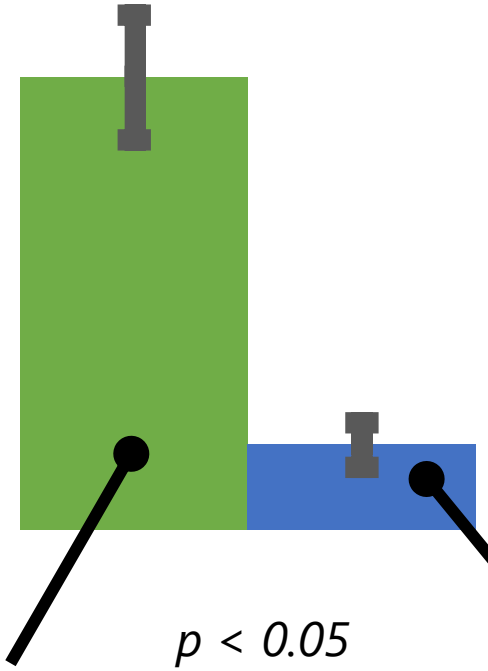
ADVANTAGES



p < 0.05

0.279
incorrect **TRIGGERS**
on average with
IFTTT

0.120
incorrect **TRIGGERS**
on average with
EUPont



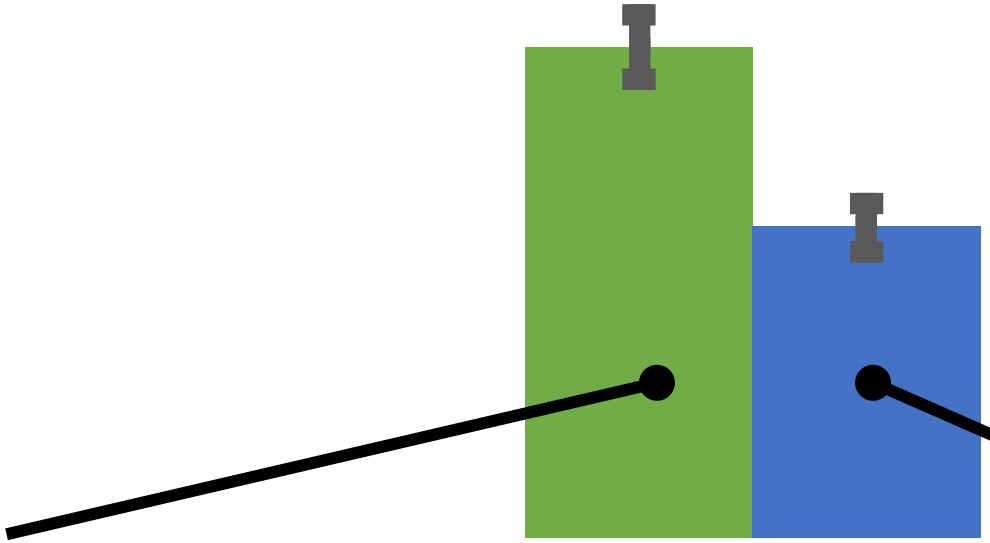
p < 0.05

0.279
incorrect **ACTIONS**
on average with
IFTTT

0.120
incorrect **ACTIONS**
on average with
EUPont

EUPont

ADVANTAGES



39.65 s
average time for defining **RULES** with **IFTTT**

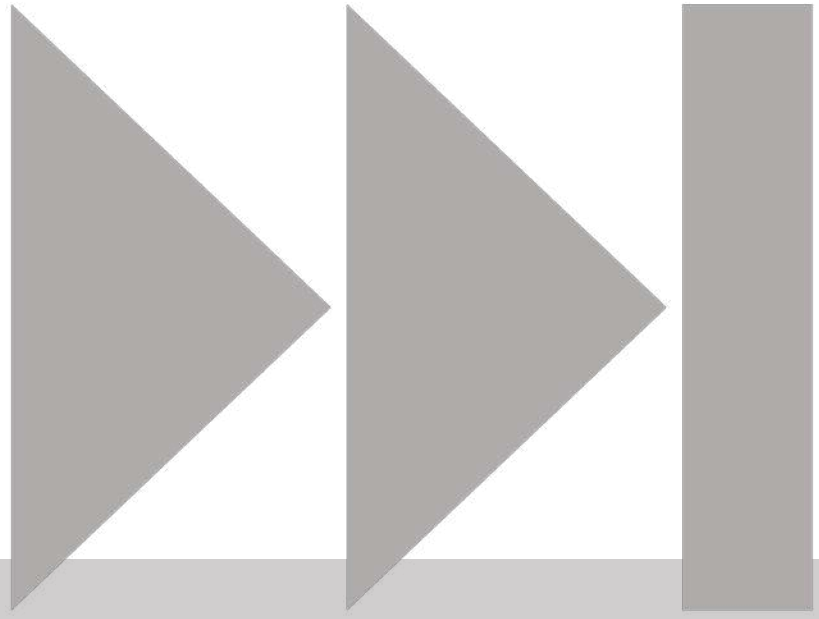
p < 0.05

25.05
average time for defining **RULES** with **EUPont**



CHALLENGES

Moving towards a **higher** level of abstraction is promising but poses **new challenges**





CHALLENGES

Adapting **Contexts**

How can we decide how to reproduce abstract behaviors?

Preferred **Level** of **Abstraction**

Which level of abstraction do users prefer?

Security, and **Privacy**

Can we execute abstract behavior by preserving security and privacy?

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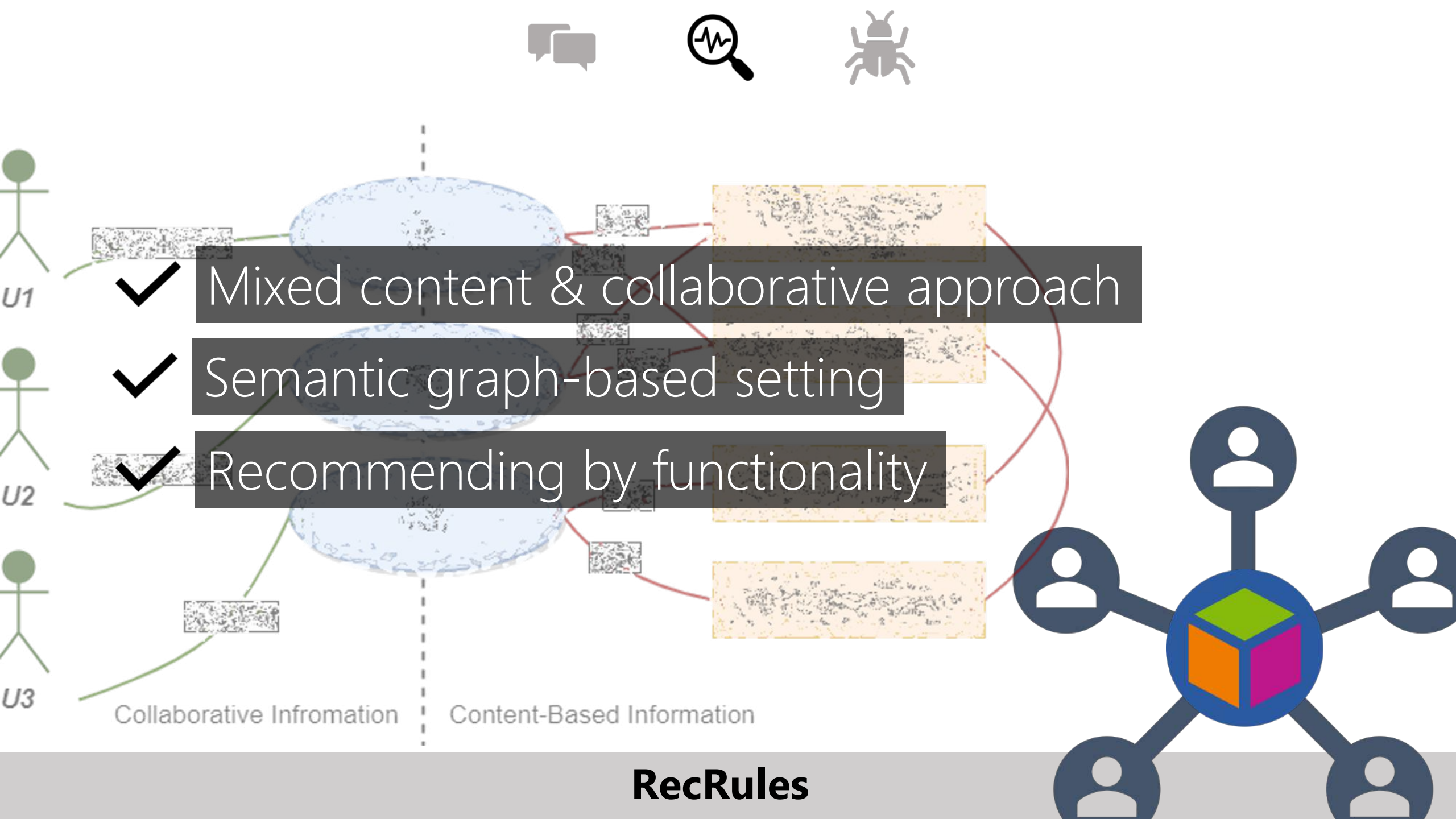

- ✓ Mixed content & collaborative approach
- ✓ Semantic graph-based setting
- ✓ Recommending by functionality

RecRules



PERSONALIZING THE TEMPERATURE WHEN I'M GOING TO USE AN INDOOR PLACE



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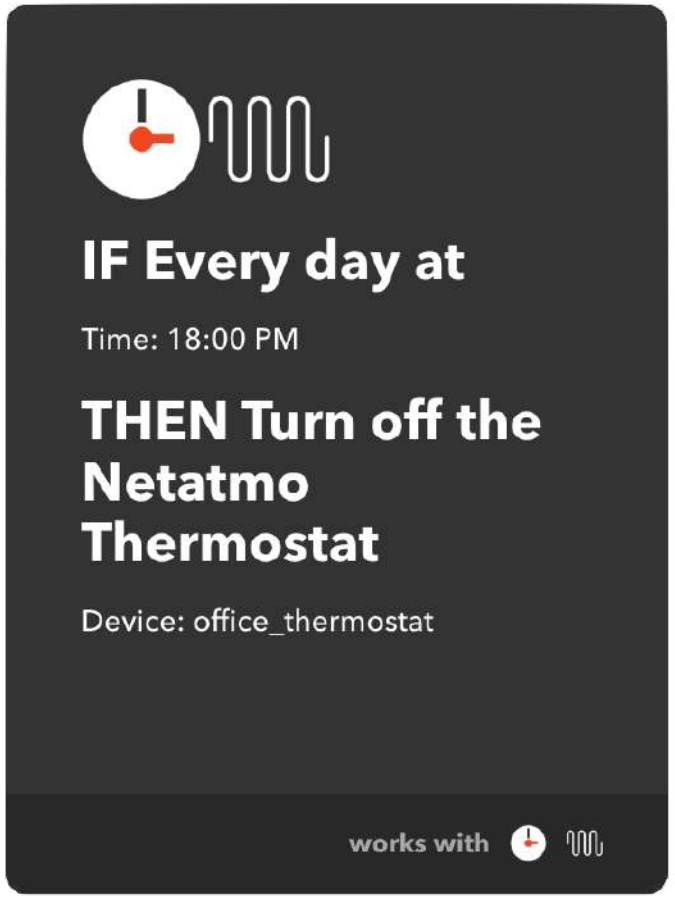

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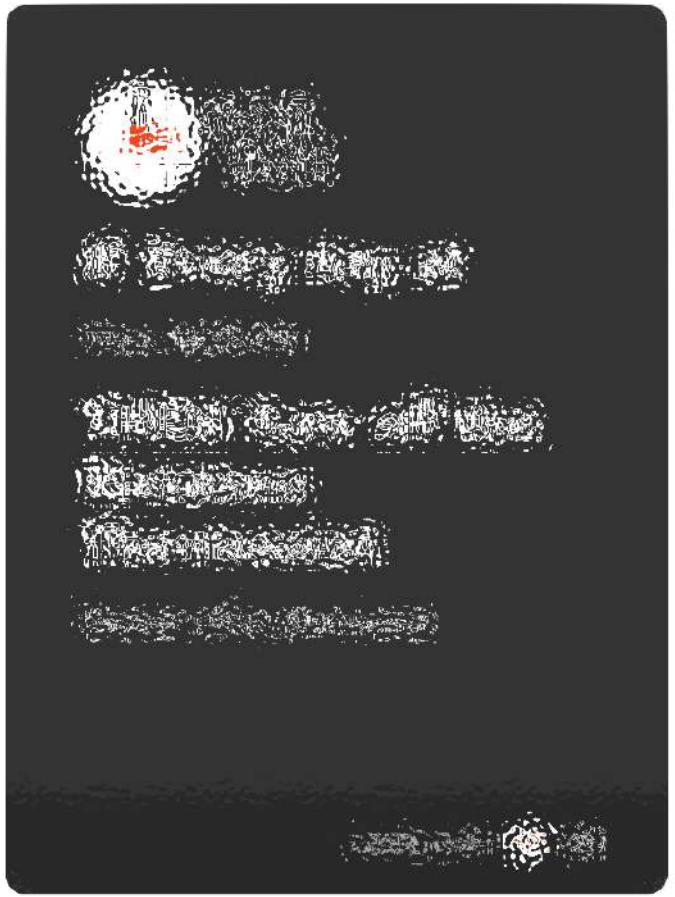

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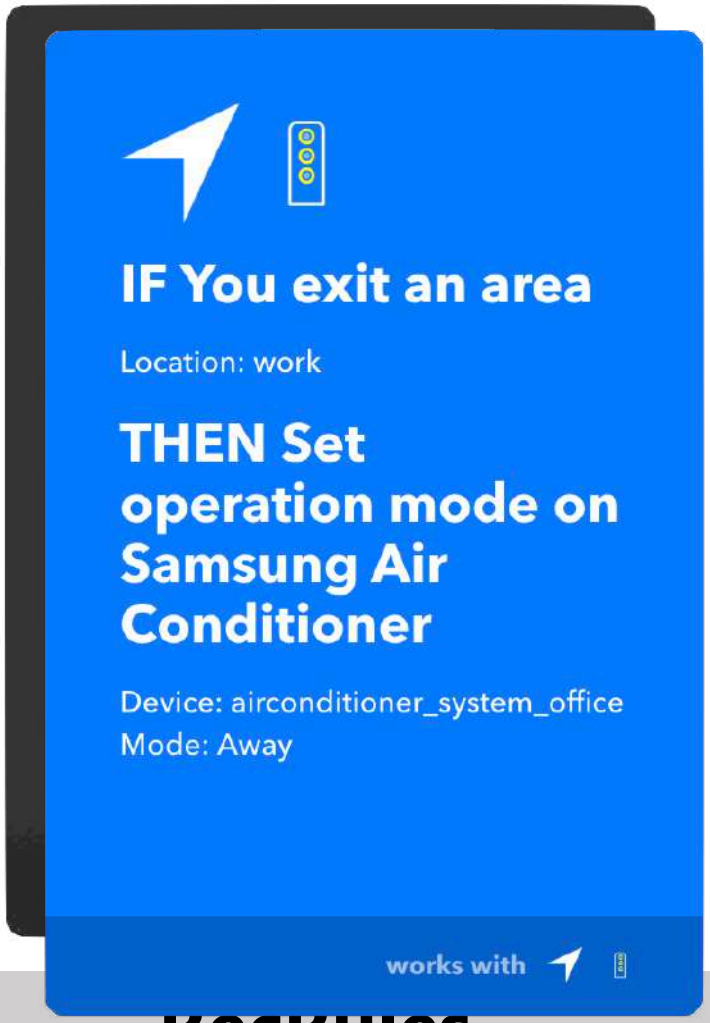
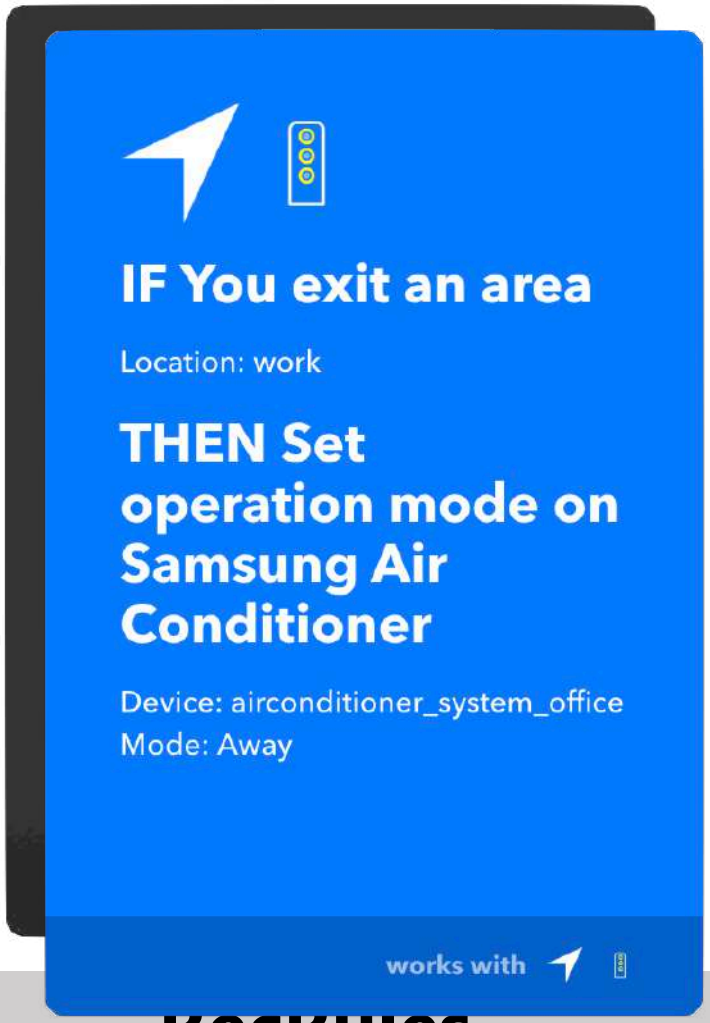
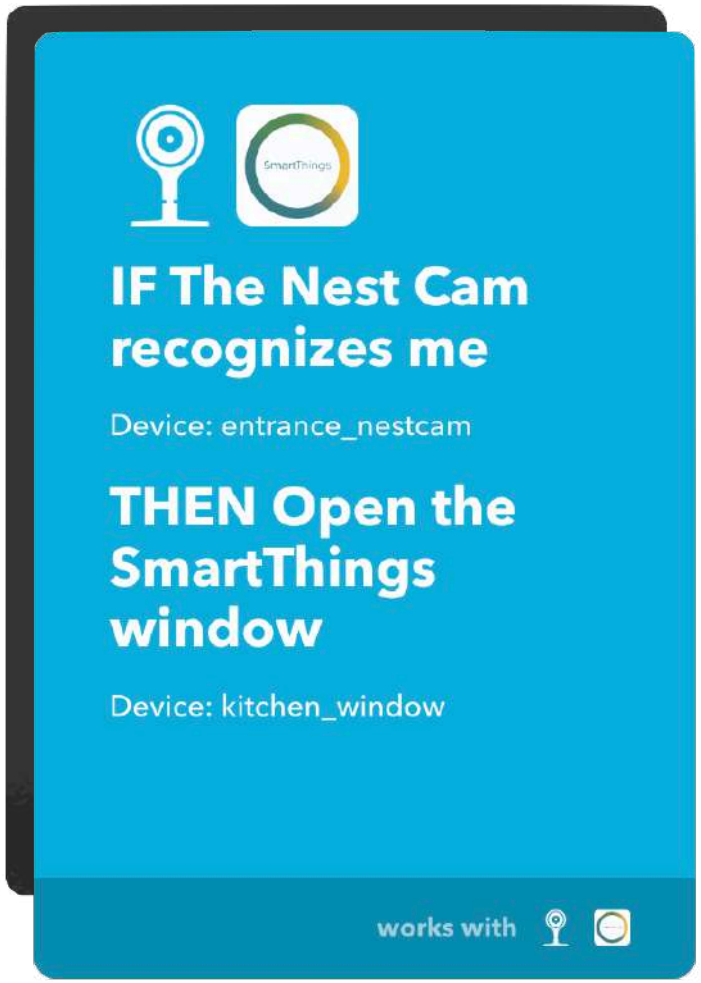


