Faculty of Technology and Society: Department of Computer Science

Master Thesis Project 30p, Spring 2015

A Visual Rapid Prototyping Environment for Smart Home Concepts

By: Emma Mainza Chilufya

E-mail: emmamainza@hotmail.com

Supervisors: Bo Petersson and Daniel Spikol

Examiner: Romina Spalazzese

October 19, 2017
Master Thesis Project: A Visual Rapid Prototyping Environment for SmartHome Concepts

Contact Information

Author:
EMMA MAINZA CHILUFYA
E-mail: emmamainza@hotmail.com

Supervisor:
DANIEL SPIKOL
E-mail: daniel.spikol@mah.se
Malmö University, Department of Computer Science.

Supervisor:
BO PETERSON
E-mail: bo.peterson@mah.se
Malmö University, Department of Computer Science.

Examiner:
ROMINA SPALAZZES
E-mail: romina.spalazzese@mah.se
Malmö University, Department of Computer Science.
Abstract

This research project is part of the Internet of Things and People (IoTaP) project at Malmö University. The project focuses on the aspects of human-computer interaction in a visual programming environment. Visual programming is becoming increasingly popular in different sector of the IT world. Visual programming allows for novices or non-professional programmers to create systems without any or extensive scripting/coding skills. The research presented in this thesis is on a visual rapid prototyping environment that is founded on an existing smart home platform, and allows for designers and developer to prototype smart home concepts using smart devices. The research methodologies used involve Design Science methods infused with User-Centered Design principles and methods (Participatory Design). The research process involves a series of workshops performed with some of the IoTaP smart home researcher. The research process also involves qualitative investigation of existing visual prototyping tools and techniques.

A prototype of a visual rapid prototyping environment was used to evaluate the research findings. The evaluation process focused on defining the benefits of a visual rapid prototyping environment and how it can help improve the design and testing process of smart home devices.

Keywords: User-centered design, participatory design, prototyping, visual prototyping, Internet of Things, smart homes, Design Science, Node-RED, rapid prototyping, user interaction, visual programming.
Popular Science Summary

The automation of homes is something that is becoming popular and less costly. Home automation has gone beyond security, it now includes technologies that allow for the remote (using mobile apps, websites, sensing devices) control, detection and monitoring of: household electronics, plants, temperature, human or pet presences, door and window. The design of smart home concepts (preset or pre-defined activities) helps put generated smart home ideas into perspective, it helps envision and evaluate ideas before the development phase. Rapid prototyping and evaluation of the design concepts using existing smart home physical devices is a technique that helps ‘bring the designs to life’. It gives a clear view of the designs and how they are to function once developed.

The goal of the research presented in this thesis is to create an environment that allows designers and developers to rapidly prototype concepts using actual smart home devices using a visual interface of a web application. The environment is to be connected to existing smart home devices and services, and the devices and services are to be visually presented in the form of drag-and-drop blocks, and links that represent relationships between the devices and services. A visual interface was selected to allow designers to develop concept without the need of advanced programming skills.

A prototype of the Visual Rapid Prototyping Environment is created after a series of workshops with a selected group of designers, and an investigation of existing prototyping tools. The created prototype is evaluated with the selected group of designers. The results of the evaluation indicate the benefits of the prototyping environment and how it can help speed up the design process, and the quality of final smart home products.
Master Thesis Project: A Visual Rapid Prototyping Environment for SmartHome Concepts

Contents

1 Introduction 9
  1.1 Project Concept ............................................. 11
  1.2 Objective .................................................. 12
  1.3 Motivation .................................................. 12
  1.4 Research Questions ....................................... 13
  1.5 Contribution ............................................... 14
  1.6 Limitations ................................................ 14
  1.7 Report Structure .......................................... 14
  1.8 Thesis Context ............................................ 16

2 Background Literature 18
  2.1 Summary ................................................... 21

3 Research Methodologies 22
  3.1 User-Centered Design ...................................... 24
    3.1.1 Tools and Techniques ................................. 24
  3.2 Qualitative Methods ...................................... 26
  3.3 Ethics ..................................................... 26

4 Visual Prototyping Concepts and Results 28
  4.1 Workshop One: Concept Generation .................... 29
  4.2 Workshop Two: Concept validation ..................... 32
  4.3 Visual Prototyping tools and techniques Review ...... 35

5 Evaluation 38
  5.1 Concept Creation .......................................... 38
  5.2 Workshop Three: Concept Evaluation .................. 40
    5.2.1 Results and Review .................................. 41

6 Conclusion 43
  6.1 Future Work ................................................ 43

Appendices 49
Appendix A - Workshops

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1 Scenarios and Menu Features</td>
<td>49</td>
</tr>
<tr>
<td>A.2 Semi-structured Interviews</td>
<td>51</td>
</tr>
</tbody>
</table>
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project focus area (idea generation)</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Interaction Design and Design Science Methodologies</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Project Iterations</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>Rapid prototyping session</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>Rapid prototyping session</td>
<td>33</td>
</tr>
<tr>
<td>6</td>
<td>The main prototyping styles of the Investigated tools.</td>
<td>37</td>
</tr>
<tr>
<td>7</td>
<td>Logical view of the prototyping tool</td>
<td>39</td>
</tr>
<tr>
<td>8</td>
<td>Customized Nodes and relationships illustration</td>
<td>40</td>
</tr>
<tr>
<td>9</td>
<td>Child Monitoring Scenario (Group A)</td>
<td>49</td>
</tr>
<tr>
<td>10</td>
<td>Device adjustments based on room occupancy Scenario</td>
<td>50</td>
</tr>
<tr>
<td>11</td>
<td>Teenager Monitoring Scenario (Group B)</td>
<td>50</td>
</tr>
<tr>
<td>12</td>
<td>Menu Tool suggestion</td>
<td>51</td>
</tr>
</tbody>
</table>
List of Tables

<table>
<thead>
<tr>
<th></th>
<th>Interviews: Group A</th>
<th></th>
<th></th>
<th>Interviews: Group B</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

52
53
List of acronyms

**IoT**  Internet of Things

**WoT**  Web of Things

**IoTaP**  Internet of Things and People

**RFID**  Radio Frequency Identification

**UI**  User Interface

**PD**  Participatory Design

**UCD**  User-Centered Design

**DS**  Design Science

**IS**  Information System

**API**  Application Programming Interface

**HTTP**  HyperText Transfer Protocol

**HTML**  HyperText Markup Language

**PHP**  HyperText Preprocessor

**IFTTT**  IF This Then That
1 Introduction

The Internet of Things (IoT) is one sector that reveals tremendous growth. It offers the potential of virtually endless opportunities for applications and services in the “Smart Home” area [4]. IoT is a concept that involves the connection of physical objects to the Internet for the purpose of: identification, making trigger (interaction), and communication with other objects. These objects are referred to as “smart objects”. Smart objects can be defined as “real artifacts augmented with computing, communication, sensing/actuation and storing functionalities” [5]. The smart objects in the case of a smart home include home appliances, security systems, Wi-Fi devices, heating and electric systems. Smart objects are developed with tools and environments that allow for the communication and interaction of smart objects. Arduino is an example of a smart object development environment.

