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WATERNOMICS: Serving diverge user needs under a single water information platform

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ABSTRACT

WATERNOMICS is a water information platform that aims to raise awareness about efficient water management using ICT to provide users with insightful and actionable data (Curry et al., 2014). This paper discusses the user needs that 3 different types of users have from a water information platform. In particular, during the early stages of development of the WATERNOMICS platform we have prepared and conducted a set of focus groups and user tests with users from the WATERNOMICS pilot sites. These pilot sites are quite divergent in terms of types of users of the information platform.

The first pilot is an airport (Linate airport, Milano – Italy) where, managers, employees and related business managers need to have access to the airport's water information in a way that supports decision making. The second pilot will be conducted in the municipality of Thermi (Greece) and will increase the awareness of participating households regarding their water consumption and give key information that can empower them to manage their water consumption more efficiently. Finally, the third pilot is to be conducted on the university and secondary school buildings of NUIG (National University of Ireland – Galway). Users inthis last environment include both managers and students. Apart from efficient water management within the school environment, this pilot will also exploit how children can transfer their increased awareness to their parents and in turn help them reduce water consumption.

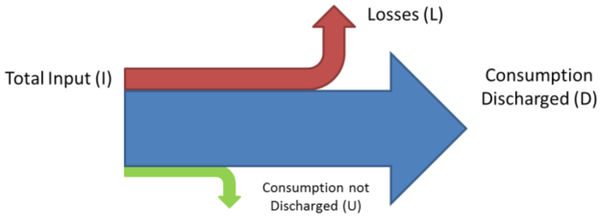
After conducting an initial set of focus groups with users from all pilot sites, we compiled a list of features requested by the users and prepared some paper prototypes of an information platform that can serve each of these stakeholders in turn. These prototypes were then presented to the users in an attempt to capture how they respond to various design alternatives and which is the best way to implement specific features. In this paper, we present our findings in terms of commonalities and differences in the needs and preferences of this diverge group of users. Based on these findings we also propose a unified approach in fulfilling those needs, through a common water information platform. Discussions also include the benefits and challenges associated with such an approach and how the WATERNOMICS platform aims to exploit the benefits and address the challenges.

Keywords: Water management, User needs, Information platform

1. INTRODUCTION

The WATERNOMICS integrated information platform for water use is targeted to develop a simple instrument that can be immediately understood by operational decision makers to achieve the water efficiency and use reduction (Clifford et al., 2014). Indeed as almost always happens, a mere graph of the probability density function is usually not immediately understood by decision makers, so the aim of the WATERNOMICS platform is to collect all the available data dealing with water consumption, network leakages, maintenance and to show them in a simple way through, for example, graphs created "*ad hoc"* for the end users necessities and also through colours coding, metaphors and gamification. The information platform of WATERNOMICS is an instrument that focuses mainly on water efficiency at household, municipality and corporate level through the change behaviours of the end users to achieve reduced water usage and improved operation and maintenance by utilities. Of course it is the main instrument through which WATERNOMICS aims to change water consumption behaviour and it will provide a personalized and customizable solution and application to end-users and doing so it will be able to help in changing water consumption behaviours and policies.

Due the different typology of end-users (household level, municipality level and corporate level), it is clear that the necessities suitable to each decision makers are very different (Curry & Donnellan, 2012). For example at household level should be more important to show, through the WATERNOMICS platform, the overall water consumption to have under control the water costs while at corporate level should be important to know for example: the volumetric performance; costs relate to water sector; savings relate to water sector; current strategies, fault detection and ongoing actions (see the images below).



Period	I (m^3)	L (m^3)	U (m^3)	D (m^3)	D/I	L/I
Day						
Week						
Month						
Annual Projection						

Figure 1: Volumetric performance

Period	Discharge Costs	Energy Costs	Total Costs
Annual Baseline			
Year to Date			
Annual Projection			
Daily			
Monthly			

Figure 2: Costs relate to water sector

Period	Discharge Savings	Energy Savings	CO2 Credit Savings	Total Savings
Year to Date				
Annual Projection				
Daily				
Monthly				

Figure 3: Savings relate to water sector

The WATERNOMICS platform despite the different end-user requests will provide a valid instrument to collect all the water data and to show the results in a very simple, understandable and customizable way for all kind of end users.

The WATERNIMICS platform will be a valid ICT tools that will help water users implement 'smarter' water management programs, conduct data analysis of consumption, leak detection and repair and most importantly facilitate communication among stakeholders to raise awareness of source exploitation (Curry et al., 2014). The approach that will be followed to achieve these goals is to bring new and existing information on the water supply chain and water consumption together in an innovative and effective ICT-based communication platform to the water user (end user) and water operator. The platform tackles the needs for multi-level water management leveraging a number of emerging ICT trends, including Open Data, Internet of Things, Event Processing and Advanced Data Analytics.

2. RELATED WORK

Water information platforms already exist in the market in various versions and with a wide variety of features. Most of them however focus on water utilities and businesses with heavy usage of water such as agriculture. In the following, existing water related information platforms are described, we will clearly see that each one is targeted to a particular end-users while the WATERNOMICS platform overcome this problem by developing a unique platform customizable and personalized for different end users.