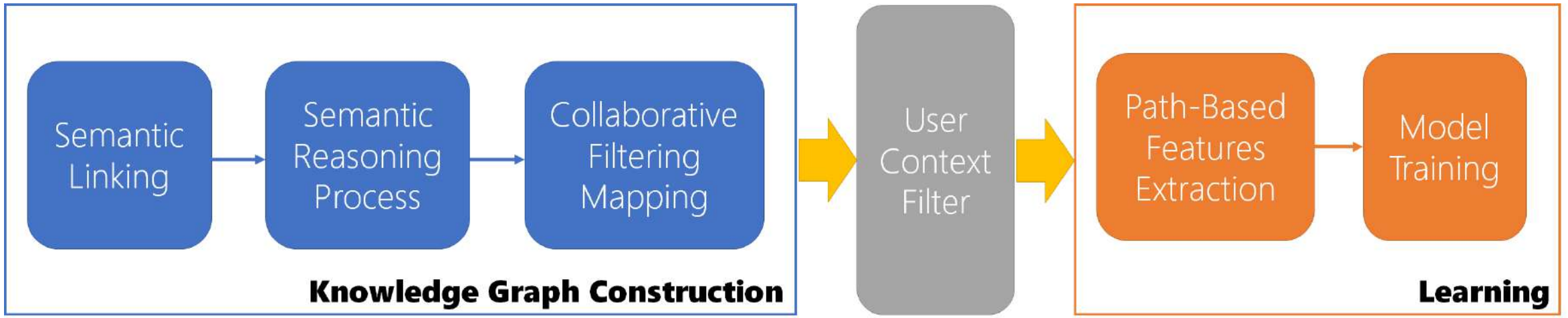
RecRules

PERSONALIZING THE TEMPERATURE WHEN I'M GOING TO USE AN INDOOR PLACE





RecRules


Semantic Linking
Semantic Reasoning Process
Collaborative Filtering Mapping
Knowledge Graph Construction
User Context Filter
Path-Based Features Extraction
Model Training
Learning

RecRules

KNOWLEDGE GRAPH

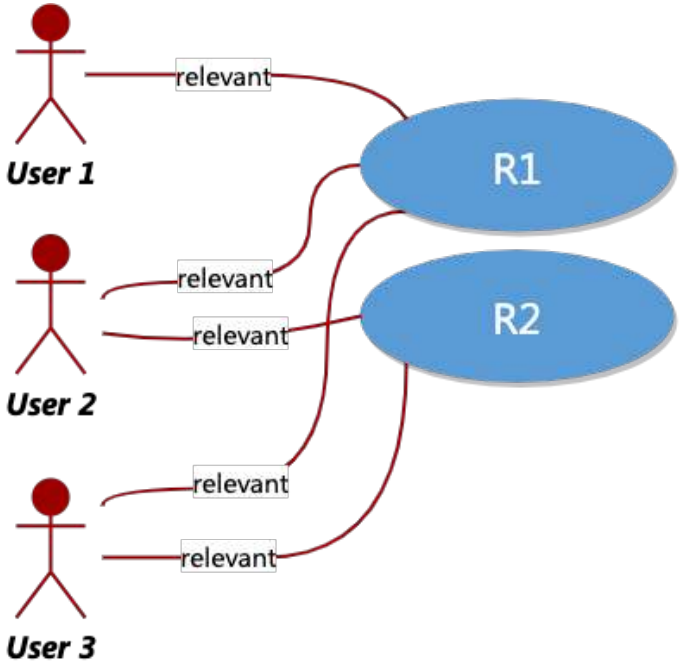
R1 **IF** the kitchen Nest Cam recognizes me
THEN turn on the kitchen Philips Hue lamp

IF the living room Homeboy Cam detects a movement
THEN open the Hunter Douglas blinds **R2**

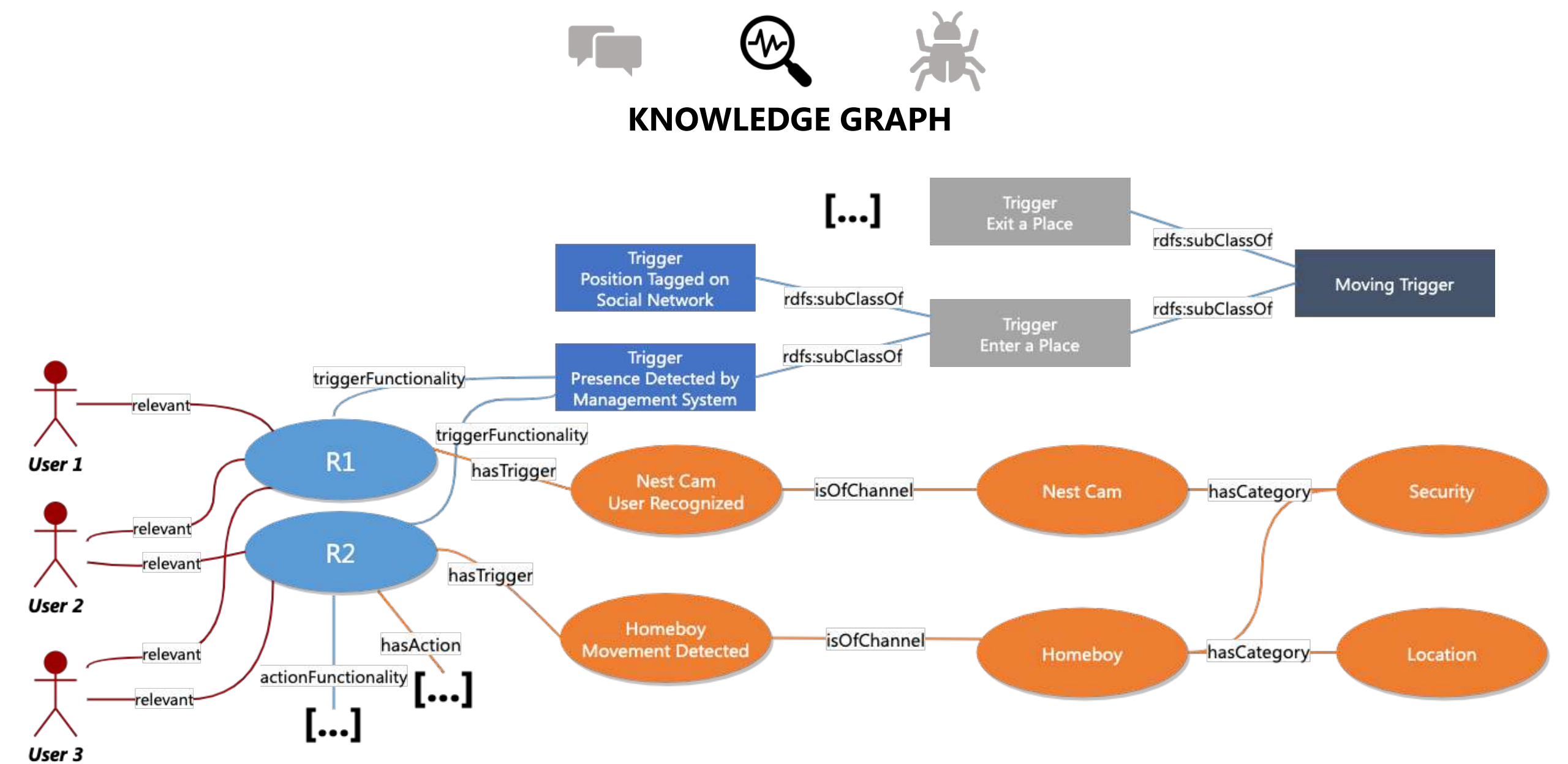
RecRules



KNOWLEDGE GRAPH



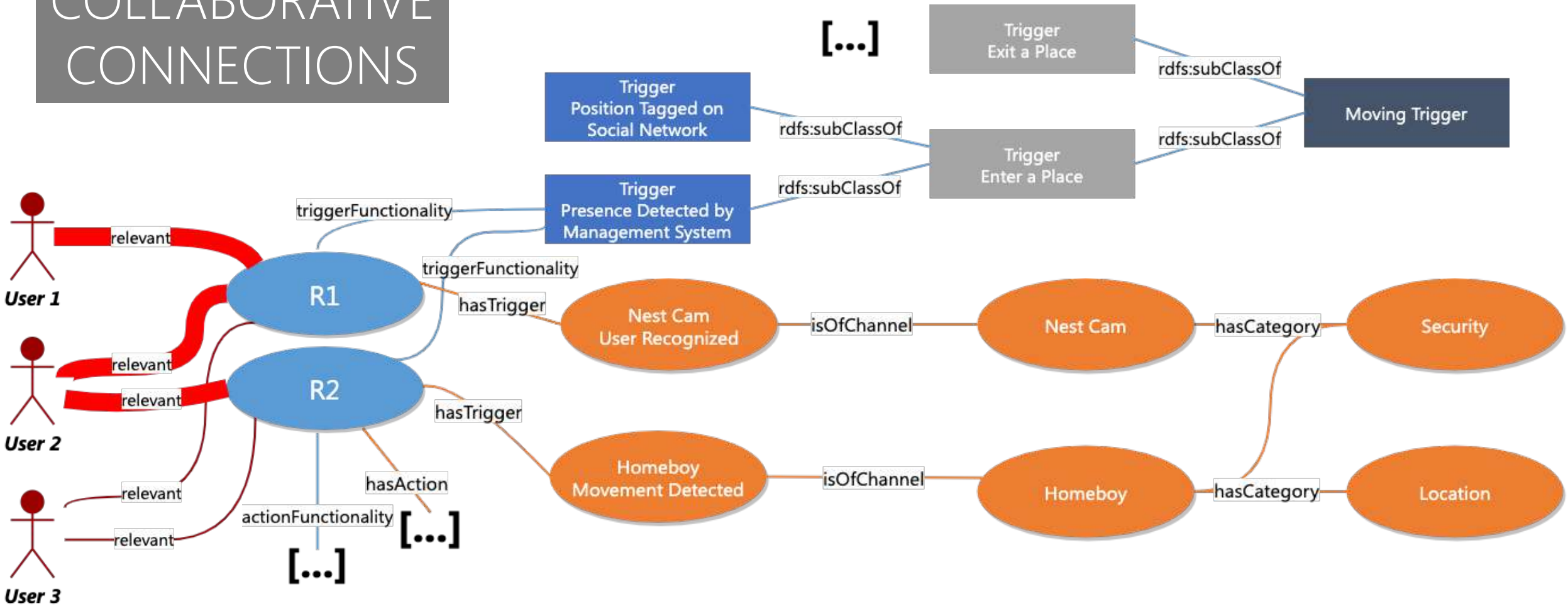
RecRules


KNOWLEDGE GRAPH
[...]
Trigger
Exit a Place
rdfs:subClassOf
Trigger
Position Tagged on
Social Network
rdfs:subClassOf
Moving Trigger
rdfs:subClassOf
Trigger
Enter a Place
rdfs:subClassOf
Trigger
Presence Detected by
Management System
triggerFunctionality
triggerFunctionality
relevant
User 1
R1
hasTrigger
Nest Cam
User Recognized
isOfChannel
Nest Cam
hasCategory
Security
relevant
relevant
User 2
R2
hasTrigger
relevant
relevant
User 3
hasAction
actionFunctionality
[...]
[...]
Homeboy
Movement Detected
isOfChannel
Homeboy
hasCategory
Location

RecRules

COLLABORATIVE CONNECTIONS

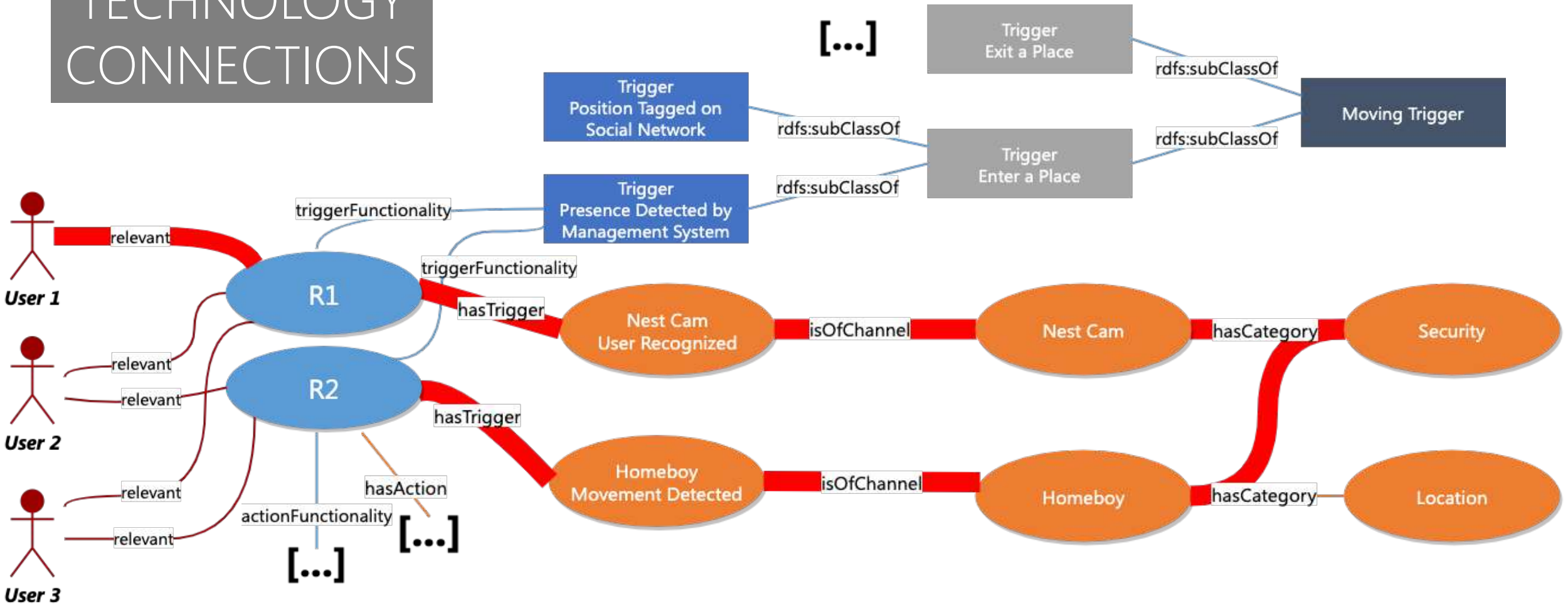
FEATURES EXTRACTION



RecRules

FEATURES EXTRACTION

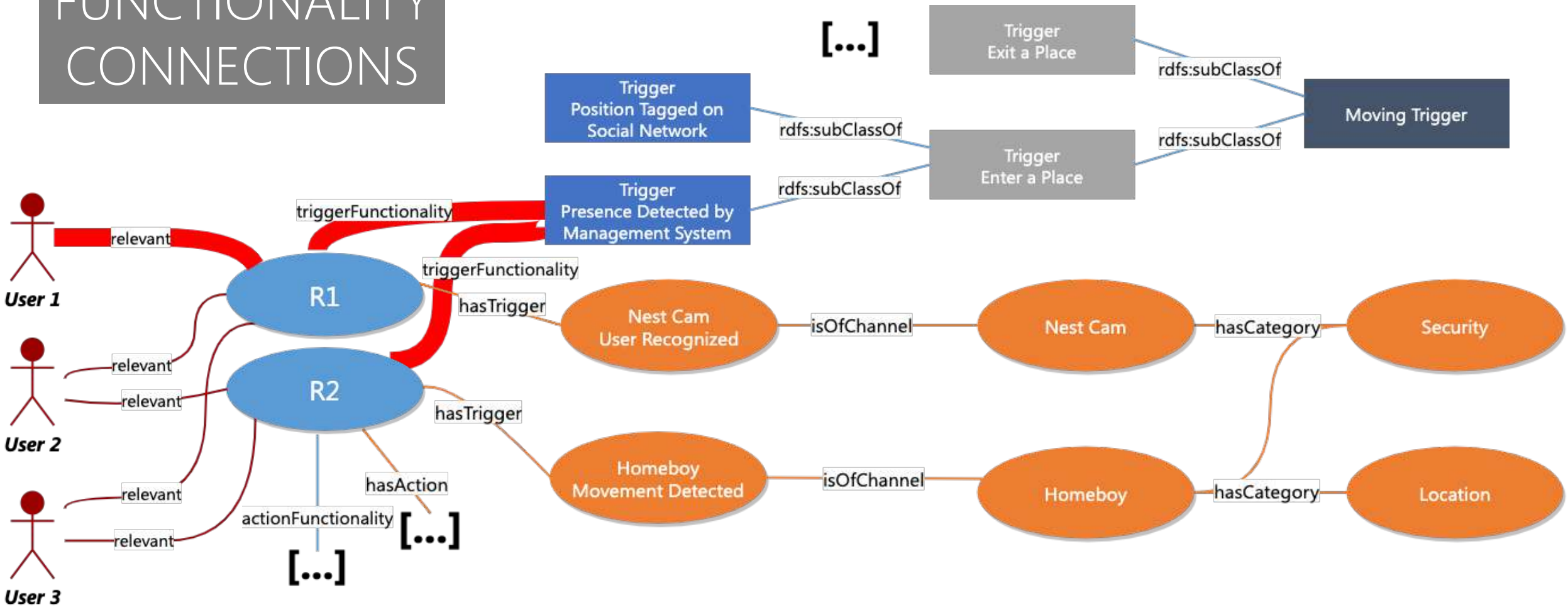
TECHNOLOGY CONNECTIONS



RecRules

FEATURES EXTRACTION

FUNCTIONALITY CONNECTIONS



RecRules



MODEL TRAINING

POINTWISE

Pointwise approaches look at a single instance at a time, and transform the ranking problem into a regression or a classification one

RANDOM FOREST

Breiman et al.

