An IDE for Visual Programming of Smart Automations in the Internet of Things

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Outline

Smart Automations for Everybody

Blockly Studio

- 1. Projects and Editors
 - Device Management
 - Visual Programming for Smart Objects
 - Visual Programming for Automations
 - Project Management
 - Demo 1st Building smart automations
- 2. Runtime and Debugger
 - Running Automations
 - User Interface for Smart Automations
 - Debugging Facilities for Smart Automations
 - Demo 2nd Running and testing automations



Smart Automations for Everybody (1/3)

- Smart connected world in the IoT era
- People's daily lives could benefit through automations
 - Taking advantage of the smart objects
- Demands for such automations
 - Highly personalized and fluid
- Examples of applicable environments
 - Smart Environment/Living
 - Home, Office, School automations etc.
 - Ambient Assisted Living
 - Smart Tourism and Mobility
 - Transportation assistant

Smart Automations for Everybody (2/3)

Example: Daily automations at home



Smart Automations for Everybody (3/3)

Scenario Example: Remote Hospitality



End-User Programming

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Highly personalized nature of automations

Typically small-scale micro-applications

Niche-market with unlike industrial interest

- End-users should be enabled to craft such automations
- End-user programming (EUP) is a vehicle to achieve this goal
 - Methods, techniques and tools that allow users (non professional developers) to create, modify, or extend a program
 - Existing techniques
 - Spreadsheets
 - Scripting Languages
 - Natural Languages
 - Visual Programming



Editors and Projects Runtime and Debugger

- Handling Smart Objects as micro services
 - Customized VPL domain elements
- Communicating with smart objects via loTivity

| | | Define Smart Dev | vice | | × |
|---------|---------|---------------------------------------|-----------------------------------|----------------------|------------|
| | | Name: Image: Background-colour: | Smart Device 1 Επιλογή αρχείου | Δεν επιλέχθηκε κανέι | να αρχείο. |
| | | | | Cancel | Create |
| | - | | Ţ | | |
| 📕 🐗 Air | Conditi | on | | | |
| | /3DF | PrinterResURI | Scan | Register | |
| | /Air0 | ConditionResURI | ~ | Register | |
| | | Name: | /AirConditionResURI | | |
| | | ID: | _air-condition | | |
| | | Properties: | | | |
| | | device-temperature | | 20 | |
| | | environment-temperatu | ıre | 23 | |
| | | swing | | bottom | |
| | | turn | | on | |
| | | | | | |
| | /Bat | teryResURI | ~ | Register | |

- Handling Smart Objects as micro services
 - Customized VPL domain elements
- Communicating with smart objects via loTivity
- Organizing smart objects in groups

| Environment | | Home 👻 | |
|---|------------------------|--------------------|-----|
| Properties (4) | | | |
| device-temperature universal-id: device-temper | rature | 20 | ۲ |
| environment-tempera universal-id: environment- | ature temperat | 23 | ۲ |
| swing universal-id: swing | | bottom | ۲ |
| turn universal-id: <i>turn</i> | | on | ۲ |
| Actions (4) | | | |
| AutoMode | Not implemented for de | | ۵ 🐌 |
| Configure | Not | implemented for de | ۵ 🐞 |
| TurnOff | Not | implemented for de | ۵ 🐌 |
| TurnOn | Not | implemented for de | ۵ 🐌 |
| Smart Groups | | | |
| | There | are no elements | |