Arduino is “an open-source computing platform” [6] comprised of a simple micro-controller board and a software development environment. It is a tool that includes sensing and interactive features that can be used to control the physical world. [6]. Arduino is a development platform that includes sensing and interactive features which can be used to develop smart objects in an IoT (smart home) environment.

IoT can be extended to include webs services, which incorporate other smart objects and services (such as mobile devices and social media) to the IoT. This is defined as the Web of Things (WoT), Guinard [7] states that “The Web of Things (WoT) explores the layer on top of connectivity with Things and addresses issues such as fast prototyping, data integration, and interaction with objects.” It embeds smart objects into the web and makes them available as resources through standard web mechanisms [8]. This is illustrated in the figure below.
This research is under the umbrella of smart homes, focusing on prototyping the interactions with smart objects over the web (WOT). The figure above illustrates the smart home entities, activities, and dependencies of our research area. These are narrowed down to our research contribution (highlighted in red), which includes the application layer, scripting engines, and controlling prototype.

The Application layer provides an interface between web technologies and smart objects. It masks the heterogeneity of the WoT entities (transparency). It provides the platform “to reuse and adapts existing web technologies to build new applications and services [8]. The Arduino open-source Integrated Development Environment (IDE) provides interaction/transparency between the application layer and physical object.
The scripting engine is a “vehicle for implementing scripts in scripting languages” [9]. It allows for the interconnection of any suitable written application or server with scripting language. The scripting engine provides a platform for the creation and compilation of application services of WoT. [10] The scripting engine allows for the interaction with the application layer.

Prototyping is a tool/method that allows for the design of product concepts. In the context of smart home systems, prototyping involves creating concepts that illustrate the interactions between web technologies and smart (physical) objects. Weis al et [11] states that the capability differences of pervasive computing appliances and applications (web technologies and smart objects) demand for different programming models. This makes rapid prototyping impractical. “Rapid prototyping therefore requires a programming model that hides the environment’s heterogeneity [11]”. Our research goal is: To design and develop a visual rapid prototyping environment that hides the environment’s heterogeneity and allows for the prototyping of interactions between web technologies and smart (physical) objects.

1.1 Project Concept

This research project is part of the IoTaP (Internet of Things and People) Smart Home Project. IoTaP is a Malmö University research center that focuses on the Internet of Things and how people (computer scientists, interaction designers, professionals and users) can get the most out of it [12]. IoTaP Smart Home focuses on home enrichment through continuous coupling of ‘things’ in the material (physical home devices), and the social world (digital interaction surfaces). Encompassing daily routines and specific social arrangements.

The IoTaP Smart Home Project is made up of a number of organizations/companies (partners) and individual projects. The individual projects are associated with different research areas including:
A Visual Rapid Prototyping Environment for SmartHome Concepts

smart home energy efficiency, Mobile services, privacy management (home security), and Smart Home Interactions. Our research is associated with the ‘Smart Home Interactions’ research. We are looking to create a prototyping environment for smart home interactions with web technologies.

Verisure is one of the companies that is part of the IoTaP Smart Home Project, and is closely associated with our research project. Verisure is a leading professionally monitored home alarms and connected services provider [13]. Verisure provides smart home services that range from security to mobile control of household appliances and fittings. These are the technologies we will use to create the prototyping environment.

1.2 Objective

The objective of our project is to develop a visual rapid prototyping environment that allows ‘power’ users (designers) such as: concept designers/developers, researchers, and ‘white-hat’ hackers to develop and evaluate new concepts and scenarios in combination with existing smart home products and services. The prototyping process will involve creating a rapid prototyping environment mounted onto Verisure’s existing Smart Home platform, ‘Verisure IQ’. The will be used to evaluate our findings with a selected group of users.

1.3 Motivation

The prototyping platform will be a visual implementation of a scripting engine. Scripts (text-based scripts such as java scripts) are presented to the users in a graphical form: interlinked nodes or blocks. The platform will be developed using prototyping tools and techniques that make it possible to develop scripts that aid interaction between the physical (smart objects) and application layer.

Our targeted users are designers who do not usually write text-based scripts when prototyping concepts.
“It is commonly acknowledged that the human mind is strongly visually oriented and that people acquire information at a significantly higher rate by discovering graphical relationships in complex pictures than by reading text” [14]

Quite a lot of effort has been made in ensuring that a programming language is efficient and expressive, but less effort has been directed at improving the language’s facility: the ease of translating requirement tasks into statements (text scripts) of a programming language [15]. The introduction of graphical programming was to allowing not only computer experts but also novices to make software implementations with ease.

The continuous growth of diverse smart objects, has introduced the demand for usable designs. Product designers commonly build a series of prototypes that structure innovation, collaboration, and creativity [16]. Designers learn about the problems they are trying to solve through prototyping. Our project is influenced by the growing graphical programming environment and the ongoing increase of prototyping platforms that in-cooperate physical and logical entities (smart objects and web services).

1.4 Research Questions

The objectives, motivation and goals helped form the research questions of the project. They form the part of the thesis investigation that influences the aim to find solutions to the research questions during the project. The research comprises of a main question with two sub questions:

- How to design and develop a visual rapid prototyping GUI over an existing smart home platform?
  - What visual (interface) prototyping features are suitable for concept designers?
  - What visual prototyping tools and techniques are suitable for embedded interactions of smart home objects?
The research questions influence solutions that contribute or help build our intended research contribution. The questions will help us understand what is required to create a rapid prototyping graphical user interface, and how it can be integrated into an existing smart home platform. The first sub question will help us understand What is required to create a rapid prototyping environment that meets the users/power users’ needs. The second sub question will help us evaluate and select the suitable visual prototyping tools and techniques.