PAIRWISE

Pairwise approaches look at a pair of instances at a time and try to find out their optimal ordering.

RANKBOOST

Freund et al.

LISTWISE

Listwise approaches directly look at the entire list of instances, and they try to produce the optimal ordering by minimizing a loss function.

LAMBDAMART

Wu *et al.*



EVALUATION

To what extent the the **different** types of path-based **features** influence the recommendation **accuracy**?

Does RecRules **outperform** state-of-the-art **recommendation systems** in suggesting IF-THEN rules?



FEATURES

Algorithm		prec@5	rec@5	nDCG@5	prec@10	rec@10	nDCG@10
Random Forest	*CT*	0.1077	0.2090	0.4920	0.0772	0.2901	0.5830
	CTF	**0.1211**	**0.2177**	**0.5054**	**0.0813**	**0.3019**	**0.6452**
Rank Boost	*CT*	0.0743	0.1309	0.4558	0.0570	0.1998	0.5515
	CTF	**0.0967**	**0.1894**	**0.4861**	**0.0660**	**0.2536**	**0.5753**
Lambda Mart	*CT*	0.0900	0.1918	0.4884	0.0633	0.2589	**0.5756**
	CTF	**0.1115**	**0.2123**	**0.4893**	**0.0858**	**0.2941**	0.5754

CT configuration: *C*ollaborative and *T*echnology features

CTF configuration: *C*ollaborative, *T*echnology, and *F*unctionality features

IFTTT **dataset**
Ur et al. 2016



COMPARISON

	prec@5	rec@5	nDCG@5	prec@10	rec@10	nDCG@10
RecRules	**0.1211**	**0.2177**	**0.5054**	**0.0813**	**0.3019**	**0.6452**
Item-KNN	0.0847	0.1807	0.1939	0.0514	0.2383	0.2095
User-KNN	0.0961	0.2103	0.2410	0.0520	0.2277	0.2419
SMR MF	0.0760	0.1716	0.1942	0.0452	0.2019	0.1905
BPR-MF	0.1085	0.1898	0.2082	0.0664	0.2148	0.2131
BPR-SLIM	0.1110	0.1976	0.2224	0.0616	0.2200	0.2216
WRMF	0.1155	0.2045	0.2228	0.0618	0.2217	0.2223
LS SLIM	0.1105	0.1970	0.2196	0.0604	0.2158	0.2229
IA KNN	0.0273	0.0845	0.2398	0.0207	0.1302	0.2357
BPR-Linear	0.0504	0.1708	0.2957	0.0356	0.2383	0.2890
EGE	0.0975	0.1918	0.4728	0.0656	0.2467	0.5625

We compared RecRules with state-of-the-art recommendation algorithms



COMPARISON

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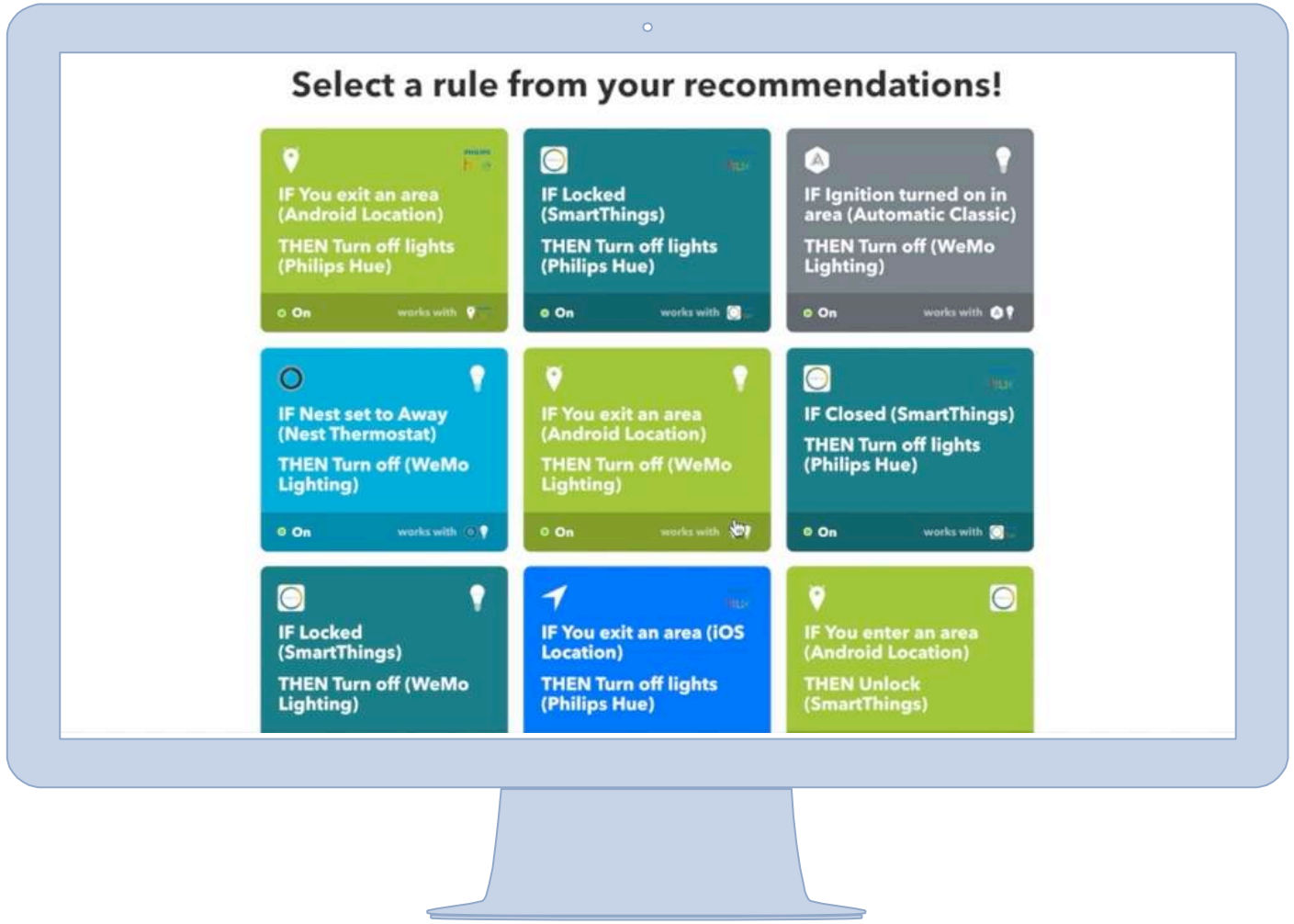

Fulvio Corno, Luigi De Russis,
Alberto Monge Roffarello

TAPrec: Supporting the Composition of Trigger-Action Rules Through Dynamic Recommendations

IUI '20

RecRules

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PROBLEMS

Loops

Redundancies

Inconsistencies

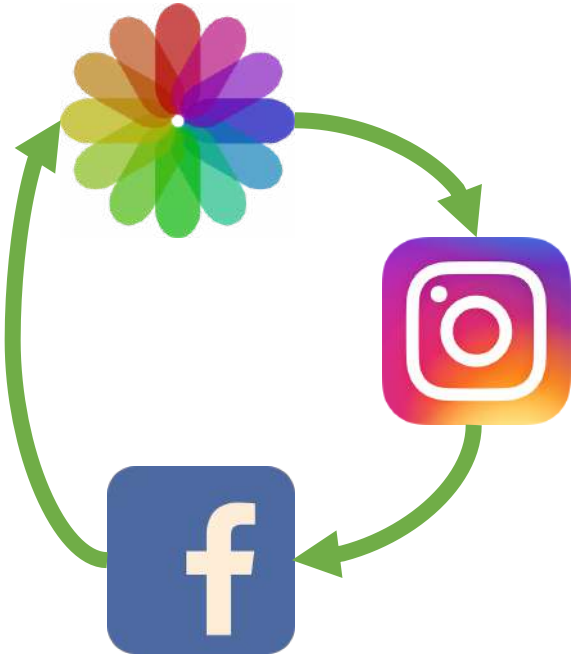


LOOPS

IF I post a photo on Facebook
THEN save it on my iOS library

IF I add a new photo on my iOS
THEN post it on Instagram

IF I post a photo on Instagram
THEN post it on Facebook



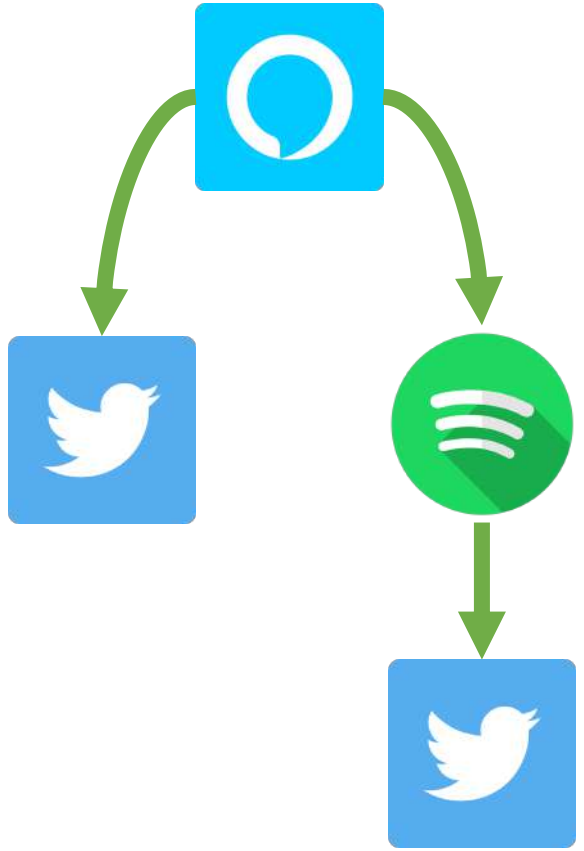


REDUNDANCIES

IF I play a new song on my Alexa
THEN post a tweet on Twitter

IF I play a new song on my Alexa
THEN save the track on Spotify

IF I save a track on Spotify
THEN post a tweet on Twitter



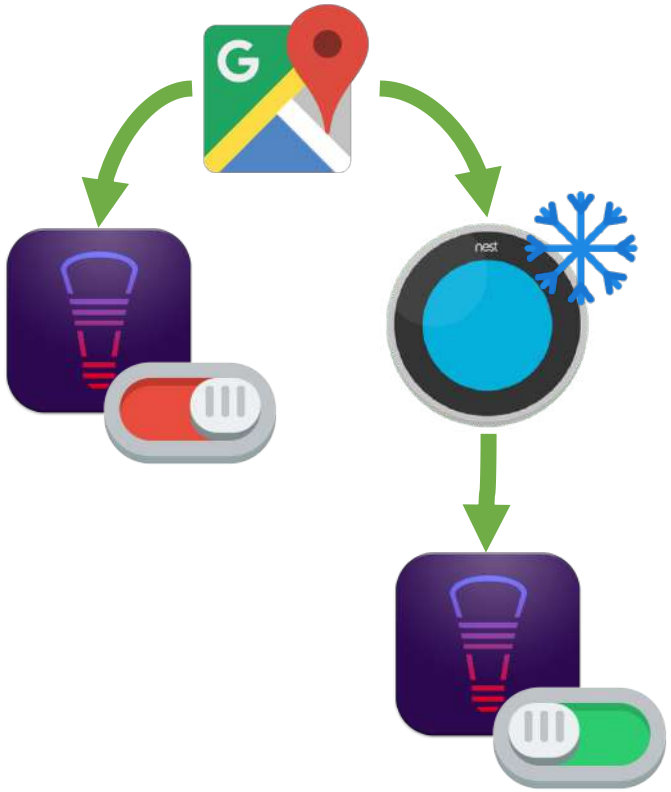


INCONSISTENCIES

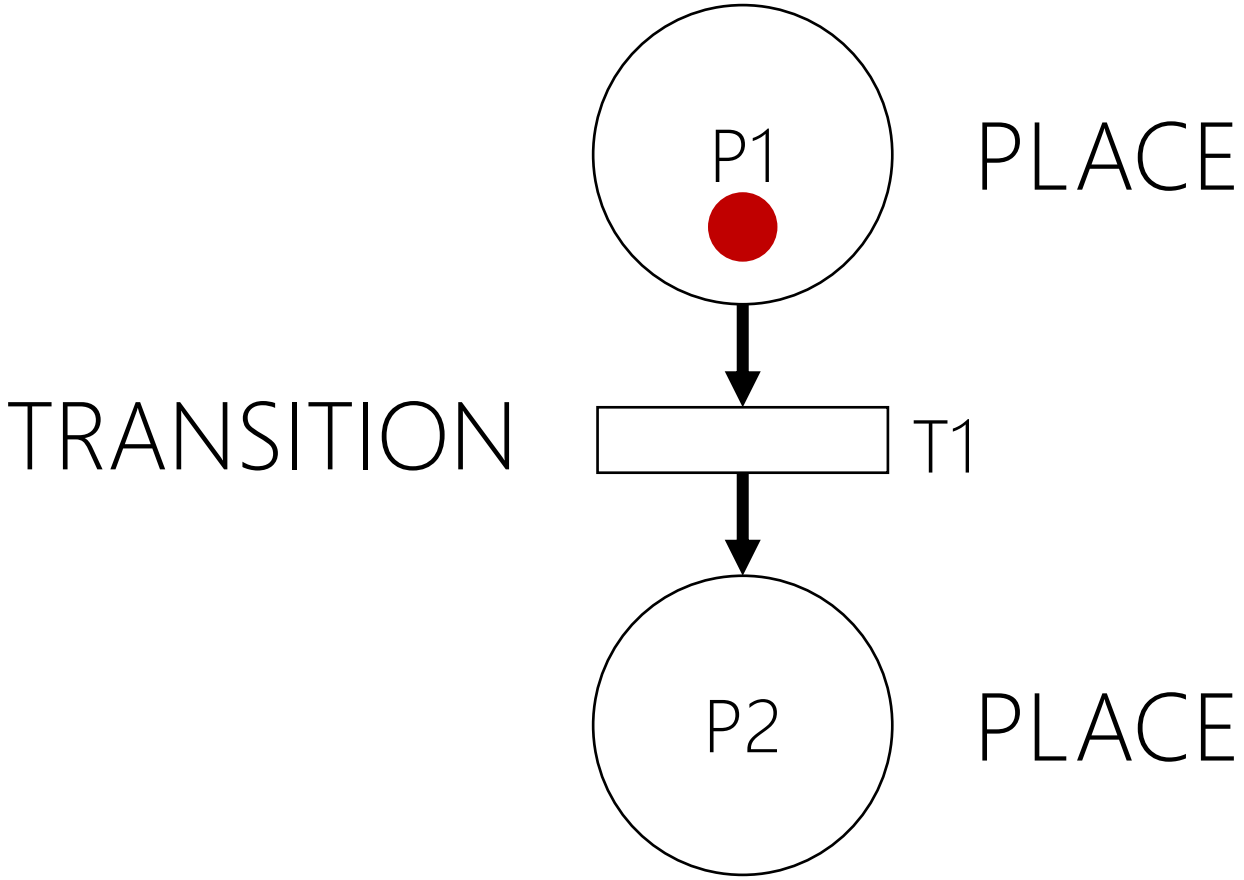
IF I exit home
THEN turn off the Philips Hue lamp

