



PersonAAL



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Techniques for Adaptation, Customisation and Persuasion (Revised)

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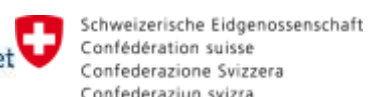
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1 INTRODUCTION

The goal of the PersonAAL project is to extend the time elderly people can live autonomously at their home. In order to achieve this, in the project we define a framework and an underlying architecture supporting developers in defining applications for elderly people able to adapt their behaviour depending on the context of use.

In addition to the framework and to the applications, a Personalization Rule Editor has been developed, whose goal is to allow people without programming experience to define their own adaptation rules taking into account the context of use. In this document we describe the updates that have been done regarding the adaptation and customisation part, more specifically the improvements that have been done in the Rule Editor for better supporting end user developers in specifying effective adaptation rules for their needs.

In particular, after a general overview of the goals of the Rule Editor, we describe the general structure of trigger-action rules and their key elements. Then (in Section 3) we describe the Rule Editor tool, and how end user developers can concretely use it to build suitable customisation rules (Section 6). Then we detail the various elements composing the trigger hierarchy (Section 7) and the action hierarchy (Section 8). In Section 9 we describe an additional support included in the tool, which allows the user to both simulate rules in order to detect possible issues in the specified behaviour, and to fix the identified errors. Since we do not have substantial updates on the Persuasion Module with respect to the previous version of the deliverable, we conclude this document by providing some closing remarks (Section 11).

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2 OVERVIEW

The Personalization Rule Editor is a Web-based application which enables users to create trigger-action rules in an intuitive manner. Its design has evolved taking into account the feedback received from its use in the project, in particular during the usability tests. In this deliverable we provide an updated description of the design and functionalities supported, in order to allow people without programming experience (as usually are caregivers and elderly people) to modify their applications and customise the behaviour of the available appliances (Figure 1).

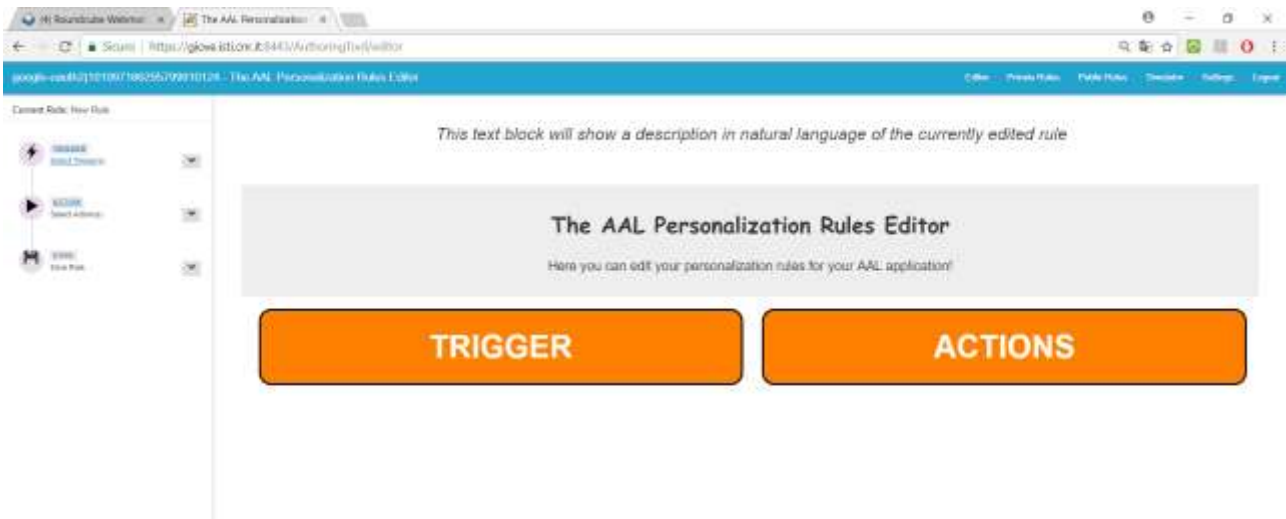
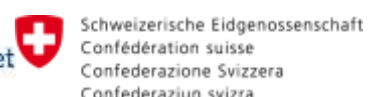


Figure 1: The Initial screen of the Personalisation Rule Editor

Its structure (see Figure 2) is composed of a main panel in the central part of the window, where the hierarchies of triggers and actions are visualized; a side bar on the left, showing the progress currently achieved by the user in the creation of a rule; a horizontal menu in the top-right part of the tool, where some functionalities are available. In particular, the menu supports access to:

- Editor:** for accessing the rule editor;
- Private Rules:** for accessing the private area where the user stores her/his own rules
- Public Rules:** for accessing the area where publicly available rules are accessible
- Simulator:** for simulating the execution of the rules
- Settings:** for changing the tool settings
- Logout:** for exiting the system

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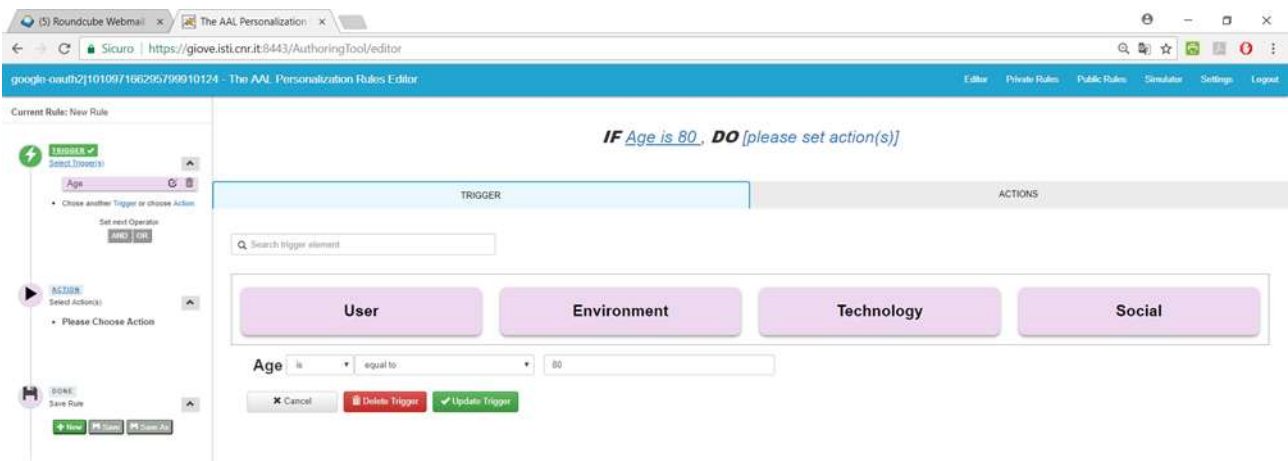