1.5 Contribution

The aim of this thesis is to contribute to Human Computer Interaction research, by developing a prototype model of the Rapid prototyping platform that enables users to: prototype interactions with physical (smart home) devices connected to existing smart home platforms, and customization of the interactions using a graphical interface. The model should allow researchers to model concepts and integrate other features or services.

1.6 Limitations

The research process has a number of limitations in relation to the fact that the project is carried with a company. Some of the limitations include: predefined integration specifications (have to be compatible with the VerisureIQ), limited type of users and or workshop participants, and company terms and policies.

1.7 Report Structure

This report is comprised of a number chapters that help define the research proceedings and methods. The background literature chapter begins with a high-level background of the research area, the ‘research gap’ and a review of the background research. The research methodologies chapter covers the methodologies used to find solutions to the research questions, and the tools and techniques used during the project. Chapter 4 covers the project activities
and outcomes. This includes the workshops and the prototyping tool selection process. The evaluation chapter covers the prototyping session and the final workshop: concept evaluation. The report ends with a conclusion chapter (which includes future work), and appendices.
1.8 Thesis Context

This thesis is part of a larger project that included another master thesis and part of ongoing research in the IoTaP research center with Verisure AB. My research area focuses on User Interaction, whilst the other focuses on backend implementations [17] of the prototyping platform. The goal is to contribute to the design of software platforms, with the intention of designing a Software tool that allows designer and developers to seamlessly create and test smart home behaviours and activities. My focus area of the project is the visual interactive aspect of the prototyping platform. This encompasses the users’ visual requirements, interface and interaction design.

In the two theses (focus areas):

- We planned, carried-out and shared the findings of the first two workshops (interpretation of findings was done separately).
  - The preparations of the third work (prototyping and user testing sessions) where done separately.

- The investigation of the suitable prototype tools where done separately due to the different focus areas, but we agreed on the final tool (based on the workshops and individual findings).

- We discussed and agreed on how the two focus areas’ findings can be created into a prototype and merge with the VerisureIQ. This was done to help meet the two research goals.

- Main project decisions were made together. Such as:
  - meetings with the different stakeholders, what tools and activities best fit each workshop.

My thesis contributes to the visual interactive aspect of a prototyping platform. Looking at what interactive interface is suitable for researcher and developer to rapidly prototype ideas. The methodologies focus on the user experience (UX) and user involvement throughout the entire project. Focusing on how their current interface interactions can influence the design of future interactions.
with the visual prototyping tool.

whiles the other thesis contributes to the integration of prototyping platform with existing systems. Looking at the "backend components to design and integrate (to Verisure IQ) a working prototype which includes minimal UI components" [17].

The similarities in the two theses include the methodologies used and the research activities. The differences include the focus areas, the investigation of the different visual prototyping platforms and the interpretation of the findings from the research activities. Each researcher carried out the investigation of the different visual prototyping platforms and the interpretation of the findings based on the different focus areas.

As a team we planned and attended all the project meetings with the different stakeholders. We discussed the steps and milestones of the project. We also planned and organized the workshops. Individually we separately carried out:

• The workshop activities. Participants were always separated into two groups and we each took one group.

• Research of the different focus areas: including the topics, research questions.

• The documentation of each focus area.

• The Presentations of each focus area.
2 Background Literature

Internet of Things (IoT) is basically an environment of interactive things or objects over wireless telecommunications for the purpose of reaching a common goal \[18\]. The objects usually include: Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones, arduinos etc. The objects are identified through unique addressing schemes. They are the building blocks for smart objects. Kortuem \[19\] states that a smart object “is, autonomous physical/digital objects augmented with sensing, processing, and network capabilities.” The distributed architectural model of smart objects allows for the access of physical devices over a network using digital attributes. The Internet of Things is more than a technical system, it should also be considered as human-centered interactive system \[19\]. This is because the activities of smart objects can be controlled by user actions over wireless telecommunications.

Smart homes are physical home environments that incorporate IoT objects/devices. The devices are defined to sense and record user activities so as to predict future behaviours in order to “prepare everything one step ahead according to the user’s preference or needs, giving them the most convenience, comfort, efficiency, and security” \[20\]. IoT enables the self-configuration and remote controlling of smart objects over the Internet, and the monitoring and controlling of smart objects using applications. An Arduino is one example of a tool that can be used to remotely control and monitor smart devices. Arduino platforms are development tools and environments that have sensing and interactive features that can be used to create smart home objects. Arduinos are ‘open source electronics platforms’ targeted at novice users (such as hobbyists, artists) who do not necessarily have a background in electronics or programming \[6\].

The remote control and monitoring of smart home devices is done over the web (as illustrated in figure \[1\]). Pintus et al \[21\] state that “The Web of Things (WoT) is a scenario where potentially billions
of connected smart objects communicate using the Web protocols, HTTP in primis”. The IoT is described as a form of connection that tackles the mechanisms to connect smart objects, whilst the Web of Things addresses the integration of the IoT embedded systems into the Web [8]. The web’s protocols represent the ‘lingua franca’ in a heterogeneous world [21]. Pintus et al [22] state that “Simple mechanisms to connect ‘things’ can foster a huge number of unpredictable applications. Towards these objectives, users, objects and networks are the ingredients to build a Web of things in which users become seamlessly the ‘programmers’”. Our research falls in this area, in that we aim to understanding prototyping tools and techniques suitable for embedded interactions of the application layer (Smart home objects).

WoT does not only integrate smart things (objects) into the Internet, it integrates them into the Web (the application layer) [23]. The application layer consist of “Popular Web languages (e.g., HTML, Python, JavaScript, PHP) used to easily build applications that involve smart things and users who leverage web mechanisms (e.g., browsing, searching, bookmarking, caching, linking) to interact and share these devices” [23]. We aim to understand which scripting languages are suitable for embedded interactions of smart home objects over an Arduino platform, and how a graphical prototyping environment can be developed using the selected language (engine).