IF I exit home
THEN set the Nest to Away mode

IF the Nest is set to Away Mode
THEN turn on the Philips Hue lamp



SCPN





SCPN

R1 **IF** I exit home (T1)
THEN turn off the kitchen Philips Hue lamp (A1)

IF I exit home (T2)
THEN set the Nest to Away mode (A2) **R2**

R3 **IF** the Nest is set to Away Mode (T3)
THEN turn on the kitchen Philips Hue lamp (A3)



SCPN

R1 **IF** I exit home (T1)
THEN turn off the kitchen Philips Hue lamp (A1)

IF I exit home (T2)
THEN set the Nest to Away mode (A2) **R2**

R3 **IF** the Nest is set to Away Mode (T3)
THEN turn on the kitchen Philips Hue lamp (A3) **UNDER DEFINITION**



PETRI NETS

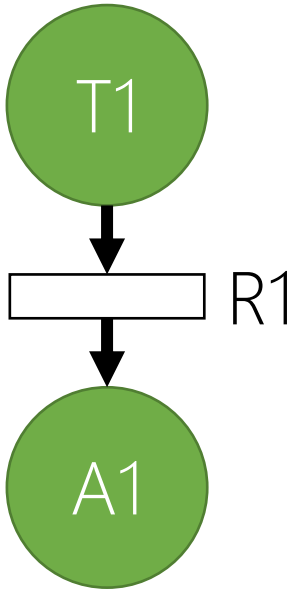
R1 **IF** I exit home (T1)
THEN turn off the kitchen Philips Hue lamp (A1)

IF I exit home (T2)
THEN set the Nest to Away mode (A2) **R2**

R3 **IF** the Nest is set to Away Mode (T3)
THEN turn on the kitchen Philips Hue lamp (A3)



PETRI NETS



T1 = I exit home
A1 = turn off the kitchen Hue lamp



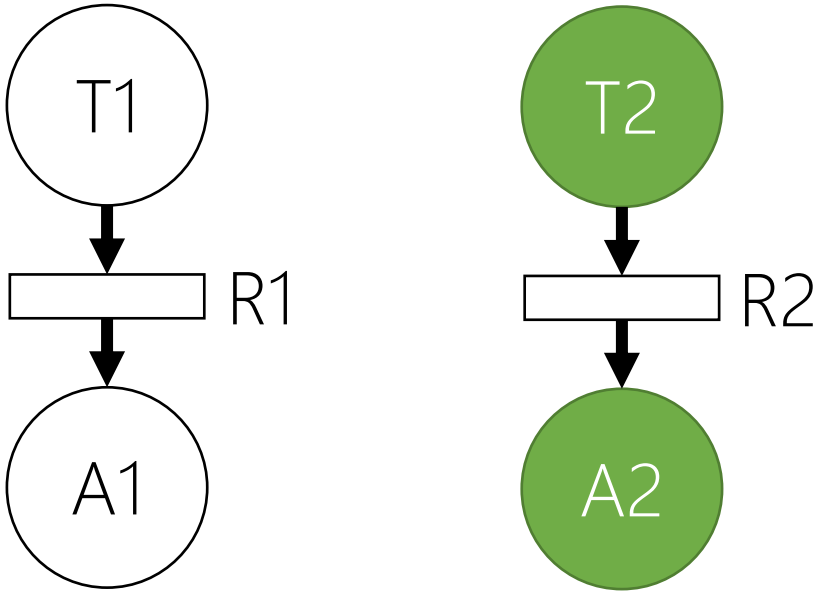
PETRI NETS

R1 **IF** I exit home (T1)
THEN turn off the kitchen Philips Hue lamp (A1)

IF I exit home (T2)
THEN set the Nest to Away mode (A2) **R2**

R3 **IF** the Nest is set to Away Mode (T3)
THEN turn on the kitchen Philips Hue lamp (A3)

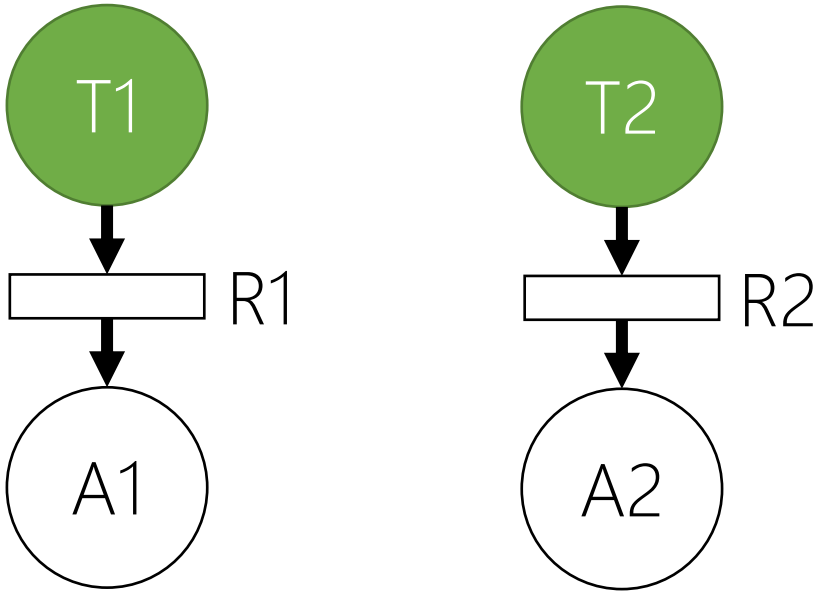
PETRI NETS



T2 = I exit home
A2 = set the Nest to Away mode

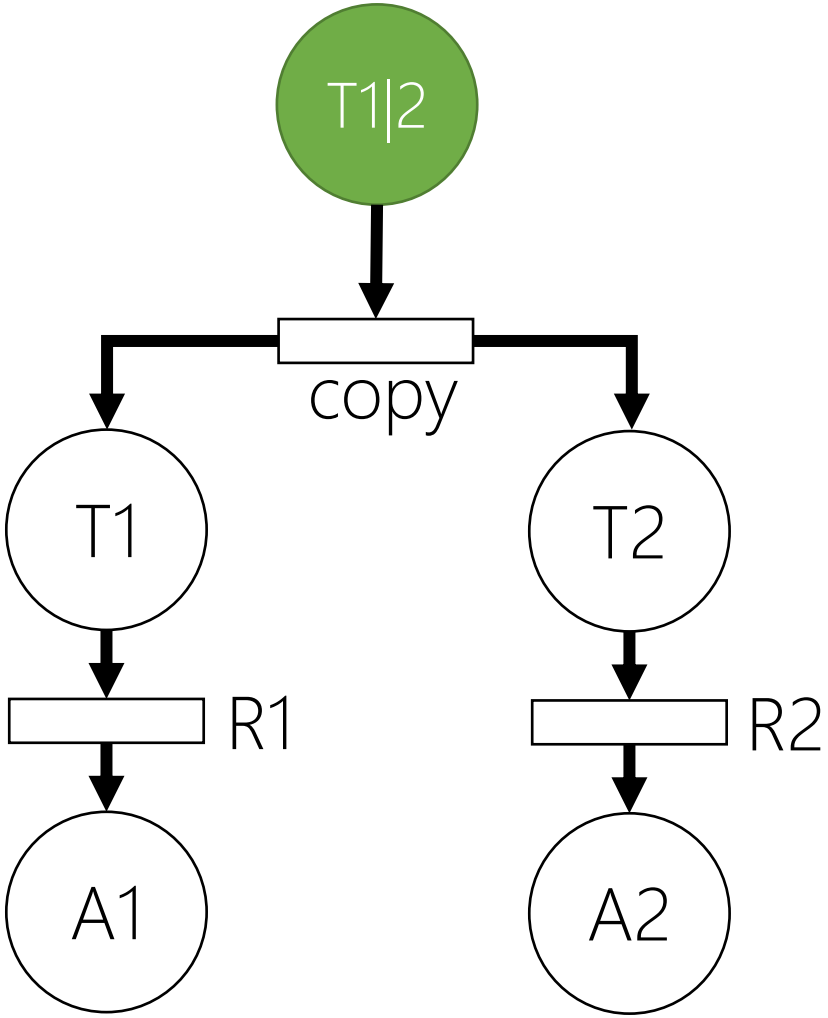


PETRI NETS



T1 = I exit home
T2 = I exit home

PETRI NETS



T1|2 = I exit home



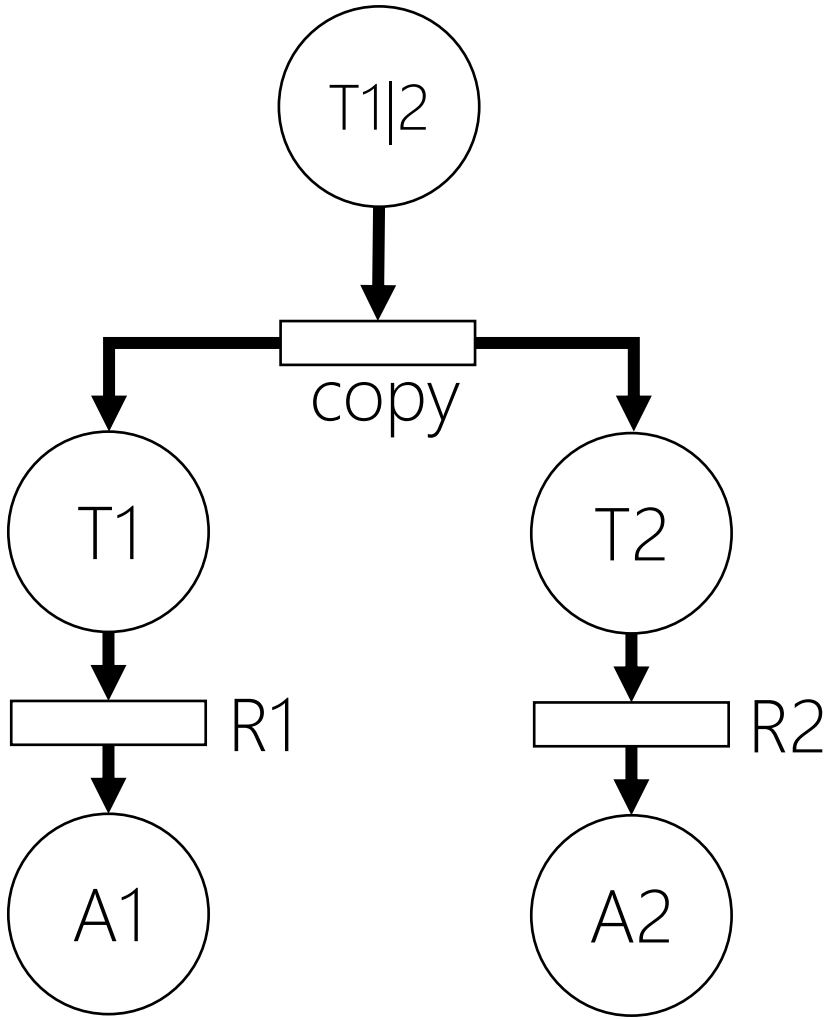
PETRI NETS

R1 **IF** I exit home (T1)
THEN turn off the kitchen Philips Hue lamp (A1)

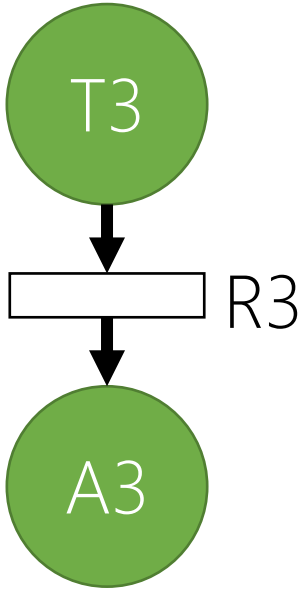
IF I exit home (T2)
THEN set the Nest to Away mode (A2) **R2**

R3 **IF** the Nest is set to Away Mode (T3)
THEN turn on the kitchen Philips Hue lamp (A3)

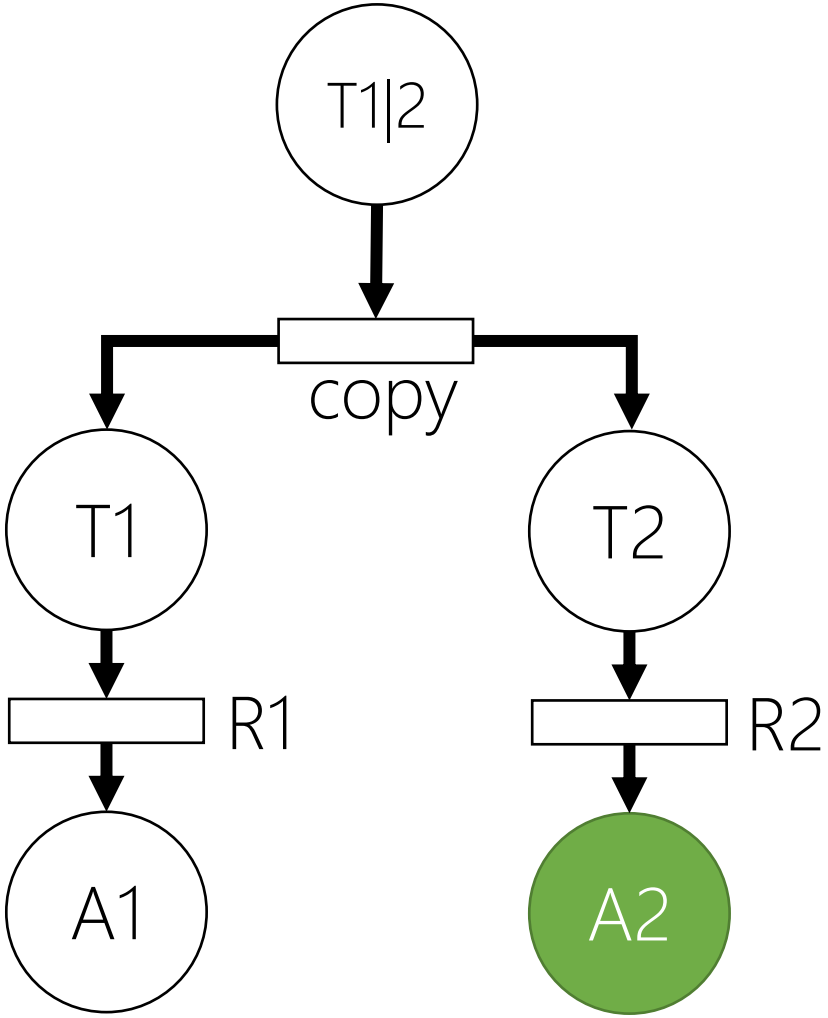
PETRI NETS



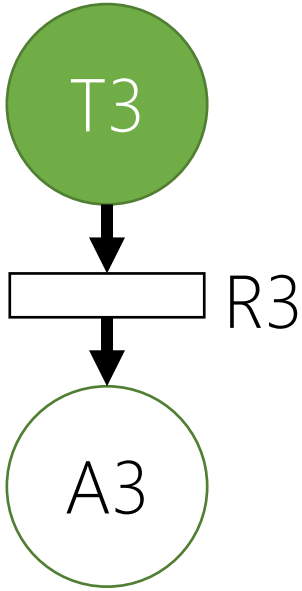
T3 = the Nest is set to Away mode
A3 = turn on the kitchen Hue lamp