Figure 2: The main areas of the Personalization Rule Editor

The *Editor* section is the part of the user interface dedicated to defining triggers and actions, the *Private Rule* section presents the list of the rules previously defined by the user, these rules can be edited, deleted or sent to the Adaptation Engine in order to be applied. A private rule can be shared with other users: in order to do it, a user has to select one or more rules from the Private Rule section and then click on *Upload to Public Repository* button. The *Simulator* section shows the list of private rules and a tree-like representation of the Context Model: its goal is supporting users in detecting errors in the rules they defined, and finding the cause of the identified errors so that it is possible to fix/remove it in the concerned rule(s). The *Settings* section allows the configuration of some aspects of the Editor such as the URL of the context model, the URL of the Adaptation Engine and the name of the target application. In order to describe the main panel of the tool, where the hierarchies of triggers and actions are visualised, we need to introduce the structure of a trigger-action rule (see next section).

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3 STRUCTURE OF TRIGGER-ACTION RULES

Each rule is composed of two parts: a trigger part, and an action part. Thus, its basic structure is:

IF/WHEN (trigger) DO (action)

For instance, in the rule "WHEN it is 5 p.m. DO send a reminder to take medicine" the trigger is: "it is 5 p.m.", while the action is "send a reminder to take medicine".

3.1 Triggers and Actions

The trigger part defines the event(s) and/or the condition(s) that activate the application of the rule in the current context of the user. The action part defines the action(s) that should be carried out when the rule is triggered.

Triggers and actions can be either elementary or composite ones.

Examples of elementary triggers are the following ones:

- "IF the user age is more than 40 years old"
- "IF it is 11 p.m."
- "WHEN the user enters the kitchen"

Composite triggers occur when two or more elementary triggers are composed together through Boolean operators (e.g. AND, and OR). For instance, we can combine some of the abovementioned elementary triggers into a newly composed trigger as here:

Composite trigger= "IF it is 11 p.m" AND "WHEN the user enters the kitchen"

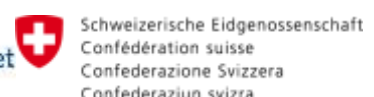
If a user specifies that composite trigger, he is interested in detecting the situation in which a person is entering the kitchen and it is late evening (11 p.m.).

A **trigger** can be either an **event** or a **condition**.

An event is an instantaneous change occurring in the current context. Thus, events should be used when we are interested in the moment when the change occurs. For instance, the user entering home represents an event, since we are interested in detecting the moment when the user changes her position (from "outside home" to "inside home"): we probably want that an action be activated in the specific moment when that change of status occurs. An action that can be typically activated in the exact moment when a user is entering home is e.g. "switch the light on". On the other hand, a condition is a continuous, ongoing state verified in the current context of the user. For example, 'the user is deaf' is a condition, also 'it is 29 July' is another example of condition, as it lasts the whole day. An example of a rule that could involve such conditions could be e.g. "If the user is deaf DO switch off audio notification": in this case the audio notification will be off only under the condition that the user is deaf. Of course, interpreting the fact of being deaf as an event would imply that we would be interested in the onset of the user's deafness i.e. when a user changes her status from "non-deaf" to "deaf".

When a condition is used in the specification of a trigger, the natural language text describing the current trigger will include "IF" at the start of the sentence and "IS" keyword inside the trigger. For instance: "IF the environment type IS indoor".

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When an event is used in the specification of a trigger, the natural language text describing the current trigger starts with "WHEN" and include "BECOMES" (to indicate that we are interested in a state change). For instance: "WHEN the temperature BECOMES more than 23°C

"