**Graphical programming:** There is a continuous growth in the number of specialists associated with design and development but lack the programming skill. As a result, this has led to a continuous rise in the number of graphical/visual prototyping tools. [24] Sukaviriya et al state that the fast production of solutions has called for a rise in visual user interface design tools. “The need to quickly create UI becomes prominent very early in business processes” [24].

**Prototyping:** Hartmann et al [16] state that “Prototyping is the pivotal activity that structures innovation, collaboration, and creativity in design”. Prototypes incorporate designers’ hypotheses and
Master Thesis Project: A Visual Rapid Prototyping Environment for SmartHome Concepts

allow designers to test them. Prototypes allow designers to frame designs as a thinking-by-doing activity that foregrounds iteration as a central concern [16].

Examples of visual prototyping tool that integrate different platforms include: SimITK [25] which is a tool used in surgery applications. This is a tool targeted at users without appropriate C++ programming experience. The tool facilitates rapid prototyping without the complexities of programming. d.tools [16] is “a toolkit that embodies an iterative-design-centered approach to prototyping information appliances”. d.tools supports design thinking through the interaction of hardware and software, and design, test, and analysis of information applications (physical prototyping).

Prototyping is an important stage of ‘multimodal’ development processes, in that it allows designers to address complex problems in an iterative manner [26]. It allows for designers to ‘plug and play with modalities’: easily combine modalities, and reuse previous stages work with little low-level programming knowledge. Lawson et al [26] state that “There is currently few ready-to-use software solutions aimed at filling the gap between the design and specification stage and the implementation process of a functional system”. They go on to say that the currently presented tools either: “present a small or hardly extensible number of input devices, they are platform and technology dependent, or they do not provide a flexible prototyping environment for a large and heterogeneous number of research products (such as new device prototypes, new algorithms, etc.)” [26]. More recent tools are either designed for specific interaction techniques or focus on hardware prototyping [16], [27]. That leads us to understand that there is a lack of visual prototyping environments that are not technology dependant or are not intended for specific interaction techniques and products. We would like to contribute to this gap by creating a tool that will provide a flexible prototyping environment that enables prototyping of heterogeneous products in an open environment (allows for extensibility).
2.1 Summary

Our goal is to contribute to the design of software platforms (provided guidelines), with the intention of designing a Software tool that allows designer and developers to seamlessly create and test smart home behaviours and activities. We are to create a prototype of the visual rapid prototyping tool (environment) to be mounted onto an existing smart home platform. This will allow designers to design and test smart home concepts using physical smart devices and connections to get immediate results. The design, development and evaluation processes will be carried out using a combination of User-Centered Design and Design Science methodologies. The methodologies will be carried out in conjunction with a series of workshops with a selected group of designers.
3 Research Methodologies

The research process of the project will be a mixed method approach which includes both Interaction Design and Design Science Research methodologies. We selected these methodologies so as to enhance the Design Science Research process with the application of Human-Computer Interaction methods that involve user-centered interactions and designs. We want to include methods that involve user experience and participation. The methodologies will include qualitative methods, Participatory design (PD) and User-Centered Design (UCD) principles.

Design Science (DS) is defined as a world view paradigm that can be seen as “a process of recognizing, defining and solving problems, and a process of formulating a goal and the systematic path of reaching that goal” [28]. DS research in Information Systems is made up of six steps [29] and these steps are iterated during the project:

1. Problem Identification and Motivation: This step is carried out during the project definition phase, which includes literature review and the first workshop.

2. Definition of the Objectives for a solution: This step is covered during the research goal (research questions) definition phase of the project, and concept generation phase with the participants.

3. Design and Development: This step is covered during the investigation, design and development phases of the visual prototyping environment. This includes the design activities with the workshops participants.

4. Demonstration: This is covered during concept demonstration activities and the evaluation phase of the project (final workshop). Demonstrations are also covered during the thesis presentations.
5. **Evaluation**: This is covered during the evaluation of the final Visual Rapid Prototyping Environment prototype. Evaluations are also iterated during the testing of concepts and development tools.

6. **Communication**: This covers all the proceedings of the project including: presentations, interviews, meetings, discussions and feedback sessions.

![Figure 2: Interaction Design and Design Science Methodologies.](image)

The figure above illustrates the processes and activities of the methodologies and how they are applied throughout the project. The workshops and investigation process are represented by coloured spheres (each having a different colour), and each Design Science step is placed in the sphere it’s to be carried out in. The **Communication** on the other hand takes place in every stage of the project. Some of the Interaction Design tools and techniques used are linked to either one or two workshops, and the agile methods are applied to all project activities.
3.1 User-Centered Design

User friendly is the term used by computer system designers and developers to label products that are believed to be easy for the end-user. However, Nielsen [30] indicates that friendly or easy for one user may not be the same for another, and as a result “principles of user-centered design have become very important in the design and development of software and information systems” [31]. User-centered design is a Human-Computer Interaction approach that became widely used in the 1980s [32]. It is a design process where product designs are influenced by the end-users’ perceptions and responses. “It is a flexible, collaborative process for software development projects that enables teams to more effectively meet the needs of users and customers” [33].

Participatory design is seen as ‘an outgrowth’ and a form of user-centered design [34]. It is the theories, practices, and studies that relate to full participation of end-users in the activities that lead to the final deliverables of a project [35, p.5]. The project activities range from requirement specifications, to design, development and implementation. We decided to use a combination of Participatory design (PD) and User-Centered Design (UCD) principles, because not only would we like to involve the end-users in the project, we would also like to know about their current practices, perceptions, responses and reactions to applied deliverables.

The design and development of the Prototyping Environment is influenced by the end-users’ needs. The main end-users involved in our research process are Verisure’s Concept design and development team, and IoTaP Smart Home researchers. The users will participate in a number of phases of the project including: requirements analysis, design, prototyping, testing and evaluation.

3.1.1 Tools and Techniques

The tools and techniques to be used during the different phases of the project as illustrated in figure 2 are:
• Rapid prototyping: This is a methodology that allows for the early and quick designing, implementation and testing of a system model \cite{36,37}. This process will be used during the workshops with the identified designers to design and redesign the prototyping environment concepts. One of the main tools for the prototyping process will be paper prototyping: quick hand-sketches (drawings) that provide a visualization of the product concepts.

• Usability Testing: is defined as systematic observation and recording (collection of information) of users’ action/interactions with a product or proposed concept \cite{15}. This is a UCD tool that will be used in the workshops with the designers.