PETRI NETS

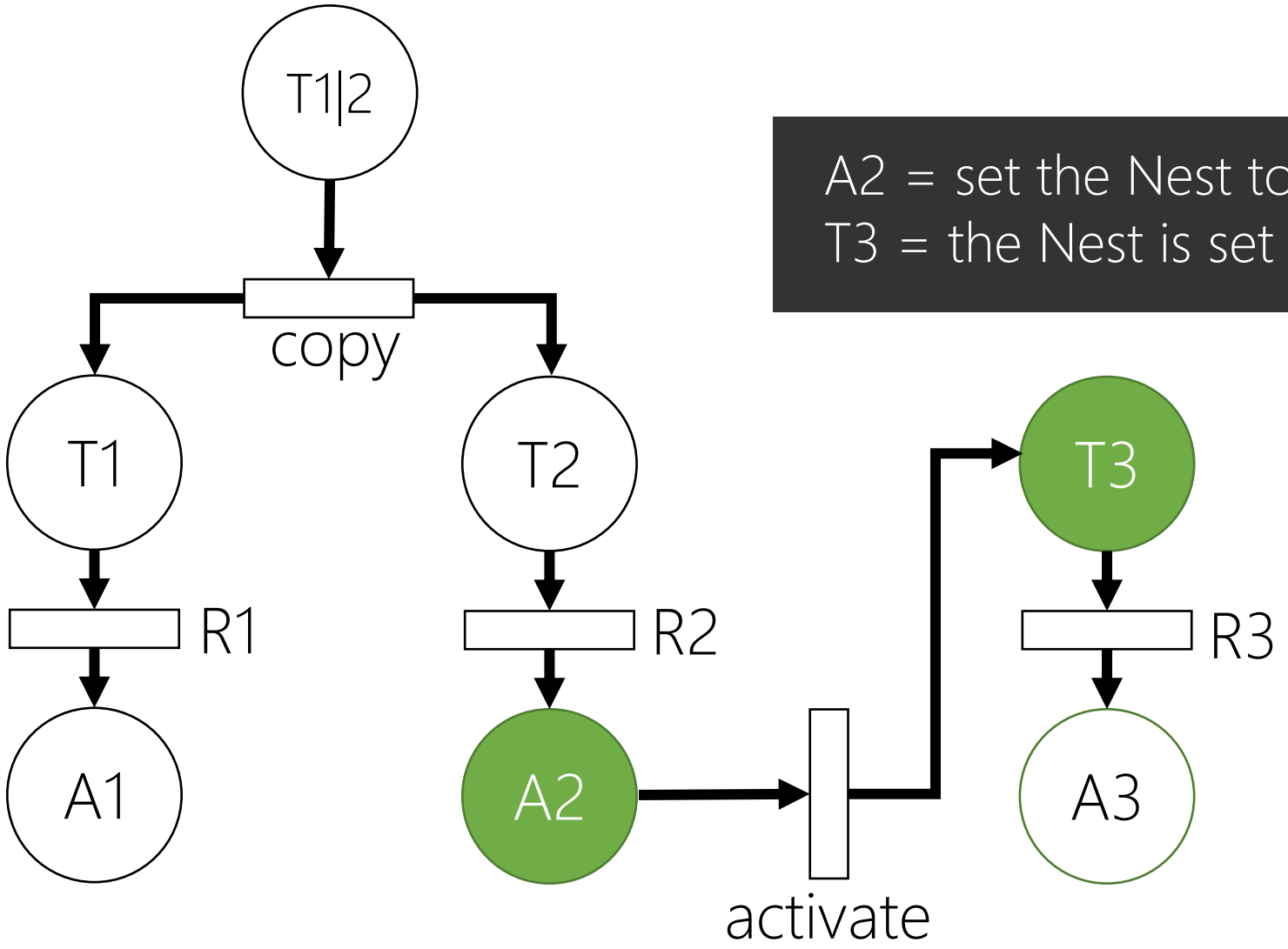


A2 = set the Nest to Away
T3 = the Nest is set to Away

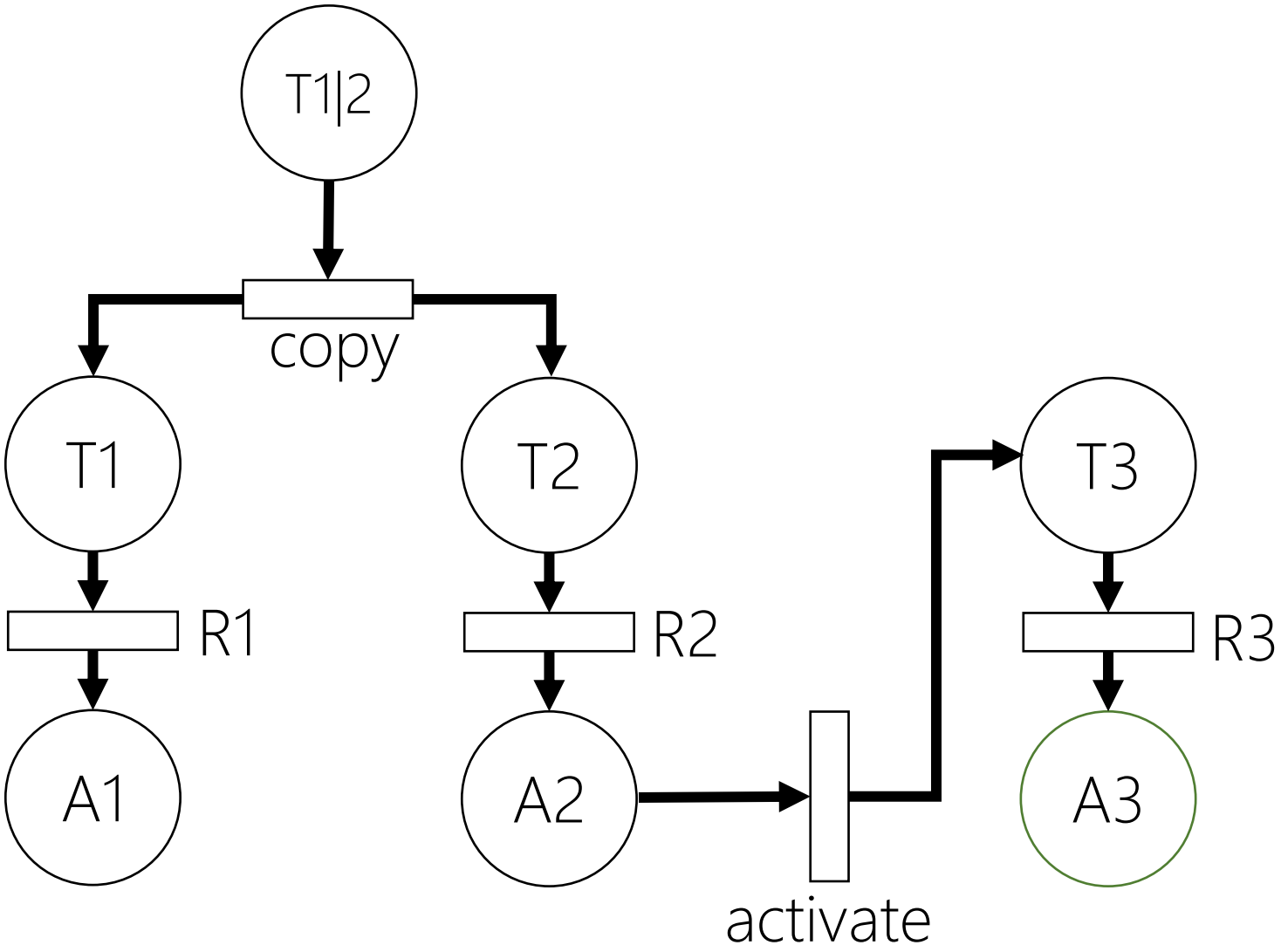


PETRI NETS

A2 = set the Nest to Away
T3 = the Nest is set to Away



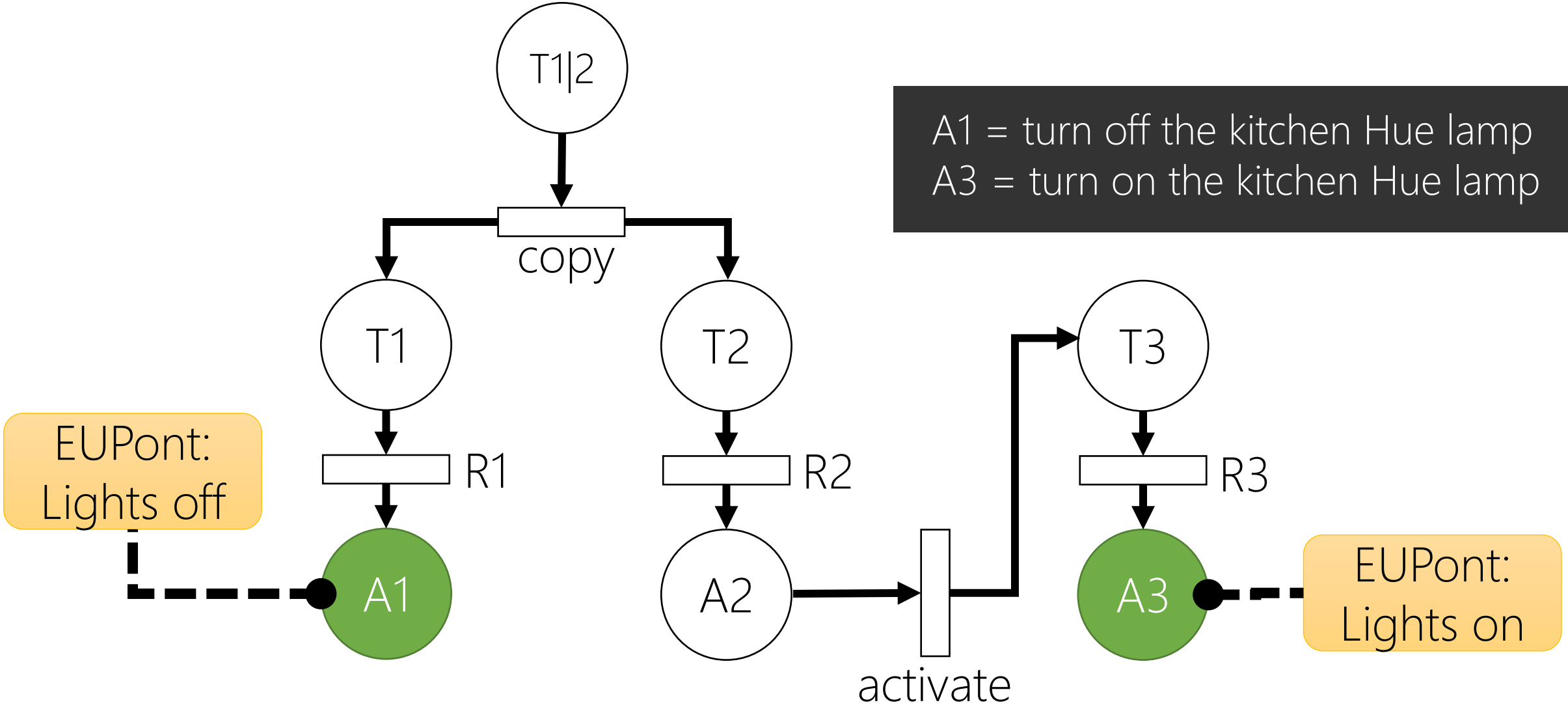
PETRI NETS





SEMANTIC

A1 = turn off the kitchen Hue lamp
A3 = turn on the kitchen Hue lamp

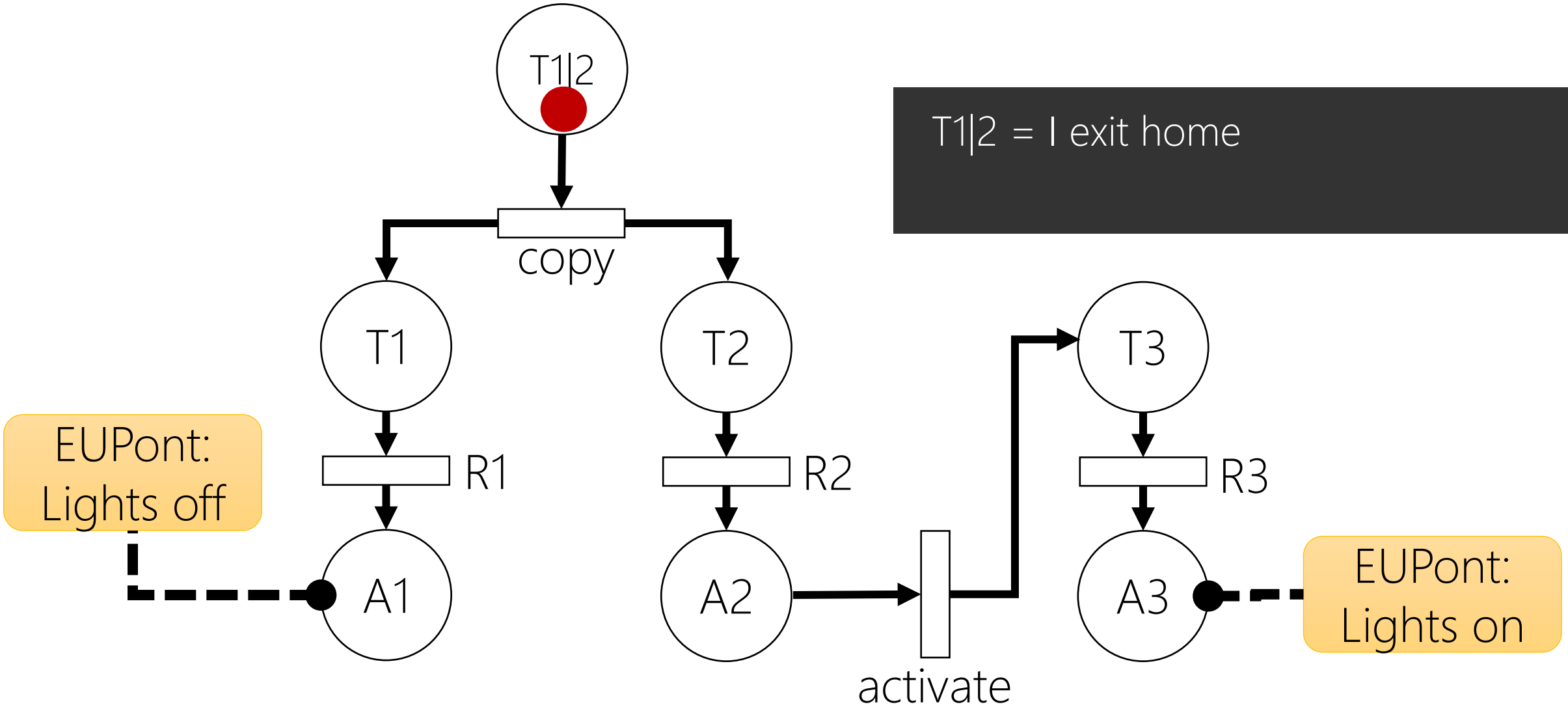


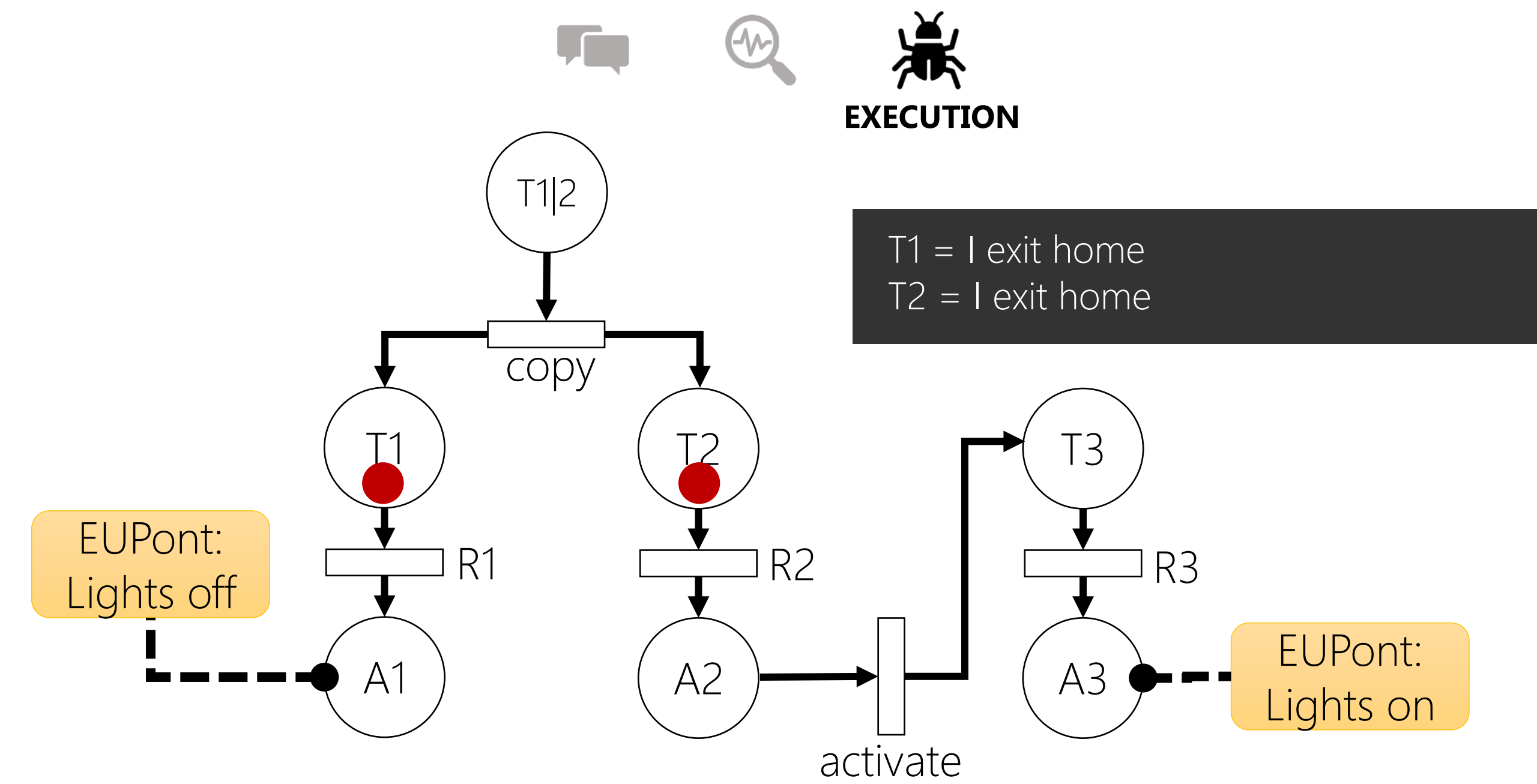
SCPN | EUDebug | My IoT Puzzle



EXECUTION

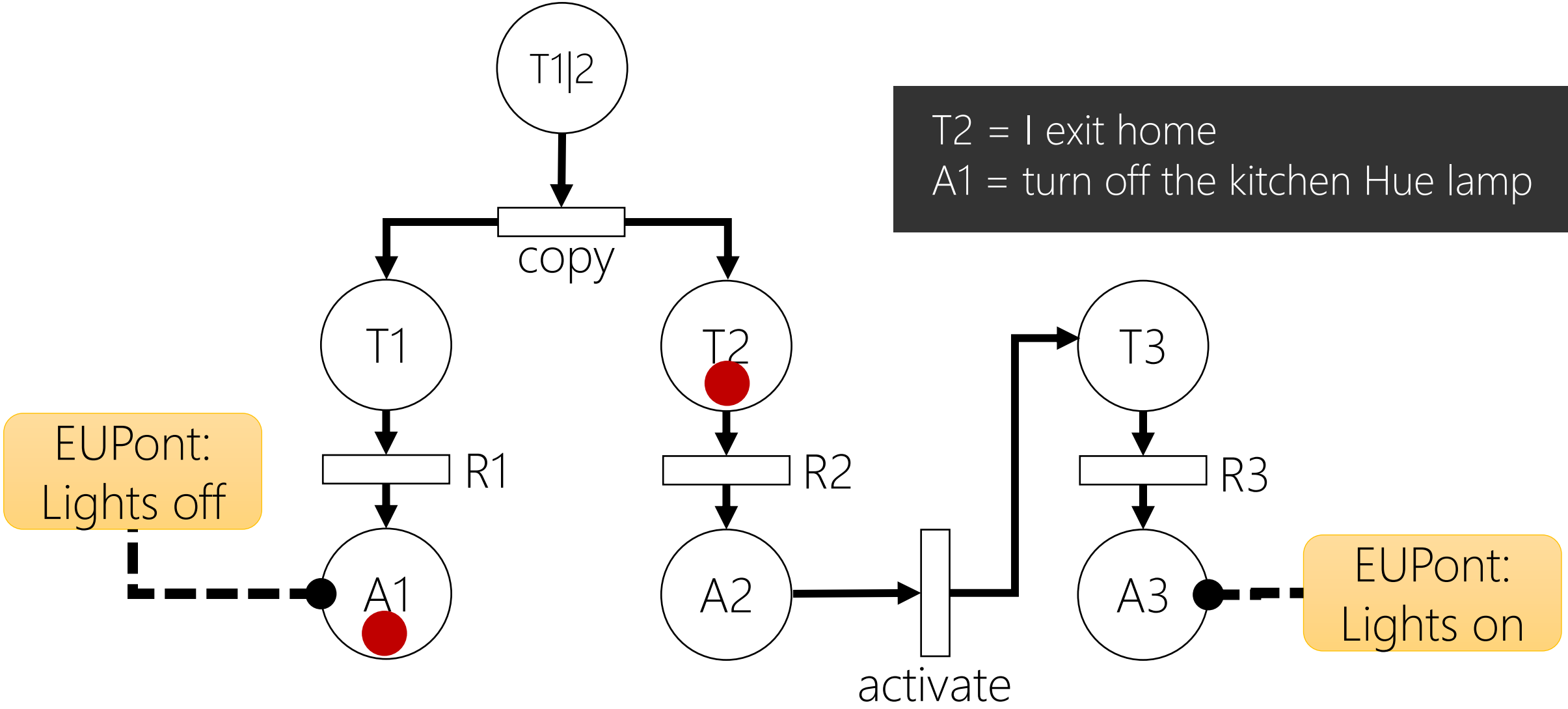
T1|2 = I exit home




EXECUTION
T1 = I exit home
T2 = I exit home
T1|2
copy
T1
T2
R1
R2
T3
R3
EUPont:
Lights off
A1
A2
activate
A3
EUPont:
Lights on