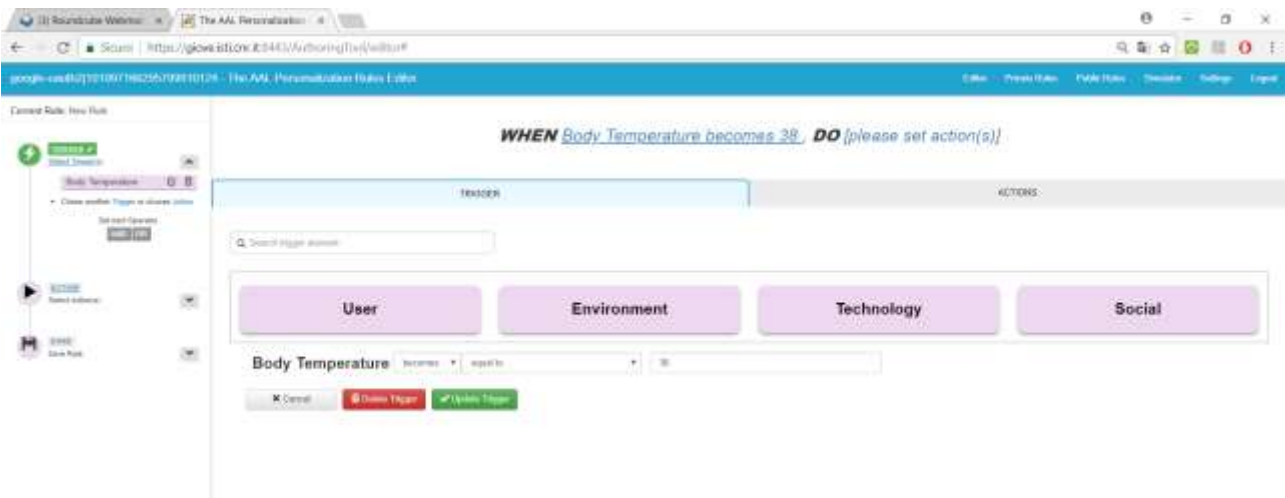


Figure 3: The part of the editor dedicated to the specification of triggers

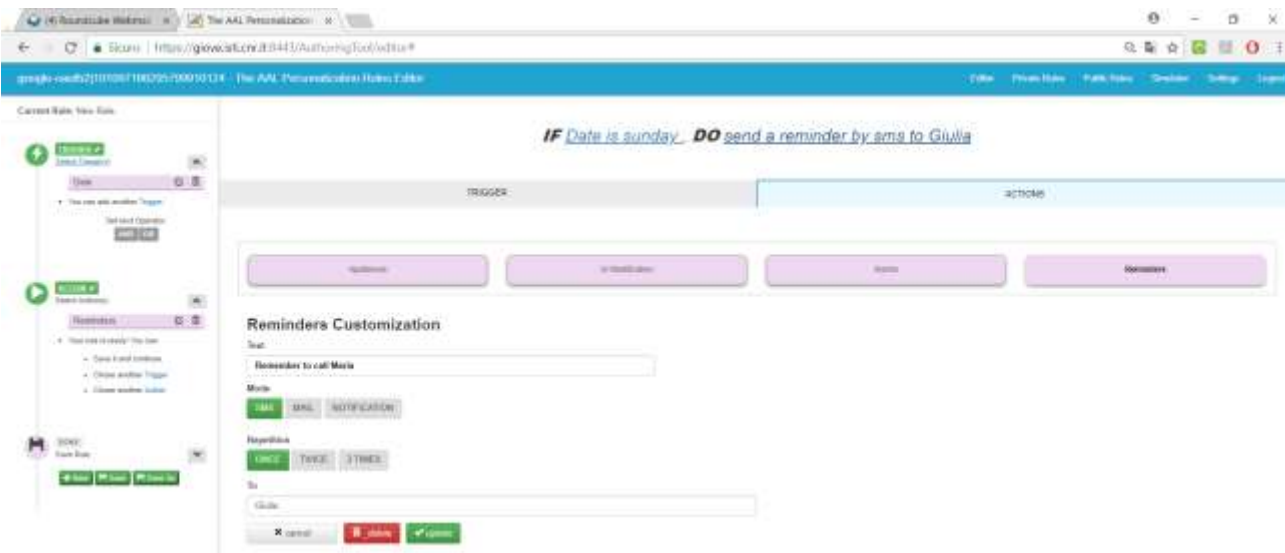
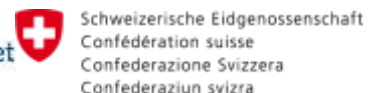


Figure 4: The part of the editor dedicated to the specification of actions

Using the tool, users can create a rule either starting from specifying triggers or starting from specifying actions.

Triggers and actions have been categorized in two distinct hierarchies. In order to specify rules, the user should interactively navigate the hierarchy of triggers and the hierarchy of actions, by

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interactively selecting the concepts that are most relevant for specifying the intended trigger and the intended action. The entities appearing at the highest levels of the two hierarchies are called dimensions.

For the **trigger hierarchy**, the dimensions (i.e. the elements that appear as roots of the hierarchy) are:

- User
- Environment
- Technology
- Social

For the **action hierarchy**, the dimensions are:

- Appliances
- UI Modifications
- Alarms
- Reminders

Both the hierarchy of triggers and the hierarchy of actions share the principle that a concept at a higher level is further refined into a number of options at its lower levels, in a top-down manner. In order to find the specific trigger that a user wants to model within a specific rule, at each level the user should ask the following question: which element of this level is related with what I would like to specify?

In order to limit the number of elements to be visualized at each level of the hierarchy, the refinements are presented in an interactive manner. This means that only the element currently selected by the user is expanded/refined and highlighted through a different color (yellow) in the tool.

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4 THE SIDEBAR

The sidebar provides information about the point currently reached by the user in the process of specifying a rule. For instance, in the next figure the sidebar shows that the user has only created a trigger, and therefore she still needs to create an action before being able to save the rule. Indeed, as you can see the “Save rule” button included in the sidebar is currently not activated yet. The sidebar also includes the buttons for creating a new rule (“New” button), save the current rule (“Save” button) and also save the current rule by specifying its name (“Save as” button). In addition, from the sidebar it is possible to do some actions that are available in the main panel (e.g. edit the elements currently included in the rule, add an operator to compose triggers). Moreover, the various elements included in the sidebar could be folded and unfolded by the user.