2.1.1 Market products

One such water information systems is WaterSmart[1] It provides water utilities for residential water efficiency programs that increase the adoption of water efficient behaviours, devices and appliances. The programs enable homeowners to better understand how they use their water, how they compare to their neighbours and what specific, personalized actions they can take to lower their water bills. WaterSmart Software helps water utilities educate and engage their customers to save water and money. It offers a cloud-based water efficiency solution that helps utilities save water through the following topics:

- facilitate communication of water utilities with customers;
- personalized home water reports to help consumers manage water consumption more efficiently;
- a customer portal for more detailed analysis of consumers' water use and water-saving recommendations;
- utility dashboard for staff to access visually insightful analytics, reporting and customer relationship tools;
- behavioural change methods.

The WaterSmart platform is specifically targeted to water utilities and domestic consumers enhancing their communication while it is missing specialization for businesses and large enterprises internal water management. The WATERNOMICS platform overcomes this problem including a customizable tool suitable also for the corporate level water management, see the Linate Airport (Italy). Moreover it is difficult to adopt the WaterSmart platform for public spaces as for example school and University buildings, see NUIG pilot (Ireland) and at the end It does not allow access to data to third parties for additional applications.

Another similar system TaKaDu[2]. Its aim is to enable the water utilities to improve efficiency and make smarter decisions. It is a decision-making platform that can be integrated across the utility from the analyst monitoring the network to the executive team considering long-term strategic investments. TaKaDu platform is cloud-based, can be implemented within weeks and can be integrated with various IT systems. It facilitates water leakage detection in water networks, fault and burst detection and it is mainly targeted to water utilities so it is particularly suitable for water network management. Its key functionalities include:

[1] http://www.watersmart.com/
[2] http://www.takadu.com/

- actionable alerts and reports about leaks, bursts and inefficiencies and network events;
- real-time alerts and dashboard;
- cloud computing;
- water quality monitoring;
- meter and telemetry failure management;
- awareness to pressure anomalies and other network inefficiencies.

In contrast with WATERNOMICS, the TaKaDu platform is specifically targeted to water utilities and network management issues while it is missing specialization for domestic users and large enterprises users. Moreover, it is not employing any specific behavioural change tactics in order to affect users' water related behaviour.

Similar to TaKaDu, Syrinix[3] is a set of solutions targeting to water utilities for efficient water network management and pipeline monitoring, It allows to:

- tackling pressure transients;
- burst detection;
- alerts with SMS, emails etc.

It is characterized by a real-time monitoring and a configurable dashboards for end users that specifically targeting network management for utilities and enterprises. However, similarly to the previous one is not using at all behavioural change tactics and for more it is not suitable for domestic users like the WATERNOMICS platform. At the last it doesn't allow access to third parties for external applications in contrast with WATERNOMICS which aims to exploit the usage of Linked Open Data technologies to allow third parties to develop applications based on the platforms data (Ahmadi Zeleti, Ojo, & Curry, 2014).

HydroPoint[4] on the other hand, developed a water platform named Water TRAK that allows the set point of controllers, sensor and software for irrigation scheduling. This platform offers a web based application for real-time monitoring. The site-specific weather data are gathered and used for adjusting scheduling of irrigation to achieve a global reduction in water consumption. To achieve that, water conservation plans are implemented and sensors and remote controllers are installed in the water network. This platform is particularly targeting agricultural uses of water dealing with irrigation planning but it misses support for any of the three types of users in WATERNOMICS. Similar to Hydrpoint's system, PureSense[5] is also a water platform developed to improve irrigation systems through planning and monitoring the existing irrigation water network. The main aspects that the platform managed to control are:

- irrigation scheduling;
- pump control;
- flow meter monitoring;
- field monitoring.

Also weather forecast is taken into account to help irrigation planning and scheduling. A team of water technicians are available for end users support and for task and operations management. Similar to Hydropoint's system, it is particularly targeting agricultural uses of water with irrigation planning and It misses support for any of the three types of users in WATERNOMICS.

2.1.2 EU funded projects

Apart from the various water information platforms that exist in the market there are also a number of EU projects[6] that are related to ICT and water. In the last round of funding (called 7th Framework Program – FP7) special attention has been put on developments in the ICT sector. The objective of the EU's FP7 was to improve the competitiveness of the European Industry as well as to enable Europe to master and shape the future developments of these technologies. The EU members have put together a total fund of 9.1 billion Euro only for the development of ICT technology. A new round for research call from the EU is currently open (Horizon 2020) with a considerate focus on technology development. Given the considerate amounts of funds available and the direction EU establishes in the development of these technologies, such research projects are very important to consider. In the list below some of the most important projects developed under FP7 related to ICT and water are synthetically described.

Table 1: EU projects developed under FP7 related to ICT and water

[3] http://syrinix.com/
[4] http://www.hydropoint.com/
[5] http://www.puresense.com/
[6] http://ict4water.eu/