- Handling Smart Objects as micro services
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| | objectitop | | | | | | |
|---|--|--|---|--|--|---|---------------------|
| Property | Universal ID | | | | | | |
| ring | ring | | | | | | |
| ringtone | ringtone | | | | | | |
| time | time | | | | | | |
| turn | turn | | | | | | |
| Groups There are a | that match w no groups which that do not r | vith your c are matched natch with | device I with the smart object h your device | | | | |
| Groups There are i Groups Air Cond | that match w no groups which that do not r dition Group | vith your c are matched natch with | device I with the smart object h your device Air Condition Group | Universe UD | Alarm Cloc | ck | - |
| Groups There are f Groups Air Cond | that match w no groups which that do not r dition Group | vith your c are matched match with | device I with the smart object h your device Air Condition Group Property device-temperature | Universal ID device-temperature | Alarm Cloc Property | ck Universal ID (select group prope | rty) |
| Groups There are I Groups Air Cone | that match w no groups which that do not r dition Group | vith your c are matched match with | device I with the smart object h your device Air Condition Group Property device-temperature environment-temperature | Universal ID device-temperature environment-temperature | Alarm Close Property ring | ck Universal ID (select group proper device-temperature | rty) \$ |
| Groups There are I Groups Air Cond | that match w no groups which that do not r dition Group | vith your c are matched match with | device with the smart object byour device Air Condition Group Property device-temperature environment-temperature swing | Universal ID device-temperature environment-temperature swing | Alarm Cloo Property ring ringtone | ck Universal ID (select group proper device-temperature swing | rty) ¢ |
| Groups There are r Groups Air Cond | that match w no groups which that do not r dition Group | vith your c are matched match with | device t with the smart object h your device Air Condition Group Property device-temperature environment-temperature swing | Universal ID device-temperature environment-temperature swing | Alarm Cloo Property ring ringtone time | ck Universal ID (select group proper device-temperature swing environment-temperature | rty) ¢ ¢ ¢ |

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| device-temperature universal-id: device-temperature | ወ |
|--|--------|
| environment-temperature universal-id: environment-temperature | ወ |
| swing universal-id: <i>swing</i> | ڻ ا |
| turn universal-id: <i>turn</i> | ወ |
| | Reset |
| Smart Objects | |

- Handling Smart Objects as micro services
 - Customized VPL domain elements
- Communicating with smart objects via loTivity
- Organizing smart objects in groups
- Do not deal with programming of their behavior
- Cooperating with IDE
 - Notifying about user actions in smart objects (create, edit, delete)

Visual Programming Editor

- General purpose editors
 - Basic programming expressions
 - Variables, Math & Logic Operations, Branches, Loops, etc.
 - We use *Blockly* library
 - Allows define new blocks per domain



- Defining new blocks to develop IoT applications
 - Blockly does not deals with dynamic handling (i.e. create, edit, delete) blocks during the EUD process
 - VPL Manager deals with it
 - Exchanging messages with IDE and creating, editing and deleting blocks

- Based on data are exported by editor for smart object
 - IDE's extension mechanism provides updated the blocks of smart objects

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Getters



- Based on data are exported by editor for smart object
 - IDE's extension mechanism provides updated the blocks of smart objects

| C 🧔 Air | Condition: get | value from | device-temp | erature 🔹 |
|---------|----------------|------------|-------------|-----------|
| ls 🛈 | Alarm clock ri | ngs | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
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| | | | | |

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Actions





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Actions





Visual Blocks for Smart Automations

Conditional Events



Scheduling Actions



- Other approaches focusing on learning experimentation than provide an IDE
 - As result, project manager is not provided

| loT Personal Automations | ≡ |
|---|---|
| Morning Automations | |
| ✓ ¥ Automations for Basic Tasks | : |
| 🐝 Care My Pet | |
| P Automations for Conditional Tasks | : |
| 🕂 Home Safety | |
| ①**Leaving Home | |
| Waking Up | |
| Automations for Scheduled Tasks | : |
| 📽 Before Wake Up | |
| 👬 Cleaning Home | |
| 🔯 Washing Clothes | |
| ✓ Smart Device Groups | : |
| Home Doors | |
| 🕎 Home Lights | |
| $\sim \widehat{\mathbf{r}}$ Smart Devices | : |
| Air Condition | |
| 🔯 Alarm Clock | |
| 👸 Bath Heater | |
| 😨 Bedroom Lighting | |
| 🔚 Coffee Machine | |
| | |
| | |
| | |
| | |