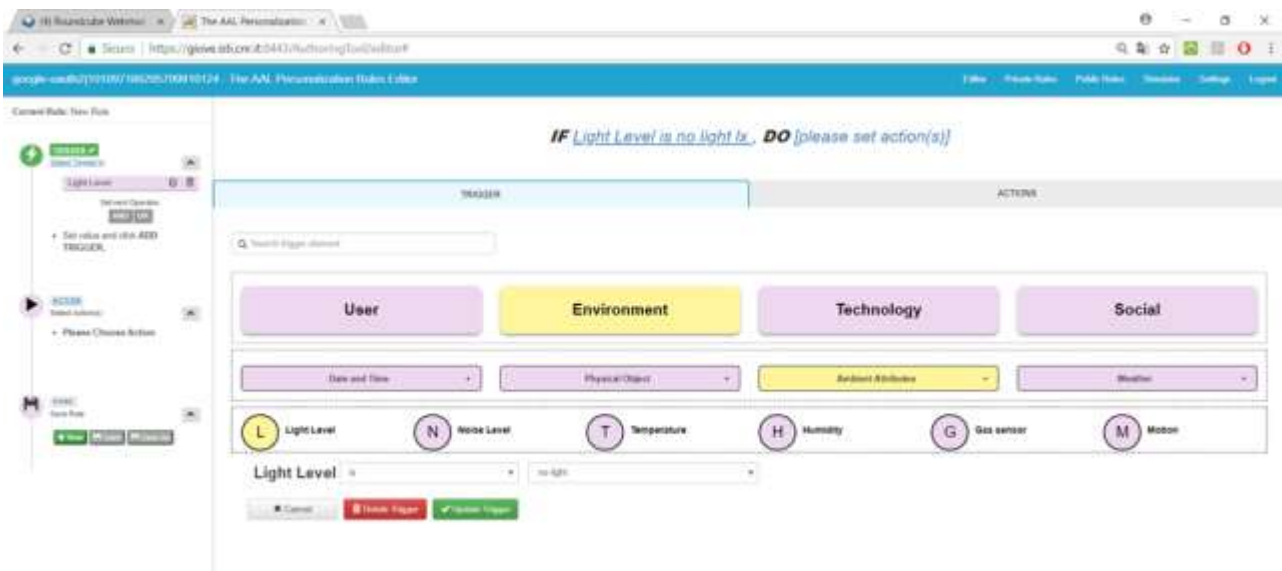


Figure 5: Modelling a trigger: the sidebar (on the left side) shows the point currently reached by the user

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5 HOW TO

5.1 How to specify a trigger using the tool

When the user has to specify a certain trigger, he/she should start from the highest level of the hierarchy of triggers (which has currently the following dimensions: user, environment, technology, social), and then go down until he reaches a leaf of the hierarchy that fits the aspect that the user would like to model. While interactively navigating in the hierarchy of triggers, at each level the user should ask the following question: "which element of this level is related with what I would like to specify?"

Thus, the user exploring a specific level of the hierarchy should identify, among the visualized elements, the one that is most relevant for his/her needs. Once having identified that element, the user should select it and then at this point two possible situations can occur:

1. *The element selected is not a leaf.* This happens when the selected element is represented by a rectangular icon in the user interface of the rule editor. In this case the user should continue visiting the hierarchy of elements, until a basic element (i.e. a leaf) is found. For instance, the element "Ambient Attributes" under the "Environment" dimension is not a leaf because it is further refined into e.g. Light, Noise, Temperature, etc;
2. *The element is a leaf.* This happens when the selected element is represented by a circular icon in the user interface of the rule editor. In this case the user can specify the values and the operators to use in the rule. For instance, the element "Heart Rate" (which can be found under User > Physical > Heart Rate) is a basic element. Thus, a trigger involving heart rate can specify, for instance "IF heart rate is more than 180" to mean that we are interested in situations when the user's heart rate is more than 180 beats per minute.

An Example

Let's consider the example of a user who wants that in her house, whenever the environment becomes dark, lights should be switched on automatically. In this case the user has to specify the following trigger: whenever the environment becomes dark. Thus, in this trigger, the key element involved is the level of light in the current environment. To this goal, the user starts navigating the hierarchy:

- 1) At the highest level of the trigger hierarchy the user will have the following options:

User - Environment - Technology - Social

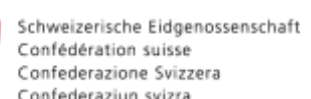
Which element will be more connected to lights? Since the light level is a property of a certain ambient/environment, the user should select "Environment".

- 2) When the user selects "Environment" a new level interactively appears, refining the "Environment" dimension, namely:

Date and Time - Physical Object - Ambient Attributes - Weather

Having in mind that the user wants to model the light level (which is a property of a specific environment), which element should be selected? In this case the answer is "Ambient Attributes"

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- 3) When the user selects “Ambient Attributes” a new level interactively appears, refining the “Ambient Attributes” dimension in the following manner:

Light level – Noise Level – Temperature – Humidity – Gas sensors – Motion

Having in mind that the user wants to model the light level (which is a property of a specific environment), which element should be selected? In this case the answer is “Light Level”

- 4) When the user selects “Light Level” (which is a leaf, as indicated by the circular icon) the user will be able to specify which light level she is interested in. In this case we want to model that the environment is not very illuminated, then we can specify “no light”. At the end we will have “IF Light Level is no light”, which corresponds to the specification of the intended trigger using the tool. In the next figure you can see the result of this specification in the tool.