Project Name	**Description**	**Example case**	**Savings Attained**	**Leak Detection and Repair**	**Implementing a Water Management Program**	**Communicating with Stakeholders**	**Upgrading Infrastructure**	**Conducting Data Analysys**
ICeWater	Develop the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs to underserved communities worldwide (Fantozzi et al., 2014)	Pilot site 1: centre-south of Milan Pilot site 2: Timisoara		X	X	X	X	X
iWidget	Advance knowledge and understanding about smart metering technologies (Kossieris et al., 2014; Loureiro, Alegre, Coelho, Martins, & Mamade, 2014)	Households and utility stakeholders (UK – Portugal – Greece)	Reduced demand for water and hence the energy required for its treatment	X	X	X		X
SmartH20	Engage citizens by means of cooperative awareness tools, such as water consumption profiling and feedback, persuasive games for behaviour change, and computer-supported community work.(Harou et al., 2014)	Households: District of London (UK) and district of Locano (CH)	Maximize the water and energy saving		X	X		X
DIAD	Challenge of improving the management of water resources through real-time knowledge of water consumption, in order to improve societal awareness, induce sustainable changes in consumer behaviour, and explore new water demand management strategies (Athanasiou et al., 2014)	Residential households	User awareness and self-induced behavioural change for delivering sustainable changes in water consumption		X	X		X
EFFINET	Optimal operational control, real-time monitoring and demand forecasting. Flow and pressure control to minimize electricity costs also through model predictive control techniques (Patrinos, Sopasakis, Sarimveis, & Bemporad, 2014)	Residential households. Two real-life pilot demonstrations in Barcelona (Spain) and Limassol (Cyprus)	Techniques for the operational control of water networks, real-time monitoring to detect and locate leaks, software solution that serves as a decision-support tool	X	X	X		X
WISDOM	Water and energy savings through the integration of innovative ICT frameworks to optimize water distribution networks and to enable change in consumer behaviour through innovative demand management and adaptive pricing schemes (Zarli, Rezgui, Belziti, & Duce, 2014)	Domestic, corporate and city users. Two pilot projects – in Cardiff (UK) and La Spezia (Italy)	Collect real-time data about water consumption at domestic, corporate and city level. Improve the awareness of household and business water users, encouraging changes in their water usage behaviour	No data	X	X	No data	X

To examine all these projects, it is necessary to catch the analogies with WATERNOMICS targets. This work will be helpful both to take suggestions from other projects and to avoid doing a redundant research. Anyhow from the table shown above we learn that to achieve the project's targets the following measures are essential:

- implementing a Water Management Program;
- communicating with Stakeholders;
- conducting Data Analysis.

WATERNOMICS possesses these essential requirements.

In terms of implementing a Water Management Program, WATERNOMICS will develop:

- a Platform that integrate water usage related information from meters, sensors, data analysis (fault detection);

- a standards-based Methodology for the design of ICT-based water management programs at domestic, corporate and municipality levels.

Regarding the communication with Stakeholders, WATERNOMICS will demonstrate and validate the platform, methodology and software across three project pilots sites that target domestic, corporate and municipal stakeholders. It is clear that communicating with stakeholders is the basis of a project's success.

Finally in terms of conducting Data Analysis WATERNOMICS will develop a low – cost leak detection method, hardware and software for water networks using dedicated microphone in combination with smartphone and an advanced flow-sensing method, hardware and software for water networks using magnetometer and mems/strain gauge based sensors. Installation of flow and pressure sensors will be developed for the pilot sites to carry out a development of a database and to allow the validation of WATERNOMICS' platform and methodology.

3. METHODOLOGY

During its first months, WATERNOMICS followed a seven step method to provide a final set of three scenarios in order to identify and describe key features that a water information platform should include. Having completed this method we introduced a linking step which connects it with the iteration cycles in the development process begun including user tests using paper prototypes of the potential applications of the platform. In this section we will describe briefly how the scenario development method lead to user test and what tools were used to conduct them.

3.1 Scenario development

Overall, scenario development has been based on three sets of guidelines and criteria. The set of final scenarios should:

- be based on end-user perceived value,
- be based on business value,
- cover all target functionality of the WATERNOMICS project, i.e., be compatible with the Description of Work (DoW) document,
- be technically innovative.

To achieve that, we used a zoom-in method, and as such the process was mainly bottom-up. By this we mean that we started by collecting a large set of functionalities and features as basis for the WATERNOMICS scenarios. Then we filtered these features, based on the criteria mentioned above, in a step-by-step way. The final results have been integrated in three scenarios that each covers a part of the WATERNOMICS project from a different perspective and together cover the complete scope of the project. In this section we detail the steps that resulted in these three final scenarios.

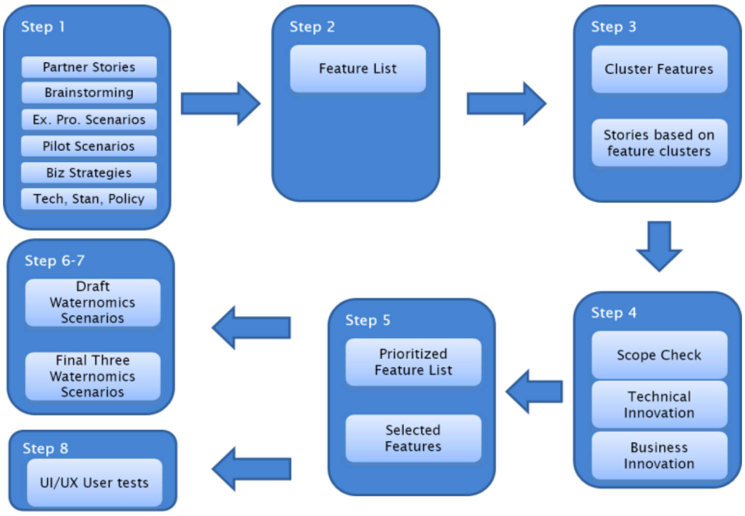


Figure 4: Scenario development methodology

3.1.1 Step 1: Feature list development

As the scenarios form the basis of the project, we decide to first generate a very broad list of functional and technical features that could be used as the basis for the scenarios. We did not want to exclude features that might have value at the start of the project. We gathered a list of features. This approach ensured a broad set of features, and thereby a large set of functionalities. These features have been developed by:

- project partners;
- brainstorming session;
- pilot scenarios;
- business strategies;
- technologies, standards, policy.