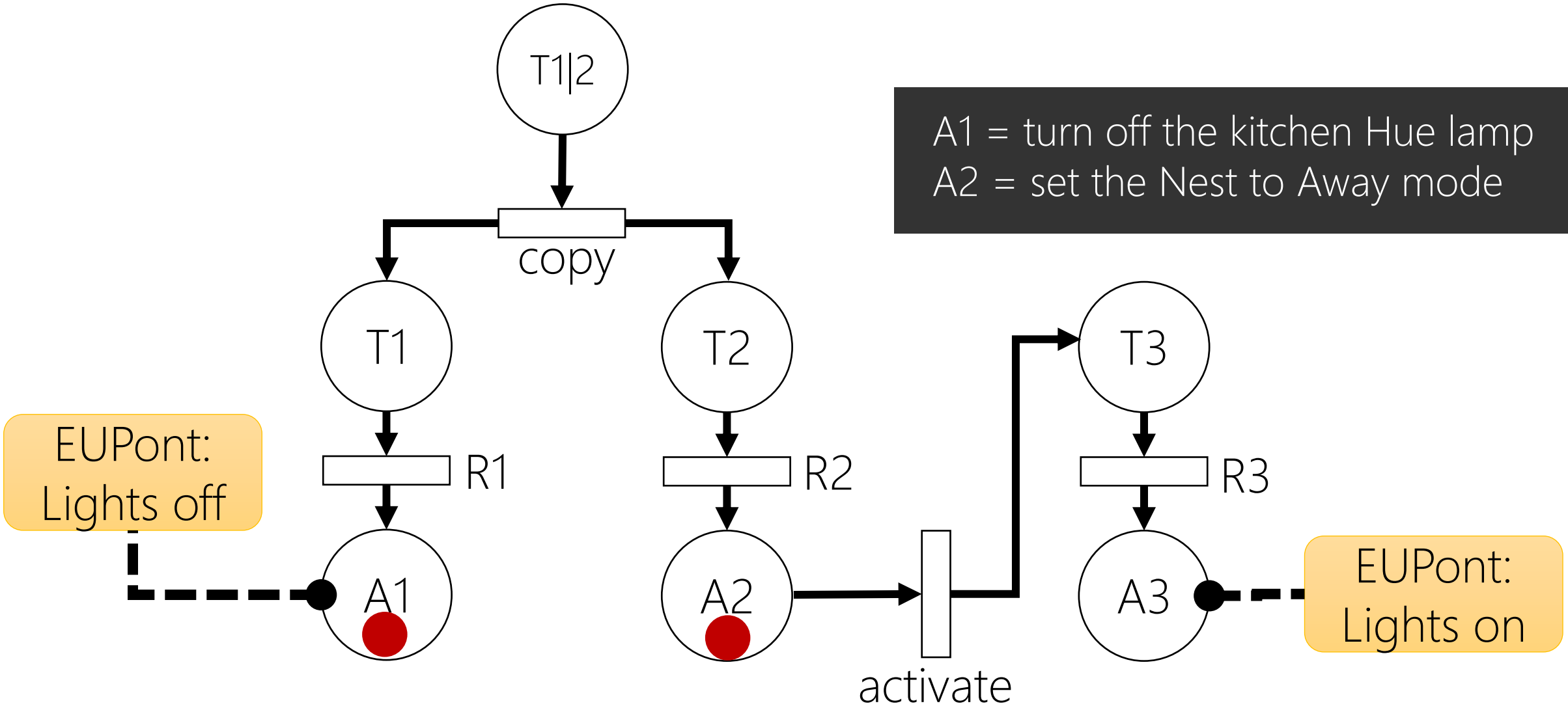
EXECUTION

T2 = I exit home
A1 = turn off the kitchen Hue lamp



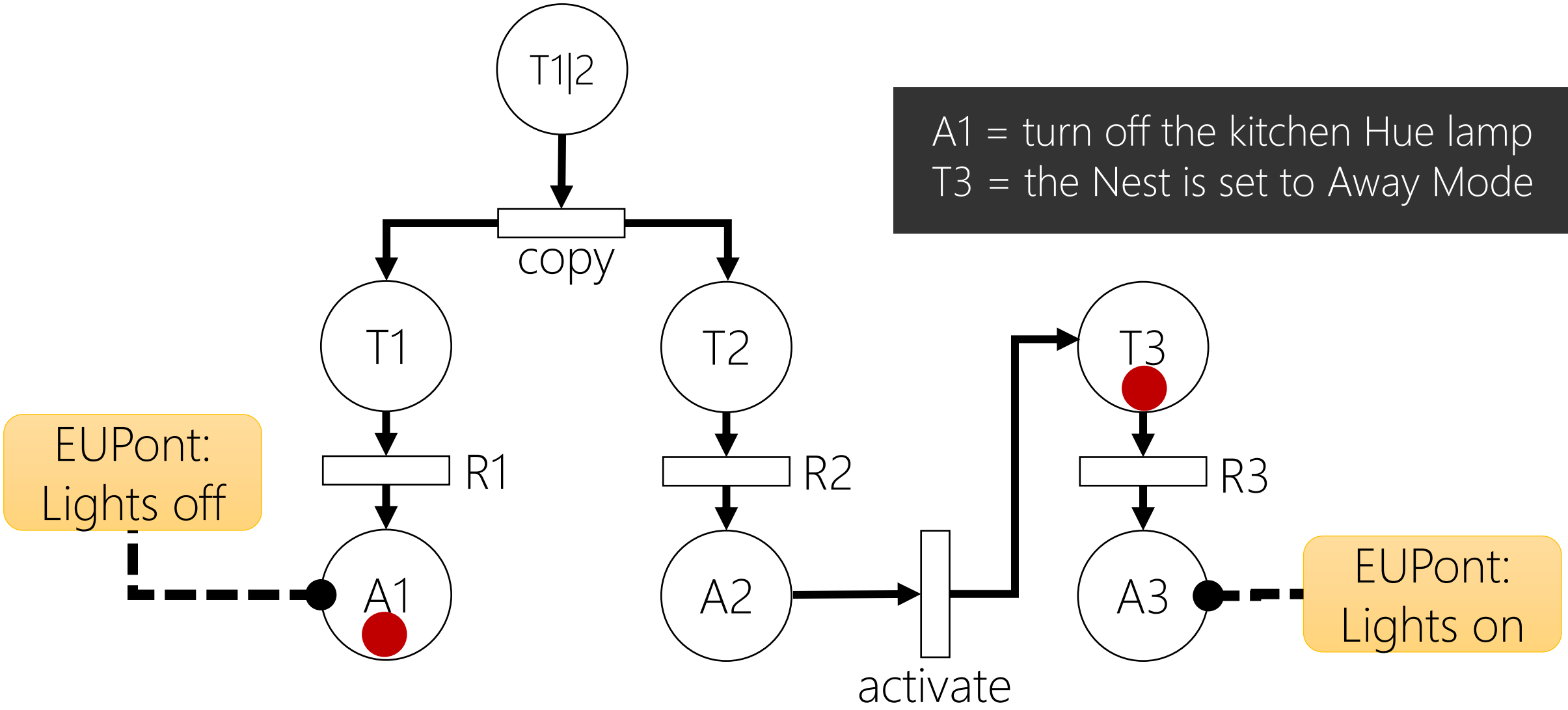
EXECUTION

A1 = turn off the kitchen Hue lamp
A2 = set the Nest to Away mode



EXECUTION

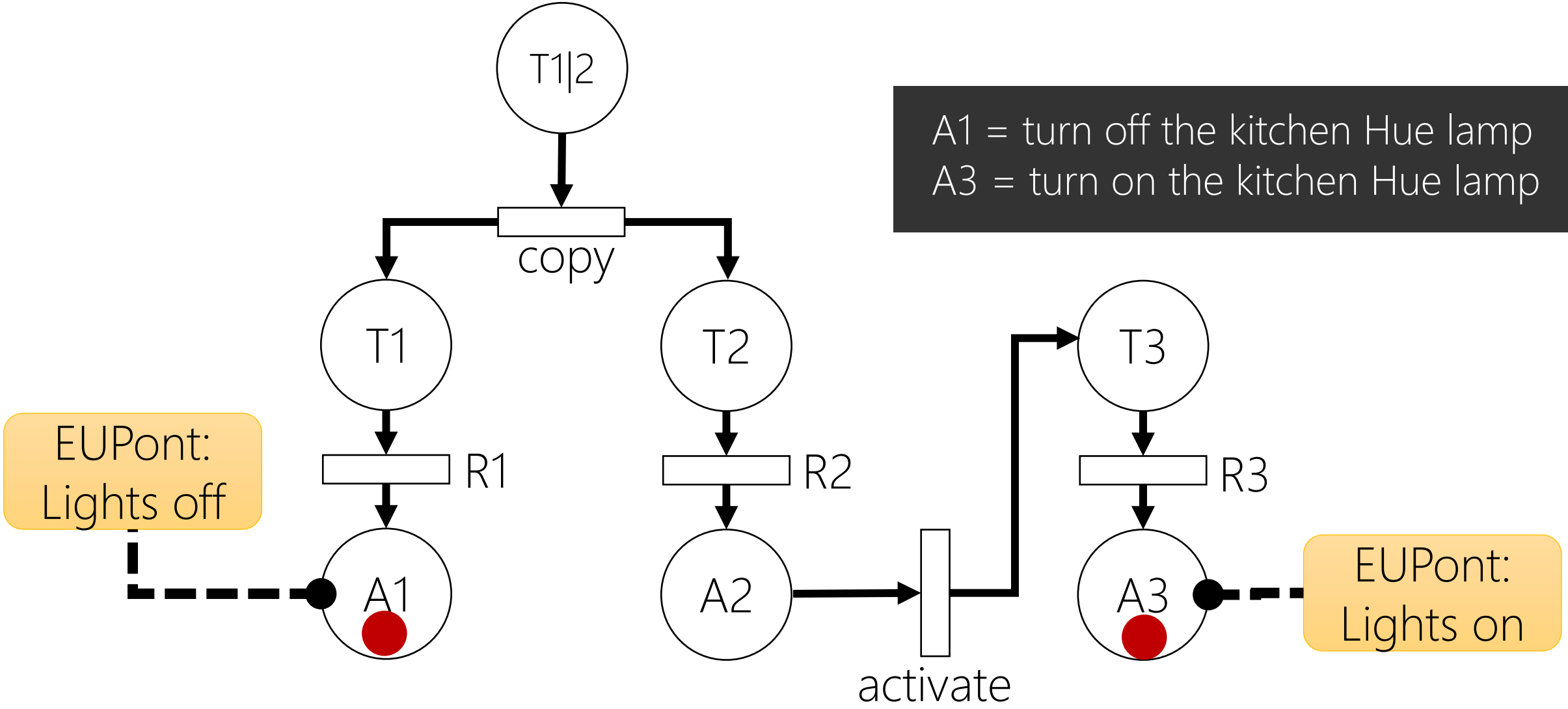
A1 = turn off the kitchen Hue lamp
T3 = the Nest is set to Away Mode





EXECUTION

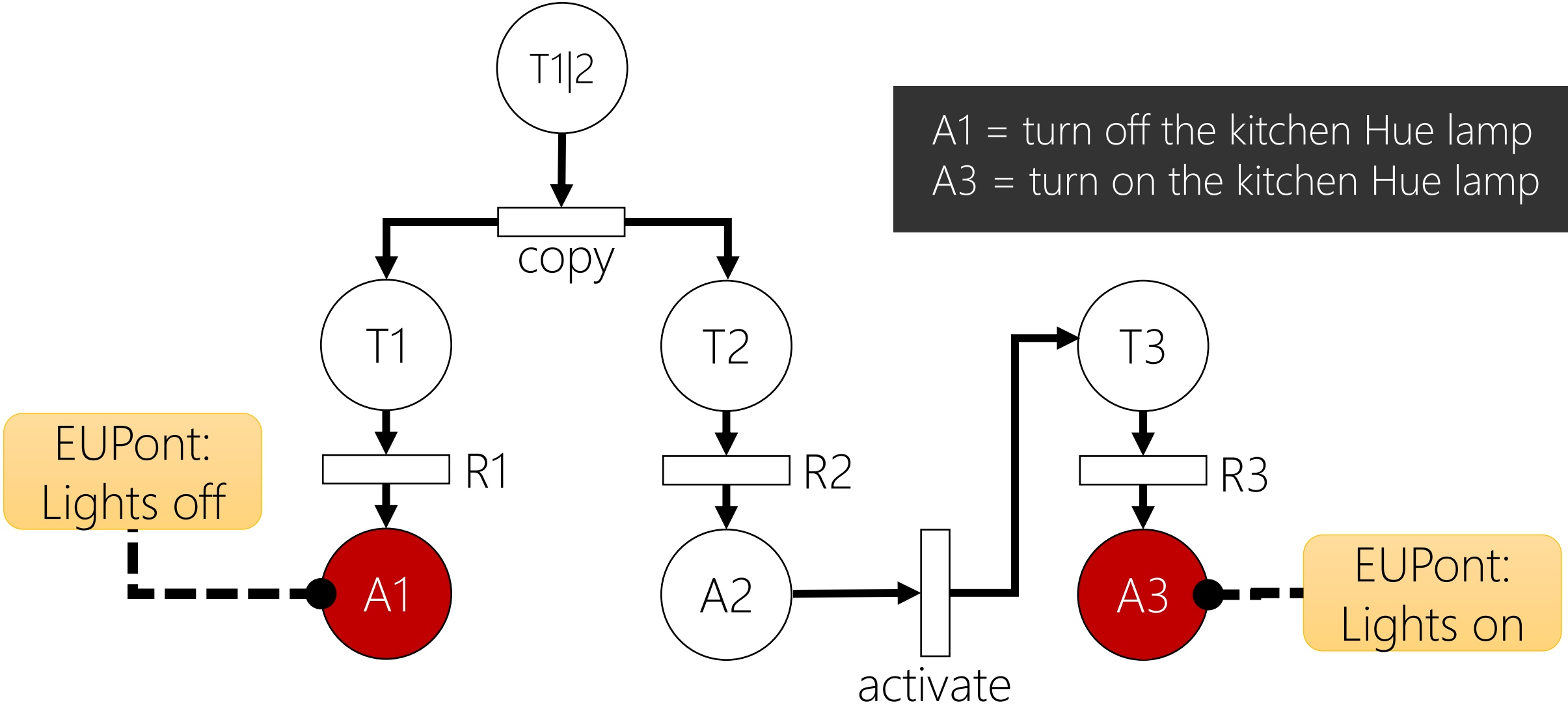
A1 = turn off the kitchen Hue lamp
A3 = turn on the kitchen Hue lamp