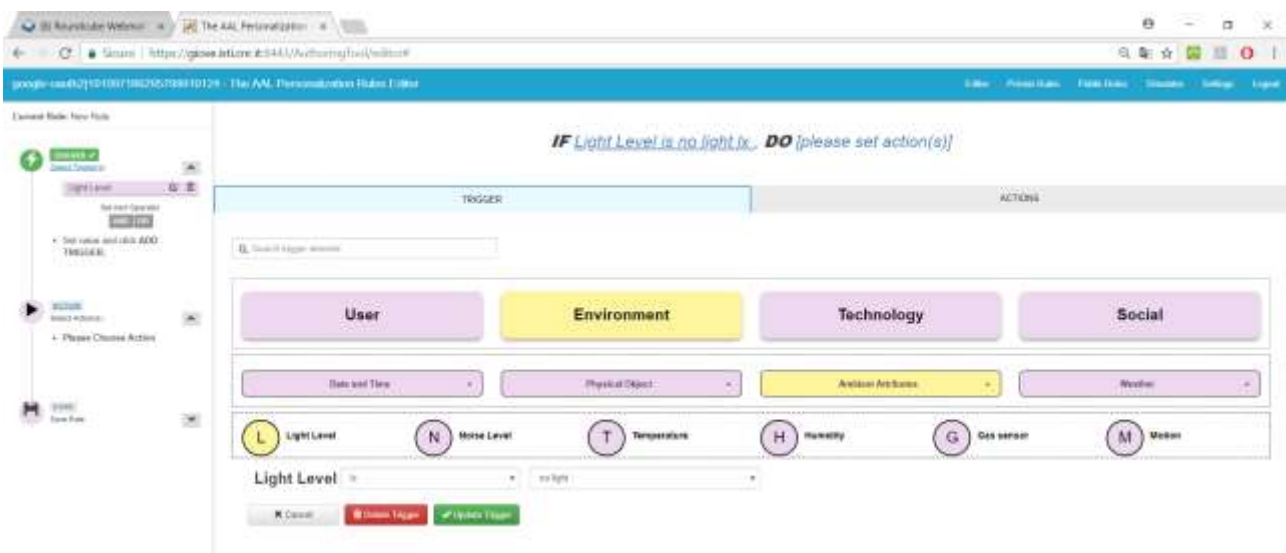


Figure 6: Modelling a trigger of a rule

5.2 How to specify an Action

What has been just described for specifying triggers can be applied similarly for specifying actions

5.3 How to specify a rule

In order to specify a rule, you should first specify a trigger and then specify an action . Alternatively, you could first specify an action and then specify a trigger.

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5.4 How to create and save a rule

To create a rule, go to the "Editor" page and start to specify a rule; alternatively, you can go to the sidebar and select "New" button. When you define a rule you can save it using the "Save" button in the side bar. You will find all the saved rules in the "Private Rules" section.

5.5 How to delete rules

Go to the "Private Rules" page. Select the rule(s) you want to delete by clicking on the checkboxes that are on the left side, then click on "Delete" button on the top of the rule list. At this point a dialog message will appear, asking for confirmation to delete the selected rule(s), click on the "OK" button to confirm the deletion.

5.6 How to apply rules

In order to run the rules, you have to select which one(s) you want to apply (click on the checkbox on the left) and then click on "Apply Rule" button on the top of the rule list. Once a rule is running the user will receive a message and the running rules will be highlighted with a green background. In this case running a rule means that as soon as its trigger is verified then the consequent action is executed.

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6 THE HIERARCHY OF TRIGGERS

6.1 User

The User dimension includes aspects that are related to the considered user, e.g. age, education, physical state, current position, social contacts. As such, the "User" dimension is refined into the following aspects:

Personal data - Physical - Activity and position

Personal data concerns "static" information about the user (i.e. information that cannot change anymore e.g. the name of the user; or it may still change, but it does not occur very often, e.g. age). As such, it is refined into:

Age - Gender

Please note that, above, we underlined them to mean that they are leaves and therefore they cannot be refined anymore (we will use this convention also for the next refinements). Age and gender have an easily intuitive meaning associated.

Physical concerns aspects associated with the current physical status of the user. It is refined into:

Weight - Heart rate - Daily steps - Body temperature - Respiration Rate - Posture - Has Fallen?

Weight refers to the weight of the user.

Heart rate refers to the speed of the heartbeat.

Daily steps refer to the number of steps that the user should do daily.

Body temperature refers to the current body temperature of the user.

Respiration Rate refers to the current respiration rate of the user.

Posture refers to the current posture of the user.

Has Fallen? allows to know whether the user has fallen.

Activity and Position groups together aspects concerning both the current activity and position of the user. As such it is currently refined into:

Position - Medication - FitBit Summary - Motivation

Position describes the current position of the user. It is refined into:

Relative Position - Absolute Position

Relative Position is used to describe the position of the user relatively to a specific key place. For instance, if in a rule you want to specify that the user is near the TV, you should use relative position, since the position of the user is defined relatively to the position of the TV.

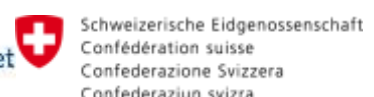
Absolute Position is for describing the user position in terms of GPS coordinates. It is refined into the following elements, which have an intuitive meaning:

Latitude - Longitude - Altitude

Medication refers to the medication currently associated with a user. It is refined into:

Medication Planned - Medication Occurred

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Medication Planned refers to the medication that the user should do. It is refined into:
Notification Time - Medication - Dosage

Notification Time refers to the time when a notification should be sent as a reminder.

Medication refers to the medicine involved in the planned medication.

Dosage refers to the dosage of the medicine that should be taken.

Medication Occurred refers to the medication that the user has actually taken. It is refined into:

Registration Time - Medication - Dosage

Registration Time refers to the time when a medication has been taken.

Medication refers to the taken medication.

Dosage refers to the medicine dosage that has been taken

Fitbit Summary refers to the daily summaries provided by Fitbit. It is refined into:

Fat Burn Zone - Cardio Zone - Peak Zone - Lightly Active Minutes - Very Active Minutes - Fairly Active Minutes - Sedentary Minutes - Resting Heart Rate - Fitbit Steps - Floors - Distance - Elevation

Peak Zone is the high-intensity exercise zone

Cardio Zone is the medium intensity exercise zone

Fat Burn Zone is the low-to-medium intensity exercise zone

Each of the above exercise zones is defined through:

Max - Min - Minutes

They refer to the level of maximum intensity reached, the minimum intensity and the minutes in which the user was in that exercise zone.

Lightly Active Minutes and Very Active Minutes: The Fitbit device recognizes and awards the minutes when the activity the user is doing is more strenuous than regular walking, which includes everything from a brisk walk to a cardio workout or run.

Fairly Active Minutes: minutes of regular walking during the day

Sedentary Minutes: minutes spent on resting

Resting Heart Rate refers to the speed of the heartbeat in resting conditions

Fitbit Steps refers to the number of steps performed

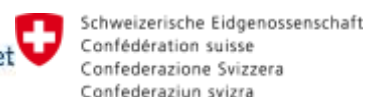
Floors: The Fitbit device counts floors, it has an altimeter sensor that can detect when a user is going up or down in elevation. The device registers one floor when you climb about 10 feet at one time.