• Task based testing: Task based evaluation is a user-centered form of evaluation that focuses on adequacy and user satisfaction \cite{38}. This tool will be used to evaluate proposed concepts with the identified designers.

• Semi-structured interviews: “Semi-structured interviews are used to understand how interventions work and how they could be improved” \cite{39}. This will be used to get feedback and steer the workshop activities during the project.

• Agile methods: “these methods focus on generating early releases of working products using mostly collaborative techniques such as having customers work on site as team members” \cite{40}. The agile methods will be applied throughout the project activities. Every workshop and or meeting with the participants will involve producing or testing a product/concept.

We selected these methodologies and principles, because they are useful in helping us understand what is required to design and develop a visual prototyping environment (Research Question 1). The methodologies and principles allow us to work closely with a group of designers (who are also the end-users) with the objective of creating a product that will be useful and easy to interact with. The tools will give us the opportunity to have direct understanding
of the end-users' current problems, their interaction practices and needs.

3.2 Qualitative Methods

A qualitative investigation and evaluation of existing visual prototyping tools and techniques will be carried out. This will help us find out which one of the tools and techniques is suitable for designing a smart home prototyping environment that can be easily mounted onto an existing platform. The evaluation of the visual prototyping tool and techniques will be based on inductive reasoning. This is because we would like investigate existing visual prototyping tools and evaluate using outlined criteria. The criteria are the functional and non-functional requirements realized after the workshops, and the visual prototyping environment design requirements. The design requirements are based on the: Learning curve, extensibility, Integration, and user specifications.

Inductive reasoning “is moving from fragmentary details to a connected view of a situation” [41].

Inductive reasoning is used during the investigation of existing visual tools to narrow the selection to a tool that is suitable for the creation of an evaluation tool. we want to create the visual rapid prototyping environment using existing tools that can be customized according to the designers’ (end-users’) needs. During the research, we will investigate and select suitable visual rapid prototyping tools and techniques that can embed interactions of smart home objects. This will provide the solution to the second Research Question.

3.3 Ethics

Research involve the collection of data from people and about people. As a result, ethical issues need to be anticipated. Researchers need to maintain confidentiality and protection of research participants, a bond of trust, integrity of research, and guard against
misconduct and impropriety that might reflect on the organizations/institutions involved \cite{42} \cite{43}. “A common ethical criterion is that material collected for scientific purposes may only be used to this end and cannot be used as instruction material or for commercial purposes” \cite{43}.

The continuous increase in the complexity of usability issues has lead to the rise of having users as valuable sources of information and guidance in design processes, and the users can no longer be viewed as generic in the case of participatory design research. The designers need to communicate with the users to be engaged in the design process \cite{44}. Macaulay et al \cite{45} state that “Participatory research is strengthened by local, jointly negotiated, ethical codes or agreements that ensure the sharing of leadership, power, and decision making from design to dissemination”. The parties involved are to agree on: “roles and responsibilities, desired outcomes of the research, measures of validity, control of the use of data and funding, and channels to disseminate findings” \cite{45}. The results are to be discussed with the participants, allowing for joint interpretation of the data. The agreements and communication can be in writing or orally.

These are some of the main ethical guidelines and steps covered during our research. Involved parties are to be informed of all proceedings of the project, and decisions and outcomes are to be discussed and agreed upon. The project will not include any personal or private information, and the data collected is anonymous (not personified). All this is done with the concert of the involved parties.
4 Visual Prototyping Concepts and Results

The Project processes have involved a literature review, ongoing workshops (user participation) and an investigation/review of current visual prototyping tools and techniques. The workshops will be used to find the solution to the Research Question: *How to design and develop a visual rapid prototyping GUI over an existing smart home platform?* focusing on the sub research question:*what prototyping features are suitable for concept designers?*. For we design the features and functionalities of the prototyping environment with the designers (IoTaP researchers). We use the investigation/review to find the solution to the sub research question:*What visual prototyping tools and techniques are suitable for embedded interactions of smart home objects?*, in that we investigate existing visual prototyping tools and techniques. In relation to figure 2, the figure below illustrates the link of the research questions to the project activities.

Figure 3: Project Iterations.
4.1 Workshop One: Concept Generation

**Purpose:** The aim of the workshop was to come up with concepts of the visual prototyping environment using existing information including the designers’ current practices and shortcomings. This is represented by the *feedback* and *scenarios* defined by the designers. The tools and techniques used during the workshop include rapid prototyping and semi-structured interviews.

**Data Collection:** The data collection process included audio recordings, pictures, and note taking.

**Activities:** The workshop involved six participants, and two facilitators (project researchers). We began the workshop with an introduction of the project, then the purpose and proceedings of the workshop.

**Rapid Prototyping Session**

The participants were divided into two groups, and each group had one facilitator. The rapid prototyping session involved the use of paper prototyping tools and some of the items used include:

- A3 sheets - which were used to represent the User Interface.
- IMAGE cut-outs - used to represent products and services.
- Posits - (blank canvases) used to include unrepresented products and services.
- Felt-pens/ markers - used to mark relationships, boundaries, and write down information.
1. scenario Creation: Each team was to create 3 smart home scenarios that would involve the use of existing smart home objects. We provided each team with the appropriate tools, including existing Verisure products and services, and online services such as tweeter representations.

2. Menu Tools: Each team had to come-up with possible menu tools and features that would be beneficial to the Visual Prototyping Environment users.

Semi-structured Interview

The interviews were one-on-one interviews between the facilitators and each group member. Each participant was asked seven questions concerning their current prototyping practices, their take on the visual prototyping environment, and feedback on the workshop as a whole. The responses from participant are in Appendix A.3.
Questions

• Q1: Currently, when you prototype similar concepts, what methodology, work-flow do you use?

• Q2: Currently, when you prototype similar concepts, what tools do you use?

• Q3: Do you think that visual programming is expressive enough?

• Q4: Do you think having such prototyping environment will be useful for your work?

• Q5: How do you intend to use it?

• Q6: What other features or functionalities do you want to see in this prototyping environment?

• Q7: Is there something you would suggest, that we could add in the next workshop?