- Other approaches focusing on learning experimentation than provide an IDE
 - As result, project manager is **not provided**
- Classic Project Manager of IDEs are not appropriate

| lot Pe | rsonal Automations | |
|---------------|-------------------------------|---|
| = 🗳 | Morning Automations | |
| ✓ ﷺ Auton | nations for Basic Tasks | : |
| * C | are My Pet | |
| 🗸 🥇 Auton | nations for Conditional Tasks | : |
| | lome Safety | |
| ſ∩*kL | eaving Home | |
| ب ∦_ْ∨ | Vaking Up | |
| 🗸 🛱 Auton | nations for Scheduled Tasks | : |
| 🌋 B | efore Wake Up | |
| 👬 C | leaning Home | |
| 0 V | Vashing Clothes | |
| 🗸 📚 Smart | Device Groups | : |
| I 🗄 H | lome Doors | |
| 🛛 🕎 H | lome Lights | |
| ✓ | Devices | : |
| M | ir Condition | |
| 🚫 A | larm Clock | |
| 🛚 📒 В | ath Heater | |
| 💡 В | edroom Lighting | |
| FC | offee Machine | |
| | | |
| | | |
| | | |
| | | |

- Other approaches focusing on learning experimentation than provide an IDE
 - As result, project manager is **not provided**
- Classic Project Manager of IDEs are not appropriate
 - Novices are not experienced on structuring projects
 - Assisted project structure is needed
 - Invent 5 types of project elements
 - Specified menu options and validation rules
 - Automatically handling dependencies of project elements



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 - Assisted project structure is needed
 - Invent 5 types of project elements
 - Specified menu options and validation rules
 - Automatically handling dependencies of project elements
 - Enabling to choose when automations will begin through project element options





Demo Part 1/2: Building Automations



1. Editors and Projects

2. Runtime and Debugger

Running Smart Automations

- Handling failed requests for smart devices
 - Connection issues or not enable action
 - Notifying users via dialogues
- How end-users build UIs for their automations?
 - Using WYSIWYG editor
 - Difficult process
 - Extremely costly
 - Not practical for micro applications



1. Smart Objects



2. Scheduled Tasks

| < | | | 2021 | | | > | < | FEBURARY 02, 2021 | > |
|-----|----------------|-----|------|-----|-----|-----|---------------------|--|----------|
| < | | FE | BURA | RY | | > | 23:24:44 - 23:24:44 | Wait Statement Block | I |
| MON | TUE | WED | THU | FRI | SAT | SUN | 23:24:44 - 23:24:44 | Wait 10 seconds to stop HiFi | |
| 1 | 2 ⁰ | 3 🄱 | 4 | 5 | 6 🎱 | 7 | 23-24-45 - 23-24-45 | Wait 10 seconds to Open window blinds, | |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 20.24.40 - 20.24.40 | TurnOff Air Condition | \sim |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 | 23:24:54 - end | Wait 10 seconds to execute TurnOn Air Condition | |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 | 23:24:54 - end | Wait 10 seconds to start television | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 23:24:55 - end | Wait 10 seconds to Invoke Prepare Bathroon | n |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 23:25:09 - end | Check every 35 seconds if bell rings | • |



2. Scheduled Tasks

| < | FEBURARY 2, 2021 | > | |
|----------------|--|---|--|
| 23:01:05 - end | Wait 10 seconds to execute TurnOn Air Condition | • | |
| 23:01:15 - end | Wait 10 seconds to TurnOn Water Heater | | Running Automations |
| 23:01:19 - end | Check every 35 seconds if bell rings | _ | Built-in Check every 35 Seconds if bell rings |
| 23:01:25 - end | Wait 10 seconds to Invoke Prepare Coffee | | Math do Main Door: set lock vo umock vo Text Main Door Open v Lists Main Light TumOn v |
| 23:01:35 - end | Wait 10 Seconds to TurnOff Water Heater | | Colour Variables Functions Television ChangeChannel with (channel:) ("Movies Channel ") |
| 23:02:25 - end | Wait 1 minute to StopPreparingCoffee | | Automations Scheduler |
| 23:05:44 - end | Bell rings in 5 minutes | | Time/Date Smart Devices Smart Device Groups |
| | | | |

3. History View

| | HISTORY |
|----------|--|
| NC. | When Block23:00:44, 02/02Status: Starts, Comment: When water is ready: open window blinds, TurnOff Air Condition, Invoke Prepare Bathroom |
| K | When Block23:00:44, 02/02Status: Starts, Comment: When coffee is ready: Stop and TurnOffHiFi, TurnOn Television and set volume and channel |
| I | When Times Block23:00:44, 02/02Status: Starts, Comment: When Times: window blinds are open: TurnOn and Play Hifi |



Why do Automations Occur?