Distance in meter of the steps performed by the user during the day

Elevation in meter corresponding to the floor climbed.

Motivation refers to the current main motivation of the user.

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6.2 Environment

Environment refers to all the aspects associated with the environment. It is refined into:
Date and Time - Physical Objects - Ambient Attributes - Weather

Date and Time refers to the aspects connected with date and time, thus it is refined into:
Time - Local Date

Ambient Attributes refers to aspects associated with the current conditions of the surrounding ambient. It is refined into:

Light level - Noise level - Temperature - Humidity - Gas sensor - Motion

Each of the abovementioned leaves has an easy-to-understand meaning. The units used are Light level: lx; Noise Level: dB; Temperature: C°; Humidity: %.

Weather refers to aspects related to weather. It is refined into a number of aspects having an intuitive meaning:

Temperature - Humidity - Wind - Weather condition

Each of the above leaves has an easy-to-understand meaning.

6.3 Technology

With technology, we consider information related to any relevant technology available, e.g., devices, smart things/appliances. In particular, technology is further divided into:

Physical Object

Physical Object refers to the physical objects that are available in the current environment. It is refined into:

Hue Color Light Entrance - Hue Color Light Kitchen - Hue Color Light Living Room

They represent the Philips hue lamps currently installed in the house. Each of them is refined into:

State - Color

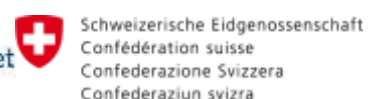
State represents the current state of the lamp (on-off).

Color represents the current color of the lamp.

6.4 Social

This dimension describes the social relationships of the user. It is refined just into "Social Networks", which is aimed at describing the various social networks of the user. This part will be better refined in future work.

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7 THE HIERARCHY OF ACTIONS

The action dimensions are:

Appliances - UI Modifications - Alarms - Reminders

Appliances refers to the actions aimed to control the home appliances (e.g. lights).

UI Modifications refers to the actions aiming at changing the user interface of the application at hand. Mainly it allows for showing/hiding elements in the UI.

Alarms refers to the specification of alarms

Reminders refers to the specification of reminders

Appliances are further categorized according to the house environment:

All - Kitchen - Living Room - Entrance

All refers to all the appliances of the house. The other categories allow for specifying actions of appliances (mainly lights) in specific parts of the house.

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8 SIMULATOR

The Personalization Editor tool allows users without programming experience to define the behaviour of Context Aware applications. However, such users could define rules to perform actions that may conflict, or they can specify rules not expressing the intended behavior.

In rule-based environments it is possible to have conflicts when multiple rules are verified in the same time interval and their actions have contradictory effects. One of the easiest ways to resolve a rule conflict is to associate a **'priority'** value to each rule; an attribute that should be set by the user when the rule is built. Once a conflict happens, the rule with the highest priority value will be fired, while the others will simply be ignored. If there are two verified rules having the same priority, further policies should be put in place to solve the conflict.

The conflict resolution strategy only based on priority values is the simplest one and works well only if users are able to set suitable priority values at design time, which is not always easy as they might not be able to predict in advance the conflicts that will occur at runtime. It is worth noting that the strategy of assigning priority values that are all different does not seem feasible when dealing with large sets of rules, as it would require a significant overhead on the user's side. Thus, more effective conflict resolution strategies should be put in place, able to identify potential conflicts and help find possible solutions, also involving users in the process.

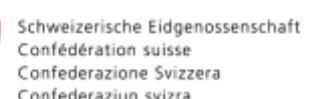
Another key point is how people can test the correctness of rules and possibly identify errors in them, e.g. triggers or actions that they might have forgotten (or inappropriately added) in the current rule specification. Here we mainly focus on the semantic correctness of rules, i.e. when rules are syntactically correct, but do not behave in the expected manner. A way to reduce the likelihood of errors in the specification of rules is to allow users to **simulate** the occurrence of the conditions and the events involved in a rule, and analyse the simulated effects that it will bring about. An alternative to the simulation could be to apply them in the current (real) context of use, to understand whether they will be verified and then identify the corresponding actions that will be carried out. However, this approach provides only a limited set of context options for the verification of the rules (e.g. the ones that can be verified in the current, real context).

While testing aims at detecting possible errors in the programs built by users, debugging is the process of finding the cause of the identified errors in the specified behaviour (e.g. adaptation rules) and fix/remove it. To this aim, we implemented a tool able to support a number of functionalities (simulation, debugging and conflict identification/resolution), by taking into account for the debugging part the Interrogative Debugging paradigm (Ko and Myers, 2004), in which the system answers **"why"** and **"why not"** questions. Thus, users can interactively ask "why" and "why not" questions to know the reason why a rule is (respectively: is not) verified. Moreover, this tool integrates in the simulator a conflict analysis functionality able to highlight potential conflicts between rules that are simultaneously verified.

8.1 An example scenario

In order to show how the proposed solution works we can consider a scenario where a user, John, wants to automatically manage the behaviour of his smart house, so that it can better fit the needs of his family (his wife and two children). To this goal, John starts to formulate a first rule

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(rule1) saying that all the windows in the house should be open from 9 a.m. in the morning, in order to have some fresh air in the house. Afterwards, John defines another rule to ensure that all the windows will be safely closed in the evening after 9 p.m. (rule2). After saving these rules John runs the simulator, setting the value of 10 p.m. as the time to be considered in the simulated context, and checks whether the two rules are verified or not. The simulator will notify John about the existence of a possible conflict between the two rules: when John activates the conflict analysis feature, the tool warns him that the windows in his house could enter an undefined state after 9 p.m., because at that time the windows should simultaneously be open (according to rule1) and closed (according to rule2). Thus, thanks to this information, John is able to identify the issue and then modifies rule1 by adding another condition to better specify the time interval in which the windows of the house should be open, namely between 9 a.m. and 13.