Workshop Review

After reviewing the workshop data and feedback, we decided reduce the number of scenarios to two. The selection was based on common features and similarities in the proposed scenarios. ‘Child Monitoring Scenario’ from group A, and ‘Teenager Monitoring Scenario’ from group B saved the same purpose, so we decided to make it into one scenario. ‘Menu Tool suggestion’ focused on devices that were not in the VerisureIQ yet, so we decided to remove the scenario. All the scenarios are in appendix A. The selected scenarios were renamed to:

• The Child-Monitoring scenario, this is a combination of parenting scenarios from both group A and B.

• Heating System, this was derived from the Device adjustments based on room occupancy scenario from Group B.

Both teams where agreeable to having the tool bar on the left side of the screen, drag and drop items (tools used to represent products and services) for the creation of events. The proposed features where centered on:
• Extensibility: the visual prototyping environment should include features that should act as serving templates. Allow for customization.

• Suggestions: Features should include tips: for instance stating possible connections. Comment and history features.

• Support: Help features that provide examples, connection to forums and

• Multi-user: Features that allow for the identification of a designer/developer in a group setting (who did what), and reuse of created solutions by others or in a different setting.

The above results help in the review and selection of a suitable visual prototyping tool.

Overall, the workshop participants see the potential benefits of the Visual Prototyping Environment. How it can help reduce design time and allow for quick testing and evaluation.

4.2 Workshop Two: Concept validation

Purpose: The aim of the workshop was to test the proposed concepts and features of the visual prototyping environment. It involved the investigation of selected node or flow based visual representations of the domain model in smart homes. The main tool used during the workshop was rapid prototyping.

Data Collection: The data collection process included audio recordings, pictures, and note taking.

Activities: The workshop involved four participants, and two facilitators (project researchers). We began the workshop with an introduction of the project, recap of workshop one, then the purpose and proceedings of the workshop.
Rapid Prototyping Session

The participants were divided into two groups, and each group had one facilitator. The rapid prototyping session involved the use of paper prototyping tools and some of the items used include:

- A3 sheet printouts sectioned into three parts - main screen, menu bar and result.
- Image cutouts with images - used to represent products and services.
- Posits - (blank canvases) used to include unrepresented products and services.
- Felt-pens/ markers - used to mark relationships, boundaries, and write down information.

![Figure 5: Rapid prototyping session.](image)

The prototyping session focused on the investigation of the event flows of the visual representations: investigation of the products
and services interactions. This was done using two scenarios and five settings. The settings are sample guidelines on how the given scenarios were to be presented.

**scenario 1:** Consider that we have 2 houses (House A and House B) equipped with a smart home platform. We want to implement the following logic: If in House A the temperature reaches 26\(^\circ\)C, Then Turn ON the lamp/smart Plug in House B, And Turn OFF the oil-heater/smartPlug in House A.

**scenario 2:** Consider that we have in one house the following:
- A climate sensor.
- An Arduino wired to a fan (motor), and a proximity sensor.
We want to implement the following logic: If the temperature reaches 25\(^\circ\), And proximity reads 5cm or closer, Then rotate the motor clockwise at max speed.

- Setting 1 - Flow representation of scenarios with a gateway node used to display all connected devices.

- Setting 2 - Flow representation of scenarios without a gateway node.

- Setting 3 - Representation of devices using two separate Input and separate output nodes (instead of one node with both input and output).

- Setting 4 - Representation of Arduino devices at pin level.

- Setting 5 - Representation of Arduino devices at function level.

Each team had to prototype scenario 1 with settings 1,2 and 3. Scenario 2 was prototyped with setting 4 and 5.

**Workshop Review**

To conclude the workshop, a sit-down discussion was held with all the participants and facilitators. The discussion was focused on the proposed concept and the rapid prototyping session. The researchers
were for the proposed concept and preferred a logical representation of an event/scenario to a physical representation. The participants stated that an abstract presentation of a device or service is better; having the details of the implementation hidden would make prototyping quicker and easy to follow.

In the case of the setting, after rapidly prototyping the outlined scenarios and with matching settings, the participants prefer to prototype without the gateway. They also prefer the representation of Arduino devices at function level, even though some situations would call for a pin level representation. The participants stated that two representations of a device (Input and output nodes) make flows clear and easy to follow. The participants outlined these views during the sit-down discussion.

4.3 Visual Prototyping tools and techniques Review

The investigation or review of the current prototyping tools was carried-out using identified criteria, (functional and non-functional requirements):

1. The Learning curve of the platform (tool): How quick can a new user learn to use the platform.

2. The extensibility of the tool: can it be easily extended and/or customized.

3. Integration: Can it be easily integrated into an existing platform.

4. The requirements specifications of the users. This includes reviews of workshops one and two.

5. The documentation of the tool: Does the tool have a rich library of components and a well-documented extension model.

6. The community and support: Does it have an active community.
The different prototyping tools and techniques reviewed were categorized as: Educational, Multimedia, Gaming, Systems/simulation, Automation, Data warehousing/business intelligence, Miscellaneous and Legacy. We reviewed and narrowed down the selection to a number of prototyping/programming platforms that fit some of the outlined requirements. The selected tools were grouped into the following categories:

1. IoT: Tools that are focused on prototyping for Internet of Things, and some of the main tool investigated include: Node-RED and Thingworx.

2. Smart Home: Tools that are focused on prototyping for smart home products and services. Some of the tools investigated include: Smartthings and openHAB.

3. DIYs (Do It Yourself): Tools that focus on prototyping hardware and or engineering products. Some of the tools investigated include: MESH, Wyliodrin, Gadgeteer, and S4A.

4. UX (User eXperience): Tools that focus on prototyping interactive experience and graphical user interface (GUI). Some of the tools investigated include: InVision, Noodl, and Quartz Composer.

5. Educational drag-and-drop programming: Tools used to teach programming of scenarios using visual features instead of scripting code. Some of the tools investigated include: Scratch and Snap.