3.1.2 Step 2: Clustering

Having collected the features from the aforementioned sources, a list of features (where a feature is defined as any identifiable block of functionality, be it user-based or technical) was compiled collaboratively by several project members. The feature lists included a total of 68 features.

3.1.3 Step 4: Filtering

In addition to the end-user based criterion we gathered three other types of criteria (project scope, business innovation, and technical innovation) in order to balance the final scenarios. These four different types of criteria have been used as filtering criteria for the initial list of features. Based on the additional 3 types of criteria a list of specific criteria was formed. The list of the business criteria has been assembled by the different project partners to be able to score the different features based on business value. The same has been done for technical innovation value. Finally, the WATERNOMICS project proposal has been used as input to evaluate to what extent a feature fitted within the scope of the project.

3.1.4 Step 5: Prioritization

Based on the four different criteria (user-value, business innovation, technical innovation and description-of-work relevancy) all features have been scored individually and separately for each of the criteria. This has been done by different project members, to ensure an unbiased way of scoring (e.g., project member A from company X scored only based on business innovation, while project member B from company Y scored only based on technical innovation). These scores have been integrated using a weighted average. This resulted in one score per feature that has been used to prioritise the list of features. In a plenary discussion involving all partners a selection of features was made based on this prioritised list. This selection was used to develop the final three scenarios.

3.1.5 Step 6-7: Scenario development

The selected features built the basis for the final three scenarios. Based on them a set of selected scenarios have been used to construct three different scenarios that each has a different perspective on the WATERNOMICS project. Three different teams were created and each team worked on one scenario. Each team kept track of which features have been used in the scenario, ensuring full traceability of the scenario back to the first step of collecting features as well as the individual scorings of the features based on the different criteria. Finally, during a face-to-face plenary workshop involving all project partners the draft scenarios have been discussed and fine-tuned resulting in the three final scenarios described in this document.

The scenarios have overlap, but they focus on different aspects. The two dimensions that have been used to focus the scenarios are the type of target user group involved, and the type of information and services involved.

3.2 UI/UX User tests

3.2.1 Paper prototypes used

As already presented, UI/UX user tests were based on paper prototypes. :Low fidelity paper prototypes are a technique that allows researchers to focus on higher level concepts and in a cheap and easy way and encourages users to provide feedback more freely (Heaton, 1992; Nielsen, 1995; Rudd, Stern, & Isensee, 1996). Therefore before conducting the user test a set of paper prototypes for some basic applications were designed in paper using Pencil[7]. In particular there were 3 applications that were focused on a) a monitoring dashboard; b) a news portal and c) a simulation tool.

In addition to those 3 applications a set of home pages for the platform was designed in order to explore the main needs and preferences a specific user has by the platform. Figure 5, Figure 6 and Figure 7 present the three options for a home designed for the WATERNOMICS platform. Version 1 employed a minimalistic approach allowing users to choose among 4 options to further work in the platform, while version 2 tries to present in a slightly equal weight the monitoring feature with water related news. Finally version 3 emphasizes on the monitoring aspects of the platform using a time line based layout for the news feed and presenting other tools as peripheral elements of the system.