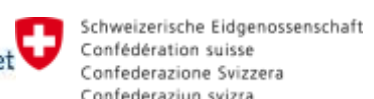
In addition to the previously defined rules, John also wants to have all the windows closed when it is raining: then he adds another rule (rule3) to his private repository. After doing this, the conflict analysis tool will notify John that there could be a potential conflict during rainy mornings since, according to rule1 the windows should be open, according to rule 3 the windows should be closed. Thus, thanks to the help of the system, John modifies rule1 by adding a further condition saying that the windows should be open during the morning only during sunny days.

John adds further rules to manage other aspects of his smart home in a context-dependent manner. For instance, he adds a rule for switching off the TV after a specific hour in the evening (to prevent children from going late to bed). Then, he could add another rule for sending the output of the house surveillance camera to his mobile phone when children are alone at home and some motion is detected near the house. He also defines additional alarms and reminders. Among the various rules created over time, he has added a rule for a weekly analysis of the history of the energy consumption in his house during the past week. In particular, he would like to have this report shown on the TV of the living room each Saturday, when he generally has time to relax. To this aim, John adds the following rule (rule4): "WHEN Date becomes Saturday AND IF User is seated AND user is in front of living room TV, DO Show Energy Consumption on living room TV". After having added this rule to his repository, John decides checking whether the smart home would actually behave as expected. By selecting the 'why not' button, the system shows that the rule is not verified, and the simulator notifies about an inconsistency between the behaviour specified in rule4 (which on the one hand would activate the report only at midnight on Saturday, as expressed by the event "WHEN Date becomes Saturday" in the trigger), and the simulated context (which on the other hand specifies the condition "Date IS Saturday", and then it would check whether the rule will be verified anytime on Saturday). After changing the following trigger: "WHEN Date becomes Saturday" into "IF date is Saturday" in the rule specification, John checks again the obtained rule through the tool simulator, which now shows that the rule is fully verified in the simulated context.

8.2 The solution

The goal is to allow end users without programming experience to be able to debug the execution of personalised trigger-action rules. In such rules an important issue is that it can be difficult to test whether the specified rules will behave as desired in the real context because often triggers depend on events and conditions that are not currently verified in the real environment (for example, a rule expressing that lights should be off at night cannot be verified if the current time

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is daytime). For this purpose, we found it important to support the possibility of simulating the state of the context of use by allowing users to assign values to various contextual aspects of interest (e.g. time, location, technology used), and then the tool will automatically check whether the indicated rules are triggered for the specified values. The simulator presents the hierarchical structure of the context model in a tree-like manner (see Figure 7, left panel). After activating the simulator, the tool will automatically unfold just the context dimensions and entities involved in the triggers included in the rules for which the simulator has been activated, while the other context dimensions will be hidden: this has been done to limit the effort of the user, who do not have to search within the context model for the elements involved in the defined triggers.

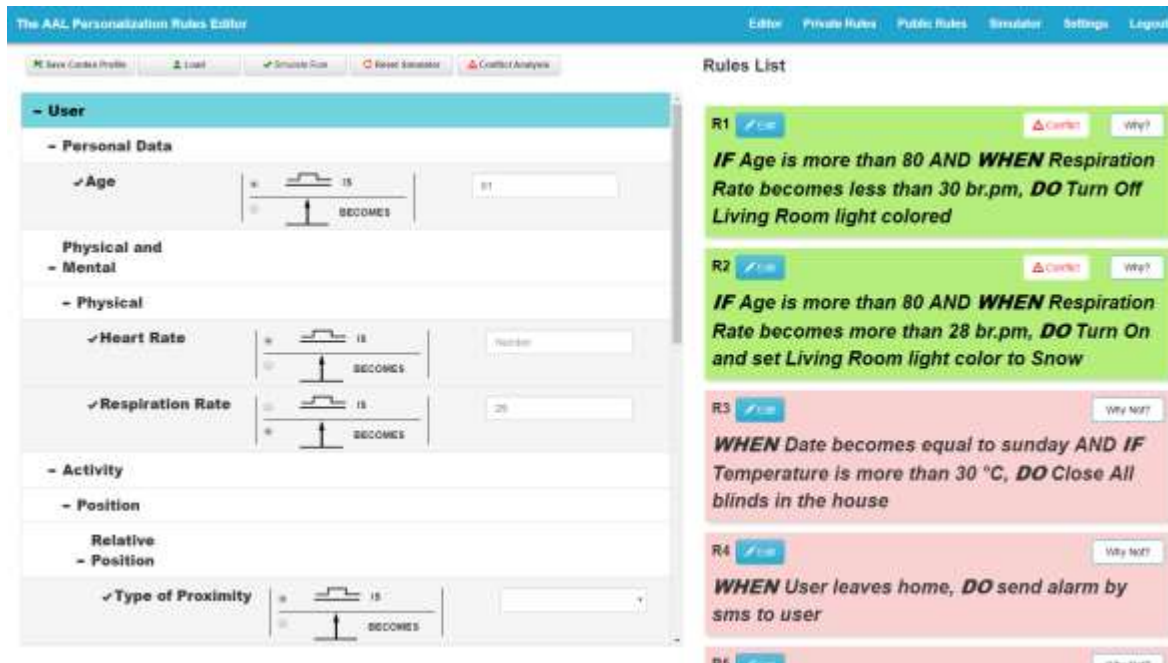


Figure 7: The environment for executing rules in a simulated context of use.