Another important criterion investigated in the prototyping style of the tools. The main prototyping styles discovered during the review are: drag-and-drop block-based, drag-and-drop node-based and scripting (Text-based). Other styles worth mentioning are form-based and layer-based. The node-based style was selected because the relationships/connections between products and services (flows) can be easily defined. Node-based is also much easier to understand and follow for first time users who do not specialize in development/programming.
We decided on Node-RED [46], which is an open source visual programming tool for wiring Internet of Things (IoT). Node-RED was selected because it meets most of our functional and non-functional requirements. It’s a node-based visual tool that is extensible and contains custom nodes that allow for versatile connectivity and integration. Node-red has an active community of contributors and accessible library. The Node-red User Interface is moderately easy to learn, and the tool provides useful help information and tips to help and guide users of the platform.
5 Evaluation

The two workshops allowed for the generation of the Visual Rapid Prototyping Environment concept. This then lead to the review and selection of a suitable tool for the creation of the visual prototype. We carried out the review and selection process with a partnering research project where the processes are elaborated in more details. [17]. The evaluation process involves the creation of the Visual Rapid Prototyping Environment prototype, and the third workshops: which is the evaluation process of the project.

5.1 Concept Creation

Node-RED is the visual programming tool that we selected to create the visual rapid prototype concept (prototype) to be used for the evaluation phase of the project. Node-RED was selected because it has an active community, rich library, open source, extensible, easy to learn and provides support (help information). More details of the selection process can be backup with information from the partnering project’s report in chapter 5 [17]. Node-RED is defined as “a tool for wiring together hardware devices, APIs and online services in new and interesting ways” [46]. This makes it feasible to wire the existing Verisure platform to the modified Node-RED User Interface.
The modification of Node-RED involved the creation of VerisureIQ menu section that includes Verisure products and services. The products and services are represented using nodes that have input/output tags to be used to illustrate relationships and types of relationships between nodes. The Node-RED platform is built in node.js and it allows for the programming of custom nodes in javascript. Each of the Verisure nodes was created using javascript. Some of the Features or flexibility provided by node customization include: help information, naming of nodes, and personalizations of node: names, functionality, interactive forms, layout, appearance.
5.2 Workshop Three: Concept Evaluation

The aim of the third workshop was to evaluate a functional prototype of the Visual Prototyping Environment. The workshop activities included usability testing session and a final discussion. The activities involved six participants divided into two groups. As the first two workshops, the third workshop began with a recap of the previous workshops then the division of participants into two groups. The usability testing session involved two setting: one setting was a demonstration of the Node-RED based prototype, and the other setting involved visual prototyping based on an outlined scenario.

The demonstration involved visual programming of selected physical devices using the Node-RED based Visual prototype tool. The devices used where an arduino Mega and a versisure smartplug. The demo event involved the wireless control of a lamp connected to the smartplug, and the control of the arduino board. The event involved...
the clicking of a button on the Node-Red Interface to either turn the lamp on/off, the signal was then sent to the Arduino board which then sent the signal wirelessly to the smart plug and the actions reflected on the connected lamp.

The prototyping setting was based on one of the scenarios first introduced in workshop two:

**scenario 2**: Consider that we have in one house the following:
- A climate sensor.
- An Arduino wired to a fan (motor), and a proximity sensor.

We want to implement the following logic: If the temperature reaches $25^\circ$, And proximity reads 5cm or closer, Then rotate the motor clockwise at max speed.

The participants worked in groups implementing the solution to the scenario. Each team was able to work with the prototype interface to come up with possible solutions to the scenario. The evaluation process was concluded with a discussion of the prototype and the proceeding of all the workshops.

### 5.2.1 Results and Review

The discussion with the participants covered the following areas:

- Interactive aspect of Node-RED.
- Benefits of Node-RED.
- Layout and functionality of custom nodes.
- Workshops 1-3 activities.

Participants found the Node-Red tool and custom nodes simple and flexible enough for visual prototyping. Some of the participants thought the Node-RED tool would be suitable for people with programming knowledge, and it can also be used as a learning tool for non-professionals. The layout of the evaluation process (workshop) could be improved with a tutorial of Node-Red. Starting with examples or guidance would have also had a positive impact on the evaluation session. Overall, visual prototyping is something most
participants found beneficial and can be really useful during design sessions.

In relation to our research questions:

- How to design and develop a visual rapid prototyping GUI over an existing smart home platform?
  - what prototyping features are suitable for concept designers?
  - What visual prototyping tools and techniques are suitable for embedded interactions of smart home objects?

We were able to research and define features suitable for designers in the line of smarthome projects, and we evaluated and selected visual prototyping tools and techniques suitable for our target group. We created a prototype of a visual rapid prototyping GUI over an existing smart home platform. The evaluation process helped justify our research finding, and all the project activities involved the input and knowledge of a selected group of designers.
6 Conclusion

A Visual Prototyping Environment is a tool that can be beneficial to concept designer who lack development skills because it allow the designers to develop concepts using visual tools and features instead of writing script (code). A smart home Visual Prototyping Environment that allows designers and developers to create and test concepts for physical and software products (smart objects) can help reduce design time, and improve the quality of the developed product.

We have been able to create and test simple events with Node-Red and we still believe it is the right choice for the Visual Prototyping Environment. So far, it has been possible to find workarounds with some of it’s short comings. The involvement of the designers through the workshop has influenced the direction of the project, and solutions to the research questions. Workshops 1 and 2 have also influenced the review of prototyping tools and the outlay of workshop 3. The creation of a prototype and evaluation of the Visual prototyping tool helped in validating the solutions to the research questions.

6.1 Future Work

The Visual Prototyping Environment concept to be extended to include develop/programming of advanced smart home concepts, that include external services such as: different smart home platforms, web services. The future work also includes Documentation and creation of the Visual Prototyping Environment in way that allows other developers to easily add to it.

One of Node-Red’s short comings is that it is not multi-user which can be useful for the designers. We have been able to find workarounds for that, but Node-Red developers are also looking into implementing multi-user feature because it is one of the most requested for features.
References


[27] Dan Maynes-Aminzade, Terry Winograd, and Takeo Igarashi. Eyepatch: prototyping camera-based interaction through ex-


Appendix A  - Workshops

Rapid Prototyping Session
Workshop 1 was carried out on the 12th of March 2015 and it took one hour 30 minutes. We used paper prototyping tools for the rapid prototyping session.

A.1 Scenarios and Menu Features

Scenarios

Figure 9: Child Monitoring Scenario (Group A).
Master Thesis Project: A Visual Rapid Prototyping Environment for SmartHome Concepts

Figure 10: Device adjustments based on room occupancy Scenario.

Figure 11: Teenager Monitoring Scenario (Group B).