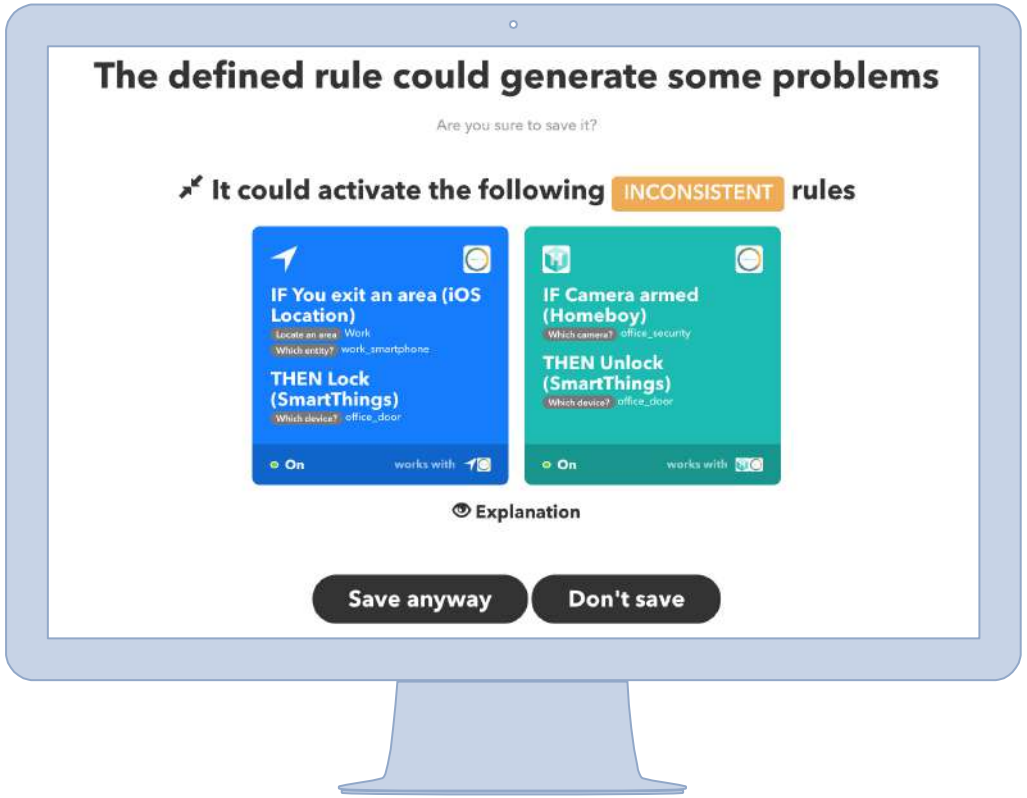




EXECUTION

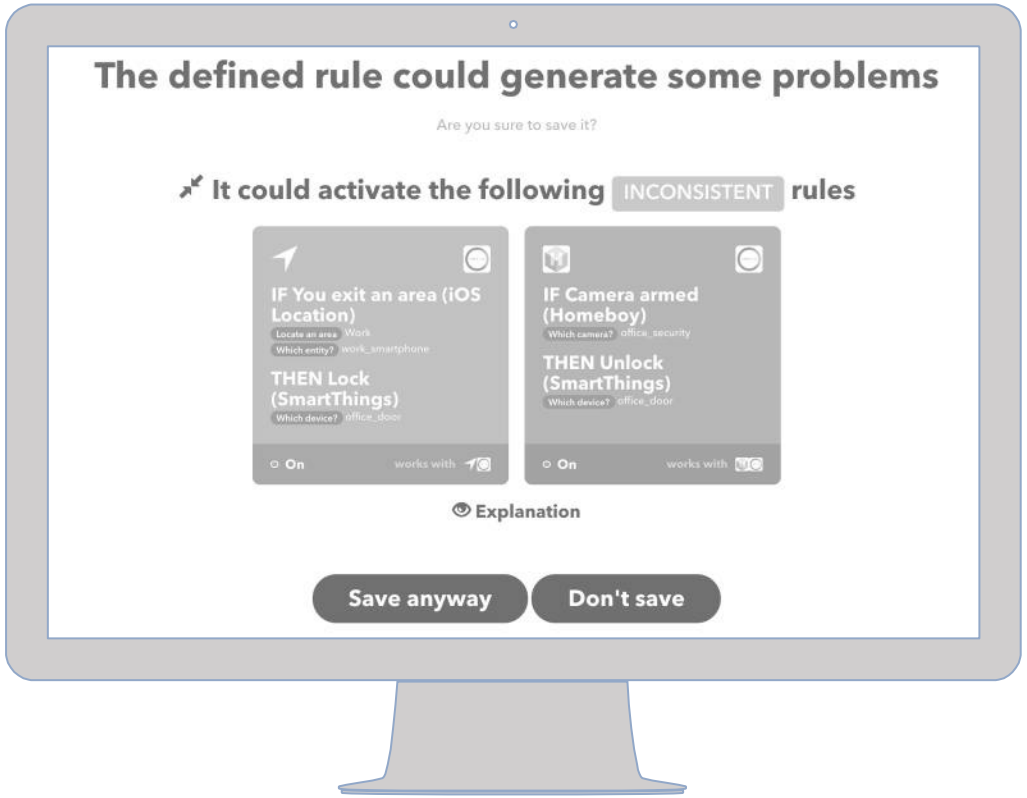
A1 = turn off the kitchen Hue lamp
A3 = turn on the kitchen Hue lamp





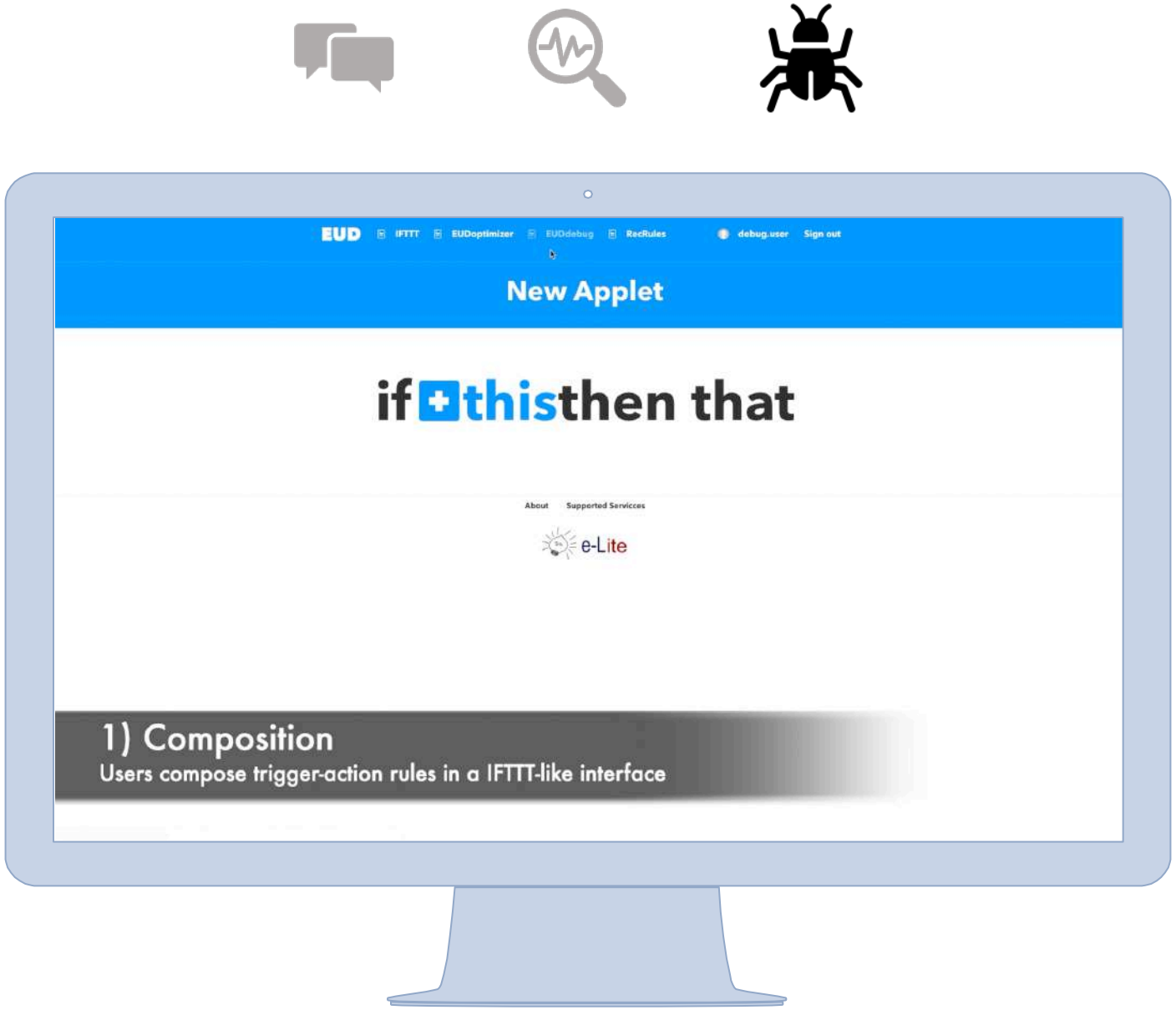
STRATEGY 1:
Highlighting
rule conflicts

STRATEGY 2:
Simulating
rule conflicts



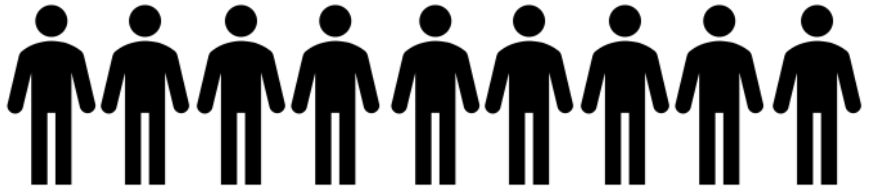
STRATEGY 1:
Highlighting
rule conflicts

STRATEGY 2:
Simulating
rule conflicts


EUD
IFTTT
EUDoptimizer
EUDdebug
RecRules
debug.user
Sign out
New Applet
if this then that
About
Supported Services
e-Lite
1) Composition
Users compose trigger-action rules in a IFTTT-like interface



USER STUDY



9 males

6 females

University students
20.34 mean **age**
No experience in computer science and programming



USER STUDY

Do end users **understand** problems and why the defined rules generate them?

Is **highlighting** the detected problems sufficient? Do users need a step-by-step **simulation** of the involved rules?



USER STUDY

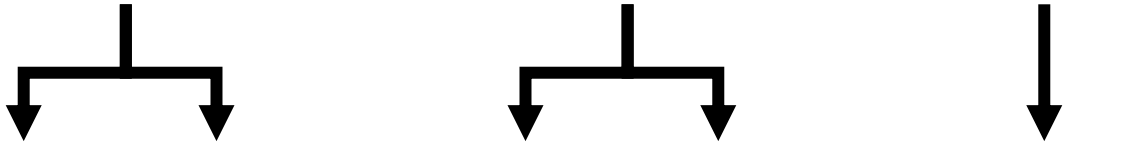
12 TRIGGER-ACTION RULES



USER STUDY

12 TRIGGER-ACTION RULES

2 Inconsistencies **2** Redundancies **1** Loop



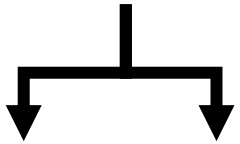
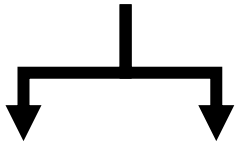
IC1 IC2 RD1 RD2 LP



USER STUDY

12 TRIGGER-ACTION RULES

2 Inconsistencies **2** Redundancies **1** Loop


IC1 IC2 RD1 RD2 LP

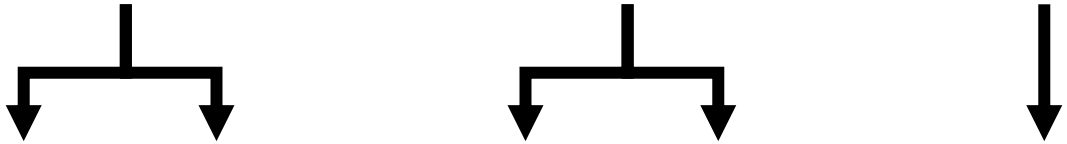
DIRECT PROBLEMS



USER STUDY

12 TRIGGER-ACTION RULES

2 Inconsistencies **2** Redundancies **1** Loop



IC1 IC2 RD1 RD2 LP

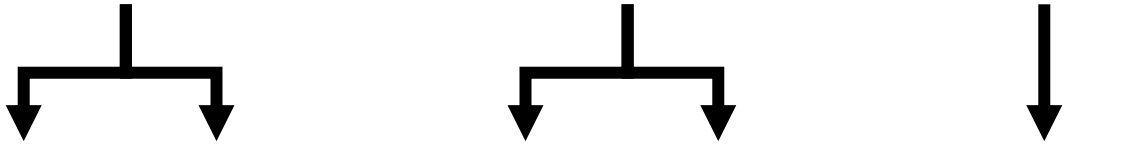
INDIRECT PROBLEMS



USER STUDY

12 TRIGGER-ACTION RULES

2 Inconsistencies **2** Redundancies **1** Loop



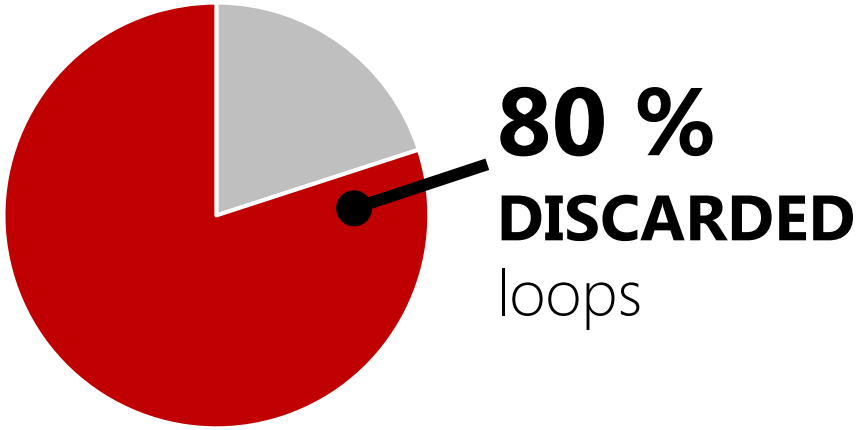
IC1 IC2 RD1 RD2 LP



PERCEPTION

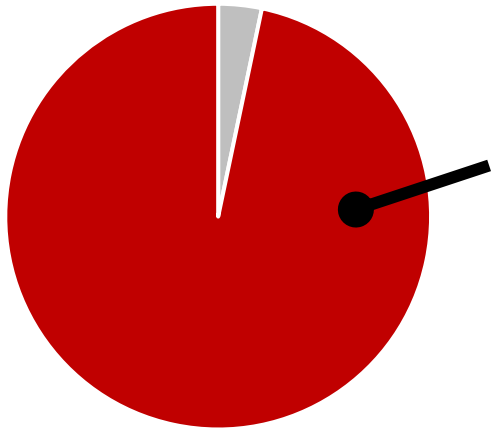
End users **perceive** problems in trigger-action rules differently: loops and inconsistencies are **dangerous**, redundancies can be even **acceptable**

PERCEPTION

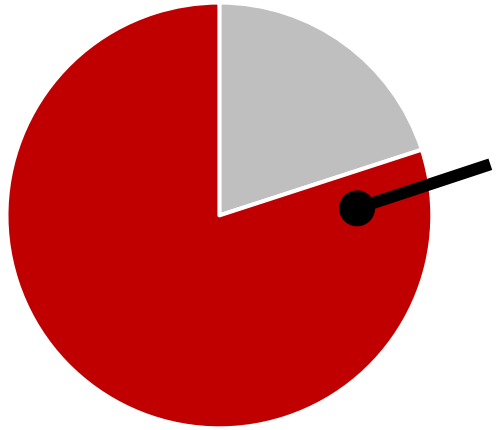




PERCEPTION

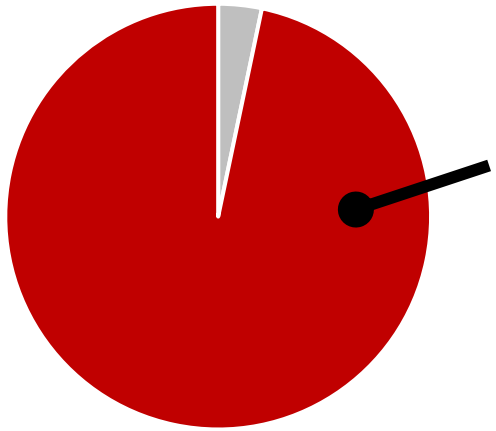


97.67 %
DISCARDED
inconsistencies

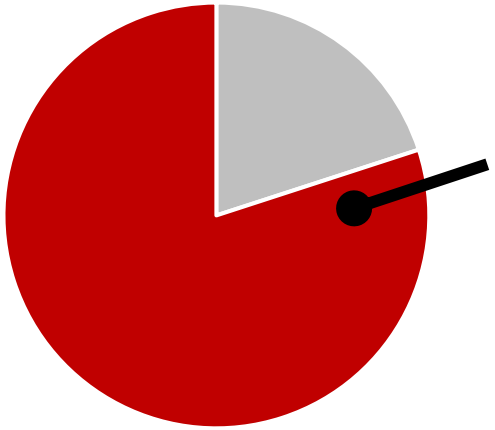


80 %
DISCARDED
loops

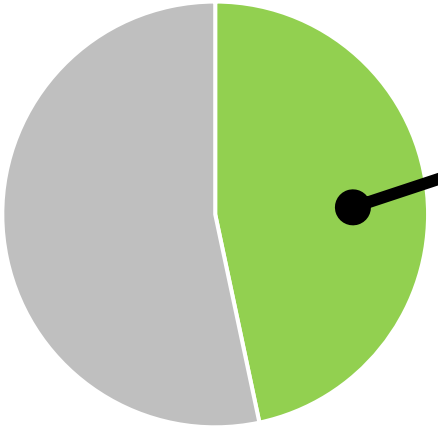
PERCEPTION



97.67 %
DISCARDED
inconsistencies



80 %
DISCARDED
loops



46.67 %
SAVED
redundancies



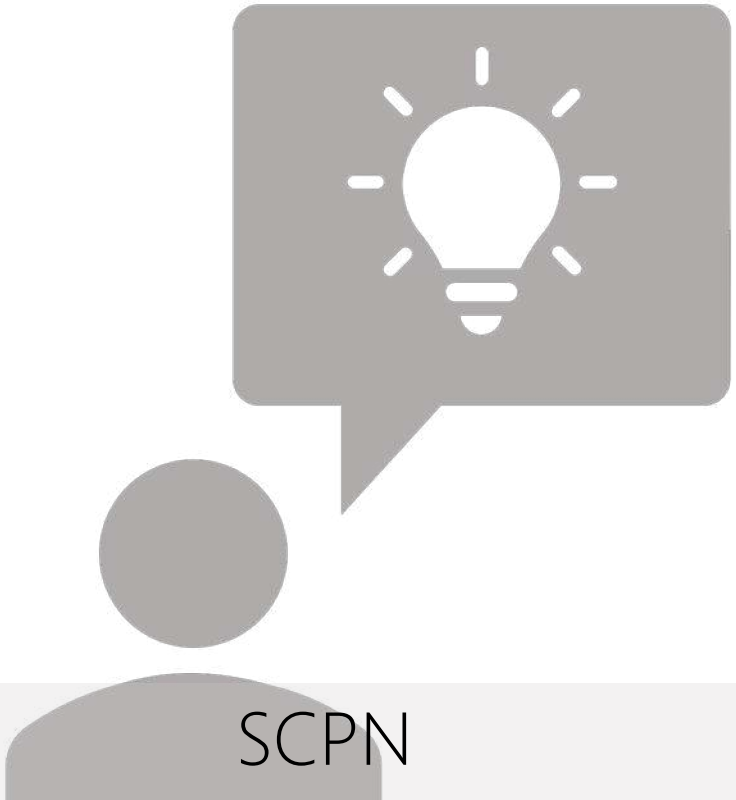
PERCEPTION

> The important thing is that the lamp is turned on, I do not care its color!