Figure 7 shows the simulator user interface: on the left part there is the (editable) instantiation of the context of use used in the simulation, while in the right part there are the rules indicated by the user. In the considered example, the context instantiation used in the simulation uses the following values: **"Age is 81"** (condition) and **"Respiration Rate becomes 29"** (event). When the user selects the *Simulate Rule* button, the tool checks whether the defined rules can be triggered when the state of the context is the one indicated on the left side. The results are shown by changing the background colour of the verified rules to green, while the colour of the rules that are not verified becomes light red. Moreover, as a result of the simulation, some buttons are displayed in each rule container: the **"Edit"** button allows users to activate the editing of a rule directly from the simulator; the **"Why"** (resp.: **"Why not"**) button is displayed only if a rule is verified (resp.: not verified): the *"Why"* button activates the highlighting of the contextual elements that are verified, the *"Why not"* button points out why the rule is not verified. Lastly, the **"Conflict"** button is displayed only if the rule is verified, it conflicts with other rule(s) and the priority of the verified rules is the same: when the user clicks on this button, this will invoke the

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conflict detection functionality, which produces an output as the one showed in Figure 9: in particular, it does not show all the conflicts but only the ones that involve the considered rule. In addition to the trigger values, the simulator also allows users to specify whether the value inserted for each contextual entity should be considered as associated with an event or a condition. To make this distinction clearer, the radio button representing the two possible choices has been augmented by two icons visually representing the difference between events and conditions.



Figure 8: Why Not Example

Indeed, on the one hand a rule is presented as verified only if the user specifies the right option (between event and condition) and provides the correct values to be used in the simulation. On the other hand, when a rule is not verified, in the explanation associated with 'why not' the tool UI highlights in red the elements that do not match, to inform the user about the reason(s) why the rule is not verified. Figure 8 shows how the interface changes after selecting the "why not" button: on the right panel only the selected rule is displayed, while on the left panel only the context elements related to that rule are shown and expanded in the tree representation of the context model. The verified triggers are highlighted in green (both in the context tree and in the natural language description shown in the right-hand panel of the window), while the parts of the trigger that are not verified will have a light red background.

As said, if a rule is not verified it could be for the following reasons: either the value used in the simulation is not able to activate the trigger contained in the rule; or there is an inconsistency between the event or the condition included in the trigger contained in the rule and those specified in the simulator; or a combination of the two situations. An example of the latter situation is shown in Figure 8. On the one hand, the natural language description of the rule specifies an event involving respiration rate (see in the right panel of Figure 8: "WHEN Respiration rate BECOMES < 30 bpm"). On the other hand, in the simulator (see left panel of Figure 8) not only a respiration rate value that does not verify the rule trigger used (namely: 31), but in the simulation that trigger is considered as a condition (in the left panel of Figure 8 the "IS" option of the radio button is selected), while in the rule specification it is modelled as an event. Thus, the simulator highlights these inconsistencies through a red border around the concerned elements in the left panel of the simulator (see Figure 8), and using a red text associated with

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the parts of the rule specification that are not verified, to indicate the reasons why the current rule fails.

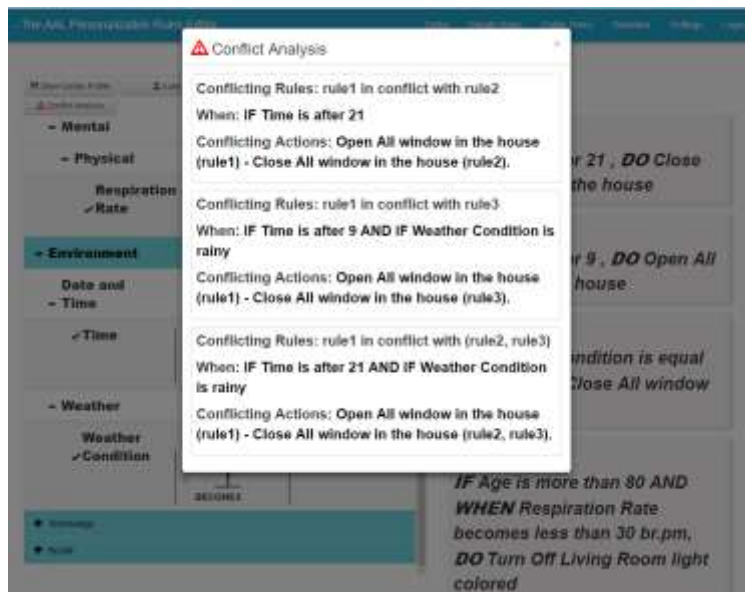


Figure 9: Conflict Detection and Analysis Tool

Figure 9 shows an example of the output produced by the tool. The rules that may conflict are 3:

- rule1: IF Time is after 9, DO Open All window in the house
- rule2: IF Time is after 21, DO Close All window in the house
- rule3: IF Weather Condition is rainy, DO Close All windows in the house
-

As we can see three conflicts are detected in the example presented in Figure 9. The results of the conflict algorithm execution show three important pieces of information: the name of the conflicting rules; when they conflict; the actions which cause the conflict. In the example the first and the second rules conflict when time is after 21. The first and the third rules presented before conflict when time is after 9 and it is raining. The first rule is in conflict with the second and the third ones when time is after 21 and it is raining.

It is worth pointing out that the tool shows the rules that are in conflict also taking into account possible priority values that have been associated with rules at design time. In this case, if there is a conflict on two rules having different priority values, the tool does not signal any conflict (since the conflict is actually resolved using priorities); on the other hand, if there is a conflict on two or more rules having the same priority, it shows them, so that the user can properly act to resolve them.

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Techniques for Adaptation, Customisation and Persuasion (Revised)



9 PERSUASION

There are no updates regarding the persuasion techniques.

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10 CONCLUSIONS

This document provides the updates that have mainly been done regarding the techniques for adaptation and customization currently supported in the PersonAAL platform. They have been mainly concretised in the implementation of a Rule Editor enabling users in creating and editing adaptation rules, as well as supporting them in detecting conflicts included in the rule set, and simulating and debugging the created rules. The design of such tool has evolved according to the feedback received during its use in the project.

We plan to further validate the effectiveness of such support through the user feedback that will be gathered in the upcoming field trials done in Switzerland and Norway.

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11 REFERENCES

Ko, A.J., and Myers, B.A., 2004. Designing the whyline, a debugging interface for asking why and why not questions about runtime failures. In Proceedings CHI'2004: Human Factors in Computing Systems (pp. 151–158). Vienna, Austria.

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