Features
A.2 Semi-structured Interviews
Master Thesis Project: A Visual Rapid Prototyping Environment for SmartHome Concepts

### Table 1: Interviews: Group A

<table>
<thead>
<tr>
<th>Q1: Currently, when you prototype similar concepts, what methodology, workflow do you use?</th>
<th>Participant A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Represent use cases on slide shows: flows, interactions</td>
<td></td>
</tr>
<tr>
<td>Mostly text based, not graphical/visual</td>
<td></td>
</tr>
<tr>
<td>When prototyping, I try to simulate, totally disconnected from the platform.</td>
<td></td>
</tr>
<tr>
<td>I use Lego, Arduino, prototypes of form factors.</td>
<td></td>
</tr>
<tr>
<td>I ask open questions to understand how the concept is perceived.</td>
<td></td>
</tr>
<tr>
<td>I use task based testing, observation and wizard of Oz.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q2: Currently, when you prototype similar concepts, what tools do you use?</th>
<th>Participant B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction designer: don’t think too much about technology.</td>
<td></td>
</tr>
<tr>
<td>I communicate through scenarios, use cases.</td>
<td></td>
</tr>
<tr>
<td>I work with wearables, user experience, UI/physical</td>
<td></td>
</tr>
<tr>
<td>Tools: Adobe suite, wireframes, slide shows</td>
<td></td>
</tr>
</tbody>
</table>

| Participant C  |
|---|---|
| Prototype software/hardware at the same time  |
| I use standard languages: Python, C, arduino, php  |
| I usually use php scripts for building the server side  |
| I also find existing services, like IFTTT, useful but not very flexible (example: can’t invoke a service using https from an arduino device, it needs higher computing power)  |

<table>
<thead>
<tr>
<th>Q3: Do you think that visual programming is expressive enough?</th>
<th>Participant A</th>
</tr>
</thead>
<tbody>
<tr>
<td>I don’t know, depends on who favourite tool programming - text based</td>
<td></td>
</tr>
<tr>
<td>For a concept design, graphical might be a bit limiting</td>
<td></td>
</tr>
</tbody>
</table>

| Participant B  |
|---|---|
| This is new for me, I have a different focus since I find this very technology oriented however I don’t find it difficult (surprisingly)  |

| Participant C  |
|---|---|
| Yes, worked with labview, simulink and scratch  |
| I don’t think there’s big need for scripting  |

<table>
<thead>
<tr>
<th>Q4: Do you think having such prototyping environment will be useful for your work?</th>
<th>Participant A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes.</td>
<td></td>
</tr>
</tbody>
</table>

| Participant B  |
|---|---|
| Yes, but I need help at the beginning  |

| Participant C  |
|---|---|
| Yes.  |

<table>
<thead>
<tr>
<th>Q5: How do you intend to use it?</th>
<th>Participant A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quickly set up new demos internally</td>
<td></td>
</tr>
<tr>
<td>Create experience -&gt; get approval (Go) on projects</td>
<td></td>
</tr>
<tr>
<td>2. Validate new functionality on real users</td>
<td></td>
</tr>
</tbody>
</table>

| Participant B  |
|---|---|
| To test concepts  |

| Participant C  |
|---|---|
| In research, teaching, private home automation projects  |

<table>
<thead>
<tr>
<th>Q6: What other features or functionalities do you want to see in this prototyping environment?</th>
<th>Participant A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Verisure devices, Arduino, third party services (IFTTT..), interaction</td>
<td></td>
</tr>
</tbody>
</table>

| Participant B  |
|---|---|
| Representations of people and furniture  |
| - combine bed with people  |
| - other objects to trigger imagination  |
| - cats/dogs.. home things  |

| Participant C  |
|---|---|
| I usually lose track of what I have gone through (problems, tricks, workarounds)  |
| I like to see automatic documentation features, or at least an integrated notepad facility  |

<table>
<thead>
<tr>
<th>Q7: Is there something you would suggest, that we could add in the next workshop?</th>
<th>Participant A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection criteria are defined</td>
<td></td>
</tr>
</tbody>
</table>

| Participant B  |
|---|---|
| The current setting is good, especially without technology involved, only paper, pens  |

| Participant C  |
|---|---|
| Satisfied so far  |

52
Table 2: Interviews: Group B

| Q1: Currently, when you prototype similar concepts, what methodology, workflow do you use? | Participant A | Low-fi prototyping: paper and mockups. Select concept parts strongly related to a research question(s), then implement part of the concept then test. Paper prototyping tools, Arduino. Quick prototyping tools (with hyperlinks). Prefer open source platforms (hardware, APIs) |
| Q2: Currently, when you prototype similar concepts, what tools do you use? | Participant B | Currently using Adobe illustrator Start with making layout of the concepts, make information architectures (scribbling ideas and flows) Move to prototyping: currently using flinto. Make a flow of static clickable screen shots. Use existing hardware for physical interaction test. - Makes simulation during test to quicken the process. Sometimes make low-fi prototypes. Other Prototyping tool include: JustinMind, Invision |
| Q3: Do you think that visual programming is expressive enough? | Participant A | It is very powerful and very much needed It is very important especially for communicating with non-skilled developers. |
| Participant B | It is a good enough tool that could be used in situations that involve programming. Would quicken the process |
| Participant C | Yes it can be useful in my current research (Family everyday life and technology) Quicken research process. |
| Q4: Do you think having such prototyping environment will be useful for your work? | Participant A | It will be useful, especially in situations were collaboration is required. The prototyping environment will help improve work practices. To share and collaborate with other developers. |
| Participant B | Would be used for end user tests and to get quick feedback. Gives the possibility of adding hardware (quick connection to hardware), which is beneficial in situations that involve hardware. |
| Participant C | Create prototypes to be used for practical Interviews and testing in the research project. |
| Q5: How do you intend to use it? | Participant A | Packages (recipes) like those found in IFTTT |
| Participant B | Feedback tool/ support, forum involving other developers. |
| Participant C | Tools that allow simultaneous work with others. Being able to see which parts have/are being worked on and by whom to avoid working on the same solution. Collaboration with others, compare solutions and communications tools such as chat and comments |
| Q6: Is there something you would suggest, that we could add in the next workshop? | Participant A | Save a little more time for joint discuss with the other groups. |
| Participant B | More time to discuss (maybe 30 mins) |
| Participant C | Have time to share information with others/ presentations from each group. |