[7] http://pencil.evolus.vn/

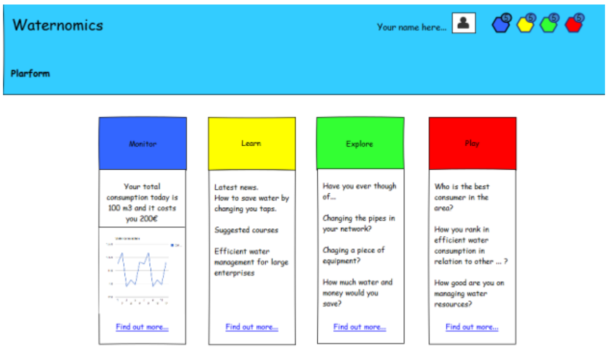


Figure 5: Version 1 of the home page

Figure 7: Version 2 of the home page

Figure 6: Version 3 of the home page

Figure 8: Version 1 of monitoring dashboard

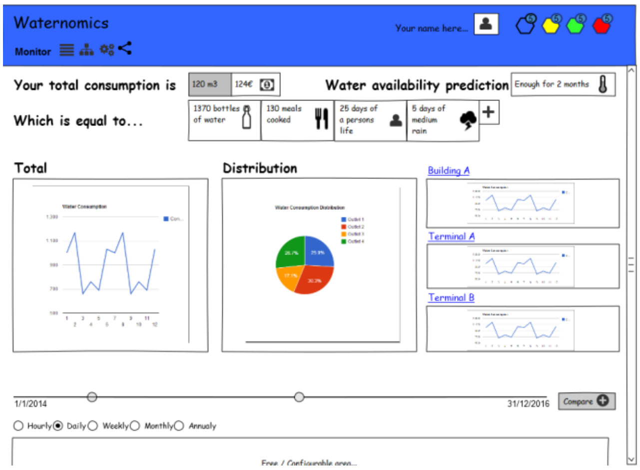


Figure 9: Version 2 of monitoring dashboard

Figure 10: Version 3 of monitoring dashboard

Figure 11: The appliances simulation application

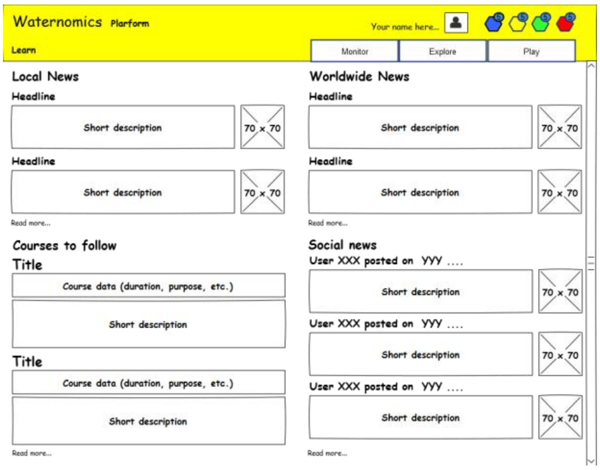


Figure 12: Version 1 of the news portal application

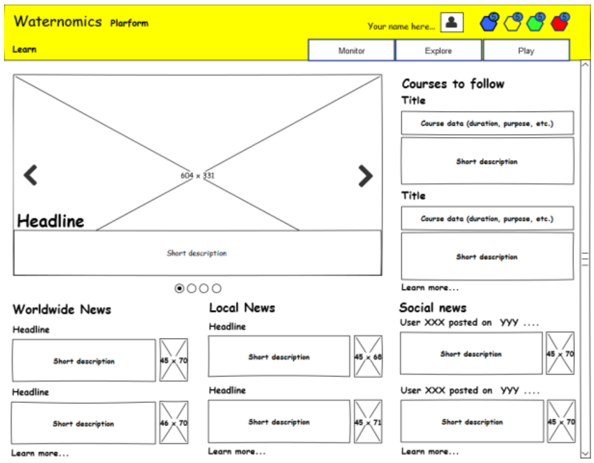


Figure 13: Version 2 of the new portal application

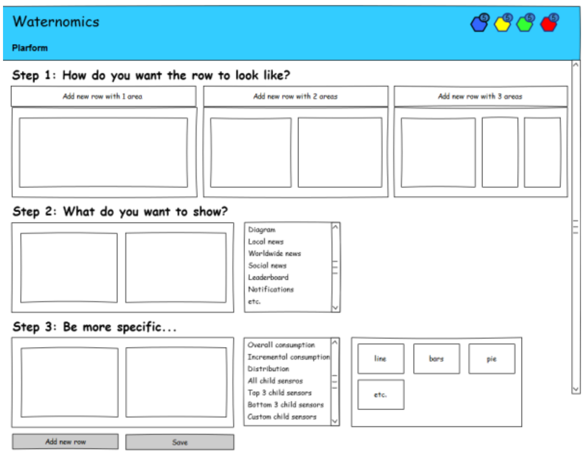


Figure 14: Dashboard configuration tool

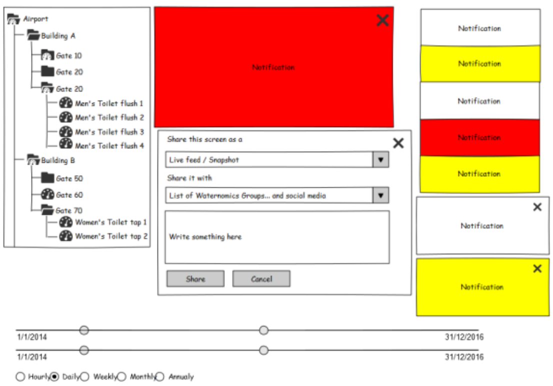


Figure 15:Additional widgets

In **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.** the 3 versions of the monitoring dashboard are presented. The first version tries to give as much space as possible to the diagrams and present a general overview of the consumption and how this is distributed in different part of the network. The design follows a 2 columns layout and leading the user based on his reading direction (left to right) to read a story that goes from generic to specific (Choudhury, 2014). The same principle is followed in the other two version as well. The user is lead based on his reading direction from a generic overview to more specific information. The main difference is that in version 2 there is an additional step showing the distribution of the consumption in an overview chart and then leads to the final step of the specific details whereas in version 3 the distribution is displayed using the time dimension as well. The information in this type of diagram tries to give users the information displayed on the 2 last columns of version 2 but in one place. The user can check the current distribution of consumption and how each specific part of the network behaved in

the recent past. Version 3 tries however to emphasize more on the metaphors (Cybulski, Keller, & Saundage, 2014) leading to them at the end of the story.

Apart from the 3 versions of the home page and the monitoring dashboards users were also introduced to 2 different versions of the news portal as a learning application. Figure 12 and Figure 13 show the home page of the 2 different approaches where on the second version some of the news items are more prominent than the rest of them being shown in a large "carousel" item. Finally, users were also introduced to the concept of the simulations application (Figure 11) through a simple example of an appliances simulation application.

3.2.2 Protocol

The test were mainly based on interviews with users of the system based on the aforementioned paper prototypes. Interviews started by introducing users to the idea of WATERNOMICS and its aims and then by introducing them gradually to different parts and applications of the platform. Initially they were given the 3 versions for the home page and they were asked to comment on them and select one as their favourite. A discussion followed their selection that helped in identifying what were the main reasons that led to their choice and how they understand various details in the user interface. The details discussed in that part of the test were mainly about the features used in the header of the platform. Their preference in presentation of the menu, in the categorization or not of notifications were the main items of discussion there.

In the next step users were given the 3 versions of the monitoring dashboard application and their initial reactions in exploring them and selecting their most favourite were observed and discussed. After that the discussion over the reasons of their selection and specific parts of the dashboard UI followed. In particular, the items examined in the discussion were about the usage of metaphor buttons and their usefulness or not, the ability to control the period of the report and the interval of the analysis, the ability to compare between different period and the ability to move into their water network and find out more specific information about their consumption. Finally the sharing feature was also discussed in combination with the ability to configure the layout and information presented on the dashboard through the configurator tool (Figure 14). The user test ended with a discussion of preferences over the 2 variation of the news portal application and their ideas based on the simulation tool.