- Users may wonder "what caused this automation to start?"
 - Not able to get information from source code executed
- Explanation notes of scheduled & conditional blocks
 - Inner blocks are able to change the execution code flow
 - Not adequate to answer questions
- Introducing new explanation blocks



Visual End-User Debugging

- Supporting full-scale visual debugger features
 - Tracing and watches
 - Breakpoints
 - Execution snapshots
 - Selecting project elements to execute

| 🚳 Debugging | | |
|---|-------------------------|----------|
| Debugger contr | rol | |
| | | |
| ✓ Debug Data | | ••• |
| Variables Watc | hes | |
| ⊕ Create a new wa ✓ I ⑦ Alarm Cl | <u>tch</u> ock rings | |
| (x + y) / 2 | 10 | |
| x | 17 | |
| У | 3 | |
| ✓ Breakpoints | | |
| 🛛 🚺 Alarm Clo | ck rings - ID 1 | |
| • 1 (Alarm Clo | ck rings - ID 2 | |
| • 📔 💼 Start TV - | ID 3 | V |
| Conditional Bread | akpoints | |
| 🛛 🕼 Thermom | eter (trig.: 1st) | 2 |
| TV (prop.: | turn ON/OFF) | |

- Is debugging & testing smart automations mission impossible?
 - Scheduled tasks
 - "Every Tuesday, Do ..."
 - Conditional tasks
 - "When smoke sensor is active then ..."

- Is debugging & testing smart automations mission impossible?
 - Scheduled tasks
 - "Every Tuesday, Do ..."
 - Conditional tasks
 - "When smoke sensor is active then ..."
- Simulating smart environment
 - Smart devices
 - Date and time



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 - Smart devices
 - Date and time
 - Actions of smart devices

| Actions (4) | |
|-----------------------------------|------------------------|
| PrepareCoffee | Implemented for debug |
| StopPreparingCoffee | Not implemented for de |
| TurnOff | Not implemented for de |
| TurnOn | Implemented for debug |
| turn universal-id: <i>turn</i> | off 👁 |

- Is debugging & testing smart automations mission impossible?
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- Simulating smart environment
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 - Actions of smart devices

| Actions (4) | |
|---|---|
| PrepareCoffee | Implemented for debug |
| StopPreparingCoffee | Not implemented for de |
| Loops Math Text Lists Colour Variables Functions Conditional | Wait (2 minute(s) then Coffee Machine: set prepare-coffee to stop to s |
| Scheduler Time/Date Smart Devices | (+) |

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 - Smart devices
 - Date and time
 - Actions of smart devices
 - Behavior of smart devices

| Title Test Ai | r Condition functionalities | Color |
|-----------------------|-----------------------------|--|
| Time Slots | | Changes |
| | | |
| Time (seconds): | 5 | ▼ Air Condition |
| Description: | Default Description | Properties |
| | | environment-temperature 29 Min:-10 Max:38 |
| | | |
| | | |
| Time 10 (seconds): | 10 | ▼ Air Condition |
| | | |

- Is debugging & testing smart automations mission impossible?
 - Scheduled tasks
 - "Every Tuesday, Do ..."
 - Conditional tasks
 - "When smoke sensor is active then ..."
- Simulating smart environment
 - Smart devices
 - Date and time
 - Actions of smart devices
 - Behavior of smart devices
 - Expected smart device values





Demo Part 2/2: Running and Testing Automations

Conclusions

- Focusing on enable non-programmers to develop smart automations
- We developed an IDE for visual programming of smart objects in the internet of Things
 - Including custom project manager, smart device registry and grouping, device dashboard, dynamic VPL blocks handling, new VPL blocks, debugging facilities, and complete runtime

Thank you for your attention!