RD1 - P13



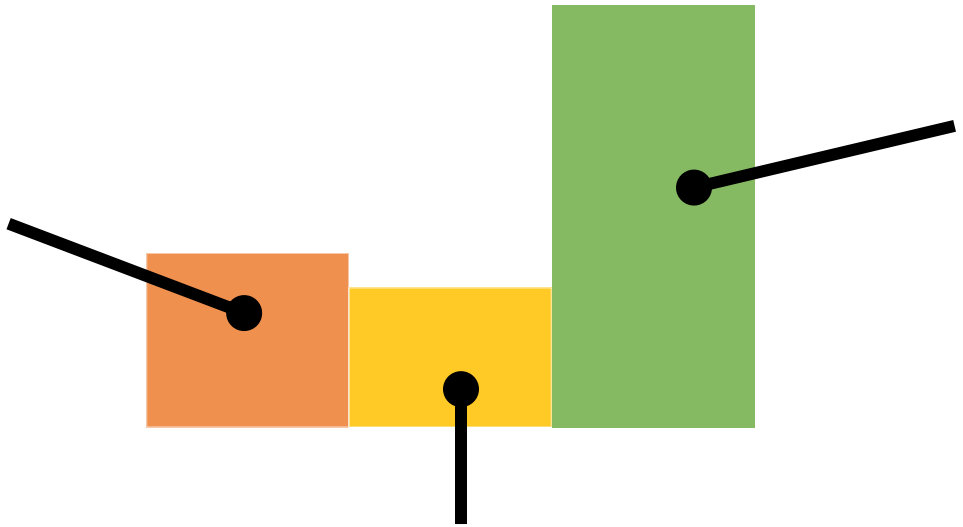
UNDERSTANDING



Some problems are difficult to understand: **loops** and **indirect problems** are often misinterpreted

UNDERSTANDING

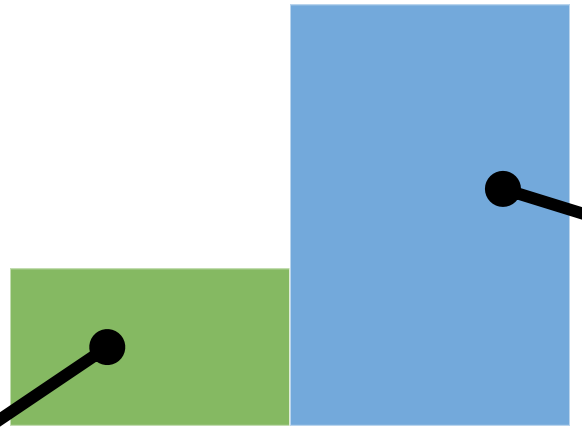
16,67 %
misinterpretations
when facing
an **inconsistency**



40 %
misinterpretations
when facing
a **loop**

13,34 %
misinterpretations
when facing
a **redundancy**

UNDERSTANDING



10 %
misinterpretations
when facing
a **direct problem**

26.67 %
misinterpretations
when facing
an **indirect problem**



UNDERSTANDING

> I am sure that this problem will never occur with the rules I have defined! Moreover, such rules are useful, because the photo will be saved in 3 places at the same time.

LP - P13

Highlighting the detected problem is often not sufficient: a **step-by-step simulation** of the involved rules helps users understand difficult problems



STRATEGIES

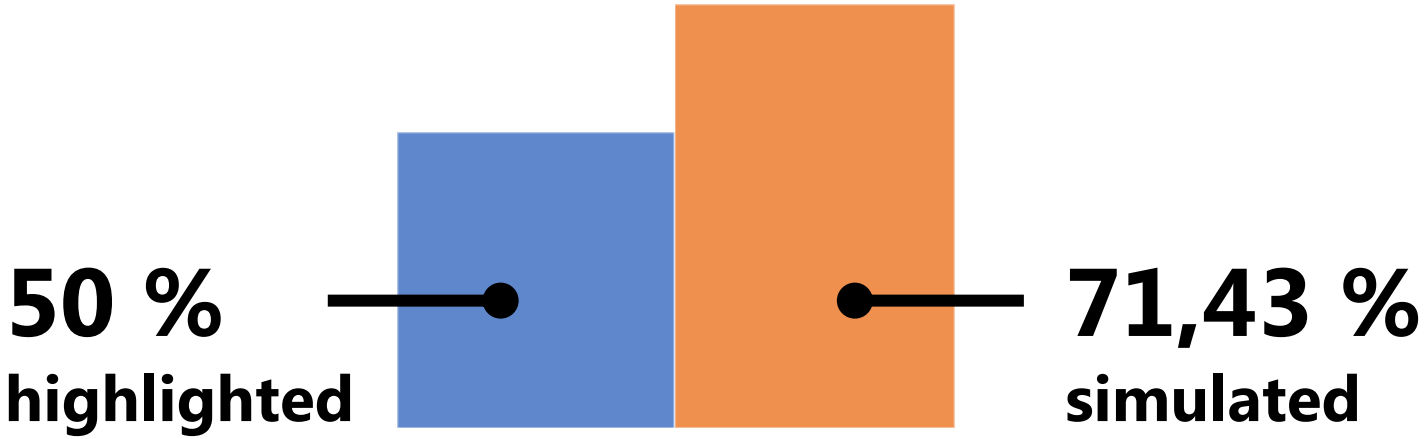
77,81 %
of correct interpretations
when a problem is
highlighted

83,78 %
correct interpretations
when a problem is
simulated

STRATEGIES

77,81 %
of correct interpretations when a problem is **highlighted**

83,78 %
correct interpretations when a problem is **simulated**



FOR **LOOPS**



STRATEGIES

> The step-by-step simulation helped me in understanding the loop because I could better see the evolution of the rules. It visually told me what happened!
>
> **LP - P6**

SCPN EUDebug **My IoT Puzzle**



FIXING

Visual languages and adopted feedback effectively help participants **avoiding and finxing** run-time problems in IF-THEN rules

1 MOVING TOWARDS A **HIGH-LEVEL** OF **ABSTRACTION**

EUPont

2 **DISCOVERING** IF-THEN RULES AND **FUNCTIONALITY**

EUDoptmizer RecRules

3 **DEBUGGING** IF-THEN RULES AT **DEFINITION TIME**

SCPN EUDebug My IoT Puzzle

1 MOVING TOWARDS A **HIGH-LEVEL** OF **ABSTRACTION**

EUPont

2 **DISCOVERING** IF-THEN RULES AND **FUNCTIONALITY**

EUDoptmizer RecRules

3 **DEBUGGING** IF-THEN RULES AT **DEFINITION TIME**

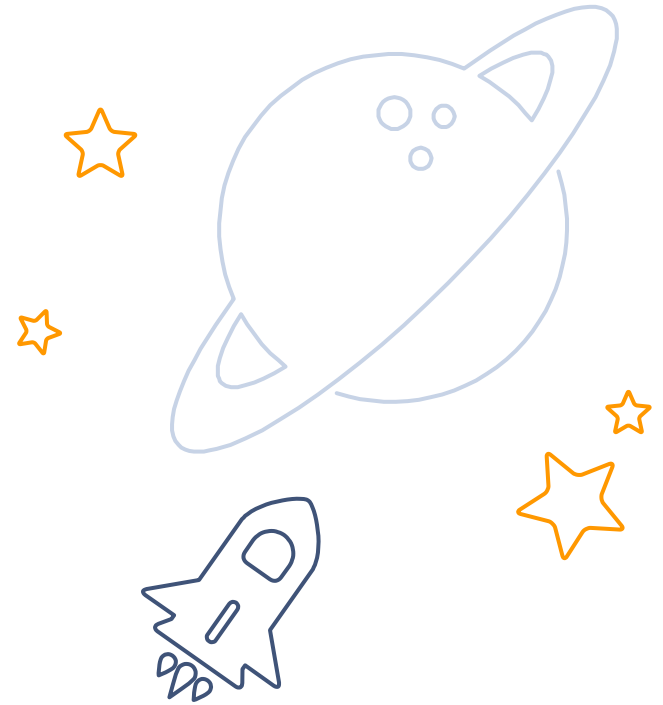
SCPN EUDebug My IoT Puzzle

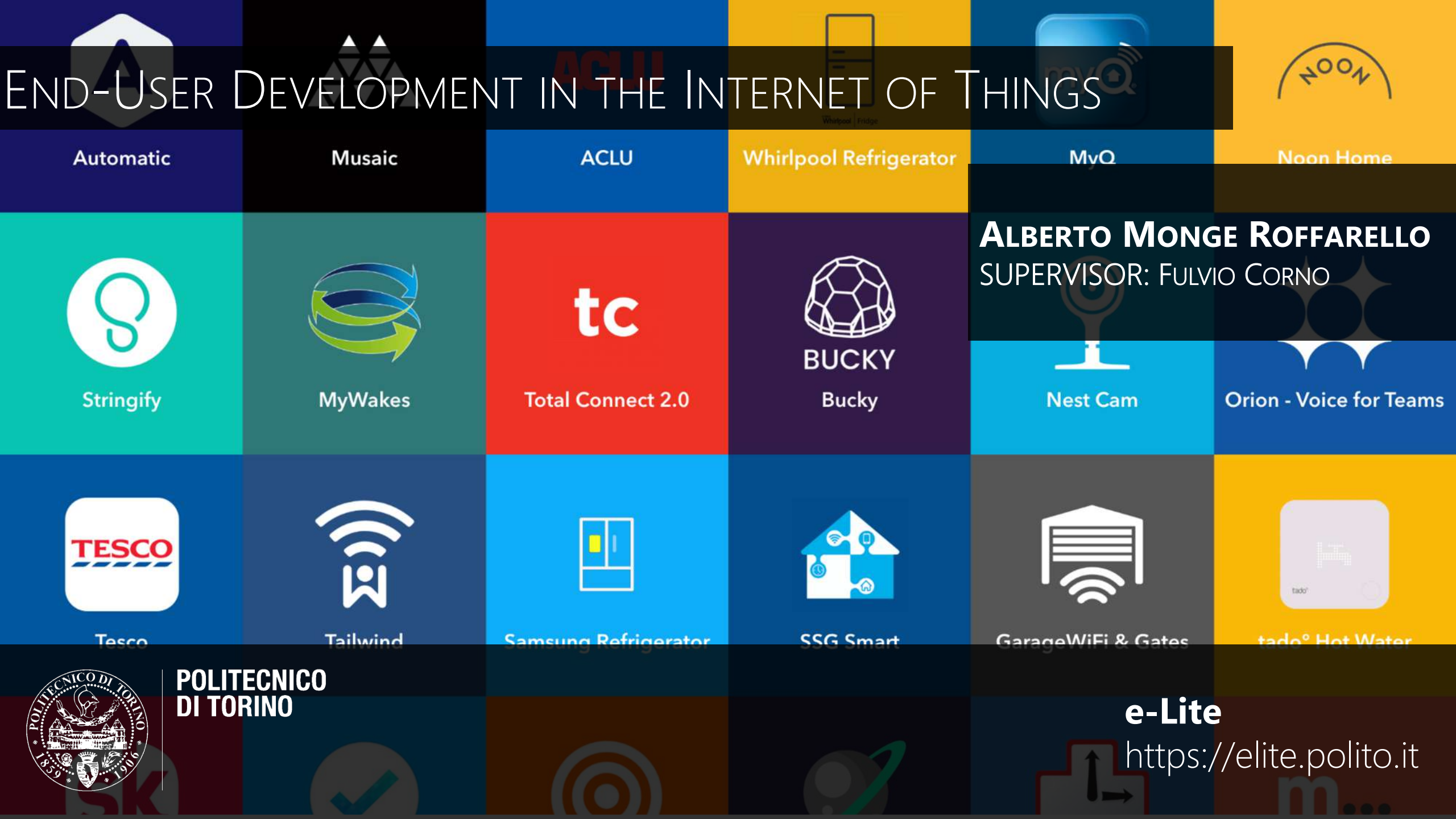
FUTURE DIRECTIONS

Security and **Privacy**

In-the-wild Studies

Trigger **Conditions** and **Multiple** actions





End-User Development in the Internet of Things

Alberto Monge Roffarello
Supervisor: Fulvio Corno

Politecnico di Torino

e-Lite
https://elite.polito.it

ACCEPTED PUBBLICATIONS – FIRST YEAR

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «A HEALTHCARE SUPPORT SYSTEM FOR ASSISTED LIVING FACILITIES: AN IOT SOLUTION», 40TH IEEE COMPUTER SOCIETY INTERNATIONAL CONFERENCE ON COMPUTERS, SOFTWARE & APPLICATIONS (COMPSAC 2016)

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «IOT FOR AMBIENT ASSISTED LIVING: CARE4ME - A HEALTHCARE SUPPORT SYSTEM», BOOK CHAPTER, INTERNET OF THINGS AND ADVANCED APPLICATION IN HEALTHCARE, 2016

L. DE RUSSIS, A. MONGE ROFFARELLO, «ON THE BENEFIT OF ADDING USER PREFERENCES TO NOTIFICATION DELIVERY», CHI 2017: THE 35TH ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «A HIGH-LEVEL APPROACH TOWARDS END USER DEVELOPMENT IN THE IOT», CHI 2017: THE 35TH ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «A SEMANTIC WEB APPROACH TO SIMPLIFYING TRIGGER-ACTION PROGRAMMING IN THE IOT», IEEE COMPUTER, 2017

ACCEPTED PUBBLICATIONS – SECOND YEAR

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «IOT FOR AMBIENT ASSISTED LIVING: CARE4ME - A HEALTHCARE SUPPORT SYSTEM», BOOK CHAPTER, WEARABLE TECHNOLOGIES: CONCEPTS, METHODOLOGIES, TOOLS, AND APPLICATIONS, 2018 (REPRINT)

L. DE RUSSIS, A. MONGE ROFFARELLO, «A DEBUGGING APPROACH FOR TRIGGER-ACTION PROGRAMMING», CHI 2018: THE 36TH ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «AWARENOTIFICATIONS: MULTI-DEVICE SEMANTIC NOTIFICATION HANDLING WITH USER-DEFINED PREFERENCES», JOURNAL OF AMBIENT INTELLIGENCE AND SMART ENVIRONMENTS, 2018

A. MONGE ROFFARELLO, «END USER DEVELOPMENT IN THE IOT: A SEMANTIC APPROACH», IE 2018: THE 14TH INTERNATIONAL CONFERENCE ON INTELLIGENT ENVIRONMENTS

ACCEPTED PUBBLICATIONS – THIRD YEAR

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «A HIGH-LEVEL SEMANTIC APPROACH TO END-USER DEVELOPMENT IN THE INTERNET OF THINGS», INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES, 2019

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «EUDOPTIMIZER: ASSISTING END USERS IN COMPOSING IF-THEN RULES THROUGH OPTIMIZATION», IEEE ACCESS, 2019

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «MY IOT PUZZLE: DEBUGGING IF-THEN RULES THROUGH THE JIGSAW METAPHOR», IS-EUD: THE 7TH INTERNATIONAL SYMPOSIUM ON END-USER DEVELOPMENT

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «EMPOWERING END USERS IN DEBUGGING TRIGGER-ACTION RULES», CHI 2019: THE 37TH ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS

A. MONGE ROFFARELLO, L. DE RUSSIS, «THE RACE TOWARDS DIGITAL WELLBEING: ISSUES AND OPPORTUNITIES», CHI 2019: THE 37TH ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS

F.CORNO, L. DE RUSSIS, A. MONGE ROFFARELLO, «RECRULES: RECOMMENDING IF-THEN RULES FOR END-USER DEVELOPMENT», TIST ACM TRANSACTION ON INTELLIGENT SYSTEM AND TECHNOLOGY

A. MONGE ROFFARELLO, L. DE RUSSIS, «TOWARDS DETECTING AND MITIGATING SMARTPHONE HABITS », UBICOMP 2019: THE 2019 ACM INTERNATIONAL JOINT CONFERENCE ON PERVASIVE AND UBIQUITOUS COMPUTING