The participants in the user tests included 7 users in different level of the organisation in the Linate airport, 8 domestic environment users at Thermi and 8 users at NUIG. Users included a diverge set of user types that included:

- users at the management level of an entity or a business such as the airport of a university building;
- users at the operational and technical level responsible for maintenance of existing and building of new infrastructure;
- users in the area of design for new infrastructure;
- domestic users responsible for managing households;
- teachers / school principals / lecturers;
- students / researchers.

All users were presented with the same designs slightly altered in terms of tiles and labels to connect better in their context. Moreover a set of additional widgets was also used to simulate the screens reactions to different actions that a user could do on it. This way users felt free to try pushing buttons to identify reactions of the system or in other cases they were asked to identify which actions (clicks on screen) would trigger a specific reaction of the system. Moreover, since users were presented with the designs printed in paper they were also asked to note on them in case of comments or feedback. Interviews were usually conducted in small groups of 2-3 users per session to allow more fluent discussions to evolve based on users comments.

After conducting the interviews comments and feedback gathered were analysed and input started to cluster under specific themes. Those are discussed in detail in the following chapter.

4. RESULTS

This chapter presents and discussed some important results in terms of common needs and specific details for particular users that a water information platform such as WATERNOMICS should employ in order to be serving a user base as diverge as the one of the user tests.

4.1 The need for meaningful information

A common theme appearing from all interviews is the need that all users have for information. However, information needs to be useful and meaningful and provided in a timely fashion and following some basic design principles to help users (Choudhury, 2014). For example, domestic users are informed about their total consumption when they get their quarterly bills. In case there is a leak or fault that results in more consumption than usual this is found by them only after a significant period and probably with the cost already billed to them. Moreover, they would like to know how much they consume for specific purposes and if this usual for their households or not. In the case of the airport, although some meters exist the information gathered from them is not complete and it is not able to answer their questions. Managers, for example, wanted to know if they face problems with leakages and water losses in their network so that they can identify and document them in order to form a strategy to tackle them. In the public building of NUIG there are more often measurements in various points of the network. Managers can have an overview of the consumption but they lack the tools to inform students about how water is being used and what effect do specific behaviour changes of students can have in water consumption of the building in order to raise awareness and affect students' behaviour.

In all cases there is also a common pattern of lack of information that also consequently leads to lack of meaningful information. For example, a domestic user that sees consumption for 3 months in his bill in cubic meters cannot realize how much is the specific amount, if it reasonable for a household of his level etc. Users need to be able to estimate easily the cost of water consumed and benchmark changes in infrastructure to understand the turnover of specific investments. In the public building case, presenting consumption information in meaningful equivalents that put their consumption into perspective could have a significant impact on their behaviour. That is why almost in all user tests the feature of metaphors was highly appreciated. Even for the enterprise case were users are more familiar with volume metrics a tool that calculated costs was appreciated.

Finally, meaningful information does not come without control. The theme of need for information was always connected with control over the information displayed in order to gain different insights on the data (Choudhury, 2013). Users depending their needs found helpful and necessary the controls for reporting period and interval granularity control. Moreover, apart from control over the focus on a specific sensor or a group of sensors in a specific area (room, building, site, floor, etc.) was also appreciated as a characteristic although in some cases the icons and buttons used in the interface were misinterpreted. Another useful control feature requested by users was the ability to control types of diagrams used to represent information and in the most demanding types of users (e.g. managers in the airport) the control over the layout of the page and the ability to control the layout, information included etc. was really appreciated. However, such kind of control was not characterized as a must have feature from domestic users who mainly went for predefined layouts.

4.2 The fear of missing out

Social media, ubiquitous connectivity and mobile devices have introduced users nowadays with a new social anxiety called fear of missing out (FOMO). Although the specific social anxiety relates with a number of factors (Przybylski, Murayama, DeHaan, & Gladwell, 2013) in our user tests we can describe it more as a need rather than as a fear. One of the common scenarios heard in many different versions was the one of leakage identification. Users either in domestic or in corporate environment knowing that sensors to be installed will be able to transmit data very often expressed their need for timely notification for potential problems in their consumption. Especially in the domestic environment where information about consumption is received every 3 months with their water bills, people were really concerned not to miss out the possibility of having a leak in their home that they could not identify by other means resulting in increased bills.

Another variation of the same need connected also with social behaviour was that people were curious to know and get updates on the way they behave compared with social norms. Therefore a frequent reminder of their achievements compared with social norms and average was requested from some users. In the case of public environment this is even more evident since people interact with other and want to feel being within social norms. This kind of information was one of the many types of information that users expressed their desire to have in an intelligent and not annoying way.

Having discussed with users different kind of interruptions they would like such a system to have and their level of intrusion in their lives a very important outcome of the interviews is that different kinds of information should have different levels of criticality and use different channels of communication to reach the user in order not to annoy him. An alert for example for a leakage could be accepted as an SMS on a mobile phone but not a notification about a new article published in the press about the reduction of consumption in their city. Therefore, the mechanism of notifications designed was welcomed with regard to the different levels of criticality of the notifications and their channel of communication.

4.3 The need for decision support

Another common theme appearing as a need across different types of users was the need to decision support. Users from management level to household leaders wanted to know what the potential impact of various decisions will be. Moreover, in some cases, when decisions are implemented a benchmarking systems was also requested in order to follow the impact and be able to estimate impact of similar decision in the future. Especially in the case of the enterprise environment this was a very clear requirement in order to follow up changes in their infrastructure in order to back up proposals for next investments.

End-users of public places would like to see the impact of behaviour changes in their environment in order to become more aware of the impact they have with their behaviours and also increase motivation for changing their behaviour. Having said that, a mechanism that would allow them to follow up and receive feedback on their consumption and following new behaviours is a crucial part of this continuous encouragement needed and this should be given to them in fun, engaging and meaningful ways (e.g. points in a game, instant rewards, eco-feedback mechanisms, etc).

Summing up the need for decision support can be supported by applications that will predict consumption and costs of specific changes in infrastructure, appliances or behaviours helping users to identify their impact by putting the benefits into perspective (e.g. how much is saved in one year, what are the equivalents in water footprint of products etc.). However, predictions and simulations should also be able to provide mechanisms for following up such changes and measuring the actual benefits for future reference.

4.4 The need for a good social status

Environmental awareness is today one of the traits that many companies and persons want to promote. In our user tests the feature of sharing information about one's consumption in social media or communities to exchange information was positively discussed. However, many users expressed their concerns in terms of privacy, which lead us to form a basic rule in such sharing features in the applications. All sharing functions should be explicitly initiated by users and give them full clarity on what information is share it with whom. Therefore, the option of sharing publicly live data from a specific sensor measurement is a feature that potentially violates that rule.

Apart from the need for making ourselves look good to other people, which was amplified by social media, social media also amplified the effect of comparing ourselves with other people. WATERNOMICS as a platform will allow users to compare with peers by letting them participate in communities and in a way that does not compromise the privacy rule

4.5 The need for education

Raising awareness can also be achieved by educating and training people. During the user test, we introduced users to the idea or a news portal where they can check news related to water management and conservation. However, a news system needs to be able to identify different types of users to present them with appropriate information. Household users will probably not care about articles for water management in large enterprises and user in the management level might not need the same type of information as technician in the operational level.

Therefore in order to serve such a diverse set of user types some classification of news items will be needed. Based on that, users will be getting more personalized information answering to their problems when entering the educational platform. Moreover, news items could possibly connect with specific events / needs that users might have in order to appear linked at the specific time. For example a household consuming more than the average on their bathroom could get news items about changing taps in the bathroom or items with advices on how to use more efficiently water in the bathroom etc.

Finally, the features of news item published in social media and the feature of courses for specific user types were also appreciated and found interesting by users.

4.6 The need for fun

Games are a fun and engaging way for people to raise awareness. Simple, quick and fun quick games can be targeted to public space users that do not take much time to complete can provide users with small useful and memorable information, Moreover, they can affect user's behaviour in the long term. In addition, games that include personalization elements and help users keep track their own performance in saving water can be used to raise awareness and affect behaviour especially in cases such as the pilot in the university environment.

A game with such personalization features that connects with real consumption statistics of users was the idea of leader boards and competitions. This kind of applications can be used in many different levels. Employees of a company compete in departments to see who is the more water efficient one, members of a family could compete among them for who is the best water consumer. In general users either on their own or in groups can be participate in such games so the application can fill in the need for fun in multiple levels. During the user tests there was not much focus on that part of the platform but some rough ideas were discussed and in general all users recognised the value and awareness that such an approach can have. The idea of leader boards was considered interesting especially when people in groups had to compete with other groups.

Games can be a fun way to engage users in using the platform and raising awareness but an interesting also feature to be exploited throughout the platform is the idea of pleasant surprises. This usually includes small changes or surprises in the way applications react to users' actions. A sound, and unexpected animation or even an unexpected message appearing on your dashboard can connect user emotionally with the tools but giving them small pleasant and memorable surprises. During user tests, we exploited the idea by using fun noises when new additional elements for the dashboard were positioned on the paper to simulate the interaction. Users seemed to enjoy the whole process and such moments seemed to loosen them up and increase their engagement in the tests.

5. CONCLUSIONS

The results from the user tests made clear that different user types even in the same environment have quite different needs. This means that there is no "one-size-fits-all" solution. However, although details between users might have big differences there are 4 main needs that can categorize those needs. Those are a) monitoring of water related information; b) learning by news, lessons and social interaction; c) exploring through simulations and prediction mechanisms and d) fun through games.

Given those facts the applications platform can satisfy all users if it allows them to choose among a variety applications targeted specifically for their user type and environment. Therefore, the approach that WATERNOMICS is going to adapt is that of a marketplace similar to what happens in many modern ecosystems (e.g. Mobile phone platforms). Users will be able to find in this market place, applications they need and select to use them. The categorization will help them find easily what they are looking for.

In addition, as observed in the user tests most users had a strong preference for a specific application with specific prominent features. The managers for example were interested in the monitoring dashboard where operational level technician preferred more a more compact mobile version of the dashboard with emphasis on the notifications mechanism. Therefore, the platform will introduce to users the concept of the primary application that will be the main entry point to the platform. This way when user log in will be seeing first their selected favourite application and then move on to others from that.

Finally there are some key features horizontal features that should be made available throughout the platform in order for consistency in specific elementary concepts. User tests identified that, notifications and the concept of equivalents or metaphors of water usage in other measurable items such as coffee cups, swimming pools or equivalents in water footprint for specific products (e.g. Orange, t-shirt, etc).

Summing up, WATERNOMICS after a series of user tests that followed a scenario development method identified when it comes to water information platform tools there is no universal solution. However, if a platform can provide through services

the information needed it provides the basis for the formation of an ecosystem within which third parties can provide their own, targeted and personalised solutions for different needs of a diverse user base.

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REFERENCES

Ahmadi Zeleti, F., Ojo, A., & Curry, E. (2014). Business Models for the Open Data Industry: Characterization and Analysis of Emerging Models. In *15th Annual International Conference on Digital Government Research (dg.o 2014)* (pp. 215–226). ACM.

Athanasiou, S., Staake, T., Stiefmeier, T., Sartorius, C., Tompkins, J., & Lytras, E. (2014). DAIAD: Open Water Monitoring. *Procedia Engineering*, *89*, 1044–1049. doi:10.1016/j.proeng.2014.11.223

Choudhury, S. (2013). The Psychology Behind Information Dashboards | UX Magazine. *UX Magazine*. Retrieved from http://uxmag.com/articles/the-psychology-behind-information-dashboards

Choudhury, S. (2014). Four Cognitive Design Guidelines for Effective Information Dashboards | UX Magazine. *UX Magazine*. Retrieved from http://uxmag.com/articles/four-cognitive-design-guidelines-for-effective-information-dashboards?utm_source=Twitter&utm_medium=ArticleShare&utm_tone=ro

Clifford, E., Coakley, D., Curry, E., Degeler, V., Costa, A., Messervey, T., … Smit, S. (2014). Interactive Water Services: The Waternomics Approach. In *16th International Conference Water Distribution Systems Analysis (WSDA 2014)*. Bari, Italy. Retrieved from http://www.edwardcurry.org/publications/Clifford_WDSA2014.pdf

Curry, E., Degeler, V., Clifford, E., Coakley, D., Costa, A., van Andel, S. J., … Smit, S. (2014). Linked Water Data for Water Information Management. In B. Brodaric & M. Piasecki (Eds.), *11th International Conference on Hydroinformatics (HIC)*. New York, New York, USA.

Curry, E., & Donnellan, B. (2012). Sustainable Information Systems and Green Metrics. In S. Murugesan & G. R. Gangadharan (Eds.), *Harnessing Green IT: Principles and Practices* (pp. 167–198). John Wiley & Sons, Inc.

Cybulski, J., Keller, S., & Saundage, D. (2014). Metaphors in Interactive Visual Analytics. In *Proceedings of the 7th International Symposium on Visual Information Communication and Interaction - VINCI '14* (pp. 212–215). New York, New York, USA: ACM Press. doi:10.1145/2636240.2636866

Fantozzi, M., Popescu, I., Farnham, T., Archetti, F., Mogre, P., Tsouchnika, E., … Bimpas, M. (2014). ICT for Efficient Water Resources Management: The ICeWater Energy Management and Control Approach. *Procedia Engineering*, *70*, 633–640. Retrieved from http://www.sciencedirect.com/science/article/pii/S187770581400071X

Harou, J. J., Garrone, P., Rizzoli, A. E., Maziotis, A., Castelletti, A., Fraternali, P., … Ceschi, P. A. (2014). Smart Metering, Water Pricing and Social Media to Stimulate Residential Water Efficiency: Opportunities for the SmartH2O Project. *Procedia Engineering*, *89*, 1037–1043. Retrieved from http://www.sciencedirect.com/science/article/pii/S1877705814023376

Heaton, N. (1992). What's wrong with the user interface: how rapid prototyping can help. *IEE Colloquium on Software Prototyping and Evolutionary Development*, 7/1–7/5. Retrieved from http://ieeexplore.ieee.org/articleDetails.jsp?arnumber=214388

Kossieris, P., Kozanis, S., Hashmi, A., Katsiri, E., Vamvakeridou-Lyroudia, L. S., Farmani, R., … Savic, D. (2014). A Web-based Platform for Water Efficient Households. *Procedia Engineering*, *89*, 1128–1135. Retrieved from http://www.sciencedirect.com/science/article/pii/S1877705814023492

Loureiro, D., Alegre, H., Coelho, S. T., Martins, A., & Mamade, A. (2014). A new approach to improve water loss control using smart metering data. *Water Science & Technology: Water Supply*, *14*(4), 618. Retrieved from http://www.iwaponline.com/ws/01404/ws014040618.htm

Nielsen, J. (1995). Using paper prototypes in home-page design. *IEEE Software*, *12*(4), 88–89, 97. doi:10.1109/52.391840

Patrinos, P., Sopasakis, P., Sarimveis, H., & Bemporad, A. (2014). Stochastic model predictive control for constrained discrete-time Markovian switching systems. *Automatica*, *50*(10), 2504–2514. Retrieved from http://www.sciencedirect.com/science/article/pii/S0005109814003471

Przybylski, A. K., Murayama, K., DeHaan, C. R., & Gladwell, V. (2013). Motivational, emotional, and behavioral correlates of fear of missing out. *Computers in Human Behavior*, *29*(4), 1841–1848. doi:10.1016/j.chb.2013.02.014

Rudd, J., Stern, K., & Isensee, S. (1996). Low vs. high-fidelity prototyping debate. *Interactions*, *3*(1), 76–85. doi:10.1145/223500.223514

Zarli, A., Rezgui, Y., Belziti, D., & Duce, E. (2014). Water Analytics and Intelligent Sensing for Demand Optimised Management: The WISDOM Vision and Approach. *Procedia Engineering*, *89*, 1050–1057. Retrieved from http://www.sciencedirect.com/science/article/pii/S187770581402339X